IIIEE Theses 2016:46

ICT and Strategic Sustainable Development

Proposing a Sustainable ICT Hardware Procurement Framework Considering Relevance and Feasibility

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Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2016

iiiee
THE INTERNATIONAL INSTITUTE FOR
INDUSTRIAL ENVIRONMENTAL ECONOMICS

Published in 2015 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
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ISSN 1401-9191

Acknowledgements

Many people have helped me to move forward in this ambitious journey, one step at a time. First of all, thank you all the interviewees for generously sharing your experiences and views. Your many valuable insights made my journey into sustainable ICT a lot richer learning experience.

Special thanks to people in IKEA, Åsa-Pia Folkesdotter, Peter Abrahamsson Lindeblad, Sofia Grauers, Jonas Warnhag and Anette Månsson, who so openly talked about the challenges and solutions in building sustainability into your daily work. Your kindness and enthusiasm gave me support, and your perspectives for this explorative thesis were of extreme value! I could not have made this thesis without you.

My dear supervisors, Åke Thidell and Charlotte Leire, thank you for always believing in me! You gave me advice even through the stormiest drafts, I truly appreciate your efforts and engagement.

My IIIEE fellow students; this year has been intensively packed with learning and I am happy I made it with you. Especially the Malmö livers, Hélène and Kim, you cheered and supported me during the last rough thesis days. I knew you were always a couple of blocks away, with a sauna! A huge thank you to Kim and her computer, it saved my last thesis writing day when my computer showed its unsustainable side by breaking down after less than two years lifetime.

I wish to say a big thank you to my parents; you have supported my choices along the way and given advice with my work when I really needed it. You have helped to reveal new thoughts with all your knowledge. I did not know in the beginning of my university years that I would finally end up following your footsteps to a similar field. Now I am grateful I did.

The Biggest thank you goes for my boyfriend, Toni, you bring so much light and love to my life! Your support has been the source of my strength when I went through roller-coasters with my thesis process.

Abstract

Information and Communication Technology (ICT) is one of the fastest growing sectors in the world in business sales, energy consumption as well as waste streams. It is pressured for conflict minerals, unsustainable raw material use and hazardous substances, and must quickly respond to these challenges. One way to drive this change is sustainable procurement, with environmental and social minimum and award criteria at its core. There are increasing number of guidelines, ecolabels and standards to guide buyers in implementing sustainable procurement. One emergent approach is circular procurement, inspired by the circular economy movement. In this solution mix, ICT hardware procurer needs to find the way among the data to develop sustainability criteria and approaches for procurement, which are feasible for their organization.

The aim of this thesis is to develop a procurement framework for sustainable ICT hardware in order to assist purchasers in this journey. The framework was derived by literature analysis of 20 existing frameworks (ecolabels, sustainable procurement guidelines, industry initiatives and academic frameworks for sustainable ICT management), 11 interviews with framework developers or managers and validated via workshop discussions with a sustainability expert, business analyst and two procurers in a large international furniture retailer. The Framework for Strategic Sustainability (FSSD) is used as an overall guiding analytical framework.

The sustainable ICT hardware procurement framework consists of two core dimensions: enabling elements (management, people and measurement) and sustainable procurement criteria (used for pre-qualification and tendering). The results show that the core elements are essential for ensuring visibility and facilitating action; yet, especially the implementation of sustainability criteria suffers from lack of procurers' uptake and accountability of using the criteria in decentralized procurement. Thus, the implementation should be a gradual process from the most relevant sustainability hotspots to a more comprehensive set to facilitate a greater uptake. The assessed frameworks do not give sufficient guidance on the first steps (where to start) and the objectives (where to aim). The strengths of the proposed framework include: the first exploration of maturity steps for sustainability criteria for ICT hardware based on back-casting as well as visualization of the link between ICT life cycle and procurement cycle. However, further testing on the feasibility of the proposed criteria structuring approach is needed.

Keywords: Green ICT, sustainable ICT, sustainable procurement, circular economy, criteria, FSSD, Strategic Sustainable Development

Executive Summary

This thesis explores procurement criteria and organizational elements for sustainable Information and Communication Technology (ICT) procurement. Sustainable procurement is procurement, which emphasizes the consideration of social and environmental value when fulfilling the organization's need. Consequently, it signals a preference for socially and environmentally responsible products, services and suppliers in the market. ICT, such as computers and mobile phones, currently poses sustainability challenges throughout its life cycle; raw material extraction may cause local and regional conflicts and environmental damage, growing use of electronics increases energy consumption and greenhouse gas emissions, and improper end-of-life treatment causes health problems and toxic waste.

Despite the potential of sustainable procurement to drive development, which can address the challenges, stronger efforts to implement sustainable procurement is needed. This includes a relevant and feasible set of sustainability criteria, which is weighted properly, implemented effectively and strives for long-term sustainability. Thus, other organizational elements, such as procurement policies and purchasers' capabilities, need to support the signalling power of sustainable procurement. If the criteria and supporting elements are better understood, practitioners can implement effective mechanisms for sustainable procurement, and consequently, use its true potential and drive sustainability changes in the ICT industry.

Therefore, the purpose of this thesis is to contribute to research in sustainable procurement of ICT hardware by exploring current problems and solutions as well as synthesizing the solutions into a sustainable procurement framework for ICT hardware. The thesis is structured and analysed through the Framework for Strategic Sustainable Development, which serves as guidance to link short-term actions and long-term goals. The analysis is structured through five levels: System (sustainability aspects), Success (objectives to facilitate sustainability), Strategic (strategic plans to support the objectives), Action (prioritisation of actions) and Tools (designing and selecting tools to implement action). The thesis is guided by three research questions:

- *RQ1: How do sustainability assessment frameworks and tools for ICT, which are designed for the end user, promote sustainability?*
- *RQ2: What core elements and criteria could be integrated for a sustainable procurement framework for ICT to better support purchasers and suppliers to move towards sustainable development?*
- *RQ3: What are purchasers' opinions of the relevance and feasibility of the proposed elements and criteria?*

Outcome of each question functions as a step to answer the next one. In order to find answers, various methods are used. First, 20 frameworks and tools were identified and analysed through literature analysis. This was supported by 11 in-depth interviews with framework developers or managers and five in-depth interviews with practitioners of ICT sustainability and procurement. Core criteria and elements were then compiled into a conceptual framework. Finally, relevance and feasibility of the framework elements were discussed in workshops with a sustainability expert, purchasers and business analyst from IKEA to validate the framework. In total, four people participated to the workshop discussions. Key findings are presented next.

RQ1: ICT Contribution to Sustainability

The current common criteria mainly address energy efficiency, hazardous chemicals, longer lifetime and design for end-of-life. This is in align with the development of sustainable ICT from green ICT focusing initially on energy and greenhouse gas emissions as well as the societal interest in the link between human health and toxics. Social criteria on human and labour rights

are emerging, notably due to the attention given to conflict minerals, though not yet perceived robust.

While sustainable procurement is implemented with the mission of developing the respective sector towards more environmentally and socially responsible practices, the end goal for single criteria is rarely expressed. Instead, the criteria are framed within a wider and less specific objective and without guidance on long-term change.

Due to rapid development of ICT sector, the criteria should be updated frequently in order to stay valid. However, information sources are scattered (e.g. suppliers, reports, ecolabelling criteria) and do not always contain information what is feasible today and what is wished to be feasible in the future. Similarly, the expansion of product scopes and varying understanding on the 'global' scope of criteria may create more confusion among the buyers. Thus, actors need to fill the gaps where action is not yet taken, simultaneously harmonizing in order to reach effective resource allocation and consumer adoption.

Assessing both criteria and the relevant core elements for sustainable procurement, including the use of the criteria, allows connecting factors, which might not be seen by exploring only one dimension. Core elements include governance and management for guidance, people for implementation and measurement for monitoring progress. The largest hurdle documented in the interviews with end user organizations is the lack of implementation of sustainability criteria; the challenge is to motivate purchasers to use sustainability tools along their core work and users to realize the benefits, such as energy savings from power management features and practices.

RQ2: Propositions for Constructive Criteria and Enabling Elements

Criteria with scoring guidance based on various ambition levels is proposed, informed by ambition levels found from the existing frameworks and guided by the Framework for Strategic Sustainable Development. The benefit of the tiered approach is to set long-term direction for suppliers and purchasers, facilitate process-based work and move resources from updating criteria to following up with the supplier's improvement. Three criteria categories are proposed; health and environment, human and labour rights as well as governance and management.

Three core elements, namely management, people and measurement, were identified as enablers for sustainable procurement. Management establishes visibility and mandate for sustainability, while signalling that the guided measures stay true to the business goals. Raising awareness and engaging people through training is the core measure for people dimension. Moreover, it is suggested to develop more participatory and early engagement methods as people are the ultimate gateway to implementation. Metrics and indicators ensure monitoring of progress; yet, they need further research. Some elements might be more relevant for large organizations with hierarchy and higher specialization amongst people, thus, the applicability for SMEs is not given. An effort was made to visualize the framework with life cycle thinking and circular economy.

RQ3: Relevance and Feasibility of the Proposed Criteria and Elements

This work seems to be the first exploring both conceptual development of criteria structuring from strategic sustainable development perspective (RQ2) as well as its feasibility in practice as procurement criteria and as contract clauses (RQ3) for ICT hardware. Not all common criteria found from the studied frameworks and tools are in align with the most relevant sustainability hotspots. Consequently, it is not recommended to use the most common criteria set. Instead, it is more beneficial to consider gradual development of the criteria set based upon the most relevant criteria as well as its feasibility regarding purchasers' and suppliers' capabilities.

In general, supplier's sustainability governance and management may provide an easy starting point. They provide indication of continuous and systematic efforts in overall sustainability performance. Energy efficiency is another well-established criterion. Second, focus can be directed to sustainable materials and hazardous substances, since they might be less familiar to procurers, yet highly relevant. Third, criteria on packaging, consumables and supply chain impacts (e.g. waste, water) could be adopted. Fourth step is visionary, including software, cloud and support services (e.g. carbon footprint of ICT consultancy). When discussing about the relevance of the proposed criteria, the sustainability experts' opinions and background review on sustainability hotspots were well aligned. However, for companies lacking sustainability expertise, more guidance is needed. Finally, all the enabling elements were considered relevant.

Recommendations

It is clear that procurement can send signals to suppliers to drive the ICT industry towards sustainable development. However, sustainable procurement suffers from weak implementation, undeveloped evaluation measures and lack of long-term direction. Overall, to increase the integration of sustainability to procurement practices, it is recommended to:

- **Foster System Thinking** - Provide guidance on constructing sustainability criteria, which is relevant for sustainability hotspots. Align the criteria with organizational feasibility of the purchaser and supplier to ensure better uptake. Sustainability criteria developed with long-term sustainability in mind can provide guidance on the meaningfulness, direction and implementation steps. This task could be taken by ecolabelling organizations, manufacturers or purchasers with organizational experience and best practices to share.
- **Clarify Success** - Establish clear objectives, which are specific for ICT sustainability and address the most significant sustainability hotspots. Objectives should also be set for the procurement process (communication and awareness, implementation).
- **Establish Strategy** - Set up guidelines and mandates via formal governance and management documents. Ensure prominent sourcing strategies, such as product-service systems, are included.
- **Drive Action** - Explore the perceived and actual barriers and drivers for progressive weighting of sustainability criteria. Overcome the barriers, enforce the drivers and implement progressive weighting practices, which align with system-level sustainability.
- **Leverage Tools** - Leverage the use of tools through simplicity, guidance, accountability and engagement. Simplicity can be guided by the 'sustainability relevance-organizational feasibility' consideration. Guidance is needed especially for Life Cycle Costing and Product-Service Systems; for example, in the form of standards and decision-making paths. Accountability measures should ensure the connection between the individual in the decision-making situation and the use of the sustainability tool(s). Lastly, raising awareness and capabilities through training is essential, however, more participatory methods, such as co-creation workshops for sustainability criteria, could facilitate ownership and uptake of tools by purchasers.

Sustainable procurement is at the core of bridging sustainable production and consumption, however, it is only one instrument among others to reach for sustainable development. Thus, it functions within international and national laws and regulatory schemes. These schemes need to foster the opportunities for sustainable procurement for purchasers and 'level the playing field' for suppliers. It is important to explore and continue to use a mix of complementary instruments to move towards sustainability through the full life cycle of ICT.

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Abbreviations

B2B	Business to Business
CE	Circular Economy
CPU	Central Processing Unit
CSR	Corporate Social Responsibility
ECMA	European Computer Manufacturers Association
EICC	Electronic Industry Citizenship Coalition
EMS	Environmental Management System
EPD	Environmental Product Declaration
EPR	Extended Producer Responsibility
EU	European Union
FSSD	Framework for Strategic Sustainable Development
GeSI	Global eSustainability Initiative
GHG	Greenhouse Gas
GPP	Green Public Procurement
ICLEI	International Council for Local Environmental Initiatives
ICT	Information and Communication Technology
IIIEE	International Institute for Industrial Environmental Economics
ILO	International Labour Organization
ITU-T	International Telecommunication Union (ITU) Telecommunication Standardization Sector

LCA	Life Cycle Analysis
LCC	Life Cycle Costing
MCI	Material Circularity Indicator
NGO	Non-Governmental Organization
PC	Personal Computer
PSS	Product-Service System
REACH	Registration, Evaluation, Authorisation and Restriction on Chemicals
RoHS	Restriction on Hazardous Substances
TCO	Total Cost of Ownership
UN	United Nations
UNEP	United Nations Environment Programme

1 Introduction

Imagine buying a new computer and you want to buy the most sustainable one in the market while fulfilling your functional needs. For your benefit, since the *green* or *sustainable* Information and Communication Technology (ICT) was brought to the agenda of the sector in 2007 by Gartner, many solutions are available to inform consumers about ICT sustainability. You could start looking at the eco-labels, sustainability certifications, environmental self-declarations by the ICT industry, websites, which rank different brands based on their sustainability performance, among others. If not yet confusing, different 'rankers' might show different companies or computers as the 'best alternative' to buy. Also professional procurers are relying on similar information than private consumers to inform the sustainability of the purchase decisions. With the mosaic of information, how can the procurers ensure that the procurement process and sustainability criteria for ICT is feasible, relevant, and open for development?

ICT, such as computers and mobile phones, is one of the fastest growing sectors in the world posing great challenges for the environment providing the materials and absorbing the waste, as well as for the people producing, using and recycling ICT. In 2007, ICT was estimated to contribute to 2-2,5 % of the global greenhouse gases (McKinsey & Company for The Climate Group and the Global eSustainability Initiative (GeSI), 2007 in ITU, 2009). Growing material consumption of ICT has also contributed to the growing electronic waste problem with 41 million tonnes of electronic waste discarded yearly, estimated to grow to 50 million tonnes by 2017 (UNEP, 2015). The industry is also well known from its complex supply chain and related human and labor right violations (BSR, 2010) as well as health hazards at the end-of-life of the equipment (Umair et al., 2013) in the Global South.

As the middle-class is estimated to grow and more people reach affluenza, ICT purchase is within the reach of more people. Notably, ICT-based solutions could also help to reduce 20 % of the global GHGs by 2030 (GeSI, 2015). However, the solutions always run on a material basis, hardware. Without sustainability improvement along the full life cycle of ICT hardware, including sustainable material and energy consumption as well as proper end-of-life practices, the problems are going to intensify with the growing adoption of ICT. Therefore, ICT must quickly address its environmental and social sustainability issues to deal with its growing use.

With growing use, energy consumption, material use for ICT and social equity issues in the supply chain, many actors have been active in developing solutions. For example, the electronics industry has developed a consortium to inform buyers about the environmental performance of the products (ECMA-370) and a set of standards for human rights, labor rights and environmental management in the supply chain (EICC). Certification and labelling bodies have addressed single issues, such as ENERGY STAR for energy efficiency, multiple environmental issues through the full life cycle (such as Nordic Swan) and recently, also including social issues in the evaluation (TCO Certified). Thus, the concept of circular economy, cultivated in academia, has also found its way to practical solutions for example through offering take-back services for printers and remanufacturing them (Mont, 2000). Essentially, the initiatives are based on various focus areas, assessment criteria and ambition levels, which can make it difficult for procurers to decide what to address with their sustainable procurement practices. In addition, the solutions are not yet transformative enough, ecolabels' effectiveness is questioned, and the path towards bridging sustainable consumption and production is rocky.

One solution under investigation in this thesis is sustainable procurement of ICT hardware. Sustainable procurement focuses on specifying environmental and social pre-qualification and award criteria (Brammer and Walker, 2011) and building supporting process-related elements, such as a sustainable procurement policy (UNEP, 2014).

1.1 Problem Definition

Sustainable procurement is flagged as the driver of sustainable product innovation, paving the market for general adoption of the society and a way to continue to live within the market economy. However, future work is needed to understand the process-wise adoption of sustainability criteria and supporting sustainable procurement elements by procuring organizations. After understanding the 1) feasible and relevant criteria based on sustainability hotspots, which 2) directs development to socio-ecological system-level sustainability, as well as understanding the 2) supporting elements at different phases of sustainable procurement adoption, sustainable procurement can be scaled up, applied in different organizations and provide meaningful change both in the production and consumption sides.

Public procurement organizations in the European Union cannot ask for a certain ecolabel when specifying tendering. Therefore, they need to use criteria, which can be verified by for example via ecolabel certification. However, the different initiatives with collective abundance of criteria and focus areas are mushrooming, with little efforts to harmonize, consequently, making it confusing for procurers to know what to focus on specifying. Although this problem is not so evident for private companies, which are free to demand or prefer labelled products, also they may wish to leverage criteria rather than a specific label in order to ensure the choices are not too limited, which can hinder choosing the most suitable and economically advantageous product. The problem is that the criteria are often a set of criteria, without providing clear, robust guidance on the relevance and direction of individual criteria. From the procuring organization perspective, it might be beneficial to start with a small set of highly relevant criteria and gain experience with that before setting more comprehensive and complex criteria. The latter might even backlash, if the sustainability criteria is considered difficult to adopt or use, decreasing the motivation to use it in practice. Hence, less is better than nothing. One approach could be setting the criteria based on the most commonly found elements. The specific problem is the lack of information of the common criteria, which address the sustainability hotspots and supporting information on how to adapt the criteria for organizational maturity in sustainable procurement. Another way of solving the abundance problem could be a common database for ICT products and services, identifying their sustainability hotspots and showing the solutions adopted (e.g. standards, certifications, labels) per product in order to make it easier for buyers to gather information for purchase decision-making. However, this is currently non-existing.

In addition, many times criteria are static, although the documents sometimes provide hints for future updating areas. Hence, they might be already outdated when they come out from the criteria building process. It is unclear how procuring organizations might set criteria, which is progressive and gives guidance of the end goal, thus, possibly reducing the need to update the criteria every time certification and labelling organizations update it (Bratt, 2014). Another question is whether this kind of dynamic and strategic criteria is even feasible.

The criteria setting is a crucial part of sustainable procurement, however, it is only one part of a wider procurement process. Sustainability criteria is not often given the triple bottom line (economic, environmental, social) balanced weighting, and cost remains to be a dominant factor (European Union, 2012). Guidance documents for sustainable procurement of ICT introduce many elements, such as life cycle costing and sustainable procurement policy, which can be adopted to enhance sustainable procurement practices. Are all of these elements contributing to sustainable procurement in practice? In other words, are there truly core elements in every sustainable procurement process? By identifying the elements, which are truly relevant and assessing their barriers and drivers, a simple and general sustainable procurement model with guidance and visual aid can be created. This is important in order to facilitate the uptake of sustainable procurement by small organizations and organizations for which sustainable procurement is a new practice.

Most of the attempts to develop these kind of models do not offer a solid set to start with, but either general guidelines (for example Bohas & Bouzidi, 2012) or more comprehensive sets of indicators with general guidelines for modification (for example Park et al., 2012).

Moreover, system scale solutions for environmental and social problems are needed. Circular economy is one of them, but little academic research has been done about business models, which contribute to circular economy and their connection to sustainable procurement (Witjes & Lozano, 2016). European Union is interested in integrating circular economy into sustainable procurement (COM(2015),614). Thus, The Ellen MacArthur Foundation calls for development of sector specific circular economy indicators (The Ellen MacArthur Foundation & Granta Design, 2015), but it is unclear whether indicators contributing to circular economy in ICT are already adopted, although maybe named and framed in a different way. The specific problem is whether circular economy characteristics are already represented in the common sustainability criteria for ICT and how to enhance circular procurement.

Hereby, this thesis strives to contribute to the field of sustainable procurement, and, more specifically, understand the feasibility and relevance of the common criteria and core elements to advance the further adoption and development of sustainable ICT hardware procurement.

1.2 Aim, Research Questions and Outline

With the problems and diversity of solutions in mind, this thesis aims to propose a sustainable procurement framework for ICT hardware for private procuring companies. A procurement framework, which incorporates the strengths of the existing frameworks as well as relevant and feasible criteria, can lead to more profound changes in the intersection of sustainable production and consumption. First, by investigating the current criteria and core supporting elements, this thesis contributes to a better understanding of the dominant sustainable ICT procurement elements and criteria. Second, the thesis contributes to the development of a sustainable procurement model for ICT hardware, which explores circular economy connections and construction of sustainability criteria from strategic sustainable development point of view, more specifically the development path of sustainable ICT procurement from a feasible start to long-term objectives. This can hopefully provide food for thought for further refinement of sustainable and circular procurement as well as continued exploration of relevant and feasible criteria setting, both by researchers and practitioners. In order to achieve the overall goal, the thesis addresses three research questions (RQ's):

- RQ1: How do sustainability assessment frameworks and tools for ICT hardware, which are designed for the end user, promote sustainability? (Chapter 4)
- RQ2: What core elements and criteria could be integrated for a sustainable procurement framework for ICT hardware to better support procurers and suppliers to move towards sustainable development? (Chapter 5.1 and 5.2)
- RQ3: How do the procurers perceive the feasibility and relevance of the proposed criteria and core elements? (Chapter 5.3)

The background chapter (Chapter 2) gives an overview of environmental and social impacts of ICT as well as solutions for addressing them. In the solutions part, focus is particularly on sustainable procurement and the contribution of circular economy to sustainable procurement. The research questions and related sub-questions are illustrated in Table 1-1.

Table 1-1. Research Questions and Sub-Questions

RQ1	How do sustainability assessment frameworks and tools for ICT, which are designed for the use or information of the end users, promote sustainability?
Sub-Questions	
System	What sustainability aspects are included in the criteria? How procurers gain information on addressing the sustainability aspects? Where are the product category and geographical boundaries set?
Success	What are the objectives for the framework or tool (e.g. vision, principles to live up to)?
Strategic	Are there strategies or plans lined out for reaching the objectives (e.g. sustainable procurement policies, prioritisation matrices)?
Action	What actions are prioritized (e.g., by focus areas, scoring and weighting practices)?
Tools	What tools are included to reach defined objective(s) (e.g., LCA, EMS, certifications, scorecards, impact monitoring and evaluation methods)?
RQ	What core elements and criteria could be integrated for a sustainable procurement framework for ICT to better support purchasers and suppliers to move towards sustainable development?
RQ3	What are purchasers' opinions of the relevance and feasibility of the proposed elements and criteria?

