Towards the identification of key aspects for future scenarios of the information and communication technology sector's climate impact – Extended abstract

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Abstract

Reduced climate impacts of the information and communication technology (ICT) sector is required to redirect digital technologies towards sustainability. Life cycle assessment (LCA) can be used to quantify climate impacts of the ICT sector and identify hotspots. Several studies have assessed the direct climate impact of the global ICT sector and arrived at quite different conclusions regarding its future impacts. The aims of this paper are to identify key aspects for future scenarios in LCAs of the ICT sector's direct climate impact and to highlight related challenges. For this, a literature screening on direct climate impacts of the ICT sector was conducted. Preliminary findings indicate that for end-user devices, the number of units is a key aspect in influencing the climate impact of the future ICT sector. For telecommunication networks and data centers, the growth in data traffic and energy efficiency improvements are key aspects. In addition, the carbon intensity of electricity generation and the lifetime of products are key aspects for all ICT subdomains (i.e., end-user devices, telecommunication networks and data centers). These key aspects significantly influence the ICT sector's climate impact and need to be carefully considered in future studies. The authors future research includes to finalize the in-depth review and to develop a framework for LCAs of the ICT sector's direct impacts.

Keywords

Information and communication technology (ICT) sector, greenhouse gas (GHG) footprint, life cycle assessment (LCA)

1. Introduction

The purpose of digital technologies needs to be fundamentally redirected towards a deep sustainability transition [1]. More specifically, the environmental and social impacts of the information and communication technology (ICT) sector must be reduced. To be able to reduce the impacts of the ICT sector, including end-user devices, telecommunication networks, and data centers, it is important that these impacts are assessed. It is also important that hotspots, such as specific processes that contribute significantly to the ICT sector's impacts, are identified. If hotspots are identified, resources and actions can be directed to where they probably will enable the largest impact reductions. Life cycle assessment (LCA) is commonly applied to assess impacts of the ICT sector, its subdomains or specific ICT applications [2]. It is a method that can be applied to identify hotspots by quantifying the impacts of products, or services, over their entire life cycle, including the raw material extraction, production, use and the waste management phase of the product [3].

So far, several studies have assessed the climate impact, or the so-called greenhouse gas (GHG) footprint, of the ICT sector, see e.g., [4], [5] and [6]. A recent review by Bieser et al. [7] conducted a

In: B. Combemale, G. Mussbacher, S. Betz, A. Friday, I. Hadar, J. Sallou, I. Groher, H. Muccini,
O. Le Meur, C. Herglotz, E. Eriksson, B. Penzenstadler, AK. Peters, C. C. Venters. Joint Proceedings of ICT4S 2023 Doctoral Symposium, Demonstrations & Posters Track and Workshops. Co-located with ICT4S 2023. Rennes, France, June 05-09, 2023.
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comparison of such studies published during the last ten years on the global ICT sector. Six studies were identified in that review to focus on direct climate impacts (see Table 2 in [7]). Direct climate impacts here refer to GHGs emitted in the production (including raw material extraction), use and disposal of ICT. Some of the studies also included future scenarios for emissions of GHGs, see e.g., [5] and [6]. Notably, the results for the future climate impact of the ICT sector in the reviewed studies, which had various scopes in terms of e.g., time frames, types of end-user devices included, life cycle phases considered, etc., differed quite a lot [7]. In general, three different types of outcomes for the ICT sector's future climate impact were identified where it will either; i) increase significantly, ii) barely increase or iii) remain rather stable. These different outcomes are in line with the acknowledged controversy of discussions around current trends of digitalization and their environmental impacts [8]. According to Bieser et al [7], further LCA case studies on different types of end-user devices, and ICT infrastructures, are needed in response to the large sources of uncertainties present in these types of studies. In addition to the knowledge gaps identified by Bieser et al., there also exist other knowledge gaps in need of attention. These include the general lack of clear motivations for, and descriptions of, the future scenarios applied in studies of the ICT sector's climate impact. Furthermore, the data representativeness in these studies are seldom described in detail, making the interpretation of the study results rather difficult. There is a need to identify the aspects that are the most important in influencing the ICT sector's climate impact and how these should be taken into consideration in the construction of future scenarios.

