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ICTFOOTPRINT.eu's Self-Assessment Tool for Energy & Environmental Efficiency in the ICT Sector

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Abstract

Information and Communication Technologies (ICT) is probably one of our most powerful and flexible tools for addressing today's great challenges: global warming and exhaustion of resources. However, ICT itself is a considerable source of carbon emissions in the environment, due to e-waste, electricity to power electronic devices, and in particular because of the huge amount of energy needed to keep data centres and the underlying infrastructure up and running. With progressive digitisation of society and business moving to the cloud the ICT environmental footprint is growing dramatically. Researchers and Industry have defined new standards and best practices for ICT sustainability and energy efficiency. Be that as it may, changes must be adopted on a large scale for achieving substantial impact. An estimate of 10 million SMEs in Europe are ICT-intensive. In the quest of raising awareness on ICT's environmental sustainability, and democratising the access to standard footprint calculation methodologies, ICTFOOTPRINT.eu has developed an easy-to-use online Self-Assessment Tool for ICT Services (branded SAT-S) to help SMEs measure the carbon footprint of ICT services, providing them with basic knowledge to raise awareness on environmental footprint methodologies, start addressing the problem and make informed decisions leading to a greener ICT. SAT-S is deliberately simple, and performs simplified evaluation based on Life-Cycle Assessment (LCA) principles and limited to two indicators: GHG emissions and primary energy consumption, following the main methodological principles and rules, as provided by existing standards and methodological guidelines specific to the ICT sector (ITU-T, GHG Protocol, etc.). This paper reports on the choices made for the development of the SAT-S tool from the methodological, algorithmic and usability perspectives. Moreover, the paper explains the strategic motivation behind the ICTFOOTPRINT.eu initiative, the prospected development beyond the SAT-S tool and an updated analysis of the ICT methodologies selected in the context of analysing energy efficiency in ICT organisations, ICT products, ICT Goods and ICT Services.

Keywords: Carbon footprint in ICT; Self-assessment methodologies for SMEs; ICT sustainability; Energy efficiency; Standards; LCA

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1. Introduction

While several studies in the recent past have highlighted the role of the Information and Communication Technologies (ICT) in mitigating environmental impacts, in particular regarding climate change mitigation, [1], [2], [3], various studies have also indicated that ICT's own footprint is expected to increase significantly over the next few years [2], [3], [4], [5]: energy consumption and greenhouse gases (GHG) emissions from the ICT sector are growing rapidly as a result of major economic and societal changes such as the uptake of network connected devices (e.g. smartphones) and the growth of web services.

In a business-as-usual scenario considering ongoing energy efficiency improvement, these emissions are expected to almost triple between 2007 and 2020 [2]. That said, the ICT sector, through the provision of innovative technology (e.g. smart grids, smart buildings), enables GHG emissions and energy savings throughout the economy: this is known as the "enabling effect". In this context, measuring the carbon and energy footprint of ICT products and services and their enabling effects become key challenges for the sector and requires appropriate GHG and energy footprints measurement and reporting methodologies.

Be that as it may, currently the ICT sector accounts for almost 10% of electricity consumption in Europe and, with a decrease of emissions of just 15%, it can generate savings of €600 billion by 2020 [6].

In Europe there are over 20 million Small- and Medium-sized Enterprises (SMEs) and over 50% of them are deemed to be ICT-intensive, i.e. they make extensive use of ICT, to the point that a failure in just some ICT-based processes may result in significant repercussions on their production and therefore severely affect business. Apart from all ICT-related issues (from cybersecurity to SW and HW procurement), nowadays one relevant aspect is, for virtuous organisations and, particularly, for

SMEs that want to differentiate from the rest of the competitors, to acquire a positioning of excellence in terms of their carbon footprint, particularly for their ICT-based processes & services. Achieving a low carbon footprint in ICT may turn into a powerful support to a "green positioning" of the organisation, thereby generating advantageous competitive edge in a more and more environmentally-aware market.