1.3 Overview of Methodology

This thesis uses different approaches to answer the various research questions, complemented with data collection triangulation. *Literature analysis* is used to identify and assess frameworks and tools for sustainable ICT hardware and highlight their common core elements. *Interviews* with framework developers and managers verify the initial literature analysis and deepen understanding of the perceived benefits and challenges related to their respective framework or tool development and use. Furthermore, interviews with procuring organizations help to shed light to the pitfalls and successes of sustainable ICT procurement in practice. *Framework design* applies the lessons learnt from the previous steps; it is constructed from the common core elements, common criteria and strengths of the identified frameworks. Effort is made to apply two guiding approaches to the design, namely circular economy and the framework for strategic sustainable development (FSSD). Validation of the framework is done through *workshop discussions* with a large procuring company. For a more detailed explanation of the methodology, see Chapter 3.

1.4 Scope and Limitations

For the purpose of this thesis, the focus is on sustainability assessment frameworks addressing negative direct impacts of ICT products and services through their full life cycle. The system effects of ICT are out of the scope. The method for identifying and including the frameworks serves as a systematic scoping mechanism, consequently limiting the representativeness of the results. Many frameworks for assessing the sustainability of ICT products and services exist, notably 74 ecolabels based on the Ecolabel Index for electronics. However, only those 1) found by systematic search on EBSCOhost database and Google search engine and 2) accepted against the inclusion criteria are included. Arguably, the most common ecolabels and certifications were captured despite the search method limitation. For further description of the search method and inclusion criteria, see Chapter 3.

The primary geographical scope is the European Union (EU). Although literature outside the EU is considered, the framework redesign is informed by the European Union legislation.

Only one large private company was included to the in-depth study of sustainable procurement practices and validation discussions on the proposed framework. This is a major limitation, since conclusions about the generalizability of the practices and framework to different companies,

geographical areas and cultures remain largely questionable (Flick, 2006). In addition, the feedback received from the workshop discussions about the redesigned model allowed improving the model qualitatively, but no quantitative conclusions or feasibility analysis from the supplier/technical perspective are made. Hence, the research was limited to conceptual design and validation based on opinions. Research on actual implementation would provide results that are more robust. There seems to be no barrier to use the framework in other organizations than large private companies.

ICT research and development by companies, science on the sustainability impacts ICT as well as sustainable ICT procurement practices by end users are evolving. The information in the Internet may not represent the technological change and related significant impacts, best practices or state-of-the-art frameworks employed by leading consultants and companies in the world. The information on the aforementioned may be indicative, but not enough for a comprehensive evaluation. In this sense, it is not possible, or even purposeful, for this thesis to make a specific, comprehensive list of criteria for ICT end users to follow. Instead, the thesis aims to clarify the strengths and improvement points of the most common criteria and provide general guidance for sustainable procurement of ICT.

1.5 Ethical Considerations

The thesis strives to respect all the interviewees and related organizations regarding information disclosure practices agreed upon in the beginning of each interview. The interviewees received the thesis draft prior to publication to comment upon in order to authenticate the author's interpretations and respect to confidentiality agreements.

1.6 Audience

The main audience is *ICT procurers*, who are experts in procurement, but not necessarily in ICT or in sustainable development issues. A conceptually redesigned and validated framework for sustainable procurement of ICT is proposed to help organizations to manage their ICT procurement in a more sustainable way. However, it is notable that the framework is explorative, thus, requires further validation and refinement especially in the case of criteria construction. This could be interesting for *researchers and information supplying organizations* (such as labelling organizations) in the field to reflect upon; how to further help procurers more effectively to set feasible and relevant, yet progressive criteria directing towards a more sustainable society. It is hoped that this thesis provides food for thought for this.

The literature analysis on the existing frameworks and tools and their respective criteria can provide reflection points not only for procurers, but also for the *developing organizations*, for example for considering the objectives and communication of criteria. Finally, the framework redesign could inspire fostering new connections between circular economy, strategic sustainable and procurement, something which can be relevant for all stakeholders, including the environment.

2 Problem Background: Challenges and Solutions

The aim of the background review is fourfold. First, to identify sustainability hotspots throughout the full life cycle of ICT hardware based on scientific evidence. For social impacts, also reports from credible organizations, such as the United Nations (UN), are used. This later guides the discussion of how the common sustainability criteria reflect the most significant sustainability aspects and impacts of ICT. Second, a brief introduction to sustainable procurement and the existing solutions to aid procurement to address the sustainability challenges is given. Third, an emerging solution, circular economy, and its contribution to procurement is explored. Fourth, the literature review clarifies the research questions.

2.1 Environmental and Social Aspects and Impacts of ICT

What is the 'ICT' that buyers and suppliers wish to make more environmentally and socially sustainable? ICT contains many product and service groups, such as personal computers (PCs), printers and servers, which allows the storage, retrieval, handling, transmission and receipt of digital information. The environmental and social aspects, impacts and solutions vary depending on the product and service in consideration. In this study the review is maintained at a general level with a focus on hardware, aiming to understand which aspects are relevant for many products and services from the life cycle sustainability perspective. The product group is specified when necessary. Arguably, it would be much to ask from purchasers to specify sustainability criteria for each specific ICT product and service and keep these criteria updated as technology develops. Further, for convenience and clarity of writing the term 'product' is used from now on, including also services. Also the electronics industry organization, GeSI, uses the term 'ICT products', including end-user devices (PCs, mobile devices, peripherals – such as monitors, keyboards etc.), telecommunication networks (fixed line, wireless), and data centers (servers, storage systems, cooling systems) (GeSI, 2012). Although other definitions exist, which are sometimes notably broader and include software (see, for example, Eurostat, 2013), GeSI's definition is sufficient enough for the scope of the thesis, namely hardware, and is applied hereafter.

In order to understand the full impact of ICT for the environment and people living in the environment, it is beneficial to understand life cycle thinking. The life of an electronic product starts from raw material extraction, in which metals, minerals etc. are extracted from the ground for further refinement. The materials are then manufactured into components, larger pieces, and assembled into the device, which enables the functioning of the device. This happens usually in a low-income country due to price competition. Then, the products are transported all over the world and handed in for retailing. The product is used, and lastly given for reuse or end-of-life treatment, namely recovery and recycling of its materials. Life cycle of ICT hardware is illustrated in the Figure 2-1 below. It depicts the current linear take-make-dispose culture. A truly circular cycle would recover and recycle the materials back to use, an approach discussed in chapter 2.3 later on.

Figure 2-1. Life Cycle of ICT Equipment

Source: Own illustration.

2.1.1 Raw Materials Extraction

Mining of raw materials produces various externalities; water pollution through cyanide, waste from mining tales and air pollution from extracting oil to produce plastic casings, among others (Doka, 2007). Thus, ICT equipment uses a variety of rare earth metals, which are part of providing their functionality. The natural stocks of certain semiconductor-compounds, such as indium and gallium and other rare earth metals are scarce (Werner et al., 2015; Bratt, 2014). The demand is predicted to increase by over 4-8% to 2020 (European Commission, 2014). Over 80 % of the quantities of specific rare earths, namely gallium, indium, iridium, palladium, rhenium and ruthenium, have been mined in the past 30 years since 1900 (Wäger et al., 2005).

Some of the minerals are mined in areas where labor and human rights, as defined in the ILO core conventions and human rights conventions, are not respected (Rosen, 2010; Benoit-Norris et al., 2012). In the Democratic Republic of Congo (DCR) the money from selling the mined metals are financing the civil war and locals have been driven from mineral-rich areas by violent means (Pöyhönen et al., 2010; BSR, 2010; Rosen, 2010). The limited supply of rare earths, their fast depletion as well as geopolitical and social risks make their supply highly uncertain.

2.1.2 Production

It has been debated whether the manufacturing or use phase of ICT is the dominant hotspot for energy footprint (Arushanyan et al., 2013). Nevertheless, manufacturing phase is material and energy intensive; in order to produce one computer over 240 kg of fossil fuels, 22 kg of chemicals and 1 500 kg of water are used (Kuehr & Williams, 2003). Similarly, in the production of semiconductors large amounts of water, electricity and hazardous substances are used (Yi & Thomas, 2007).

During microchip production, chemical exposure and emissions might cause long-term health effects on workers, their families and local communities (Kuehr & Williams, 2003). Occupational health and safety in the factories is often poor (Yoon, 2012). Wages are low and long working time is needed to reach the minimum wage (Ciroth & Franze, 2011; Grießhammer, 2006). Child labor (Grießhammer, 2006) and forced labor (Schipper & De Haan, 2005) are common. ILO freedom of association and collective bargaining is not accepted, and social security and Codes of Conduct are poorly implemented (Grießhammer, 2006; Ciroth & Franze, 2011).

2.1.3 Distribution and Retail

This phase is often disregarded because of the global nature of the business. However, some studies suggest transportation is a minor phase regarding environmental impacts (Herrmann, 2008), whereas, for example, in the case of mobile phones others state that transportation is a phase of high significance especially when the products are sent as air freight (Moberg et al., 2014).

2.1.4 Use

Use phase is estimated to be the most significant phase due to energy consumption and related greenhouse gas emissions by Malmodin et al. (2010). According to Malmodin et al. (2010), the energy footprint of ICT originates mainly from PCs, followed by third-party enterprise networks and data centers, and access networks. According to the EuP preparatory study on imaging equipment, energy used to produce paper is up to 6 times higher than the printer's energy consumption during use phase, which is why two-sided printing is promoted as an energy saving option (European Commission, 2008).

2.1.5 End-of-Life

E-waste is one of the fastest growing waste streams in the world, with 41 million tons discarded every year (UNEP, 2015). The increase in the variety of materials used in ICT hardware makes recycling more challenging and less efficient; for example, a microprocessor today has 60 elements in comparison to 12 elements in the 1980s (National Research Council, 2007; Behrendt et al., 2007, Löser, 2015). Hence, ICT components entering waste streams can affect the recycling possibilities of other materials (Kohler et al., 2011; Wäger et al., 2005).

Processing, recycling and disposal in the Global South countries often face improper working conditions and health hazards for workers and communities around. Workers in refurbishing and recycling of e-waste have been found to have long working time of 10 hours or more (Umair et al., 2015; Prakash et al. 2010; Ciroth & Franze, 2011), low wages (Prakash et al., 2010; Ciroth & Franze, 2011), and no employment or social security (Prakash et al., 2010; Franze and Ciroth; Umair et al 2014). Hence, child labor was found by studies in Ghana, China and Pakistan (Prakash et al., 2010; Ciroth & Franze, 2011; Umair et al., 2015). Further, Ciroth and Franze (2011) showed that the social hotspot in advanced economies was fraud and corruption, and consequent illegal shipping of e-waste to Global South.

Health hazards are related to improper recycling techniques, including open incineration resulting to emissions of toxic dioxins, furans and ozone-depleting chlorofluorocarbons (CFCs), halogenated flame retardants as well as rudimentary recycling practices (such as breaking the device with stones) resulting to inhalation of hazardous cadmium dust and other pollutants (Prakash et al., 2010). Thus, exposure to toxic metals, and persistent organic pollutants (POPs) may cause several health hazards (see e.g. Brigden et al., 2008; Wong et al., 2007).

2.1.6 Design

Development and design decisions of ICT have a significant role in turning ICT sector more sustainable. ICT in the past was designed for technical performance, henceforth, it is facing design paradigm shift towards energy efficiency and sustainability. Currently, the material complexity is increasing (National Research Council, 2007; Behrendt et al., 2007), lifetime is decreasing and the replacement cycle of ICT equipment is fastening (European Commission, 2008). Therefore, especially for fast moving devices, such as PCs and notebooks, it is important to design modular and upgradeable devices. Notably, the development of software contributes to higher consumption and replacement rate of hardware; new software often requires more CPU hardware, "pushing consumers to upgrade their hardware for new software, although the actual need was a small part of functionality" (Appelman et al, 2013).

Overall, energy use and greenhouse gas emissions are more researched than other problems, possibly leading to sub-optimisation and problem shifting (Arushanyan et al., 2013). Although many of the problems are unknown (ibid.), some sustainability hotspots based on the background review can be summarized:

- energy source and consumption in the production and use
- hazardous chemicals in the production and end-of-life
- heavy metals in the end-of-life
- labour rights in the production and end-of-life
- human rights, especially addressing "conflict minerals", in the raw material extraction

2.2 Sustainable ICT Procurement

Sustainable procurement aims to address the environmental and social challenges arising through the ICT hardware value chain. The challenges have been recognized and tackled more notably after the publication of the report "Green IT: a new industry shock wave" by the ICT research and consultancy firm Gartner in 2007 (Mingay, 2007; Hilty et al., 2011). The following definition of sustainable ICT is adapted from Elliott (2007) for this thesis: "the design, production, operation and disposal of ICT and ICT-enabled products and services in a manner that is not harmful for the environment nor people, and may be positively beneficial to the environment during the course of its whole-of-life". This chapter first introduces sustainable procurement in general, followed by an overview of frameworks and tools for sustainable ICT procurement.

2.2.1 What is Sustainable Procurement?

Procurement is the fundamental link between sustainable production and consumption. Sustainable public procurement can be defined as "a process whereby public organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life cycle basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst significantly reducing negative impacts on the environment" (UK Sustainable Procurement Task Force, 2006). The main difference to traditional procurement is the integration of environmental and social criteria into the tender (Brammer and Walker, 2011). These criteria should cover the significant sustainability issues throughout the full life cycle of the product or service as well as the supplier's capacities to address them (UNEP, 2011). Moreover, while traditional procurement focuses on a product unit and lowest price (Kiiver and Kodym, 2014), sustainable procurement focuses on 'best value of money', which can be further operationalized by sustainability specifications and Life Cycle Costing (Kiiver and Kodym, 2014). Although much of the discussion focuses on public procurement, there seems to be no barrier to adopt this definition and characterization of sustainable procurement for private sector as well, thus, used henceforth.

Procurement process may differ between organizations, products and services, however, a general process can be illustrated. The procurement process consists of four main stages; preparatory, specification, sourcing and utilization, as defined and further explained in accordance with UNEP (2011). In the *preparatory* stage, the actual need is defined by applying 'functional thinking' (for example, in the case of printing the actual need is communication) and investigating demands of stakeholders. This results to the first set of specifications of what is going to be procured. Market research is conducted in order to identify suppliers, solutions and establish dialogue. A green and socially responsible title is chosen in order to send a signal to the market. Furthermore, the most significant sustainability impacts should be identified and considered as the main risks that sustainable procurement aims to mitigate. This stage might also include pre-qualification, which sets a bar on supplier capabilities; who is considered applicable to participate in further consideration. The pre-qualification requirements for sustainability can include for example existence of an environmental management system and compliance with national and international laws, such as EU RoHS and Basel Convention.

The second step, *specification*, consists of further development and detailing of requirements, such as environmental, technical, social, and performance specifications, product lifetime and modularity. For example, energy efficiency of computers, or environmentally friendly material specifications, such as recyclability, could be used in this phase. This raises awareness amongst the suppliers to be resource efficient and responsible of what happens also out of the scope of their direct responsibility (Preuss, 2009) in order to close the life cycle of the product (Guide &

Van Wassenhove, 2001). Weighting practices are determined in order to signal the supplier, which requirements are considered more relevant than others.

In *sourcing* stage, also known as *tendering*, the final set of product or service specifications and weighting are published for potential suppliers. The contract is awarded for the most suitable one based on the economic, environmental and social performance of the product or service. The UN suggests using Life Cycle Costing (LCC) to implement the 'best value for money' principle and evaluate offers in terms of payback, net present value (NPV) or internal return on investment (IROI). However, LCC could also be used in other procurement steps, such as the planning stage. Many other actors have also encouraged using LCC, also called as Total Cost of Ownership (TCO) (Gartner, 2016; UNEP, 2011).

The final step covers utilization and contract management, in which product or service is supplied and used. The end user may set key performance indicators (KPIs) and estimate the potential savings and benefits during the contract. Contract management clauses for environmental and social performance might be set, but more so if the issues are not specified in other phases. The contract may also include clauses for consequences in case of non-compliance. Collaboration with suppliers to improve their sustainability may be set.

Overall, sustainable procurement can signal the preference of sustainable products and services to suppliers, set trends, which may enhance the uptake of environmentally preferable technology, drive responsible product development (Parikka-Alhola, 2008; Walker & Brammer, 2012) as well as reduce brand risks and provide monetary savings for the procuring organization (CIPS, 2009). However, common challenges are lack of management support, information, knowledge, practical tools and training as well as lack of systematic implementation and integration to management systems, among others (Bouwer et al., 2006).

2.2.2 Frameworks and Tools for Sustainable Procurement

Programs, policies and procurement guidelines for sustainable ICT have been developed by various organizations, including international organizations (United Nations), supranational unions (European Union), governments (for example, the United Kingdom and Australia), municipalities (for example, Stockholm), universities (for example, University of Gothenburg and Harvard University), and private companies (for example, Qantas airlines). The purchasers use various tools, such as maturity matrices for improving their sustainable procurement processes and buying standards to evaluate potential suppliers (HM Government, 2011). However, procurers may lack knowledge of the sustainability impacts of the product group they buy, hence, they may need help to include sustainability considerations into purchasing.

There are tools that attempt to address this information gap between the supplier and buyer by providing information and evaluating the products and companies, also known as informative tools. Ecolabels (ISO 14024 Type I labels) are one type of an informative tool; they are independent third party certifications, and the standards are published and transparent. Along with independence and transparency, other strengths of the ecolabels are wide coverage of life cycle impacts addressed, participative stakeholder democracy to criteria building and uptake by consumers (Horne, 2009). However, the increasing number of eco-labels along with non-transparent criteria may increase confusion and decrease trust of the consumer towards the label (Bratt, 2014). As a response to the growing variety of labels, harmonization efforts have been called upon (DIGITALEUROPE, 2015). Moreover, market effects of eco-labels have been questioned regarding welfare outcomes, incentive issues, compliance and international trade, and problems of burden shifting, with some economists suggesting eco-labels may not produce environmental benefits in a global market economy (Robertson, 2007). However, for example EPEAT estimates that its program has contributed to the reduction of toxic materials, such as

mercury, of 0,6 metric tons and energy savings of over 12 billion kWh of electricity in comparison to the baseline of buying non-EPEAT registered products in 2013, among other benefits (Green Electronics Council, 2016a).

Some actors aim to inform consumers buy assessing companies (see for example, Greenpeace, 2012), but most focus on product assessments. From product assessment methods, Life Cycle Analysis (LCA) is a widely used tool; it models the sustainability aspects and impacts of the product during the product life cycle (European commission, 2010). However, modeling is challenging in the case of ICT, because ICT is a fast developing sector, it has a complex supply chain and the impacts of especially hazardous substances might not be known or shown in the data (Arushanyan et al., 2013). Although procuring organizations do not do LCAs themselves, they can apply the concept of *life cycle thinking* as a guiding logic for evaluating products by considering the aspects and impacts along the value chain, as UNEP promotes (UNEP, 2011). A related tool is Life Cycle Costing (LCC) for evaluating the cost of the product through its full life cycle (UNEP, 2011). In order to help procurers to calculate potential benefits and cost savings, calculation tools have been developed, such as EU Energy Star Calculator and EPEAT Electronics Environmental Benefits Calculator. Thus, many tools assess both companies and products, arguing that the assessment is not complete with only one approach.

The ICT industry has also responded to the sustainability challenge. For professional (B2B) procurement, the standard informative tool by the industry in the European Union is ECMA-370, which is an Environmental Product Declaration (EPD) (ISO 14025 Type III label). Although EPDs can provide more information than ecolabels, their weakness is the lack of external evaluation and verification of the presented data (Aalto et al., 2011). Notably, Fujitsu has also developed a "Green IT label" (ISO 14021 Type II label), with arguably a close connotation to 'ecolabels'.

2.3 Circular Economy

The frameworks and tools can arguably go as far as their objectives and focus areas go. Fundamentally, large socio-economic system scale changes are needed to maintain the consumption and resource extraction within the planetary boundaries. Therefore, sustainable procurement needs to evolve from supporting incremental product development through limited sustainability specifications to support business models, which contribute to wider socio-ecological system sustainability. One recent solution proposed to the wider challenge of resource scarcity and take-make-use-dispose economy is the concept of Circular Economy (Ellen McArthur, 2014; Murray et al., 2015).

In essence, circular economy aims to decouple economic growth from the consumption of finite resources (Ghisellini et al., 2016; Ellen MacArthur Foundation & Granta Design, 2015) by closing the material loops through resource recovery, consequently, maintaining materials in the cycle of production and consumption instead of disposing them as waste (Yuan et al., 2006). Closing the loops is expected to provide resource efficiency gains (Yuan et al., 2006) and shifts in value creation from generating profits by selling products to "generating profits from the flow of materials and products over time" (Bakker et al., 2014 as cited in Bocken et al., 2016).

Circular procurement can be described as sustainable procurement, which "stimulates circular economy by fulfilling the needs for goods and services in a more circular, resource efficient way, by closing the loops of products, their components and the resources used as far as possible" (Circular Procurement Congress, 2016) by demanding circular products and services. In order to include circularity into procurement, this section aims to enlighten the principles, characteristics and enablers of circular economy in order to explore the conditions towards what the market would be steered towards.

2.3.1 Principles, Characteristics and Indicators for Circular Economy

Circular Economy is defined and characterized in different ways by different actors (see, e.g. COM(2015),614; Ellen MacArthur Foundation, 2014; Yuan et al., 2006). On prominent actor is the Ellen MacArthur foundation with business partners testing and applying the circular economy concept in practice at the company level. The Ellen MacArthur Foundation has defined three hierarchical levels of circular economy; principles guide action towards circular economy, characteristics help to operationalize the principles and indicators aid to measure the transition to circular economy (Ellen MacArthur Foundation & Granta Design, 2015). Details of these levels are further explained in Table 2-1 below.