In response to these knowledge gaps, the aims of this paper are to identify key aspects for future scenarios in LCAs of the ICT sector's direct climate impact and to highlight related challenges. This involves identifying and highlighting important factors that might significantly affect the climate impact of the ICT sector both today and in the future. The intended audiences of this paper are researchers with an interest in ICT sustainability, ICT manufacturers, ICT users and policy makers.

2. Method

In a first step, a literature screening on direct climate impacts of the ICT sector was conducted. The method that will be applied in the continued research is an in-depth literature review of studies on the direct climate impacts of the ICT sector with an emphasis on the six studies on the global climate impact of the ICT sector included in the study by Bieser et al [7]. These studies, e.g. [4], [5] and [6], and the review by Bieser et al [7] itself, will all be reviewed in detail with a focus on identifying key aspects in the construction of future scenarios for the ICT sector and its climate impact. Both scientific articles and grey literature sources written in English will be included.

3. Results so far and future research

Preliminary findings from the initial literature screening are summarized in Table 1. In addition, general hotspots for specific subdomains of the ICT sector, in terms of life cycle phases, are also presented in Table 1 based on Bieser et al [7]. The key aspect identified for end-user devices specifically, includes the *number of units* that are in use in the future ICT system, also involving the types of units applied. In the reviewed studies, the estimated number of end-user devices in the scenario representing the current situation were typically scaled up for the future scenario(s). Potential changes in the ICT system, e.g., by the introduction of emerging ICTs, on the other hand, were in general not considered. This is a challenge for these studies and problematic since the ICT sector is developing very fast. For telecommunication networks and data centers, *data traffic growth* and *energy efficiency* both constituted key aspects in influencing the climate impact of these ICT subdomains in the reviewed studies. Estimating future changes in data traffic and energy efficiency improvements is challenging. One way to handle this could be to construct several future scenarios as done in some of the reviewed studies. In addition, some key aspects are relevant for more than one ICT subdomain. The *carbon intensity of electricity generation* and the *lifetime of products* were identified to be important for end-user devices, telecommunication networks as well as data centers. Particularly, in some of the reviewed studies, the data applied, such as data on the carbon intensity of electricity generation, were selected to

be the same in both the current and future scenario(s). This suggests that there will be no differences in the electricity generation system in the future compared to today, which seems unrealistic.

In summary, the identified key aspects (Table 1) have a significant influence on the ICT sector's climate impact and the selections made for these aspects need to be carefully considered and clearly motivated in future studies. Future research by the authors of this paper will include to finalize the in-depth review of studies on the ICT sector's climate impact to provide a detailed overview of key aspects. This will also include the identification of strategies employed in previous studies for future scenario construction. Furthermore, a framework for LCAs of the ICT sector's direct climate impacts will be developed with the goal to provide recommendations to LCA practitioners on how to, for example, handle challenges related to key aspects in the creation of future scenarios.

Table 1 Non-exhaustive list of key aspects in influencing the climate impact, or the so-called greenhouse gas (GHG) footprint, of the information and communication technology (ICT) sector including its subdomains. Information on general hotspots in terms of life cycle phases were based on Bieser et al. [7].

ICT subdomain	Hotspot (in general)	Key aspects
End-user devices	Production phase	○ Number of units
Telecommunication networks	Use phase	○ Growth in data volume/traffic ○ Energy efficiency
Data centers	Use phase	○ Growth in data volume/traffic ○ Energy efficiency
All	-	○ Carbon intensity of electricity generation ○ Lifetime of products

4. Acknowledgements

The financial support from Ericsson, KTH Digital futures and KTH Climate Action Center is gratefully acknowledged.

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