Extensive work has been carried out, in the past decade, by the ICT sector (public research institutions as well as private organisations) and SDOs (Standards Developing Organisation) to develop accurate methodologies for the evaluation of the environmental footprint of ICT products, services and organisations. The results are on the one hand impressive, in terms of abundance of solutions and field-specific methodologies to assess ICT environmental footprint, in particular carbon and energy footprints, and, on the other hand disheartening, in terms of awareness and implementation of these methodologies within the ICT sector. A survey conducted in the first half of 2016 by the authors showed that although most respondents are aware of the existence of footprint methodologies (either ICT sector specific or not), very few have implemented it at least once. Four challenges were identified as key points to be addressed for SMEs and local authorities to assess environmental footprint of a product / service:

- The lack of time and resources within organisations, particularly for SMEs,
- The lack of knowledge/expertise on footprint methodologies,
- The lack of tangible benefits to be expected from implementing such approaches,
- The lack of incentive to invest time and resources in the implementation of footprint methodologies.

As a result, large organisations with a high motivation in their Corporate Social Responsibility (CSR) or sustainability policy, seem to have the capacity and resources to apply such methodologies for themselves. Apart from virtuous exceptions, SMEs are not only unable to afford such footprint assessments, but most likely unaware of the existence of footprint methodologies.

Since implementation of the 7th Framework Programme, the European Commission has funded research & innovation projects in the field of Energy & Environmental Efficiency in the ICT sector. In particular, during the Horizon 2020 Framework Programme (2013-2020), efforts allowed researchers to develop specific carbon footprint calculation methodologies, identify best practices, and contribute to standards. Currently, the unit "Smart mobility and Living" of DG CONNECT is supporting ICTFOOTPRINT.eu as the main initiative to raise awareness, in particular among SMEs, and to foster the adoption of a systematic approach to reduce ICT's environmental impact applying existing calculation methodologies and following recognised best practices.

The ICTFOOTPRINT.eu initiative aims to address the challenges described above, by raising awareness around environmental footprint methodologies (with a focus on carbon and energy footprint methodologies) in ICT and delivering a range of services and opportunities to all ICT-intensive organisations, and particularly the SME-intensive ones, to initiate capacity building on this topic. One of the most prominent applications that has been developed by the ICTFOOTPRINT.eu Consortium is an online service to calculate the carbon footprint of an ICT-based service. The present paper describes such a service and provides the early results obtained with it.

2. Democratising sustainable ICT: The innovative approach pursued by ICTFOOTPRINT.eu

Despite the ever growing number of ICT-intensive SMEs and organisations, basic knowledge about the environmental impact of ICT is often missing or insufficient. Even if large-scale initiatives, such as the PEF/OEF one have recently been launched [7], aiming at harmonising and spreading environmental footprint methodologies in Europe (with a specific pilot on IT storage), public incentive mechanisms are fundamentally not sufficient to motivate and mobilise most SMEs to systematically address the problem. On the other hand some of the ICT Industry big players (e.g. Google, Apple and Microsoft) have included environmental friendliness in their core strategy and investment for ethical reasons and public image concerns, but also because it corresponds to increasing energy efficiency which implies reducing electricity expenditure.

It is evident that technological, but also behavioural, economic and political innovation is needed to guarantee a sustainable ICT. Therefore, raising awareness on the ICT environmental footprint and ways to reduce it is of crucial importance.

Bridging the gap between science/research (where the knowledge resides) and business, in particular SMEs (where the largest fraction of the environmental impact is generated), and regulations (where informed decisions must be made and policies are decided and enforced) is one of the greatest challenges.