Table 2-1. Circular Economy Principles, Characteristics and Indicators

Hierarchy Component	Explanation
Principles	
Preserve and enhance natural capital	Renewable resource flows are used sustainably, a.k.a. have time to regenerate. Finite material stocks are controlled by recovering and restoring them.
Optimise resource yields	Products, components and materials are circulated to use their highest utility by designing for remanufacturing, refurbishing and recycling. Highest utility can be achieved by circulating products, components and materials in closer loops, slowing down the loops by designing for longevity and cascading to them lower value applications.
Foster system effectiveness	Reveal negative externalities and reduce, manage and design them out. Negative externalities are impacts, such as pollution, which are not paid for.
Characteristic	
Design out waste	Biological materials are non-toxic and compostable. Technical materials (human-made compounds) are reusable and fit back to the material cycle. Waste does not exist, instead, material is a resource for another application.
Build resilience through diversity	Diverse systems are more resilient for external shocks; design for modularity, versatility and adaptivity.
Work towards energy from renewable resources	Systems run on renewable energy.
Think is systems	Think how different parts affect each other in the socio-ecological context. Avoid unwanted consequences.
Think in cascades	Create value by cascading material from high value creation to lower.
Indicators	
Material circularity indicators	
Input to the production process	How much input is coming from a virgin and recycled materials and reused components?
Utility during use phase	How long and intensely is the product used compared to an industry average product of similar type?
Destination after use	How much material goes to landfill (or energy recovery), how much is collected for recycling, which components are collected for reuse?
Efficiency of recycling	How efficient are the recycling processes used to produce recycled input and to recycle material after use?
Risk indicators	
Material price variation	no explanation given in the sources
Material supply chain risks	no explanation given in the sources
Material scarcity	no explanation given in the sources
Toxicity	no explanation given in the sources
Impact indicators	
Energy use	no explanation given in the sources
CO2 emissions	no explanation given in the sources

Source: Adapted from the Ellen MacArthur Foundation & Granta Design, 2015; Ellen MacArthur Foundation, 2015

Although the Material Circularity Indicator (MCI) was originally developed as an example to assist product developers to assess how well products and companies adapt to circular economy, notably, it could also be used for "rating and evaluating companies" in the market (Ellen MacArthur Foundation & Granta Design, 2015).

2.3.2 Product-Service Systems for Circular Economy

The shift to circularity can be facilitated by various means, such as business models, which provide a mix of products and services, instead of purely products. These solutions, known as product-service systems (PSSs), consist of "tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs" (see e.g. Tischner et al., 2002 in Tukker, 2004)". In PSS, the focus of the tender shifts to buy the 'function' of the product, such as mobility instead of cars (Mont, 2002), similarly to the concepts of 'solution' development (Kowalkowski, 2010) and 'functional sales' (Lindahl et al., 2006). Behind this is the rethinking of what the client actually needs, which is argued to be the performance, or in other words, what the product and service solution enables the client to achieve, rather than the product or service *per se* (Manzini & Vezzoli, 2003). This could be for example storage of data per megabyte.

From the environmental perspective, PSS is expected to shift the society towards sustainable production and consumption practices, more specifically to reduce the total number of products, close material loops by leaving the ownership to the supplier or through take-back services and decrease the amount of waste due to improved material flows by for example refurbishing (Mont, 2002). In addition, providers can have a wider sight over the life cycle of the product, securing material circularity and handling trade-offs raising along the life cycle (e.g. Lindahl et al., 2011; Thompson, 2012).

In order to facilitate circular flows, different actors need to collaborate and create suitable material exchange patterns (Ghisellini et al., 2016), such as getting the product back for remanufacturing (Östlin, 2008). It is argued that the PSS can set a basis for this, because it brings the supplier and buyer to a closer relationship (Lay et al., 2009). However, the physical and socio-cultural proximity between the actors (in this case supplier and buyer) is argued to be a success factor for collaboration (Hannon, 2012; Walker and Brammer, 2011). Notably, connection to the customer and customer demands were the most interesting drivers for PSS by manufacturing companies along with competitiveness (Lindahl et al., 2009). Some researchers also point that together with discussions on technical specifications, PSS also requires discussions on socio-cultural specifications, such as training personnel in order to realize the expected resource efficiency benefits (Borgatti, 2003).

However, the collaboration strategy the supplier and procurer might take to seek the solution of buying a product, service or their joint system, might depend on whether the need, or in other words problem, is well-defined and explicit (Kowalkowski, 2010). Kowalkowski (2010) suggests that in the case of ill-structured problems and heuristic problems, a collaborative route for solution seeking might be valid. However, in case of well-defined problems, the procurer can specify the need without communication with the solution providers (Ibid.).

2.3.3 Challenges for Circularity

Circular economy is heralded to lead to environmental and economic "win-win" situations, but there are also challenges that need to be recognized. First, the discussion of circular economy is

still in its roots of industrial economy and physical flows, whereas monetary flows are largely not analyzed yet (Mathews and Tan, 2011; Andersen, 2007). Second, in practice 100 % recycling is impossible due to the second law of thermodynamics, also known as the law of entropy (Andersen, 2007). Arguably, circular economy can still work as a vision to reach for. Third, increasing miniaturization, such as smaller laptops, and integration, can work against circular economy aim of closing the material loops because some metals are contained in smaller concentrations and, consequently, need industrial recovery processes, which might not be profitable (Hilty, 2011). Fourth, the hazardous substances included in the electronics and growing material complexity make recycling even more difficult (Hilty, 2011). Fifth, although GeSI estimates that ICT solutions could decrease the total greenhouse gas emissions by 20 % when compared to the projected total GHG emissions in 2030 (GeSI, 2015), the study does not take into account rebound effects. In practice, although ICT is becoming more energy-efficient, its absolute energy consumption and related greenhouse gas emissions are growing due to the lack of energy efficiency improvements to keep up with the growing use of ICT (Hilty, 2011). Conclusively, closing the material loops and decoupling energy consumption from growing adoption of ICT solutions is posed of challenges, including technical, economic, and behavioral accompanied with trade-offs with environmental, health and social impacts.

2.4 Knowledge Gaps and Research Questions

Integration of circular economy to sustainable procurement has been set to the agenda of the European Union (European Union, 2012). The shift to and functioning of the circular cycles requires systemic multi-level changes, including technological innovation, new business models and stakeholder collaboration (Witjes & Lozano, 2016). However, the exploration of how sustainable procurement could contribute to circular economy is still in the beginning (Ibid.).

2.4.1 Knowledge Gaps

Some research has been done on sustainable business models and their contribution to circular economy (Bocken et al., 2016), but only few explore the link between sustainable business models for circular economy and sustainable procurement (Witjes & Lozano, 2016). Thus, there are calls for further development of the existing circular procurement models and their empirical testing (Witjes & Lozano, 2016), understanding case studies, best practices and implementation challenges (ibid; Hoejmose and Adrien-Kirby, 2012), research on linking sustainable business models and sustainable procurement in general (Brammer & Walker, 2011; Witjes & Lozano, 2016) as well as educating procurers on business models contributing to circular economy and establishing guidelines and standards for circular procurement (Ellen MacArthur Foundation, 2014; EREP, 2014; Wijkman & Skånberg, 2015). Moreover, "methods for assessing the environmental, social and economic sustainability of circular products and business models need to be developed" (Bocken et al., 2016). There are few initial efforts to create circular economy indicators, however, their adaptation to specific industries is still unexplored (Ellen MacArthur Foundation & Granta Design, 2015; Ghisellini et al., 2016).

One solution, which may facilitate circular economy, is product-service systems (PSSs). The procurement frameworks should be designed in order to allow considering PSS solutions more effectively (Hannon, Foxon & Gale, 2015; Bratt, 2014). However, it remains unclear in which situations and what kind of PSS solutions are the most beneficial. In PSS the service provider is assumed to be the expert, which is why it can be less costly and risky for the procurer to move towards a service based solutions and focus more on the core business (Bratt, 2014). However, Bratt (2014) notes that the value concepts, such as 'best value procurement', which are used to evaluate the risks and benefits of PSS, have been applied mostly "within sectors with a high degree of risk- and cost-related performance issues", leaving the benefits of application of PSS questionable in different kind of sectors.

Environmental and social value can be indicated by for example ecolabels. However, increasing number of ecolabels and other information tools can be overwhelming and confusing to procurers. While it is the benefit of many ecolabels that they are comprehensive in addressing (mostly) environmental problems through the life cycle of the product, procurers might have difficulties in choosing what criteria to specify. Arguably, there should be more guidance on prioritization of criteria, which is related to the relevance of the sustainability hotspot as well as feasibility of the criteria uptake. Complex criteria may hinder the implementation and finding the first success experiences in the learning path towards sustainable procurement in the procuring organization. Thus, the criteria are often not constructed with long-term goals (Bratt, 2014). In order to address this, Bratt (2014) suggests using back-casting for criteria development, or in other words, visioning the desired objectives and then building criteria progressively to achieve them. However, the practical application and challenges for this approach needs further research (Bratt, 2014). As far as the thesis author's knowledge, there are no examples on this for sustainable ICT hardware.

2.4.2 Rationalisation of Research Questions

With the identified knowledge gaps in mind, this thesis aims to investigate the core elements in sustainable ICT procurement and circularity elements of the common sustainability criteria for ICT hardware (*RQ1*) in order to propose a sustainable ICT hardware procurement framework with exploration on back-casted sustainability criteria development (*RQ2*), which feasibility and relevance is validated (*RQ3*). Thus, the Framework for Strategic Sustainable Development with a specified methodology on evaluating procurement by Bratt (2014) is further tested.

3 Methodology

The development of the sustainability framework for ICT procurement consisted of four stages, including background research, identification and evaluation of the existing sustainable ICT assessment frameworks (*RQ1*), conceptual framework redesign (*RQ2*) and workshop discussions to validate the proposed framework (*RQ3*).

In the first research stage, data was collected via literature review and supporting interviews with framework developers or current managers. The use of multiple sources of information assists in testing the consistency of the key findings by comparing whether the informants and researcher have similar observations, thus, it increases the validity of the findings (Denzin, 1989). Similar approach was used in the next two research steps by first redesigning the framework based on multiple sources (conceptual research) and then discussing its elements with procurement practitioners, hence, revealing whether the proposed elements could be sound in practice (empirical research). Table 3-1 below illustrates the overall research design with data collection and analysis methods striving to answer the research questions, by research objectives, by using the outcome of each stage as a stepping stone for the next one. These are further explained in this chapter.

Table 3-1. Overview of Research Methodology

Data Collection and Analysis Methods	**Research Question**	**Outcome**
Background research	Research Clarification	Aim and Research Questions
Literature Analysis Interviews FSSD Analysis	*RQ1: How do sustainability assessment frameworks and tools for ICT, which are designed for the user, promote sustainability?*	Synthesis of Existing Frameworks and Tools
Framework Building from Synthesis of Results, FSSD and Background Research	*RQ2: What core elements and criteria could be integrated for a sustainable procurement framework for ICT to better support purchasers and suppliers to move towards sustainable development?*	Framework Redesign
Workshop Discussions	*RQ3: What are purchasers' opinions of the relevance and feasibility of the proposed elements and criteria?*	Validation

3.1 The Framework for Strategic Sustainable Development

The background methodology and analytical approach adopted in this thesis is Framework for Strategic Sustainable Development (FSSD). FSSD is used to 1) assess the existing frameworks and tools, 2) guide the redesign of a sustainable procurement framework and 3) structure the discussion and analysis. FSSD is scientifically grounded with 25 years of scientific development and successfully applied to guide strategic decision-making in various companies (Broman & Robért, 2015) and to assess tools and concepts for sustainable development (Robért et al., 2002), among others.

The framework consists of five levels, which guide planning towards a sustainability objective (Broman & Robèrt, 2015). The main idea is as follows; socio-ecological system sustainability is described (*System*), in order to define the objectives of a plan to reach the system sustainability (*Success*), to develop strategic guidelines to reach the objectives (*Strategy*), which are then prioritized to guide the focus of action (*Action*) and implemented with the support of tools for monitoring, coordination and decision-making (*Tools*). The methodology and more detailed level descriptions are based on Bratt's (2014) methodology, which is argued to bring a systematic approach for sustainability criteria development assessment and called for further development, testing and validation. Bratt (2014) used it for assessing criteria development of labelling organizations, however, testing of the methodology with frameworks developed by various actors as well as for guidance for redesigning an explorative sustainable procurement framework provides a new perspective in testing it. The use of analytical frameworks where they can provide strong scientific support but do not prohibit the exploration of new elements is arguably ideal. Therefore, FSSD is further adapted for the purpose of this thesis. Below, in Table 3-2, is a more detailed description of the various levels and related research questions and sub-questions (adapted from Bratt, 2014).

Table 3-2. Research Questions and Sub-Questions within the Framework for Strategic Sustainable Development

RQ1: How do sustainability assessment frameworks and tools for ICT, which are designed for the use or information of the end users, promote sustainability?	
Level Description	**Sub-Questions**
System - The System Level describes relevant knowledge about the system in which planning and acting takes place. For development of procurement criteria this includes knowledge of (i) sustainability aspects being addressed, (ii) products and services and their market, including innovations and potential substitute products and services and related research and technologies, (iii) stakeholders that are relevant to include in the criteria development and their interrelations and functions throughout the life cycle and (iv) juridical laws and regulations.	What sustainability aspects are included in the criteria? How procurers gain information on addressing the sustainability aspects? Where are the product category and geographical boundaries set?
Success - The Success Level includes (i) a definition of a successful outcome, including (ii) compliance with some shared objective of sustainability**.** For development of procurement criteria this also includes (iii) short- and long-term objectives for each product/service category that support social and ecological sustainability.	What are the objectives for the framework or tool (e.g. vision, principles to live up to)?
Strategic - The Strategic Level includes strategic guidelines for criteria development, which should include (i) guidelines for strategic selection and prioritization of actions by the working group and for strategic selection and prioritization of criteria that will stimulate coming actions in value chains to systematically fulfil short- and long-term objectives in a strategic pathway towards sustainability. Furthermore, there should be guidelines for how to (ii) communicate future criteria strategies to allow for predictability.	Are there strategies or plans lined out for reaching the objectives (e.g. sustainable procurement policies, prioritisation matrices)?

Actions - The Action Level includes actions that will help move a project, organization, region, etc., towards compliance with a definition of success. That means actions that are prioritized and carried out in line with the strategic guidelines to achieve success in the system. For development of procurement criteria this includes actions of the participants in the development process as well as desirable actions in value chains that should be stimulated by the criteria.	What actions are prioritized (e.g., by focus areas, scoring and weighting practices)?
Tool - The Tools Level includes concepts, methods and tools used to decide on, manage, measure and monitor actions so that these are aligned with strategic guidelines to achieve defined objectives. For development of procurement criteria this includes concepts, methods and tools used by the working group during the development process as well as concepts, methods and tools that the working group might recommend to the users of the developed criteria.	What tools are included to reach defined objective(s) (e.g., LCA, EMS, certifications, scorecards, impact monitoring and evaluation methods)?
RQ: What core elements and criteria could be integrated for a sustainable procurement framework for ICT to better support purchasers and suppliers to move towards sustainable development?	
RQ3: What are purchasers' opinions of the relevance and feasibility of the proposed elements and criteria?	

Source: Methodology Framework and Level Descriptions adapted from Bratt (2014)

Ideally, at the system level the sustainability assessment process is designed with explicit purpose and a comprehensive set of criteria addressing the relevant sustainability issues during the life cycle of the ICT equipment, from raw material extraction to end-of-life treatment, acknowledging interlinkages of sustainability aspects. This would serve absolute system sustainability and avoid major harmful trade-offs, thus, informing decision-making more strategically beyond their own organizational boundaries and conventional way of procuring (Bratt, 2014).

3.2 Exploring Existing Frameworks and Tools

A systematized literature review was used to fulfill the first research question, namely to identify and assess how the existing sustainability assessment frameworks and tools for ICT promote sustainability. This constituted of various tasks: (1) identify existing frameworks to assess ICT sustainability, (2) identify the common criteria and elements of the frameworks, and (3) assess the frameworks against the FSSD analytical framework, (3) compare the identified common criteria and elements to existing prominent circular economy (CE) and product-service system (PSS) definitions and indicators (see Chapter 2.3) in order to find similarities and differences. It is notable that only the framework search was systematized and other reviewed background literature was found by more free ways of searching.

Systematized literature analysis method refers to analyzing academic articles, books and grey literature and other sources with a systematic search strategy and inclusion/exclusion criteria, however, being less comprehensive than a systematic literature review (Grant & Booth, 2009). The method was chosen due to the inclusion of grey literature, which has many hits and the most reviewed ones appear first in the search engines, hence providing an indication that they might be worth to look at.

3.2.1 Search Strategy

Systematized searches were completed in the electronic database EBSCOhost for peer reviewed articles and in the Internet (Google search engine) for grey literature. EBSCOhost covers Business and Management literature, chosen to search articles in green/sustainable ICT management. The inclusion of grey literature assured the coverage of a variety of frameworks, including sustainable procurement practices of public organisations, criteria sets by labelling organizations and evaluation methods by interest groups, such as Greenpeace. Google was chosen, because it is currently the most widely used search engine (NetApplications.com, 2016). Keywords used in search string combinations included: sustainable OR green AND tool OR scorecard OR procurement AND ICT OR IT OR electronics. Green ICT is a well-established concept, instead of for example "environmental". Although the key words are incomprehensive, they depict important elements that could be searched for finding frameworks for procurement purposes. The first 20 results of each combination were screened for relevance by reading the title, abstract and conclusions of peer reviewed articles. In the case of non-academic literature, the first 20 results were screened by reading the table of content or full text if it was a webpage. For larger documents, such as procurement guidelines, the text was skimmed to identify core themes. Not all websites contained a full description of the frameworks they mentioned. When there was limited access to information, a purposive search in Google or EBSCOhost was conducted to explore access to the framework. When sufficiently detailed description of the framework was accessible by the aforementioned means, it was considered in the next step. Searches were performed between May 23 and June 3 in 2016. Comprehensive procurement frameworks used by private companies were not found, but two large private companies were consulted by interviews.

3.2.2 Selection Criteria

The following inclusion criteria was developed for the selection of the frameworks guided by the purpose of the thesis: First, the framework was *developed or managed by scholars, expert groups or practitioners*, excluding for example BSc work. This served to enhance rigour of the selected frameworks by depending on the quality screening of the research database or adoption by experts or practitioners, which was important since other systematic quality evaluation was not included. Second, the framework was *developed or managed between 2006 and 2016*. Technological development of ICT is rapid and therefore it is necessary to have a sufficiently recent time span for inclusion. Third, only *frameworks described in the English language* were included, since most of the academic business journals, large end users and certification and labelling bodies publish in English. Publishing in English arguably increases their possibility to be found and applied as well as the thesis writer's possibility to find relevant frameworks. Fourth, only frameworks directly *addressing ICT sustainability assessment* with 1) a broader recognition of environmental dimension (with the exception of Energy Star as a single-issue label) and 2) comprising either of a set of sustainability criteria or management elements were included. Consequently, frameworks considering only for example energy efficiency were excluded. Finally, *the full descriptions of the frameworks* needed to be *freely accessible* via Internet or libraries in Sweden. This highlights the accessibility and scale-up possibilities of the frameworks, which are important when striving for sustainability. It can also enhance the capability for independent application by procurers. Therefore, frameworks of which access depends on membership or payment for consultancy service (e.g. GeSI's Sustainability Assessment Standards Framework or Gartner's Green IT scorecard), or books, which availability was limited, were excluded. In uncertain cases, interviews were requested to understand the relevance of the framework. The framework was excluded if no further information was received or when information indicated that the framework was not suitable for procurer purposes (e.g. Dzoro & Telukdarie, 2016). The use of the inclusion criteria led to a reduction to 20 frameworks as listed in Appendix C.

3.2.3 Expert Interviews

11 semi-structured interviews were organized with the developers or managers of the frameworks. The interviews aimed to verify results interpretations and improve the initial evaluation of the frameworks based on literature. They were an appropriate way to triangulate findings and strengthen the validity of findings (Yin, 2014). Thus, 5 interviews with procurers from large organizations were interviewed in order to have multiple points of views and deepening understanding of practical experiences on sustainable ICT procurement.

Interview guide was developed to steer the conversation and refined according to reflections from the first two interviews and feedback from the supervisors, mainly resulting to re-wording of questions to enhance simplicity and understanding of the questions. The basic interview guide after modifications can be found in Appendix B. The following main themes were addressed during the interviews: description of motivations and justifications for method choices (e.g. criteria chosen, scoring practices), as well as highlight benefits and limitations of the framework or tool. The discussion points were similar in each interview, however, the guide was slightly modified for each interview to reflect the purpose and characteristics of the specific framework as well as the expertise of the interviewee.

The points of contact were identified through organisation websites, relevant documents or 'snowballing' (Flick, 2006). The primary mean of contact was direct e-mail to the framework developer or manager. In some cases, this information was not available. Then, a secondary mean was to use contact forms in the organization websites or a generic contact e-mail address such as info@organisation.org. Of the total 22 email addresses, 3 did not reach the intended respondent. The first e-mail was personalised, short and simple to read and included a pdf or PowerPoint to introduce the thesis. In the case of finding interviewees from large procuring organizations, the snowballing method was used, meaning the first point of contact, in this case the sustainability expert of IKEA, was asked to suggest further points of contact (Flick, 2006).

Interviews were conducted between June and August 2016. A complete list of interviewees is found in Appendix A. Most of the interviews were conducted via Skype. However, in one case questions were requested via e-mail instead of an interview and in another case combination of Skype and phone was used due to technical difficulties. Each interview lasted between 45 minutes and 2 hours. Skype interviews were recorded with the permission of the interviewee. This allowed the interviewer to guide the interview, ask follow-up questions and provide alternative formulations of questions or clarifications to them. Notes were also taken during the interview in case the recording fails and to note main messages. The records were not transcribed, but they were consulted in the case of uncertainty when clear-writing. The framework results were iteratively updated and refined during July.

A draft copy of the thesis was sent to each interviewee prior to publication in order to provide the interviewees an opportunity to comment upon and correct misunderstandings. Interviewees, as experts, were also encouraged to comment the thesis draft and the procurement framework, thus, providing a validation method for findings. However, since tool developers and managers have a vested interest to represent the elements in their tools, the workshop discussed later was considered as the primary validation method. Overall, 10 informants responded, of which two informants provided further content-wise feedback on the thesis.

Some interviewees preferred anonymity regarding some content, thus, a decision was made by the researcher to characterize the interviewees as listed in the Table 3-3 below. The order does not represent the order of interviews in Appendix A or list of frameworks and tools in Appendix C.

Table 3-3. List of Interviewees

Interviewee	Type of Organization
Interviewee 1	A certification or labelling body
Interviewee 2	A certification or labelling body
Interviewee 3	Non-governmental (NGO)
Interviewee 4	Non-governmental (NGO)
Interviewee 5	Non-governmental (NGO)
Interviewee 6	ICT industry consortium or individual ICT supplier
Interviewee 7	ICT industry consortium or individual ICT supplier
Interviewee 8	ICT industry consortium or individual ICT supplier
Interviewee 9	Procurer
Interviewee 10	Procurer
Interviewee 11	Procurer
Interviewee 12	Procurer
Interviewee 13	Procurer
Interviewee 14	Academic/Consultancy
Interviewee 15	Academic/Consultancy
Interviewee 16	Academic/Consultancy
Interviewee 17	Academic/Consultancy

3.2.4 Data Analysis

Analysis was based on open *coding* and *categorizing* of words or phrases. The focus was on identifying the most common elements of sustainable procurement (such as policies and procuring strategies) and criteria used for sustainability assessment. In this thesis, criteria is defined as a condition attribute to characterize and assess the sustainability of ICT, making it possible to make a judgment about the relative sustainability of different alternatives (Foxon et al., 2002). Thus, criteria and indicators are used interchangeably in the thesis for the convenience of reading.

Coding focused on identifying the textual and sometimes numerical matter in the criteria in order to find common areas (Flick, 2006). The interest of this study was not to study the criteria in a highly detailed level, since ICT technology and assessment criteria develop fast, but to provide general guidance for identifying common criteria for sustainable procurement. The identified codes were for example: company "provides effective voluntary takeback and reports e-waste collection", "has the brand (company) a take back program and is the take back recycling rate higher than 5 % of the weight of the annually products sold", which were adapted to a more general level of "does the company provide take-back options for used and obsolete equipment". Different ambition levels found were then used for constructing scoring guidance. This coding example aims to increase the interpretative reliability (Flick, 2006, p. 370). In order to manage the data, the criteria were stored in an Excel spreadsheet.

The criteria in the frameworks are usually categorized, for example, by triple bottom line of economic, social and environmental dimensions. Therefore, the criteria *categories* were decided to be developed in sequences to increase the reliability (Flick, 2006, p. 370). This meant that after the first framework was analyzed and the data was stored to the Excel spreadsheet, also the preliminary categorization of criteria was developed. After the analysis of the next framework, the categorization was refined when appropriate. At the end of criteria database construction and final categorization, the 536 criteria were screened and grouped into three categories, namely governance and management, health and environment as well as human and labor rights, with seven sub-categories in total. This enabled comparison of criteria and

analyzing frequencies, which further enabled identifying the most common criteria consolidated into 32 criteria.

Next, the common criteria were compared to the circular economy principles, characteristics and indicators found from background research. This enabled considering differences and similarities between the common criteria and circular economy elements. It is notable that no systematic effort to add new circular economy criteria in the case of difference was considered, thus, some circular economy aspects might have been lost in the comparative analysis based on only common criteria. Full set of categorized most common criteria is shown in Appendix D and is further used in the framework design.

3.3 Creating a Sustainable ICT Procurement Framework

A framework for sustainable ICT procurement was designed from the synthesis of common elements and criteria of the existing frameworks and tools with a strategic sustainability perspective as guidance. The design was validated with workshop discussions considering relevance and feasibility of the proposed elements, criteria and related scoring guidance.

3.3.1 Selection of Criteria and Elements

The core elements of sustainable procurement, which were identified 'ground up' from the frameworks and tools in the study, were further themed and compiled into a visualization of circular procurement. The development of generic criteria is a challenge, because ICT develops fast and different product groups have different hotspots. However, a detailed product specific procurement is resource-intensive to set up and update and therefore, the most common criteria were chosen for further analysis as they can guide towards using harmonized criteria sets and build upon the work of expert organizations and academia. Exploring different ambition levels arising from different frameworks and tools relating to the same criteria topic, such as end-of-life schemes by the supplier, allowed to construct a 'map' from the low level of ambition to the estimated end goal, an effort of back-casting criteria. Sometimes this ambition level construction was more subjective in case there was no clear statement of the end goal, but an indication of the direction of the criteria. Although share of renewable energy was not the most common criteria, it was an exception outside the common criteria taken into further consideration due to its importance in circular economy and possibility to explore the opinions on a simple example of back-casting.

3.3.2 Validation with Workshop Discussions

In the final step the question arises, whether the proposed conceptual framework is functional. In this stage the purpose was to improve the construct validity of the proposed conceptual framework (Yin, 2014). The case company is a large international furniture retailer, IKEA. As a large end user with existing experience on developing sustainable procurement practices for ICT, it is a suitable organization for learning about the challenges and success stories on the way of improving the ICT procurement sustainability.

The perceptions and opinions on the feasibility and relevance of the proposed criteria and elements were validated with three workshops, in which the researcher worked as a facilitator. Each workshop hosted 1-2 people and lasted approximately 2 hours. The most relevant criteria address the significant sustainability hotspots of the ICT product, whereas the feasibility tells about the procuring organizations capabilities to adopt the element or criteria. The aim was to have enough informants from relevant areas of expertise, more specifically ICT procurement and sustainability expertise. This ensured that the boundaries for analysis are complete enough and the most important perspectives are presented in the findings (Yin, 2014, p. 202-203).

Materials and guiding questions were sent to the participants in advance. During the workshop, notes were taken, but not all of the workshops were recorded. After the structured discussions, if time allowed, some participants were asked about the overall value of the criteria and elements and whether there was something essential for sustainable ICT procurement missing. In total, four people from the company participated to the workshop discussions. The opinions were categorized to relevance and feasibility. The information provides valuable indication whether the framework could by feasible in an organizational context in practice and how it could be developed further.

3.4 Methodological Limitations

Limitations related to every methodological choice exist, but they do not pose a significant validity risk for this research. The most notable limitation comes from the systematized literature search strategy, which was chosen to structure and set a time limit for the search phase. However, with only one database and limited "hits" screened from the Internet, many possibly relevant frameworks and tools have been left out from the thesis, decreasing the reliability of the results. Thus, frameworks and tools used by private companies were not accessible through this method. Despite this shortcoming, Google shows results by relevance by using algorithms, and serves the purpose of finding the most pertinent frameworks with limited search. Arguably, the most prominent and common frameworks and tools were captured (such as ENERGY STAR, EPEAT, TCO Certified, ECMA-370, UK Greening Government ICT strategy, among others), with sufficient information guiding the research on common criteria and common sustainable procurement elements. Thus, background research was used as a secondary source for the framework design phase. For further research, the search could be extended with more academic databases (such as ScienceDirect, Emerald Management and SpringerLink), NGO databases (e.g. Ecolabel Index) and search words for a richer variety of frameworks and tools. Further, although the searches were conducted in English and some frameworks and tools developed in non-English speaking countries might be underrepresented, this is not considered as a major barrier since the commonly used frameworks communicate also in English in order to have a higher scale of influence.

Clearly, devising a general tool for a variety of ICT hardware faces limits regarding accuracy and technical specificity. Details and perspectives may have been lost in categorizing and aggregating the criteria as well as in only investigating the common criteria further. However, the benefits of devising a general framework and broader criteria are rather straightforward from the purchaser point of view; the simpler, the more motivating it can be to integrate sustainability to the core procurement process. Therefore, the interest of this study was not to study the criteria in a detailed level, but to explore a practical, yet progressive and systemic approach.

The progressive and systemic approach was intended to be reached by using the Framework for Strategic Sustainable Development (FSSD). Notably, with another analytical framework the end results could have been different. With FSSD guiding, the criteria scoring guidance developed was highly explorative; with a strength of suggesting a strategic scoring guidance with an end goal thinking and with a weakness of bringing stronger subjectivity into the research process in this phase. Hence, with another approach the scoring guidance could have been turned different, for example avoiding the valuation of different kind of actions by suppliers. However, the validation of this approach with a case company provided useful insights to how the scoring approach could work.

A limitation in the validation phase is that interviewees represented only one company. Another validation round with multiple actors from various organizations would provide a stronger basis for generalizing findings (Flick, 2006) and testing counterarguments and -examples (Yin, 2014). Arguably, identifying all conditions to predict a certain outcome with certainty in social sciences

might not be possible. Also, the results could have been different in another organization. Hence, the stated opinions and views might be skewed with social bias (Flick, 2006) and empirical evaluative research of whether the framework elements and criteria enhance sustainability in practice, in other words usability evaluation, would be highly valuable. However, the interviewees provided examples about the successes and, also, pitfalls in the sustainable ICT procurement and management process, which may indicate that social bias was not strong enough to influence the findings substantially. In addition, the interviewees within the case company represented experts from both sustainability and procurement, which enables depicting different perspectives and, consequently, enhances credibility of the results. Hence, there is no evident barrier for the use the framework and related criteria by other organizations with a sustainable procurement goal.

Subjective researcher interpretations have been alleviated through triangulation, as suggested by Flick (2006); interviewing the framework developers and managers to verify their motivations. Although the influence of the researcher cannot be fully eliminated in interviews, semi-structured interviews with open-ended questions allowed the reduction of researcher influence, yet, allowing structured guidance to address certain areas of the research interest. However, not all interviews were recorded, which might have reduced the reliability of the results, yet, the risk was reduced by notetaking. Arguably, it was more beneficial to gather information from various sources with notes in the limited time with follow-up and clarification options than focusing on reducing the bias risks.

Finally, although the criteria and elements might seem relevant and feasible currently, validated by within one company procurement team, organizations change, markets change, technologies changes and legislation changes. Hence, some elements and criteria proposed to be relevant today might not be so in tomorrow's markets, ICT and organizations. With these methodological choices and their limitations in mind, the research findings are presented and discussed next.

4 Findings: Framework and Criteria Synthesis

The findings presented in this chapter are based on literature analysis and supporting interviews with the developers or managers of various frameworks and tools (see Appendix C) as well as interviews with sustainability experts and procurers of large private companies. Examples of frameworks and tools, in which the certain criteria or element was found, are referenced regarding their number in Appendix C to aid readability. First, the common sustainability criteria are examined, including their variabilities, related product groups and geographical scope. Furthermore, it is explored how the sustainability aspects and related criteria are informed to stakeholders. Second, principles guiding the sustainability frameworks are investigated in order to understand the underlying boundaries that are driving them. Third, strategic guidelines and plans relating to procuring organizations work towards sustainable procurement are examined. Fourth, ways of scoring and weighting are investigated. Finally, tools helping to build all the above into practice are briefly explored.

4.1 System and Criteria

The technical complexity of the criteria addressing sustainability aspects as well as the various ambition levels of the criteria posed a challenge for the scope of this research. Criteria are many times expressed and specified in different ways, which lead to the need to consolidate the criteria in order to identify common core criteria. Hence, the criterion was considered common if it was present in at least four frameworks in the consolidated form. This lead to a criteria set, which was rich and manageable enough.

4.1.1 Common Criteria

The following criteria topics were common in the studied sustainable ICT frameworks (the number in brackets shows in how many frameworks and tools the criteria is present):

- energy efficiency, with a reference to ENERGY STAR for products, PUE/EUE for data centers (16) and power management features (6)
- lifetime considerations; spare parts availability, warranty and upgradeability (14)
- restrictions on hazardous substances; halogens, heavy metals or phthalates (13)
- disassembly and recyclability; easily separable materials, labelling for recyclability and reduced number of material types (11)
- user information; advice on energy saving functions, disassembly and repair, proper disposal, hazardous substances and material safety sheet (10)
- consumables management; duplex printing and use of recycled paper or paper sourced from sustainable forest management (references, for example, to FSC) (8)
- noise emissions (8)
- take-back schemes (6)
- greenhouse gas emissions of the company's 'own operations' (5)
- environmental management system (5)
- environmental policy (4)
- policy and proof of 'conflict-free minerals' initiatives (4)
- compliance with ILO core conventions (4)
- material footprint; weight, recycled content and recyclable content (4)

For more detailed explanation on criteria and verification methods, see Appendix D. In general, most of the frameworks cover environmental issues rather broadly, while social issues are dominated by conflict minerals or general referencing to ILO and/or EICC. Most common

specifications on human rights are tracing and publishing smelters, no child-labour, freedom of association, no forced labour, existence of a formally registered employment relationship, no discrimination, a sufficient living wage and a maximum working week of 60 hours (7, 15). Notably, it is not so common to specify human and labour rights.

Most of the frameworks cover both product and company attributes, the latter frequently referring to ISO 14001. However, company requirements are not harmonised and many consultants "come up with their own ideas and increase competing systems instead of harmonising the system" (Interviewee 6). Consequently, the industry is looking for developing a company program (Interviewee 6). EICC is mentioned as an encouraging example of harmonisation, initiated by Dell and now agreed by many companies (Interviewee 6).

Lack of robustness and consumer demand were the reasons mentioned on why certain aspects are not addressed. One reason why social criteria may mature more slowly is indicated by interviewee 3: "*there is no robust way of evaluating social issues*", pointing to the need of science base before applying new criteria. Social criteria encompassing various supply tiers is challenging because of the complex and large supply chains; a company can have over 600 suppliers just in the first tier (Interviewee 6). When interviewees were asked for further development ideas on their framework, the development of social criteria was the most frequently mentioned (Interviewee 2, 3, 6 and 12). Hence, a reason for not promoting material circulation by using recycled material was pointed out by interviewee 8; a company tried to introduce a product with recycled content, but in practice it did not sell, thus, it was forgotten.

4.1.2 Various Ambition Levels

Although the criteria share commonalities, they also differ, mainly in respect to their ambition level, scope and practice of awarding additional points. For design related features, most of the frameworks refer to user manuals on repair, or professional reparability. Open Eco Rating (V3) asks about design that makes the mobile phone easy to disassemble and repair with common tools. It is also frequent is to ask for default settings for energy management features. A specialty so far found only from Open Eco Rating (V3) is whether the device proactively advices the user on energy saving measures. Whereas most of the frameworks and tools ask about possibility to disassemble, UN awards additional points if one qualified person alone is able to disassemble the product. Similarly, most of the frameworks ask for ENERGY STAR certification, whereas the UN awards additional points when the product is "more energy efficient than specified in the latest ENERGY STAR® standards for energy performance". Uniquely, Greenpeace asks examples of innovation for lifetime extension and whether the warranty offered is above average for best-selling products. Notably, Open Eco Rating (V3) is the only framework calculating multifunctionalities; for example, if the mobile phone has videoconferencing capacity and a capable camera, which could indicate more efficient use of resources since the other commodity (such as a camera) would be replaced.

Recycled or recyclable content is a frequent question, but it usually relates to plastics or packaging. However, for example Open Eco Rating (V3) asks for recycled content of aluminium and internal and external steel in addition to plastics. Some also ask for weight percentage of renewable or bio-based material in plastic parts. Hence, the Australian Government provides a target-based effort to increase the use of post-consumer recycled content in general use office copy paper from minimum requirement of 50 % to 100 %.

Most of the evaluators ask for involvement in initiatives in conflict-free minerals, but different approaches exist. Some frameworks recognize only joint initiatives, whereas some reward individual company activities, such as being active in developing conflict mineral tracing, monitoring and certification processes or auditing mineral suppliers (3,8). Other sustainability

activities, such as involvement in GeSI, are less recognized. A tiered approach has been adopted by Rank a Brand, which gives more points if companies are involved in more sustainability initiatives. An emerging approach is due diligence, which is adopted by EICC. Due diligence approach means that the company should prevent the use of conflict-minerals first and remedy only if prevention fails.

Many frameworks refer to EU REACH or RoHS regarding criteria on hazardous substances. Some chemical specifications, which are less common, are that the product is free from antimony and beryllium (7,8,9) and product surface is free from nanosilver (2,3,4). Few frameworks address ozone-depleting substances in data center refrigerants (2,16), which might reflect the methodological choices limiting the representativeness of frameworks addressing data centers. In general, there are three approaches with chemicals: common static "black-lists" of individual substances (e.g. no mercury), less common active identification of new hazardous chemicals to manage, restrict or eliminate (6,8,15) and a visionary holistic approach of actively tracking chemicals and developing a "sustainable materials lists" (Interviewee 6).

Within the first approach, it might not be possible for producers immediately find a solution to reduce, eliminate or substitute the specific chemical. The UN suggests requiring proof of commitments to phase-outs timelines for certain substances by a certain year goal (e.g. proof of commitment of a phase-out timeline set to PVC in all product components and packaging by latest 2010). Another way is to award additional points if either 1) all of the product components or 2) certain product components are free from a certain hazardous substance (10). Moreover, the ambition level with regards to specific substances varies. For example, EPEAT requires that large plastics are PVC free, ECMA-370 asks whether electrical insulation cables of internal and external cables are PVC free and Greenpeace and Rank a Brand ask whether all products are PVC free, thus tackling different components and scales.

It is common to ask for greenhouse gas emissions (GHG) disclosure. The demand for disclosure of GHG emissions vary; for example, Greenpeace demands for scope 1-3, whereas scope 1-2 is more common. Demands regarding results of elimination, reduction or compensation of GHG emissions are less common. However, for example, the Nordic Swan demands that certain greenhouse gases (NF3, SF6) should be abated in the production process of the LCD panel of a notebook or display unit. Only few take into account the emissions from transportation; Open Eco Ecorating (V3) uses transportation estimation for a LCA and the UN requires transportation, which has low environmental impacts measured in GHG emissions. Moreover, questions on policies, targets and commitments for reduction or compensation of GHGs (4,7,8) or share of renewable energy (2,8) are less frequent. However, it is noticeable that Greenpeace asks both past reductions and current goals in order not to award windfall wins for companies who have just started to address greenhouse gas emissions, but have not performed well before.

Lastly, many frameworks ask for take-back schemes, but only few suggest that the procurer should also evaluate whether the supplier has evidence and experience on redeployment, recycling or reusing the equipment (7,17). Rank a Brand has a tiered approach to this; first, whether the company has a take back program and the take back recycling rate is higher than 5% of the weight of the annually products sold, second, whether the take back recycling rate is higher than 10% of the weight of the annually products sold. Notably, Greenpeace asks for free, easy and global take-back for the products sold. It is less frequent to ask for participation of collection and recycling systems for end-of-life products. Related to end-of-life treatment are logistics as well as data erasure and related certificates, notably raised only by few frameworks (9,15,17).

4.1.3 Product and Geographical Scope

Almost all frameworks have sustainability criteria for many product groups, such as mobile phones, PCs, multifunctional devices and printers, separated to less or more wide categories. Only Open Eco Rating (V3) targets one product group, namely mobile phones. Further, most of the organizations wish to expand their product coverage, as stated in the interviews. However, together with developing product categories comes the difficulty in addressing and updating large number of products and their varying environmental aspects (Interviewee 6).

Where does the criteria influence extend then? Most frameworks claim to be global or generally applicable to various organisations and geographical regions. Global scope is seen as a strength, since "procuring organizations can advance their green procurement agenda everywhere" and do not need to "reinvent the wheel every time", as stated by interviewee 2. When the frameworks are stated as regional or local, the criteria are specific to certain legislative or regulatory area, such as the European Union. This is due to the varying legal requirements, which make it challenging to have a global coverage for the criteria (Interview 6). However, market requirements tend to be more global than legal requirements (Interviewee 6). Since Europe and North America tend to cover the largest part of the market, their legislation is normally followed by suppliers, thus, other customers globally also get the same social and environmental baseline (Interviewee 6). Moreover, although ECMA-370 is stated to be regional due to the EU regulatory framework, the effect of the declaration also extends to other regions, such as Asia and Mexico, because most of the products are manufactured there (Interviewee 6). However, the UN gives two criteria scopes, basic and advanced, based on the accessibility to sustainable products in different regions.

4.1.4 Information Flows

There are two common channels for procurers to obtain information about the sustainability aspects of a product and characteristics of a company: directly from suppliers or via a third party, a certification body. Suppliers also provide harmonized information through the industry self-declaration, ECMA-370; it aims to harmonize the criteria from the most applied ecolabels in the industry (Interviewee 6). Labels and certifications provide information in a simplified form, whereas ECMA-370 declaration is more informative, but complex. Both have their strengths; one on hand many interviewees state that consumers cannot take much information and it is "complex and beyond the capabilities of most users to compare different services on the basis of their sustainability", but on the other hand professional procurers can benefit of more detailed information. In addition, both certification organisations and some procurers stated that they also use a third channel, namely external experts, to set up and evaluate criteria (Interviewee 1 and 12). For procurers, an external consultant can be also valuable for setting up a sustainable ICT strategy and measurement system, as credited by interviewee 12. Sustainability initiatives from ICLEI were also mentioned worthy to follow for criteria updating.

In the end, everybody comes back to the supplier dialogue, because they know what criteria is feasible to set currently or in the near future. Ecolabelling and certification bodies balance between feedback from purchasers (what people state they will buy) and manufacturers (what is practical to manufacture if the development in the supply chain process takes five years and the equipment is used for two years) (Interviewee 2). Suppliers can advance the cause of ecolabels by adopting their label and criteria. Notably, the criteria of each ecolabel and certification is set in a specific institutional context, which influences its adoption; for example, EPEAT is 'de facto' in the U.S., whereas Blue Angel is 'de facto' in Germany (Interviewee 6). Nevertheless, the ecolabels adoption can be strong also abroad, such as in the case of EPEAT, which currently covers 43 countries worldwide (Green Electronics Council, 2016b).

Challenges regarding information flows are its slow pace between suppliers and buyers, abundance of disharmonized information as well as "copypasting" of contract language. First, constructing sustainability criteria of ecolabels takes time and it might be technology-wise already out-dated once it is published (Interviewee 2). Also the UN notes that previously used procurement criteria might be out-dated and prompts for updating the criteria regularly. One suggestion, described by interviewee 6, is to look at industry best practices from latest published ECMA-370 footnotes. Second, when interviewees were asked about the desired future development, some stated that they would want to see a common database where different sustainability attributes of a product would be searchable (Interviewee 2, 6). Third, copy pasting of criteria from one labelling organization to another (Interviewee 6) and from one procuring organization to another (Interviewee 1) causes a problem when the initial criteria is not feasible or is incorrectly worded. Thus, criteria in ecolabels is sometimes difficult to measure, as in the case of upgradeability or modularity, and interpretation on how to fulfil the criteria has to be sometimes clarified (Interviewee 2 and 6).

In addition, Hans Wendschlag from Hewlett-Packard provided an insight of a collaborative procurement route. With product-service systems, in this case leasing, clients might be concerned of the data security when they return the equipment back to the supplier. As one client was concerned about this, the company developed a solution together with the client, in which data is erased and certification of erasure is given upon the physical return of the equipment with the logistics organizer. Hence, they expressed their experience on working with end-of-life equipment and releasing the product to secondary markets to continue its lifetime and avoid electronic waste.

4.2 Success and Principles

Most of the frameworks have principles related to sustainability aspects, impacts and scientific information. Sustainability criteria should be measurable, accurate and verifiable (1,6,9,17). Although completeness is referred only by one framework as a key principle (9), some frame principles against life cycle stages (2,6), and most of the frameworks recognize life cycle thinking elsewhere than in the stated principles. Thus, relevance is another frequently referred principle, meaning that the criteria must address, not all, but significant sustainability hotspots throughout the life cycle of the equipment (1,4,9,17). However, this is challenging, because standard development takes a lot of time; both product and standard development might take three years, leaving the standard out-dated already when it comes out (Interviewee 2). Hence, it might be difficult to establish relevant leadership criteria (Interviewee 2).

Economic and market principles are also commonly mentioned. Some of them relate to monetary benefits, such as cost efficiency (6), best value for money (10,13), and return on investment or payback (1). Others are related to fair competition, such as having products widely available and offered by more than one manufacturer (1), ensuring suppliers from developing countries have right to access the buying organisation market (10), and being equitable and fair to all suppliers (9,17).

Product-related principles have more variance. They focus on comparability, meaning the sustainability criteria should enable comparing competing products (9,17), effective differentiation of products (1), maintaining or enhancing energy efficiency performance (1), and rewarding product innovation (6). Hewlett-Packard also states that there should be a technically feasible alternative available with material restrictions (17). Manufacturers are not otherwise always able to comply with the requirements as in the case of EU Ecolabel regarding its demanding chemical requirements (Interviewee 6). Other stated principles or norms are voluntarity (6), interest of the organization (10), steerability (4), harmonisation and recognition of international standards (17), simplicity (6,9) and transparency (6,9,10).

4.3 Strategic Guidelines and Plans

While criteria are helpful elements in sustainable procurement, they always operate in a societal and organizational context. Here, the focus is on strategic plans of the procuring organizations. Most of the actors suggest devising a green ICT strategy and aligning it with the organizational strategy, such as the UK Green ICT strategy is a sub-strategy of their ICT strategy. One interviewee recognized the integration of sustainable ICT to organization process as the core strength; sustainable ICT was directly responsible for top management (Interviewee 12). If the sustainable ICT was not integrated to the core procurement process with a management mandate, it was argued to be forgotten fast (Ibid.). Similarly, the UN specifies and mandates two sourcing strategies in their procurement guidelines:

> [*Purchase/ lease*] of energy efficient and socially responsible produced [*PCs, notebooks and monitors*] with a reduced content of hazardous substances

Other common elements are a sustainable procurement policy or sustainable ICT policy and related action plans. The policy is argued to ensure the management approval. This was further strengthened by one interviewee in a procuring company, stating that the key to success has been the support of few key people, including top management of procurement "with a strong voice across the company" (Interviewee 11). A sustainable procurement team or a sustainable procurement expert in a procurement team was suggested to be essential to integrate sustainability into procurement. Vision is defined only by few actors, such as the UK Government. Goals and objectives are more common in policy documents. Interestingly, one interviewee shared their sustainable ICT goal; decoupling of business sales and energy consumption from ICT use. The same interviewee recognized targets as the strength of their framework. Notably, targets aligned with organizational goals have a better buy-in across the organization (Interviewee 12). "It's fantastic if economic and environmental is integrated and you can point to parts of it like money or security, like e-waste and risks" (Ibid.).

Maturity models used to monitor and improve the sustainable procurement process was used by the Connection Research-RMIT Green ICT Framework as well as UK Government, with a Green ICT Maturity Model and a workbook on best practices to be used by the government bodies. One organizational hurdle, which hinders the maturity, and Life Cycle Costing especially, was the disconnection between the procurement unit and actors, who bear the life cycle costs, or in other words, disconnection between the procurement decision-maker and beneficiary of savings (Interviewee 11, 12 and 15). In this case, the costs and benefits are argued to be lost in overheads, meaning people are not responsible for what they buy or consume (Interviewee 15). Reconnection of these is challenging in a large company with various departments (Interviewee 12).

4.4 Actions on Scoring and Weighting

Most of the frameworks use or suggest a simple Yes/No/Not Applicable (N/A) scoring for evaluating the answers to individual criteria. Rank a Brand uses interrelated Y/N questions to benchmark and separate different ambition levels, nevertheless leading to one overall score. Greenpeace gives higher points regarding the same question, but higher ambition level in the answer. Some organisations use minimum standards, such as requirement for a minimum of EPEAT silver (13) and mandatory criteria (6). Most of the ecolabels have a pass/fail approach or they have initially started with that approach before developing tiered approaches. Tiered approaches differentiating performance levels are found in EPEAT (gold, silver, bronze), Rank a Brand (A to E), Open Eco Rating (V3) (0-5), and the new EU Ecolabel proposition of core and comprehensive criteria. EICC is currently developing a system for grading members, such as from A to D, based on the implementation of standards, from signing the Code of Conduct

to seeing that the company does things in practice (Interviewee 6). From the procurers' perspective, UK is scoring its performance with a Green IT Maturity Model to assess its maturity level and monitor progress.

Regarding weighting of the sustainability criteria in tendering, it is still rare that sustainability is given much weight in comparison to other criteria, such as cost and functionality. The weighting practices for sustainability criteria either do not exist (6,7), they are at the suggestion level (11,13) or they are miniscule in practice (Interviewee 6). As stated by interviewee 6, the supplier will "not move" if the criteria is given "0,001 % weight". The most advanced weighting of 35 % given to social criteria was stated to be exceptional (Interviewee 6).

4.5 Tools and People

The tools found include cost-benefit calculators, best practice workbooks and sustainability criteria in various forms, such as scorecards. Here, the practical example of IKEA is detailed further. The main tool for including the consideration of sustainability into procurement of ICT in IKEA is a sustainability scorecard. Essentially, the scorecard includes criteria currently used in the tendering phase in order to compare different suppliers based on their sustainability performance. The first scorecard development started in 2011 with the aim to build a baseline on hardware. IKEA's internal sustainability expert developed the scorecard by background research and dialogue with major ICT suppliers. Then, the scorecard was sent to the current suppliers. The answers are used to build the baseline, meaning the average quality level of the market informed by the average score in the scorecard, once enough information is gathered. The idea is to use the baseline to develop minimum criteria, which can work as a "showstopper", as some interviewees call it. The latest version of the scorecard, also described as "the third version, which is usually more valid", has guidelines related to each question in order to raise awareness of the sustainability issues among purchasers and suppliers. Furthermore, the company recently introduced a key performance indicator (KPI), more specifically the use rate of sustainable procurement criteria, in order to track how many purchasers use the sustainability scorecard and measure the success of the tool. The track record goes through finance department and leads directly to the purchasers, which creates accountability for using the tool. The scorecard was perceived to make the sustainability integration to procurement "professional" and the presentations on the scorecard results by the sustainability expert in the evaluation phase as "good practice", as stated by one purchaser.

The biggest challenges have been developing understanding among the purchasers of the importance of the scorecard and implementing the scorecard to wider use by purchasers. In addition, when using the scorecard, the purchasers might not always know how to interpret the answers from suppliers. In one case, as described by one purchaser, answers received to the scorecard raised doubts, because some suppliers stated that they could with the criteria, whereas other major suppliers stated that they could not comply. This confusion was overcome by the sustainability expert calling to suppliers and verifying the statements (audit calls), revealing that not even the suppliers who stated 'Yes' were actually able to comply with the criteria. Furthermore, one interviewee wished to find ways to update the sustainability criteria and to know up to which tiers of the supplier the demands could extend.

To trickle the sustainability consideration to other levels, the sustainability expert in the procurement team has a part in the training for new procurers. Notably, the new procurers are often unaware of life cycle thinking. One team member acknowledged that she does not have knowledge on international regulation and sustainability issues, hence, the sustainability expert was considered as a valuable member of the team. Training is seen as an essential tool in most of the other frameworks as well. Many frameworks recognize not only procurer training, but also supplier training; informing suppliers of what kind of sustainability criteria is coming.

However, one interviewee noted that many suppliers are not mature enough yet to answer many sustainability related questions (Interviewee 11).

Challenges mentioned are the non-control over decentralized procurement, lack of standard TCO modeling, decision-making guidance for product-service systems and, when calculated, the impact of buying a "greener" electronic is perceived low by some interviewees. One interviewee stated that buying ENERGY STAR certified equipment is a standard, but "it doesn't make a huge difference to the life cycle costs" (Interviewee 13). One interviewee said it would be good to have more automation to include sustainability considerations, such as energy savings calculations, to the procurement process, thus, reducing the dependence on people applying the tools (Interviewee 12). Thus, the consideration of 'need' among various actors differs. For example, technicians often "want the best solution", whereas the need might be less than "best" (Interviewee 10). The view of the need was also related to product-service systems; is there really a need to own some assets (Ibid.). However, the consideration of service related solutions is hindered by the lack of formal written document, such as strategy mandating the service solution, as indicated by one interviewee.

Stated compliance verification methods are often third party verifications. However, many interviewees said it would be good to be better at follow-ups so that "it's not just a certification paper" and measure the realized value, both in monetary and environmental term. Evaluations could provide a stronger signal for investment decisions, but currently they are largely missing. However, another interviewee recognized that the company is still in the phase of developing working methods with sustainability in indirect procurement, thus, it is too early to measure (Interviewee 11).

Overall, the sustainability aspects addressed are screened through a variability of difficult criteria with different ambition levels informed mainly by suppliers and credible organizations, such as the UN and ecolabelling organizations. The principles are mostly related to scientific credibility or economic terms, including 'best value for money'. Strategic guidelines give a mandate and facilitate an action plan, whereas actual weighting is cautious. Thus, it all comes down to people and the challenges of implementing sustainability to other core business processes, including people's core work.

5 Proposed Sustainable ICT Procurement Framework

The development of the framework is based on 1) literature on sustainable procurement and circular economy, 2) literature and complementing interviews on the strengths and common elements found in the existing frameworks as well as 3) findings from interviews with large private procurement bodies. First, the core elements are described and guiding steps identified related to each element. Second, graphic visualization and value proposition is given. Third, possible shortcomings are documented for further research.

5.1 Consider Feasibility

Some elements can be considered fundamental, namely management bringing visibility, action consisting of people implementing tools and operationalizing principles as well as measurement, seeing where we are and where we go. These are briefly considered next, but since they are largely documented elsewhere, they are not the core focus. Hence, they are mainly used for devising the core of the circular procurement framework, including its visualization later on, and linking criteria and procurement solutions to organizational reality.

5.1.1 Management

This perspective includes strategies, policies, principles, goals, targets and action plans. Top management support documented in sustainable procurement policies are essential in adopting sustainability consideration into procurement. Notably, the support should be expressed more precisely for some solutions, such as product-service systems (Bratt, 2014). The inclusion of strong policies and strategies was further strengthened by interviewee 10: without a formal support for, for example, service based buying, the discussions for considering them in the procurement might take a long time. In short, the following elements were identified essential:

- ensure top management support for sustainable procurement
- formalize sustainable procurement with strategy, policy, goals, objectives and targets
- mandate possible new solutions contributing to company goals and sustainable development goals, such as product-service systems
- Measure need and value in function instead of cost/price
- Consider an alternative route to sustainability specifications and solution development through supplier – buyer collaboration (as suggested and discussed by Bratt, 2014; Witjes & Lozano, 2016)

5.1.2 People

This perspective exists in many frameworks and is specified in various ways. It is widely recognized that the lack of knowledge and experience are the most prominent barriers for sustainability solutions (Bratt, 2014; UNEP, 2013). Essential elements to overcome these are awareness, attitudes, competence and behaviour. The main tools found and integrated to this dimension were training of suppliers and buyers, building of procurement teams with sustainability expertise, as well as work tools, such as sustainability scorecards.

One less documented aspect related to people, but demonstrated by interviews with practitioners, is that different people understand need in different ways. Identifying the true need is at the core of product-service systems and especially functional procurement. Functional procurement is identified to be the most promising from environmental perspective (Tukker, 2004). Hence, aligning the understanding of true need and mandating its use can enable better functional procurement. In order to "direct the procurement processes towards the final need

of the procuring organization" and assess the different ways to fulfil the true need, guidelines and routines in the procurement process are needed (Bratt, 2014).

The management perspective and people perspective are interrelated. First, people should be aware of the company's sustainability vision, sustainable procurement strategy and objectives to make decisions aligned with them (Bratt, 2014). Second, individual people can be "sustainability champions" within an organization, but sustainability efforts may vanish if the people move out from the organization, as illustrated by interviewee 11. Therefore, their knowledge and working methods should be translated into a formal continuous process via management policies and strategies. Third, automation could decrease the dependency on decisions and actions of individual people, suggested by interviewee 12. The people dimension is summarized below:

- give meaning to use sustainable procurement working methods (motivation)
- set up training (raise awareness and competence)
- link sustainability measures to personal motivating drivers (ensure accountability)
- consider when sustainability awareness and expertise steps in. It might be relevant to integrate sustainability in the early stage of procurement process (level up influence)
- ensure the continuity of good practices by formalizing them to guidelines, policies and other appropriate means (process continuity)
- explore and provide Life Cycle Costing guidelines and decision-making paths for Product-Service Systems (develop decision-support systems)

5.1.3 Measurement

As the saying goes, "you cannot manage what you cannot measure". Measurement can be used for tracking sustainability benefits within the organization and evaluating the scale of sustainability integration to procurement. The sustainability integration could be evaluated for example through the adoption rate of sustainable procurement working methods, such as tracking how many procurers use sustainability criteria in contracts (Interviewee 11). Arguably, a similar step could be to track how many contracts have sustainability related contract clauses. However, this also necessitates follow-up methods, which were not visible in the sources studied. Conclusively, procurers are encouraged to explore innovative and effective options for measuring success, since no solid evidence of best practice was documented in the thesis scope.

- Develop Key Performance Indicators (KPIs) for sustainable procurement goals

5.2 Consider Relevance

This part aims to shed light into the construction of criteria with an explorative method, namely back-casting from ambitious criteria as well as from circular economy principles and characteristics. This can provide food for thought beyond general well-documented guidelines.

5.2.1 Construct Criteria and Activate Action

This area focuses on the ICT life cycle and how the challenges arising from the material life cycle are addressed during the procurement cycle. The two are embedded and should be understood from an integrative point of view. Two dimensions in criteria structuring are separated: supplier and process-related criteria, which can indicate the contribution of the company to sustainable development, and product-related criteria, which address specific aspects directly attributable to the product. Criteria structuring is meaningful from the environmental and social perspective when it addresses the relevant sustainability hotspots and matches the organizational sustainable procurement maturity. Hence, organizations should consider aligning these when possible. Often the new procurers are not familiar with life cycle

thinking, thus, raising awareness of life cycle thinking and its application to sustainable procurement is fundamental (Interviewee 11). It is recommended to:

- raise awareness of life cycle thinking. This can be done by various ways, such as training and visual illustration.
- explore the organizational sustainable procurement awareness, motivation and behaviour in order to suggest feasible, yet meaningful sustainability criteria (define organizational feasibility and sustainability relevance of the criteria)
- consider the objectives of sustainable procurement and translate these to the criteria (progressive criteria building based on back-casting)
- identify criteria, which could be suitable for contract management purposes (improve the supplier)
- decide on appropriate weighting, which translates sustainable procurement objectives into practice

Ultimately, the sustainability criteria should be structured to support both "procurers and suppliers in a systematic and strategic stepwise approach towards sustainability" (Bratt, 2014, p. 40). Thus, Bratt et al. (2012) suggests that suppliers could inform procurers on the social and environmental life cycle impacts. It is plausible that with increased collaboration between the supplier and buyer and a common sense of sustainability direction, the procurer might not need to update the criteria so often, since the direction is visible, and the supplier might be driven to improve their sustainability impacts more long-term.

An example of using back-casting and criteria structuring is given in Table 5-1. The desired objective, shown as the highest possible answer option, is 100 % renewable energy, in align with circular economy principles. If the selected supplier is currently in 10 %, the next step of 20 % could be negotiated into the contract clauses to be fulfilled within the contract period, if feasible, and nudge the supplier to move forward with sustainability objectives. Feasibility can depend on negotiation power and contract period, thus, the target should be adjusted with consideration of the timeline. A full set of explored criteria covering governance and management, health and environment as well as human and labour rights, can be found in Appendix D.

Table 5-1. Example Criteria Proposal

Criteria	Example Verification Method	Scoring Guidance (left: supplier answer options, right: awarded points)	
Renewable energy: What is the share of renewable energy of the total electricity consumption of the company in its 'own operations'?	declaration of the use of share (%) of renewable energy from electricity demand (scope 1 & 2)	100 %	5
		80 %	4
		60 %	3
		40 %	2
		20 %	1
		0 %	0

5.2.2 Collaborate and Update Criteria

The development of the current criteria does not take into account new technology and new problems. Interviews revealed that it is challenging for procuring organisations to find a systematic way of keeping up-to-date with criteria relevant for each product group. For procurers to keep in the wave of procuring the best environmentally preferable products, information flows need to be established. Bratt et al. (2012) as well as Witjes & Lozano (2016) also recognize the need for enhanced dialogue between suppliers and buyers.

The procurer and supplier collaboration channel could be opened in the preparation phase (sourcing strategy consideration), in order to facilitate the learning and understanding of sustainability impacts of the solutions, thus, inform relevant and feasible technical and non-technical specifications (Witjes & Lozano, 2016; Bratt et al., 2012). The following actions were identified for activating information flows and learning from internal information flows:

- Update sustainability information periodically. Updating sources may depend on the criteria and procurement approach chosen. Major suppliers, ECMA-370 footnotes and ecolabelling criteria can provide guidance. While some ecolabelling criteria might not be feasible for suppliers, ECMA-370 footnotes could inform best practices. Hence, in the pre-procurement dialogue suppliers could be asked about their main sustainability impacts and procurement criteria suggestions in order to benchmark.
- Review and learn; check how goals address the significant sustainability hotspots. Communicate the progress internally, and possibly, externally. Adjust the tool(s) according to the organizational development, adopt new criteria if feasible.

Although Witjes & Lozano (2016) formed their framework based on the paradigm change from products to product-service systems, the thesis author based the proposed framework on opening the variable opportunities between product-service focus, nevertheless, not closing the product focus. This approach was chosen due to the lack of sufficient evidence on the actual environmental impacts of product-service systems in different cultural, legal and geographical contexts. Circularity is emphasized by direct take-back systems or third party collection of products back to recovery and recycling. Figure 5-1 next page shows the visualization of the proposed elements into the proposed sustainable ICT procurement framework, inspired by Bratt et al. (2012) and Witjes & Lozano (2016). The visualization of the link between the ICT life cycle and procurement cycle might be helpful for procurement practitioners to better understand life cycle thinking and the concept of circular economy, as well as to place the proposed sustainability criteria visually to a larger scale. Next the framework is validated with large private company procurers and sustainability experts.

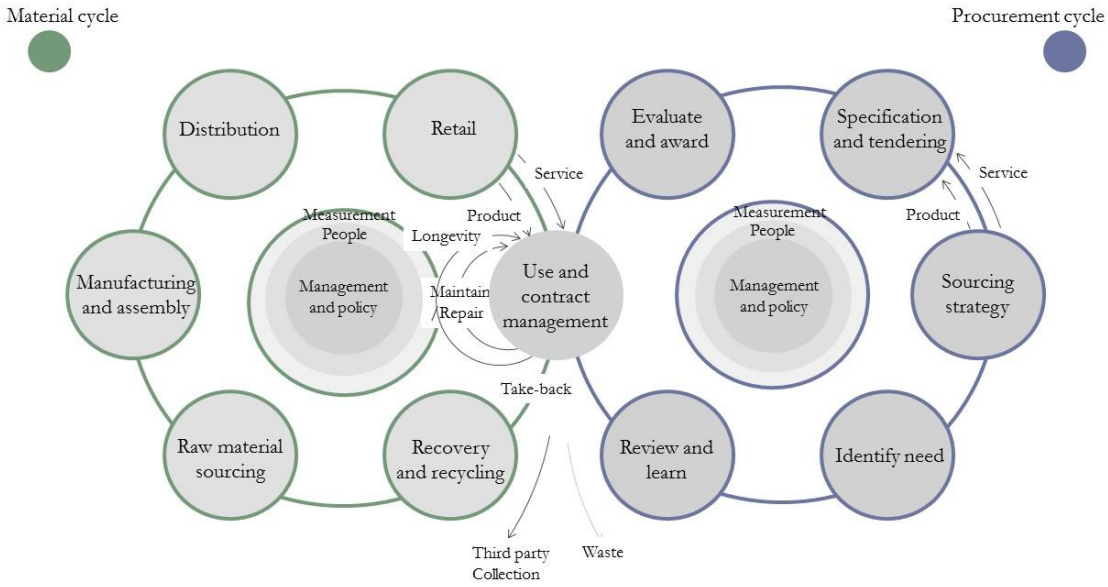

Figure 5-1. Sustainable ICT Procurement Framework

Source: Own illustration

5.3 Workshop Discussions

This part of the thesis draws lessons learnt from the workshops with IKEA purchasers, a sustainability expert and a business analyst regarding the proposed sustainability criteria and elements for sustainable procurement. Similar comments were made to several elements and criterion, thus, the criterion and elements are categorized into low and high relevance as well as according to similar comments. High relevance is further broken down to feasible in the early stage of sustainable procurement adoption and feasible in the later stage, when sustainable procurement is more mature in the organization. Low relevance is often also a feasible 'low-hanging fruit', hence, it was not considered necessary to consider the feasibility levels for those criteria and elements. Table 5-2. details the comments made by the workshop participants about the sustainable procurement elements.

Table 5-2. Comments on Core Sustainable Procurement Elements

Element referred to	**Comments**
…with high relevance	
Strategy Vision Sustainability policy with support for PSS	Provides visibility. Makes clear where to focus, initiates action and commitment. Possible to lift arguments based on vision including sustainability. Would be good to make PSS visible to inform and train each other (colleagues). Present good data over lifetime by TCO in order to justify product/service sourcing strategy, put value on risk you avoid. Guidelines, such as a decision-making tree, for case-by-case consideration of the product or service system would be good.
Mandate	Personal judgement if no mandate, mandate shows it is good for the business.
Supplier collaboration	Good for narrowing down criteria in the early stage of setting sustainable ICT procurement criteria and learning about new initiatives.

	Fantastic idea to ask suppliers about their sustainability aspects and possible criteria during sourcing, they'll tell criteria what they can fulfil and overall data from multiple suppliers gives a strong tool to improve sourcing.
Goals	Important for getting attention and resources. First goal can be communication. Decoupling of energy consumption and business sales could be interesting. People do not have interest or training on what is decoupling.
Targets	Important in order to bring issues to the agenda. Smart IT guys built their own solutions to shut down PCs when nobody uses them, targets would be good overall, to benchmark and communicate the efforts.
Principles	Principles harmonize action across the organization, for example looking for best price over life time, not best price and upfront cost. TCO good to use, but would be good to have a model to use it.
Focus areas	The real problem to find out where to start, from internal knowledge and interest or external views of what people see as problems; people do not read energy efficiency issues, but they are interested in e.g. social perspectives. Informed by company's internal sustainability Code of Conduct (IWAY). Would be good to have criteria valuing consultants coming from Sweden than flying consultants from UK - would be ok to pay 50 kronor more for local resources. We should calculate consultants travel costs as an input in the pre-study.
Sustainability expertise	Sustainability not a natural part of project pre-study - the sustainability expertise comes later, earlier would be better.
Best practices	Best practices can work as ideas, but each market like UK should do it on their own to figure out what to do and why. Best practices are communicated in the company newsletter. (Data centers) should market more what they do, they have good practices. (About UK maturity matrix) good idea, brings more focused discussion, you should make sure people read it.
Scoring and weighting	Better to demand sending documents and answers than ask. Y/N might not capture other elements that the supplier is doing well, better to capture the right attitude and help the supplier to mature. Y/N comes from practical perspective, impossible to handle open answers from large number of suppliers. Conflicting goals in weighting sustainability, other requirements and business goals maybe don't fit to higher sustainability weighting. Important to have minimum criteria to have go/no-go decisions.
Maturity levels	Good to do it in sequence. People like it, because it gives a sense of being in the right way. Works if helps to be in the process of improvement, but should not stop after reaching highest static maturity.
KPIs	Slow process without them. Provides a tool for accountability (e.g. tracking sustainability scorecard use to the procurer). Qualitative KPIs would be interesting. Tells a bit, but not the full picture, captures quantifiable and tangible things, possibility to do tracking. KPIs good, but they need to be linked to what the organization wants to achieve, goals behind KPIs.
Training	Express what to do and why. After introduction, voluntary repetition trainings. Knowledge sharing between peers, can identify who to ask later. Not everyone needs to be an expert, but aware of the issues.

	Tricky to understand ecolabels and standards – what happens before you get the label?
Implementation	Getting easier because more exposure to environmental messages. People forget, make people aware and make things mandatory to implement. Show a strong business case or a compelling story, e.g. reduction in TCO or happier people.
Updating channels	ECMA—370 footnotes good way to find best practices. Good to be involved in criteria development process, e.g. TCO Certified. Follow—up with the research world should be part of the innovation process. Difficult to know whether the ecolabelling criteria is feasible for manufacturers. Would be a dream to have a database on products with sustainability characterisation. Collaboration with competitors beneficial.
…with low relevance	
not identified	

Later feasibility means that the procurement team needs more competence to adopt the criteria. The starting point is to gain experience with early feasibility criteria. In general, the five-step scoring was not seen as rewarding the supplier for other areas they might be good; individual criterion takes into account only one area instead of the whole life cycle. However, it was seen practical and for most of the interviewees it was seen as a good option for some criterion, such as for ENERGY STAR and energy efficiency differentiation. Similarly, in the case of gradual rise in the share of renewable energy, the idea for having it for contract clauses was seen as a good option. When discussed about the verification methods, auditing was seen as the best option, followed by third party certification and self-declaration with a common database of peer pressure. When asked about missing elements, international conventions and social criteria were responded by one interviewee. Other interrelated elements considered by another interviewee were reusability, modularity and multifunctionality, for example by introducing multiple user accounts or operating systems in one laptop to allow using one computer both at work and home, thus, reducing the need for material consumption. Table 5-3 details the comments about the proposed sustainability criteria:

Table 5-3. Comments on Proposed Procurement Criteria

Criteria referred to	Comments
…with high relevance, early feasibility	
sustainability policy international labour rights	Basic.
environmental management system	Starting point, certifications are valued but not demanded. Not good enough to differentiate best suppliers.
conflict-free minerals	Important to ask what the suppliers do and why, the suppliers may have a good answer for not participating to some initiative.
renewable energy	Would be great to have renewable energy goals in contract clauses. We should first understand it through our own company where we are, "open people's minds", then we can ask suppliers. If not an internal target, difficult to put to the contract clauses.
Greenhouse gas emission targets and past reductions	Good idea. Not sure if the division to 10 %, 20 % et cetera makes sense.
product energy efficiency	Energy Star as a minimum, but not a big differentiator, because most have it. Scoring good, but somebody else thought it's difficult to understand (similar scoring had been suggested before).

	Scoring relevant, not asking only for Energy Star; this can be brought to TCO.
take-back, collection and recycling schemes	Not so important to differentiate between direct take-back and join collection and recycling schemes – end result matters. Relevant to know what the supplier does with the returned equipment, e.g. refurbishing or donating to charity.
legislative compliance with EU REACH, RoHS or similar	Highly relevant, good to motivate REACH compliance, also for international suppliers.
data center efficiency	Ask if the operators measure.
power management features	Built-in requirement, but relevant if you need to enable it.
…with high relevance, later feasibility	
greenhouse gas emissions – goals and targets	Good to recognize both goals and past reductions in order to not to be fooled. Worth to have a target, not only track record.
disassembly and recyclability upgradeability	Not good for a start phase. (Plastics recyclability) seems complex, ask when you're more up in the maturity ladder. You have to think about the maturity of your organization and the supplier, many things hardly implemented yet so focus on making bigger difference, capture what's possible. Everything should be recyclable, but first step would be to make it easier for us to change modules.
halogen-free products	Time question; not too many questions for procurers' sake, "if they don't understand halogens, how would they (procurers) be motivated to use it (the criteria)?". General approach better than specifying many elements; first scorecard version was comprehensive but not implemented well. Might be too detailed in the scorecard context. Hazardous substances change all the time, black lists problematic.
phthalates	More on the agenda of suppliers now, if it comes free - take it.
packaging free of hazardous substances	Relevant, also ask if the product comes without packaging.
…with lower relevance	
user information spare parts availability restriction on nickel	Not the most important one. Up to suppliers how they want to achieve product use of five years, we should not specify solutions too much.
warranty	Required, but overruled by better service agreements.
material footprint: weight-based question	Not much to gain by asking weight, devices are getting lighter. It feels you need to understand what is good and what is not (confusion for what purpose less weight is good).
duplex printing responsible paper sourcing	Paper is good material; not hazardous, not so significant. Focus on products, then packaging. (Duplex printing) is a requirement and every supplier fulfils this.
noise emissions	Much higher noise levels in the factories in which they are produced than the computers themselves. Points to the importance of listening to co-workers.

5.4 Refinement of Criteria Construction

Based on the feedback received, all the core elements were deemed relevant and feasible. However, the structuring of the criteria was elaborated in order to reflect the journey that organizations take in implementing sustainable procurement; too comprehensive and complex criteria set may face implementation problems especially in the beginning of the organizational learning for sustainable procurement (Interviewee 11). There are variable perceptions between actors on the relevance of different criterion. Therefore, further guidance is needed to direct

focus to drive meaningful changes. This framework aims to address this feasibility-relevance nexus and assist new organizations starting with sustainable procurement regarding what to consider, how to set up a working method system and avoid some possible pitfalls on the way. More refinement could be made based on the feedback, but it is out of the scope of the time of the thesis (see further reflections in Chapter 7.2.). The criteria development is advised to evolve as illustrated in Figure 5-2. below.

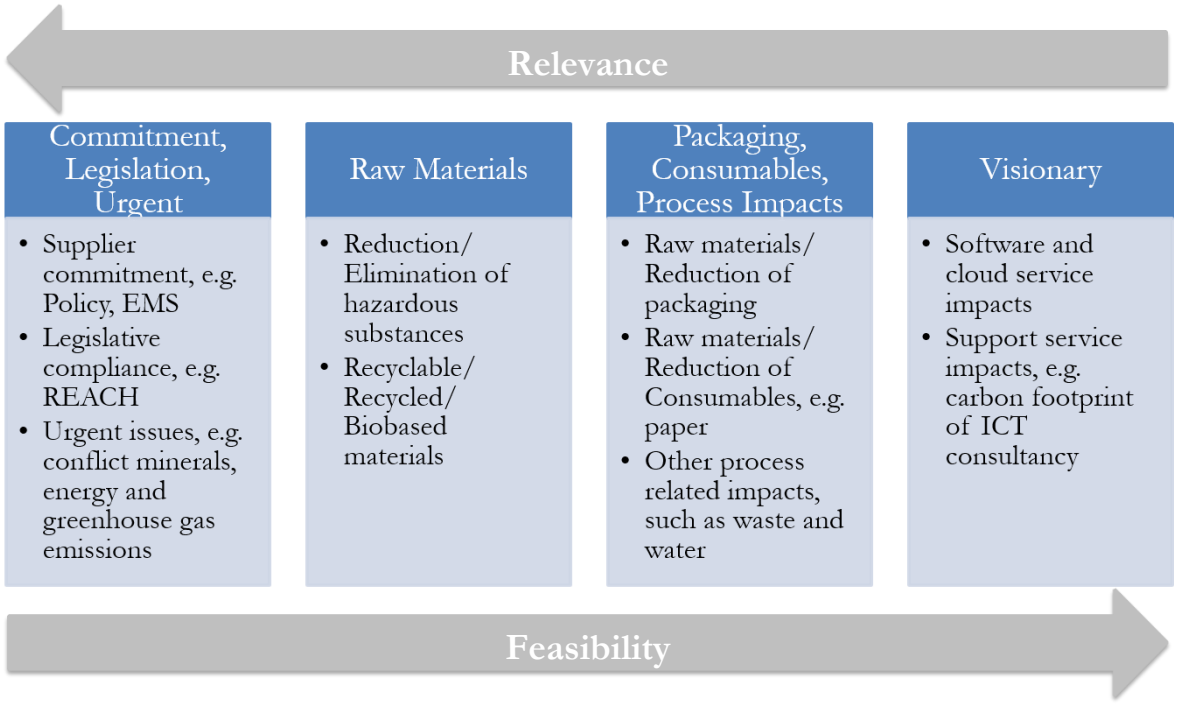

Figure 5-2. Criteria Development based on Relevance and Feasibility Growth

Source: Own illustration

It is important to have a solid baseline in supplier's legislative compliance and management systems, which indicate a minimum and systematic method of addressing sustainability issues. It is also recommended to ask about the most urgent issues, such as conflict minerals as well as energy and climate aspects at the time of writing this thesis. After the procurers gain experience with sustainability criteria, the feasibility of adopting other criteria increases. The visionary stage shows less relevant and less developed sustainability criteria. Less developed criteria include for example support service impacts, of which relevance is unknown or highly dependent on the procuring organization. Lastly, this criteria development is not meant as definite, but more of a guideline. Thus, it should be considered against organization's procurement needs when an organization starts to develop their sustainable procurement methods.

6 Conclusions and Discussion

In this chapter, the concluding remarks are presented based on the findings (Chapter 4 and 5) for the three research questions (Chapter 3), followed by a discussion on the findings. In short, the purpose of this thesis was to redesign a sustainable ICT procurement framework based on existing frameworks and tools, complemented by interviews and background research on circular economy.

6.1 Conclusions

The common criteria mainly address energy efficiency, hazardous chemicals, longer lifetime and design for end-of-life, followed by user information, consumables, noise emissions as well as environmental governance and management. Social criteria on human and labour rights are emerging, notably due to the attention given to conflict minerals. Criteria have rarely an end goal or direction expressed. Procurers gain information directly from suppliers as well as from labelling criteria and credible organizations, such as the UN. However, it remains uncertain what criteria are feasible if the information does not come from the supplier.

According to the interviews, the largest hurdle with end user organizations is the lack of implementation of sustainability criteria; new procurers are often unaware of life cycle thinking, thus, they need to be motivated to use sustainability tools along their core work. Trainings and accountability measures are used to implement the sustainability criteria. Moreover, a gap remains between the procurer and the end-user, disconnecting the one making purchase decision and the one gaining the benefits or bearing the costs. An attempt was made to visualize the core elements into a circular procurement framework, which establishes a link between ICT material life cycle and procurement cycle.

Overall, the attempt to construct criteria, which could inform pre-qualification and award criteria as well as contract clauses, and is constructed from various ambition levels leading to a desired objective, proved partly successful; for example, renewable energy goals were considered relevant and feasible, whereas the chemical criteria was seen too complex. Workshop discussions showed that it would be good to construct the criteria set from small, but highly relevant to more comprehensive gradually in order to consider the organizational feasibility level of the procurer and supplier. Thus, the key elements for sustainable procurement, namely management, people and measurement, were confirmed to be relevant.

The following discussion seeks to analyze the findings through the five levels of the Framework for Strategic Sustainable Development – System, Success, Strategy, Action and Tool – which inform what to consider when reaching for sustainable development.

6.2 System

Clearly, we are far from reaching the balance of socio-ecological and economic systems, which support people's needs now and in the future without depleting natural resources faster they can replenish, together with ensuring rights for other living organisms in the planet to exist. Efforts reaching sustainable development are needed in every sector, including ICT, in which energy consumption and waste levels are increasing due to the growing adoption rate. Hilty et al. (2011) suggest that an approach combining efficiency and sufficiency is needed to reach full ICT sustainability. This could be interpreted as the former relating to technology and the latter relating to people's attitudes and behavior (interpretation by the thesis author). Here, sustainable procurement has a central role in promoting efficiency and sufficiency; sustainable procurement should be informed by the actual need (sufficiency), supporting strategies and policies (organizational attitude) and sustainability performance of the product and supplier (efficiency).

In order to examine the current state of sustainable procurement, and frameworks and tools supporting it, we need to answer the first research sub-question:

What aspects are included in the criteria?

While energy efficiency and Energy Star reference are dominating, Energy Star's value is questioned since "most of the products have it" (Interviewee 13). The dominant focus on energy efficiency and greenhouse gases makes sense taken into account the historical evolvement of ICT sustainability from Green ICT emerged only in the 2007 (Coroama & Hilty, 2009; Mingay, 2007), exposure to climate change messages and possibility for monetary gains from energy savings. Hence, energy aspects are more understood and tangible (ITU-T, 2012), whereas for example toxicity and social issues as more complex and unknown.

This awakens the question: what are the relevant aspects for ICT sustainability that should be considered in procurement? As concluded in Chapter 2, energy consumption, hazardous chemicals, heavy metals as well as labour and human rights are significant in most ICT product groups. All of them are reflected in the depicted common criteria, however, social criteria have relatively minor representation. The sustainability expert's and business analyst's opinions on relevant criteria are well in align with the hotspots identified from background research. Purchasers gave higher relevance to more aspects, possibly because they are not experts in identifying sustainability priorities. For example, noise emission criteria for the use phase might be trivial in comparison to noise emissions in the production factories. In short, not all the criteria, which is common, is highly relevant.

Hence, some process related criteria, such as water consumption, use of renewable energy and labour rights are less common, though highly relevant. It is unclear how the aspects are selected into different frameworks, since most of the actors claim to include the most relevant aspects throughout the life cycle of ICT. Notably, significant process-related aspects are more difficult to manage since they are more far away in the complex supply chain; yet, at the same time conflict-free minerals at the very up of the chain are an emerging requirement.

Some criteria, which are missing from the set of common criteria, such as water and renewable energy, are expressed in circular economy principles and indicators. Arguably, not all the circular economy indicators as suggested by the Ellen MacArthur Foundation & Granta Design (2015) are the best ones for ICT. For example, material weight might not be the most relevant one to include to procurement criteria. However, circular economy principles could possibly inform overall criteria development in order to see whether some sustainability initiatives, which could contribute to circular economy, are missing, such as use of renewable/bio-based plastics. Renewable/bio-based plastics were depicted in the criteria database, but was not the most common to ask for, maybe due to its unfamiliarity to the wider audience. Thus, as many frameworks explored rely on life cycle thinking and LCAs to justify criteria development, the LCA method might not depict all prominent and emerging solutions, which proactive, and possibly more mature, procurers could strive for. This might indicate that further guidance is for purchasers in choosing sustainable procurement criteria for ICT and understanding where to focus their efforts at which time to make a meaningful change.

Notably, criteria phase-outs are an issues in the increasing abundance of labels and related criteria. In some cases, such as duplex printing, the criteria have become 'de facto', every supplier is able to comply with it. In other cases, it might be relevant to maintain some criteria, which seems redundant in the European Union, such as certain chemical restrictions based on legislation, since many new non-EU suppliers are functioning in the market and might apply substances, which are not restricted in their country of sales. This might be of importance mainly

for international organizations supplying ICT globally, less so for companies working within the European Union boundaries. Hence, exposing non-EU suppliers to sustainability requirements is valuable for educational reasons to foster sustainability thinking. This is even more important if they gain more growth and market power globally. The situation that stringent European and North American legislation and ecolabels define the market requirements, is a situation, which, hypothetically, may fluctuate.

In align with Bratt's (2014) findings, the criteria in the studied frameworks and tools are not expressed with long-term objectives, which could guide both suppliers and procurers achieving long-term objectives. An attempt to structure one set of criteria and scoring guidance based on different ambition levels found from different frameworks was performed in this thesis in order to explore one possible way of constructing step-wise strategic criteria. Industry initiatives, such as ECMA-370 and EICC (which refers to International Labour Organization core conventions) could be regarded as baselines for supplier action for sustainability. At best, industry initiatives with ownership and shared best practices coupled with transparency and peer pressure, can provide effective results. More credible initiatives would in addition deploy NGOs as watchdogs. Once suppliers develop, lower scoring level can be moved to minimum criteria. In the same token, the selected supplier could be negotiated with to set contract clauses in order to reach for the next scoring level within the contract period, for example renewable energy targets or phase-out timelines for hazardous chemicals. Preliminary findings suggest that this approach could be relevant and feasible. However, the workshop informants pointed out that the criteria need to be implemented in a feasible order; from easier and relevant criteria to more complex in order to implement anything at all. This is rarely attempted by actors who guide criteria development.

The criteria structuring explored in the thesis was only the first attempt to express the final goal and use back-casting method for criteria development for sustainable ICT hardware. However, this approach is supported by the fact that sustainable procurement works as a market-based instrument (MBI), and gradually increased stringency is a key aspect to successfully implement an MBI (Stavins, 2003). The first proposal of the criteria set did not take into account feasibility and functionality. Maybe 100 % free of flame retardants would have serious negative human health risk trade-offs, this is not taken into account. Hence, optimal state could describe the goal better in some cases instead of a full elimination.

How procurers gain information on addressing the sustainability aspects?

When examining how purchasers set sustainability requirements for ICT suppliers, it is important to consider how they access timely information on sustainability aspects and possible criteria. As expected, the large procurers gain information directly from suppliers, with complementing information found through labelling criteria and reports from credible organizations, such as UNEP. However, purchasers have difficulties to know whether labelling criteria is feasible for suppliers and whether it has trade-offs with functionality. On the other hand, it is also challenging to find the most progressive sustainability requirements, since some labelling organizations are dependent on financing through criteria adoption, creating a conflict of interest and a barrier to set highly proactive criteria. Conclusively, the information suppliers are challenged to provide meaningful and simple information on the sustainability hotspots, criteria, its direction and final objectives, which could indicate best practices to those who wish to implement more proactive criteria. Currently, the information is compiled into rather static criteria, aggregated to one rank (e.g. Rank a Brand), label (e.g. ENERGY STAR), a couple of tiered labels (e.g. EPEAT bronze, silver and gold) or shown in more comprehensive and technical documents, such as ECMA-370.

Where are the product and geographical boundaries set?

Most of the actors host criteria for a variety of ICT product groups and they are either in the process of expanding their product scope or wishing to do so. While expanding product scope might be a positive development in areas where no credible and stringent requirements exist, in product groups already occupied by other ecolabels and standards it might work against harmonisation efforts and create further confusion among purchasers. Thus, information on the geographical coverage was unclear. It seems that various actors define geographical scope in different ways; for example, ECMA-370 through legislative fit to the European Union and EPEAT through registered products global sales scope. This is not to say one actor's definition is correct, but more of note that it could be beneficial for international purchasers to know, which ecolabels and standards are applicable for global purchase. However, market requirements tend to be global, as one interviewee stated.

6.3 Success

The normative rules adopted by the labelling bodies, suppliers, industry associations and NGOs influence the purchasers (Scott, 2008). In short, criteria and the process surrounding its development are constituted within the underlying boundaries of the principles and norms, which guide further action. Hence, it is worthwhile to investigate what kind of principles and evaluation methods describe the success of the frameworks and tools.

What are the objectives for the framework or tool (e.g. vision, principles to live up to)?

As "strategic guidelines are only logical in the context of clear objectives" (Bratt, 2014), both the criteria and supporting organizational elements should have clearly defined objectives in order to send clear signals to the desired sustainability direction. With a defined objective, the direction for stringency would be set, which could drive innovation in the ICT industry. Soft principles, such as 'best value for money', transparency and relevance often guide focus, but they do not yet provide clear and operational definitions of the long-term objectives. The most common more specific objectives are related to energy efficiency; yet they alone do not represent the necessary conditions regarding full sustainability. The UK Government is more specific regarding principles; for example, 'removal of hazardous substances' serves as a more specific guidance than 'sustainable development'. Often the objectives are not related to specific criteria, thus, do not guide thinking on what kind of conditions need to be fulfilled in order to reach socio-ecological system sustainability. This might not be a possible task for purchasers, but the actors guiding the development of sustainability criteria development should take a stronger role of defining and expressing the objectives. If the labelling bodies systematically and strategically sharpen the criteria, with stakeholder engagement processes, the procurers and producers are given chances and incentives to follow and gradually develop their procurement processes and product portfolios in this direction. All in all, this requires a shift from re-activeness to pro-activeness amongst all stakeholders.

In the proposed criteria structuring, an attempt was made to guide the criteria to the right direction. However, it remains uncertain what is the objective for each criteria; is it full elimination of specific hazardous substances although no sustainable substitutes are available? Is certain amount of hazardous substances allowed if they are safely kept in the technological cycle? Constructing criteria from back-casting perspective is not an easy task with the time the thesis was conducted. However, the exploration revealed that it might be easier for some aspects, such as renewable energy, than other aspects, such as chemicals. Thus, the proposed criteria should open up more flexible platforms. Currently, some initiatives are valued more than others, which might not be the right way of encouraging solution development. Currently, the scoring guidance prefers for example direct take-back schemes instead of joint collection and

recycling schemes although the end result might remain the same (Interviewee 11). Hence, the criteria objectives and flexibility need further development.

When interviewees were asked how they would evaluate the success or usefulness of their scheme, most of them said they do not evaluate their success very well. This finding is in align with UNEP, which recognized that ecolabelling organizations and sustainable procurement organizations largely lack evaluation (UNEP, 2015). Hence, uncertainties remain about the actual and potential impacts of sustainable procurement costs and benefits for the business, society and environment. These impacts are hardly measurable if they are not monitored against objectives and targets.

Furthermore, a commonly referred sustainable procurement objective is to fulfil the need with social and economic benefits but minimum environmental degradation by considering the *actual* need. This can either refer to rethinking the need for the equipment (whether it is indeed needed at all) or thinking about the *function,* which is desired to be fulfilled. Essentially, the question "What do I need?" shifts to "What do I need it for?". For example, the need is communication in the case of printers rather than a new printer. This thinking can allow considering product-service system solutions, however, it needs to be mandated in strategic guidelines.

6.4 Strategic

In examining sustainable procurement, many actors highlight the need for strategy, policy and management, which then can inform action plans. Essentially, strategies guide "what is good for business" (Interviewee 13). In ICT procurement, two capital streams can be identified; capital cost (buying etc.) and operational (running e.g. paying per service) (Park et al., 2012). With this in the background, we can discuss what guidelines direct various actors supporting them in the economic and other organizational goals against the following sub-question:

What kind of sustainable procurement strategies or plans are outlined, if any?

Most of the sustainable procurement programmes have some kind of gradual development process, such as the Australian and UK Government through green ICT strategy and related targets. Hence, one interviewee told about their experience of setting sustainable procurement; from small set of criteria to a more comprehensive one, by exploring the baseline of suppliers' sustainability and then envisioning of setting minimum criteria once the baseline is more clear. It would be beneficial if this kind of information would be more easily accessible, so that not all procuring organizations need to go through this process individually of finding out what is the average sustainability performance of the industry. Hence, for efficient resource use, it could be beneficial for procuring organizations to share their product and supplier sustainability baselines or have a joint database.

All the interviewees confirmed the value of strategies and policies as mandating and guiding organizational work towards business goals. However, they expressed a need for developing strategic guidelines, such as "decision-making trees" for deploying product-service system solutions. Similar need for PSS guidelines was found in case studies by Bratt (2012). This illustrates a prominent barrier for PSS implementation; it is uncertain when service-based procurement is a better sourcing strategy in comparison to buying a product, both from economic and environmental terms. On one hand, owning assets is the conventional method, which might not be rethought often, whereas for example buying storage space for data and paying per MB is seen as an operational cost. Further, TCO was seen as one tool, which allowed a purchaser to opt for leasing in one case due to monetary benefits. However, the lack of guidelines and standards for both PSS and TCO clearly hinders their adoption. Nevertheless, recognizing PSS and TCO as potential solutions, which need further guidelines and evidence

base, is arguably enough to include them visibly into a sourcing strategy in order to start to gather information and develop experiences.

6.5 Action

Actions are prioritized by scoring guidance and weighting practices in procurement criteria. Essentially, the criteria scoring and weighting that credible actors use alter the perception of the wider audience what is the most favorable design of the product and solutions developed by the supplier. Thus, this is explored further under the following sub-question:

What actions are prioritized (e.g., by focus areas, scoring and weighting practices)?

When proposing the criteria structure on ambition levels and Yes/No/Not applicable answers (the most common approach), the workshop discussions revealed that approach might not be perceived as the best option. Its benefit is the possibility to show direction and objectives, which ideally would be defined in collaboration with suppliers, as well as practicality to provide a simple platform for purchasers to record answers. However, this approach may not reveal other areas and solutions where the supplier is doing well. From back-casting point of view, this makes sense; a chess match can be won by various moves. However, with the latter approach, the procurement process needs more interpretation and support from the sustainability expert. It is out of the scope of this thesis to provide an answer to the debate of the two approaches, but it would definitely be an interesting point of research for further.

Again, from the back-casting perspective, weighting should arguably be close to the triple bottom line balance by weighting economic, social and environmental criteria equally. Only one weighting in align with this suggestion in practice was brought into the interview discussions, more specifically 35 % weighting for social criteria by one procurer. Interviewee 6 saw that organizations are not "walking the talk", since weighting is often not progressive in practice. It seems that weighting is valued, but the weighting practices are too cautious taking into account long-term risks, such as climate change and bioaccumulation of POPs. One hurdle documented related to weighting was the opinion that weighting sustainability should not have trade-offs with weighting functionality. It is unclear whether this poses an actual trade-off.

The suggestion that organizations should weight criteria according to their needs is somewhat puzzling in sustainability, because it means that ends users set a value for sustainability aspects and impacts, which are mainly not born by them, but somewhere else in the lifecycle by the people who manufacture the products, disassemble it with exposure risk to toxics and people who suffer from the impacts of climate change due to energy consumption along the value chain, thus, impacts born by other living organisms. What kind of a need from the procuring organization can override the need for safe and healthy work place and environment in the society? Although this would require another discussion, sufficient to point that weighting practices need to be levelled up in order to provide a true signal to the markets regarding sustainability; starting from breaking the perceived and actual barriers for higher weighting of sustainability in tendering for ICT purchase and creating progressive strategic guidelines.

6.6 Tools

Tools are needed to implement sustainable development in practice. More is needed to understand what kind of tools are used for sustainable procurement of ICT and what kind of tools are missing, which could help to achieve the aforementioned goal. This section seeks to investigate the answer the following research sub-question:

What tools are included to reach defined objective(s) (e.g., LCA, EMS, certifications, scorecards)?

The tools can be automatic or used by people. When people are the users of the tools, such as sustainability scorecards, they need to be aware and motivated to use them. Two interviewees reported that the biggest difficulty is to get people purchasing solutions de-centrally to implement the sustainability tools, such as sustainability criteria. In addition, one of them observed that comprehensiveness of sustainability criteria is in conflict with implementation by purchasers. Thus, the company had adopted a flexible approach, learnt through experimenting different scorecard designs, starting from a simple scorecard to raise the adoption rate amongst purchasers, and slowly develop it further in the next versions. This approach is only partly in the existing tools, which suggest initial levels for all the criteria, but do not offer sufficient assistance in prioritizing the first criteria to be adopted. Thus, the lesson learnt is that a smaller set of criteria is a better starting point than a comprehensive set of criteria, since no matter how low ambition level the small set would have, it is still better than no adoption in practice. This can then be gradually expanded once it has gained more familiarity and engagement among the purchasers. This is due to that the use of sustainability criteria is driven by individual purchasers, not a central procurement team, which would have control. Thus, the situation might be different in highly centralized procurement in which adoption of more comprehensive, ambitious criteria might prove more feasible. Conclusively, the comprehensiveness at the system level, should start from feasibility at the tool level.

Furthermore, various tools can be used to aid the adoption of sustainability tools by (other than sustainability) people. Training is the most common to raise awareness and capabilities, however, according to the interviews accountability measures, such as tracking the tool use through financing department, have been more successful in driving implementation of sustainability criteria. Thus, motivation and action themselves are more important for the end result. While a sustainability expert was central in building tools, they have a limited role in bringing sustainability into the procurement process. One interviewee noted that sustainability comes when it is asked to come, often only in the evaluation phase. This might reflect the lack of staff in sustainability to meaningfully engage earlier in the procurement process or simply lack of maturity of the sustainability integration to procurement. Notably, in most of the examples end-users were engaged only in the 'launch' and 'use' phase of the tool. Some proactive examples of end users using tools, such as TCO by learning by doing were also found, but these were likely embedded to individual interest. However, if all the purchasers would be given the possibility they are engaged already in the design phase (participatory methods), this could create stronger ownership and commitment in using the tools, such as a sustainability scorecard.

Tools for follow-up and to understand the realized benefits are largely missing. They are more developed in energy consumption measurement and related savings. In general, certifications are a valued verification tool by many actors, since they are verified by more objective third parties. However, also joint industry initiatives, such as ECMA-370, which is prone to peer pressure and error checking by competitors, is considered as a good option by purchasers (Interviewees 10,11 and 13). There are also misuse cases reported in the third party certification schemes (LEDs magazine, 2009), so the case might not be whether misuse happens, but rather when it happens, what mechanisms do the actors have to perceive it and control it. Claims from suppliers are also verified through other documents, such as environmental policies and Code of Conducts. However, the problem in the credibility of Code of Conducts is that most of the ICT products are produced in East Asian and China, where most the suppliers may not be compliant and their monitoring operations deceive what is happening in actual operations (Egels-Zanden, 2007). This strengthens the concern for inclusion of social criteria as it is less robust, however, it could be equally valid to argue from ethical point of view that it is better to start asking and developing solutions than wait until more robust solutions exist.

Lastly, all the tools and strategic sustainable development through procurement relies on purchaser interest and action, as it works as a market-based instrument. As one interviewee illustrated the pre-condition for sustainable procurement to function as a solution; a supplier tried to introduce products with recyclable content, but it did not sell, thus, it was forgotten. Sustainable procurement as it has developed so far has limitations regarding implementation and reaching more long-term system level changes, such as circular economy by supporting business models contributing to circularity. Essentially, consumers need to be aware and interested to buy more sustainable solutions so that sustainable production and consumption can match. If this is not the case, other tools have to be used along with, such as regulation and legislation. Thus, the availability of resources, shapes of cultures, legislation and regulation are all co-creators of production and consumption. Overall, a mix of solutions is needed to reach sustainability in the socio-ecological system, rather than sustainable procurement alone. As one interviewee said, sustainability of ICT "is not an area to rest upon".

6.7 Recommendations

The recommendations below address the target audience, procurers. Other stakeholder groups are specified if suitable. Overall, the following recommendations can be given based on the thesis study:

- **Foster System Thinking** - Provide guidance on constructing sustainability criteria, which is relevant for sustainability hotspots. Align the criteria with organizational feasibility of the purchaser and supplier to ensure better uptake. Sustainability criteria developed with long-term sustainability in mind can provide guidance on the meaningfulness, direction and implementation steps. This task could be taken by ecolabelling organizations, manufacturers or purchasers with organizational experience and best practices to share.
- **Clarify Success** - Establish clear objectives, which are specific for ICT sustainability and address the most significant sustainability hotspots. Objectives should also be set for the procurement process (communication and awareness, implementation).
- **Establish Strategy** - Set up guidelines and mandates via formal governance and management documents. Ensure prominent sourcing strategies, such as product-service systems, are included.
- **Drive Action** - Explore the perceived and actual barriers and drivers for progressive weighting of sustainability criteria. Overcome the barriers, enforce the drivers and implement progressive weighting practices, which align with system-level sustainability.
- **Leverage Tools** - Leverage the use of tools through simplicity, guidance, accountability and engagement. Simplicity can be guided by the 'sustainability relevance-organizational feasibility' consideration. Guidance is needed especially for Life Cycle Costing and Product-Service Systems; for example, in the form of standards and decision-making paths. Accountability measures should ensure the connection between the individual in the decision-making situation and the use of the sustainability tool(s). Lastly, raising awareness and capabilities through training is essential, however, more participatory methods, such as co-creation workshops for sustainability criteria, could facilitate ownership and uptake of tools by purchasers.

7 Reflections

Overall, this thesis opened my mind to the world of ICT sustainability and strategic sustainability. The Framework for Strategic Sustainable Development served as a good window to explore the research questions: how the existing frameworks and tools assessing sustainable ICT promote sustainability (RQ1), how their core elements and criteria would be integrated into a circular, sustainable procurement framework for sustainable ICT hardware (RQ2) and how feasible and relevant the proposed frameworks elements are (RQ3). Looking back, the thesis aim was ambitious. However, with Jodorowsky's words (in Pavich et al., 2014): "I have the ambition to live 300 years. Maybe I live one year more. But I have the ambition", it was worth it. This chapter reflects on the methodological choices and suggests further research.

7.1 Reflections on Methodology

The literature analysis looked at those frameworks found from EBSCOhost database and systematized Google search. Notably, Google search was more effective than the scientific database search. At the time of starting the thesis, the systematized search seemed like an appropriate option to conduct the literature analysis, in order to move on to other phases in time. However, the lack of wider number of databases used and cross-referencing might have limited some quality sources. Further attempts would use more suitable databases and key words. However, the search was able to capture widely used labels, such as ENERGY STAR and EPEAT. Hence, it allowed using Rank a Brand and Greenpeace, with more demanding criteria, and provide a suitable platform for building back-casted criteria.

In short, interviews are a challenging data collection method. I became aware how the interviewer is always present and the interview situation can never reach full objectivity. The balance between probing questions, fast response and creating a relaxed interview situation is fine, and perhaps a skill to be learned by doing. Many framework developers and managers were contacted, however, only approximately half (11 representatives out of 20 frameworks) an interview was successfully arranged. This might reflect the summer season of doing the thesis and people preparing their final work before going for holidays. Of the total 17 interviews, many were enlightening and broadened my perspective of the challenges in the ecolabel and procurement jungle, both from the ICT industry's and procurers point of view. People seemed to be highly open and honest of what's happening in the ICT field regarding sustainability, showing both pessimism and hope. This summarizes the interviews as a data collection method – it is about people's opinions and views. This was sometimes hard to analyse.

The framework creation was a balance between objective findings and subjective construction, resulting to a highly explorative framework building through back-casting method. However, people can come to the end result with various means, like in chess with different moves. Similarly, the end result of this research might have been different with a different researcher. Hence, it is difficult to draw conclusions of the reliability of the results. Arguably, somebody could repeat the study and come up with similar conclusions, but explorative research does have its scientific 'risks'. However, the benefits of having the first test of back-casting criteria development for sustainable ICT hardware arguably outweighs these. In the end, somebody can test a similar approach by following the study explanation, which was aimed to be expressed as transparently as the page limit allowed and thesis writer's awareness skills allowed. Thus, this works as science should; the findings can be rejected, modified or strengthened.

Workshop discussions were intensive and there was a lot to talk about with a short time. Not every criteria was touched systematically. The researcher as a facilitator made choices of skipping some criteria or asking more follow-ups, thus, bringing subjectivity into research. Hence, four workshop participants is a small number to generalize the findings. However, the participants

represented people from different roles, namely sustainability and procurement expertise, which makes it more credible to base findings upon. The discussions were highly valuable, providing either rejection or support for the explorative direction that especially the criteria structuring took, hence, contributing to the overall methodology as a crucial part of the whole research.

Furthermore, although the approach the thesis took in creating sustainability criteria by using the FSSD with only few probes given by the data could be described as risky from the scientific point of view, arguably it is overweighed by the benefits of it. As far as I know, this thesis is the first attempt to use the FSSD and back-casting for the development of ICT sustainability specifications and contract clauses as well as gaining empirical feedback on it, contributing to the respective scientific field. Thus, the workshop shows that the approach taken might be feasible at least with certain criteria, such as the share of renewable energy. For the explorative aim of the thesis, these results were fruitful, but they need additional testing, validation, and most importantly, implementation and evaluation if further proved to be feasible.

However, procuring organization interviewees were found through snowballing, most likely indicating that people who already support the integration of sustainability into procurement, were willing to participate for an interview within the organization, including both interviewees and workshop participants. Despite of this limitation in snowballing, interviews proved to provide valuable insights in understanding the practices and development of sustainable procurement of ICT in the organization. Further insights to decentralized purchasing and the purchasers' practices in relation to sustainability could be additionally enlightening as would insights to end user disposal practices, not captured well in this thesis, in order to get the "full picture" of the ICT procurement and management system.

In addition, in order to get the "full picture", a system perspective should be taken more comprehensively. Hardware is not the only one to be considered, it is also software and ICT services. As one interviewee mentioned, ICT consultants fly over the Atlantic for projects and nobody is looking at their carbon footprint. There is no data how large this footprint is, but certainly, it should be feasible to consider carbon footprint and opportunities for using local resources or compensating the footprint of flying consultants from abroad.

Lastly, the collaboration method especially used for identifying new sustainability issues and criteria through the suppliers for tendering might not work in some other industries. ICT industry has some large players with highly competent sustainability people working within them. Hence, they are arguably more knowledgeable on the sustainability issues and solutions relating to their equipment than the procurers from other organizations, and consequently, can be highly valuable to collaborate with and gain information on social and environmental analysis. However, the smaller ICT companies as well as other industries consisting mainly from small and medium enterprises might not have similar competence in relation to their sustainability issues, hence, information search through collaboration might not prove such a useful method.

7.2 Further Research

The research on integrating sustainability to ICT is only in the beginning. There are many unanswered questions and many unimplemented solutions, which are still in the idea stage. Here, some of them are discussed briefly to give possible direction for further research.

Further testing of the suitability of the proposed framework, especially the criteria structuring is needed. Back-casting seems to work with some criteria, such as renewable energy, where the end goal is clear and feasible. However, some issues with functional trade-offs, such as chemical elimination, might be challenging. More case studies on implementing sustainability related contract clauses would be beneficial. There was clear support for this within the workshop

participants, but uncertainty about the implementation remains. Thus, flexibility of criteria should be opened up and restructured to allow more solutions from the suppliers to be rewarded; current criteria might be too narrow in specifying solutions in scoring guidance especially. Hence, the objectives of specific sustainability should be investigated by back-casting and clarified to allow progressive sustainability criteria development.

In addition, it could be interesting to research the various ways of structuring criteria; Yes/No/Not applicable seems to be the dominant one, but the workshop participants questioned it since it does not allow seeing other dimensions, in which the supplier might do well. This kind of research could possibly take an experimental approach and investigate the perceptions of both suppliers and procurers of different structures of criteria sets; questions with Yes/No options, questions with multiple levels of options (as devised in this thesis), direct demands for documentation and information, among others. Thus, it could be beneficial to understand the perceived and actual trade-offs for example between higher sustainability weighting and functionality of the equipment.

Currently social criteria are less common, although emerging. However, it is still searching for a robust way of measuring and verifying, thus, this should be addressed in order to allow procurers to send a signal to the market not only relating to the "easy" criteria of energy efficiency, but also other complex, but highly relevant issues.

More research is needed on tools; automation of sustainability integration to procurement processes, Total Cost of Ownership calculation standards and Product-Service System decision-support systems. Thus, alternatives to traditional training could be explored, for example, whether introduction of co-creation workshops of sustainability criteria with procurers would increase engagement and implementation. Thus, practitioners need effective KPIs and measurement tools to show the benefits of sustainable procurement of ICT. In addition, the procurers struggle with knowing when to replace their equipment; it is about balancing between energy efficiency and material replacement. Research could try to help to find decision-support systems also for problem.

Currently, there is confusion what criteria is feasible to suppliers and what not. Hence, this should be clarified; it could be relevant to ask in which criteria the industry is mature, thus, criteria could be phased-out, or whether it should be kept there for international supplier purposes, notably for non-EU law compliant suppliers. Hence, further advice of prioritization and choosing criteria, which is meaningful, is needed. Essentially, which criteria is worth to ask and has "transformative" potential for ICT industry.

Finally, some challenges that touch ICT are not solely ICT's challenges. For example, conflict minerals; ICT is the industry pressured on this although it is only one industry using conflict minerals. This is not to say it is not right to target ICT, but more to say that responsibility belongs to all and there should not be a free-rider problem in solving the problems. Hence, sustainability criteria by the users of other, major, industries using conflict minerals deserve higher research attention as well. Arguably, if there is one buyer who does not care and do their share to solve the problem, in market terms, there is going to be supply for conflict minerals if there is no demand for conflict-free minerals from all the actors.

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Appendix A. Personal Communications

Interviews with Framework Developers and Managers

1. Michaela Rose, *Sustainability Advisor, Forum for the Future* | *Open Eco Rating (V3)* - June 10, 2016
2. Moses Dzoro, *Former Master's Candidate at the University of Johannesburg* | *Rapid Deployment Tool Set for Green ICT Evaluations in the Banking Sector* - June 15, 2016
3. Karl Lundfall, *Former Master's Candidate at the VU University of Amsterdam* | *The Green Practitioner* - June 17, 2016
4. Annika Overödder, *Market Developer, TCO Development* - June 27, 2016
5. Graeme Philipson, *Research Director, Connection Research* | *Connection Research-RMIT Green ICT Framework* - June 28, 2016 and July 10, 2016
6. Josée Auber, *President of ECMA International* | *Standard ECMA-370* - July 5, 2016
7. Jonas Allen, *Director of Communications, Green Electronics Council* | *EPEAT Registry* - July 6, 2016
8. Hans Wendschlag, *Social and Environmental Responsibility Manager, Hewlett-Packard* | *Standard ECMA-370* - July 8, 2016
9. John Smiciklas, *Consultant, the International Telecommunication Union (ITU)* | *Toolkit on Environmental Sustainability for the ICT Sector* - July 8, 2016
10. Kannan Mohan, *Professor of Computer Information Systems, Baruch College* | *Green IT Balanced Scorecard* - July 8, 2016
11. Madeleine Cobbing, *Environmental Consultant, Greenpeace International* | *Guide to Greener Electronics* - August 1, 2016

Interviews with Circular Economy Indicator Experts

1. Luca Petrucelli, *Project Manager, Granta Design* | *Circularity Indicators* - July 15, 2016

Interviews with Purchasers

1. Lotta Bergström, *Green IT Coordinator, H & M Hennets & Mauritz AB* - June 10, 2016
2. Sofia Grauers, *Team Leader, IT Procurement, IKEA Indirect Material and Services AB* - June 27, 2016
3. Anette Månsson, *Purchaser, IT Procurement, IKEA Indirect Material and Services AB* - July 7, 2016
4. Jonas Warnhag, *Purchaser, IT Procurement, IKEA Indirect Material and Services AB* - July 8, 2016
5. Åsa-Pia Folkesdotter, *Sustainability Specialist, IKEA Indirect Material and Services AB* - July 15, 2016

Informal Discussions and Email Correspondence

1. Radboud van Delft, *Managing Director, Rank a Brand* – June 8, 2016 | July 12, 2016
2. Miriam Börjesson Rivera, *Postgraduate, KTH Royal Institute of Technology, Sweden* - July 5, 2016
3. Simon Harvey, *Senior Associate, The Natural Step NZ* – July 4 | July 16, 2016

Workshop Discussions

1. Åsa-Pia Folkesdotter, *Sustainability Specialist, IKEA Indirect Material and Services AB* - August 24, 2016
2. Sofia Grauers, *Team Leader, IT Procurement, IKEA Indirect Material and Services AB* and Jonas Warnhag, *Purchaser, IT Procurement, IKEA Indirect Material and Services AB* - August 25, 2016
3. Peter Abrahamsson Lindeblad, *Business Analyst, IKEA Group* - September 2, 2016

Appendix B. Semi-Structured Interview Guide Template

Interview Questions

By: Tanja Tanskanen

Background Information:

- What is your role in the (*specify framework*) development process?
- Why was the (*specify framework*) decided to be developed in the first place?
- Could you describe me the purpose of the (*specify framework*)?

Specific Information on the Criteria:

- What kind of sustainability related criteria does the framework cover?
- How did you decide what criteria to include?
- How did you balance with making the criteria simple and general, but also meaningful and accurate? Were there other trade-offs you needed to balance with?
- Do you think there are some aspects missing? If yes, why do you think they are not included?
- Could you describe the scoring and weighting method, if any?
- Technology develops fast. Do you have any insights how procuring organisations can stay up-to-date with their sustainable ICT procurement guidelines, standards and criteria?

Stakeholder involvement:

- What are the users' experiences of applying the framework/criteria? What kind of feedback do you get from the users?
- Do you know what the suppliers'/producers' responses to the criteria are? How easy or difficult it is to apply the criteria?

Evaluation of the Framework:

- How do you evaluate the success or usefulness of the (*specify framework*)?
- What would you say are the strengths and good elements of the framework?
- What do you think is missing from the framework or what is not considered enough?
- How would you develop (*specify framework*) further?

Appendix C. Frameworks Included in the Study

N.	Name	Developer/ Manager	Notes and Reference
Certification and labelling organizations			
1	ENERGY STAR	US Environmental Protection Agency (EPA)	Single issue label focused on energy efficiency. Study based on summarized requirements, such as: https://www.energystar.gov/products/office_equipment/computers/key_product_criteria
2	Blue Angel	The Environmental Label Jury, The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, The Federal Environmental Agency, RAL gGmbH (Germany)	https://www.blauer-engel.de/en/companies/basic-award-criteria
3	EU Ecolabel	European Commission	http://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html
4	The Nordic Swan Ecolabel	Nordic Ecolabelling Board	http://www.nordic-ecolabel.org/criteria/product-groups/
5	TCO Certified	TCO Development	http://tcodevelopment.com/tco-certified/tco-certified-product-categories/
6	EPEAT	Green Electronics Council	http://www.epeat.net/resources/criteria/
Initiatives by non-governmental organizations (NGOs)			
7	Rank a Brand	Rank a Brand	http://manual.rankabrand.com/wiki/Main_Page
8	Guide to Greener Electronics (18th ed.)	Greenpeace	http://www.greenpeace.org/international/en/Guide-to-Greener-Electronics/18th-Edition/Introduction/
9	Open Eco Rating (V3)	Forum for the Future with Telefónica, O2 and Vodafone	Currently available only for mobile phones. https://www.forumforthefuture.org/project/open-eco-rating/overview
Procurement guidelines by governments and intergovernmental organizations			
10	ICT Guidelines (on Sustainable Procurement)	United Nations Environment Programme	http://www.unep.org/resourceefficiency/Home/Society/SustainableUN/ReducingtheUNsImpact/Procurement/Guidelines/tabid/101228/Default.aspx
11	EU Green Public Procurement criteria	European Commission	http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm
12	Greening Government ICT Strategy and related publications (Green ICT Maturity Model and Government Buying Standards)	Government of the United Kingdom	https://www.gov.uk/government/publications/greening-government-ict-strategy https://www.gov.uk/government/publications/green-ict-maturity-model https://www.gov.uk/government/publications/sustainable-procurement-the-gbs-for-office-ict-equipment
13	ICT Sustainability Plan 2010-2015	Australian Government	https://www.environment.gov.au/topics/sustainable-communities/government-sustainability/ict-sustainability-plan

Initiatives by ICT industry consortiums or individual ICT suppliers			
14	Standard ECMA-370 (The Eco Declaration)	ECMA International	http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-370.pdf
15	EICC Code of Conduct v. 5.1	Electronic Industry Citizenship Coalition (EICC)	http://www.eiccoalition.org/standards/code-of-conduct/
16	Data Center Maturity Model (DCMM): Other IT: Procurement	The Green Grid	http://www.thegreengrid.org/en/Global/Content/white-papers/DataCenterMaturityModel
17	A Sustainable IT Purchasing Guide	Hewlett-Packard	http://h20195.www2.hp.com/V2/GetPDF.aspx/c03844101.pdf
Academic/Consultancy frameworks			
18	The Connection Research-RMIT Green ICT Framework	Connection Research (market research and consultancy company) and RMIT University	Philipson, G. (2010). A Green ICT Framework: Understanding And Measuring Green ICT. Connection Research. Molla, A. & Cooper, V. (2009). Green IT Readiness: A Framework and Preliminary Proof of Concept. *Australasian Journal of Information Systems, 16*(2), 5-23. doi: 10.3127/ajis.v16i2.545
19	Green IT Balanced Scorecard	Wati, Y. and Koo, C. (2011)	doi: 10.4018/978-1-60960-531-5.ch007
20	Maturity Assessment Tool of Eco-Responsibility Inspired by the Balanced Scorecard	Bohas, A. and Bouzidi, L. (2012)	doi: 10.1007/978-3-642-33332-3_14

Appendix D. Summary of Proposed Sustainability Criteria

Notes:

1) Scoring guidance is based on different characteristics and ambition levels found in the sources as well as the back-casting method. As back-casting is based on the identification of the desired objective, the highest score (the objective) is sometimes visionary. For further discussion on objectives, see Chapter 6. The benefits of this method are an illustration of the long-term direction and a signal to suppliers. Hence, the tiered approach in criteria scoring might be beneficial for setting contract management clauses. For example, if the awarded supplier is able to provide a PVC-free product except one product component → contract can have a clause for phasing-out PVC fully within the contract period.

2) Unnumbered criteria were added based on selective decision; they are not the most commonly found criteria.

N.	Category	Sub-category	Criteria (Yes/No/Not applicable)	Example of verification method(s)	Scoring guidance		Sources	Circular economy attribute(s)
1	**Governance and management**	Communication	**User information:** Does the company deliver the product with information on how the product is best used from the environmental perspective (such as information about energy saving functions, disassembly and repair instructions, advice on proper disposal, information on hazardous substances and a material safety sheet for ink/toner)?	(a) a copy from instruction manual, (b) a separate printed document, (c) a digital file or printed in the user manual, (d) a direct link from the user manual or digital file to the document on the manufacturer's website	digital document	2	2, 3, 4, 7, 8, 9, 11, 12, 13, 17	enabler reduce material use by dematerialisation
					printed document	1		
					no user information	0		

2		Vision, strategy, policies, goals, management	**Sustainability policy**: Does the company have a documented sustainability policy approved by management?	written corporate sustainability/ environmental policy document	documented policy approved by management	2	10, 14, 15, 17	foundational
					documented policy	1		
					no policy	0		
3			**Environmental management:** Does the company have an environmental management system certified in accordance with ISO 14001, EMAS or equivalent?	a third-party EMS certification that meets ISO 14001, EMAS or equivalent	certified EMS	2	5, 6, 13, 14, 17	foundational
					documented EMS	1		
					no EMS	0		
4		Sustainability initiatives	**'Conflict-free minerals' initiatives:** Does the company have a policy and proof of involvement in initiatives aimed at establishing a conflict-free supply chain of metals and minerals (Tantalum, Tin, Tungsten and Gold)?	(a) declaration of compliance on the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas ("The Guidance"), iTSCi, CFTI, GFSI, SfH, CTC or other relevant initiative, which proves the commitment to an initiative that aims to increase legitimately sourced minerals, (b) every initiative the	proof of conflict-free sourcing of all metals and minerals	5	5, 7, 15, 17	not characterized
					proof of tracing, monitoring and publishing their smelters	4		
					policy and proof of auditing	3		
					policy and proof of involvement in one or more initiatives	2		

				Company is a participant shall be provided* *note: TCO Certified currently accepts initiatives with smelter/refinery certification programs, although the mandate mainly focuses on the 3T+G mined minerals in the DCR region	documented policy	1		
					no policy and proof	0		
			Other sustainability initiatives: Does the company participate to other citizenship coalition initiatives (such as GeSI or EICC)?					not characterized
5	**Health and environment**	Energy and climate	**Greenhouse gas emissions**: Does the company track and document its greenhouse gas emissions of its 'own operations' (scope 1 & 2)?	disclosure on the greenhouse gas emissions according to the GHG Protocol	disclosure of scope 1-3	2	7, 8, 9, 15	minimisation of negative externalities
					disclosure of scope 1 & 2	1		
					no disclosure	0		
			Greenhouse gas emissions: Does the company has policies and targets to reduce and/or compensate its greenhouse gas emissions from scope 1 & 2? Has the company already reduced its greenhouse gas emissions	a public declaration of policy, targets and timelines	carbon neutral operations (scope 1-3)	5		minimisation of negative externalities
					reduction target for the next 10 years/reduction in the past 10 years 40 %	4		

			from scope 1 & 2 in the past 10 years?		reduction target for the next 10 years/reduction in the past 10 years 30 %	3		
					reduction target for the next 10 years/reduction in the past 10 years 20 %	2		
					reduction target for the next 10 years/reduction in the past 10 years 10 %	1		
					reduction target for the next 10 years/reduction in the past 10 years non-existent	0		
			Renewable energy: What is the share of renewable energy of the total electricity consumption of the company in its 'own operations'?	declaration of the use of share (%) of renewable energy from electricity demand (scope 1 & 2)	100 %	5		renewable energy
					80 %	4		
					60 %	3		
					40 %	2		
					20 %	1		
					0 %	0		

6			**Product energy efficiency:** Is the product compliant with the current ENERGY STAR version for relevant ICT equipment? If yes, please specify the energy consumption kWh/a in the following modes, if applicable: active, off, sleep, long idle and short idle* according to the Energy Star criteria	(a) a technical dossier of the manufacturer, (b) a test report from a recognized body	yes, and 40 % or more efficient than the current Energy Star	5	1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 13, 14, 16, 17	energy efficiency
					yes, and 30 % more efficient than the current Energy Star	4		
					yes, and 20 % more efficient than the current Energy Star	3		
					yes, and 10 % more efficient than the current Energy Star	2		
					yes	1		
					no	0		
7			**Data center energy efficiency:** What is the EUE, PUE and/or DCiE for data centers?	a) report documenting the EUE/PUE value no more than three months old, b) in case of EUE, specification over 12 months unless the data center is new, as required in Blue Angel	≤ 1.2	5	2, 12, 13, 16	energy efficiency
					≤ 1.4	4		
					≤ 1.6	3		
					≤ 1.8	2		
					measured and reported	1		
					not measured	0		

8			**Power management features:** Does the device include power management features, such as sleep mode, on-off switch, ACPI-power save mode, switching off background applications, networks or CPUs cores when not in use? If yes, are they set as default, if applicable? *Note: Includes also smart technology, which is energized on demand, as recognized by the Green Grid.	(a) a declaration of compliance, with explanation specifying the power management features and whether they are set as default, (b) Energy Star certification or equivalent	yes, and set as default	2	1, 3, 4, 9, 10, 16	energy efficiency
					yes	1		
					no	0		
9		Resource consumption	**Disassembly and recyclability**: Can you confirm that the parts and labels of the product that have to be treated separately are easily separable to recyclable material streams at the end of life?	(a) declaration of compliance, with instructions showing/explaining the professional disassembly of the device free of charge in written, photo, drawing or video format, (b) a third party certification	yes, in a digital format	2	2, 3, 4, 6, 9, 10, 12, 14, 17	design for recovery and recycling
					yes, in a paper document			
					no	0		
10			**Plastics recyclability:** Can you confirm that plastic parts greater than 100 grams consist of one material or of easily separable materials?	(a) declaration of compliance, with specification of the plastics used for plastic parts greater than 25 or 100 grams in mass, (b) a third party certification	plastic parts greater than 25 grams consist of 1 plastic type	5	2, 5, 6, 10, 11, 12, 14, 17	design for recovery and recycling
					plastic parts greater than 100 g consist of 1 material	4		

					plastic parts greater than 100 g consist of 2 separable materials	3		
					plastic parts greater than 100 g consist of 3 separable materials	2		
					plastic parts greater than 100 g consist of 4 or more easily separable materials	1		
					no	0		
11			**Plastics recyclability:** Can you confirm that all plastic parts heavier than 25 grams are coded by material type according to ISO 11469, referring to ISO 1043, Part 1-4? *Exemption: transparent plastic of which function requires transparency	(a) declaration of compliance, with specification of the plastics used for plastic parts greater than 25 or 100 grams in mass, (b) a third party certification	yes, all plastic parts labelled	2	2, 3, 4, 5, 6, 9, 10, 11, 12, 14, 17	design for recovery and recycling
					-			
					no	0		
12			**Material footprint:**	(a) declaration of total product weight, (b) declaration of materials used by weight or volume, (c) a third party certification	declared weight of rare earths by type	2	5, 6, 7, 9	reduce material usage by lightweighting
					declared total product weight	1		

					not declared	0		optimise materials: reduce the use of scarce materials
13			**Recycled content:** Is there postconsumer recycled material content used in the product (such as postconsumer plastic, aluminium or steel)? If yes, please, specify the respective weight of recycled material by material type.	(a) declaration of percentage of materials used that are recycled (calculated as % recycled material by weight of total weight of material), (b) a third party certification, such as EPEAT *Note: Scoring does not specify the material recycled.	more than 20 %	5	2, 3, 4, 5, 6, 7, 8, 9, 14	optimise materials: use recycled materials
					20 %	4		
					15 %	3		
					10 %	2		
					5 %	1		
					0 %	0		
14			**Recyclable content**: Can you confirm that all of the (a) packaging and (b) product is recyclable?	declaration of % of recyclable material by product/ packaging/ material type weight	packaging and product components are 100 % recyclable	5	2, 5, 6, 10, 12, 14, 17	design for recovery and recycling
					100 % of packaging and of the mass of plastics, metals of housing parts and chassis recyclable by type of material (excluding energy recovery) * also free of metal coating accepted	4		
					80 % of packaging and of the mass of plastics, metals of housing parts	3		

					and chassis recyclable by type of material (excluding energy recovery)			
					packaging 100 % recyclable of compostable	2		
					packaging 80 % recyclable or compostable	1		
					no	0		
15			**Duplex printing:** Does the supplier provide two-sided (duplex) printing?	declaration	yes, set as default	2	10, 12, 14, 17	reduce material use
					yes, not set as default	1		
					no	0		
16			**Responsible paper sourcing**: For **product**: Can the company confirm that paper containing recycled fibres that meets the requirements of EN12281 can be used? For **product-service system**: Does the company provide	(a) declaration that paper containing recycled fibres that meets the requirements of EN12281 can be used, (b) declaration of % of recycled paper per weight, (c) declaration of % of sustainably sourced paper per weight (FSC certification or equivalent is deemed to comply with the criteria)	yes, 100 % recycled/certified paper	2	8, 9, 11, 12, 13, 14, 17	optimise materials by using recycled material minimise negative externalities by using sustainably sourced fibre
					yes, at least 50 % recycled/certified paper	1		
					no	0		

			paper, which contains recycled or FSC certified paper? For **packaging and documentation**: Can the company confirm that the product packaging and documentation contains recycled or sustainably certified paper (such as FSC or equivalent certified sustainable source)?					
17			**Repairability/Spare parts availability:** Can you confirm that spare parts and service are available _ years after the end of production?	a written guarantee signed by a responsible person	not characterized	5	3, 5, 7, 11, 12, 14, 17	maintain/prolong lifecycle
					yes, 4 years after	4		
					yes, 3 years after	3		
					yes, 2 years after	2		
					yes, 1 year after	1		
					no	0		
18			**Warranty:** Does the supplier provide a product warranty (minimum of _ years) on all markets where the product is sold?	a written guarantee signed by a responsible person	not characterized	5	3, 5, 7, 8, 9, 10	maintain/prolong lifecycle
					yes, 4 years warranty	4		
					yes, 3 years warranty	3		

					yes, 2 years warranty	2		
					yes, 1 year warranty	1		
					no	0		
19			**Upgradeability:** Can the company confirm that the product can be upgraded, such as with a processor, memory, cards or drives? If yes, can you confirm that upgrading can be done with commonly available tools?	(a) a declaration of compliance, with explanation of the respective options for upgradeability, (b) a third party verification *Note: Since this is not applicable to all ICT-products, N/A option is required. e.g. expandable RAM doesn't apply to portable computers.	yes, the product can be upgraded with common tools	2	2, 3, 4, 6, 9, 10, 11, 12, 14, 17	maintain/prolong lifecycle
					yes, the product can be upgraded and upgradeable parts are specified	1		
					no	0		
20			**Take-back schemes:** Does the company provide take-back options for used and obsolete products?	(a) information provided on the geographical coverage of the take-back system, (b) a third-party verification including take-back option criteria, such as TCO Certified	free, global take-back scheme and proof of sound reuse, refurbishment and recycling of used and obsolete hardware (such as a track system and volume of resold products)	5	5, 6, 7, 8, 13, 17	enabler collection for reuse, recycling and recovery
					free, global take-back scheme	4		
					take-back provided at least in one market	3		

					where the product is sold and where electronics take-back regulation is not in practice at the date of application			
					no, but the company participates in collection and recycling schemes in all the markets where its products are sold	2		
					no, but the company participates in a collection and recycling scheme at least in one market where its products are sold	1		
					no	0		
21		Health	**Legislative compliance:** Does the product comply with legislation aiming to reducing hazardous substances such as EU RoHS, REACH or equivalent?	declaration of compliance	Suggested minimum criteria (Pass/Fail)		6, 9, 16, 17	elimination of toxic substances
22			**Halogen-free products**: Is the (a) product, (b) printed circuit boards (without components) greater than 25	(a) a technical file/report/dossier, (b) certification	product or any of its components do not contain halogens	5	2, 5, 9, 10, 12, 14, 17	elimination of toxic substances

			grams, (c) electrical cable insulation material of power and signal cables, (d) cover/housing plastic parts greater than 25 grams, (e) all of the aforementioned halogen-free?		-	4		
					cover/housing plastic parts greater than 25 grams do not contain halogen	3		
					electrical cable insulation material of power and signal cables do not contain halogen	2		
					printed circuit boards (without components) greater than 25 grams do not contain halogen	1		
					none is halogen-free	0		
23			**Halogen-free products**: Can you confirm the product does not contain the following substances: PBB, PBDE, PCB, PCT and HBCDD?	(a) a technical file/report/dossier, (b) certification that meets the legal requirements of the European RoHS Directive (2002/95/EC) or equivalent	Product does not contain PBB, PBDE, PCB, PCT or HBCDD	5	2, 3, 5, 10	elimination of toxic substances
					Product does not contain 4 of the identified substances	4		
					Product does not contain 3 of the identified substances	3		

					Product does not contain 2 of the identified substances	2		
					Product does not contain 1 of the identified substances	1		
					no	0		
24			**Halogen-free products:** Can you confirm that the product (a) does not contain, (b) has reduced amount of BFR, CFR and PVC?	(a) a technical file/report/dossier, (b) certification that meets the legal requirements of the European RoHS Directive (2002/95/EC) or equivalent	Product does not contain BFR, CFR and PVC	2	6, 7, 8, 9, 10, 14	elimination of toxic substances
					Product does not contain one or two of the criteria substances	1		
					no	0		
25			**Halogen-free products**: Can you confirm that the plastic parts greater than 25 grams do not contain halogenated flame retardants? Note: TCO Certified has stricter criteria as plastic parts greater than 5 grams shall not contain halogenated flame retardants. This comes with an exemption of printed wiring board	(a) a technical file/report/dossier, (b) certification that meets the legal requirements of the European RoHS Directive (2002/95/EC) or equivalent	yes	2	2, 3, 5, 6, 9, 10, 12, 17	elimination of toxic substances
					-	1		
					no	0		

			laminates, electronic components and all kinds of cable insulation.					
26			**Halogen-free products:** Can you confirm that this product does not contain short-chain SCCPs?	(a) a technical file/report/dossier, (b) certification that meets the legal requirements of the European RoHS Directive (2002/95/EC) or equivalent	yes	2	4, 6, 9, 17	elimination of toxic substances
					-			
					no	0		
27			**Heavy metals:** Can you confirm that this product (a) does not contain heavy metals (cadmium, mercury, lead and hexavalent chromium)?	(a) a written guarantee signed by a responsible person, (b) a technical file/report/dossier, (c) certification that meets the legal requirements of the European RoHS Directive (2002/95/EC), criteria by EU ecolabel, TCO Certified, Blue Angel, EPEAT (criterion 4.1.3.2), ECMA-370 (v. 2006 or later with point P7.20) or equivalent	yes, product does not contain heavy metals	2	3, 4, 5, 6, 10, 11, 12, 14, 17	elimination of toxic substances
					light sources free from mercury additional for ink/toner: ink/toner does not contain with a combined total of more than 100 ppm of heavy metals (lead, mercury, cadmium or chromium)	1		
					no			
28			**Heavy metals**: Can the company confirm that the parts with direct and prolonged skin contact do not release nickel in concentrations higher than		yes	2	3, 4, 14, 17	elimination of toxic substances
					-			
					no	0		

			specified in 76/769/EEC, amendment 94/27/EEC?					
29			**Phthalates:** Can you confirm that the product does not contain phthalates?		yes	2	4, 5, 7, 8, 9	elimination of toxic substances
					-			
					no	0		
30			**Packaging free of hazardous substances:** Can you confirm that the (a) packaging, (b) user manual and product documentation, do not contain - chlorine - halogenated substances, including PVC - heavy metals (lead, cadmium, mercury or hexavalent chromium)? Note: Limit values are according to Directive 94/62/EC on packaging and packaging waste.	written guarantee signed by a responsible person	yes, neither packaging nor user manual and product documentation contain chlorine, halogenated substances or heavy metals* also digital format of user manual/product documentation is deemed to comply with the criteria	2	5, 6, 12, 14, 17	elimination of toxic substances
					yes, packaging does not contain chlorine, halogenated substances or heavy metals	1		
					no	0		
31			**Noise emissions**: Has the company tested the statistical upper limit A-weighted sound power level (LWAd)?	declaration of the 'A-weighted Sound Level' (LWAd) according to ISO 9296,	maximum limits vary depending on the product		2, 4, 5, 10, 11, 12, 14, 17	minimize negative externalities

				measured in accordance with ISO 7779				
32	Human and labour rights	Labour rights	**International labour standards:** Does the product manufacturing follow ILO's eight core conventions (29,87, 98, 100,105, 111,138 and 182)? *In situations with legal restrictions on the right to freedom of association (87) and collective bargaining (98), non-management workers must be permitted to freely elect their own worker representative(s) (ILO Convention 135 and Recommendation 143). (TCO Certified)	(a) an independent third party certification, (b) a declaration of Honour that the manufacturer of the product complies with the ILO core conventions, (c) Code of Conduct in align with ILO core conventions, (d) annual reporting of results of the its labour policy in align with ILO core conventions, (e) other written guarantee that the criteria is fulfilled, such as an up-to-date EICC declaration, with documentary support of the implementation and monitoring measures, (f) allowing random inspections, (g) sharing audit results and corrective action plans, including % of (final) manufacturing stage facilities audited	Company has social responsibility requirements and proof of compliance with all ILO core conventions through the whole supply chain (Original Equipment Manufacturers, Electronic Manufacturing Services and Original Design Manufacturers, contract manufacturers)	5	5, 7, 10, 15	not characterized
					Company has social responsibility requirements and proof of compliance with all ILO core conventions through the first tier (e.g. third party audits)	4		
					At least 50 % of the final manufacturing stage production facilities in high risk countries are compliant to the social	3		

					responsibility requirements			
					The company shares auditing results and corrective action plans annually	2		
					Yes, the company has public social responsibility requirements for suppliers (such as a Code of Conduct or labour and human rights policy), which is in align with ILO's eight core conventions	1		
					no	0		

Sources: 1: ENERGY STAR; 2: Blue Angel; 3: EU Ecolabel; 4: The Nordic Swan Ecolabel; 5: TCO Certified; 6: EPEAT; 7: Rank a Brand; 8: Guide to Greener Electronics (18th ed.); 9: Open Eco Rating (V3); 10: ICT Guidelines (on Sustainable Procurement); 11: EU Green Public Procurement criteria; 12: Greening Government ICT Strategy and related publications (Green ICT Maturity Model and Government Buying Standards); 13: ICT Sustainability Plan 2010-2015; 14: Standard ECMA-370 (The Eco Declaration); 15: EICC Code of Conduct v. 5.1; 16: Data Center Maturity Model (DCMM): Other IT: Procurement; 17: A Sustainable IT Purchasing Guide; 18: The Connection Research-RMIT Green ICT Framework; 19: Green IT Balanced Scorecard; 20: Maturity Assessment Tool of Eco-Responsibility Inspired by the Balanced Scorecard