For a non-expert audience, ICT environmental footprint calculation methodologies can be perceived as complex to implement; as they provide a general methodological framework by setting methodological principles and requirements which are often left open to the interpretation of the user. In other words, no ”ready-to-use” complete algorithm are generally provided in such methodologies standards or guidance. Thus, calculating environmental, carbon or energy footprint often requires the intervention of experts in the field of environmental footprints such as researchers or specialised consultants, in addition to the background expertise necessary on the specific product, service or activity under assessment. On the other hand SMEs and organisations are not willing to spend time or money in this kind of activity, especially if there is no economic motivation to do so.

There are many standards that apply for the assessment of ICT carbon footprint. In order to understand the environmental impact of a product it is necessary to consider its whole lifecycle from the extraction of raw materials, design and production, down to the development, usage and final disposal and recovery. LCA (Life-Cycle Assessment) methodologies provide different degrees of guidance to the practitioner assessing the life-cycle impact. Boundaries and assumptions, which depend heavily on the practitioner's experience and background, have a great impact on the results. Surprisingly, *if the same practitioner conducts an LCA for the same product or system using the same data, and the same assumptions, the choice of methodology used does not have a big impact on the results. If two different practitioners are using the same standard, the results will vary more since they may use different data and assumptions* [8].

LCA methods are useful to gain knowledge on complex issues like GHG emissions related to ICT systems, however they present several challenges:

- High and specific level of skills and knowledge required: Practitioners should have previous experience in conducting LCA
- Large amount of resource is required, both financial and people. It requires skilled resources as well as elevated costs (in the region of hundreds of thousands Euro) and at least 6 months of work per company or organisation to achieve the basic knowledge level [9]
- Data collection is difficult for highly complex products in a global and highly complicated supply chain.

Finding the most appropriate balance between rigorous research methods and calculation algorithms on one side, and simple analysis, understandable results and practical solutions on the opposite side is a delicate matter of equilibrium. ICTFOOTPRINT.eu is addressing this challenge by developing tools for raising awareness on ICT carbon footprint and calculation methodologies. In the quest of raising awareness on ICT's environmental sustainability, and democratising the access to standard footprint calculation methodologies ICTFOOTPRINT.eu provides an interactive map of ICT standards and developed an on-line free Self-Assessment Tool (SAT) to allow a simplified calculation of the ICT carbon footprint of services, products and organisations.

3. Existing standards for ICT footprint calculation methodologies

The most active SDOs and initiatives in the field of ICT-specific environmental footprint methodologies have produced various standards and guidance, as reported in Figure 1 below. The figure includes methodologies based on Life-Cycle Thinking concept (e.g. environmental, carbon, energy footprints applied to products/services or organisations) and other methodologies for the evaluation of sustainability Key Performance Indicators (KPIs), i.e. indicators based on performance assessment (e.g. energy efficiency) or compliance to environmental criteria (e.g. qualitative evaluation of environmental hotspots).

“Footprints” methodologies belong to the family of the environmental assessment methods based on Life-Cycle Thinking (LCT), i.e., an approach that takes into consideration the spectrum of resource flows and environmental interventions associated with a product, service, or organization from a life-cycle perspective, including all phases from raw material acquisition through processing, distribution, use, and end-of-life processes. ICTFOOTPRINT.eu provides information on methodologies specific to the ICT sector and related to the environmental footprint implementation, with a particular focus on carbon footprint and energy footprint. Additional methodologies may be applied to calculate performance indicators, for instance in terms of energy consumption. Performance indicators considered within this project are, among others, Power Usage Effectiveness (PUE) or Carbon Usage Effectiveness (CUE).

Some of the methodologies presented in ICTFOOTPRINT.eu are standards, i.e., developed by an official Standards Developing Organisation (SDO). The others are voluntary initiatives, developed by a consortium of various private/public stakeholders. This article focuses only on methodologies based on Life-Cycle Thinking.

Standards are organised in 3 areas of operability: Products & Services, Organisations and Cities. Each standard and initiative is described in dedicated factsheets, providing key information about their scope, features and examples of implementation. Examples of existing standards and guidance for the ICT sector are also provided in Figure 1.

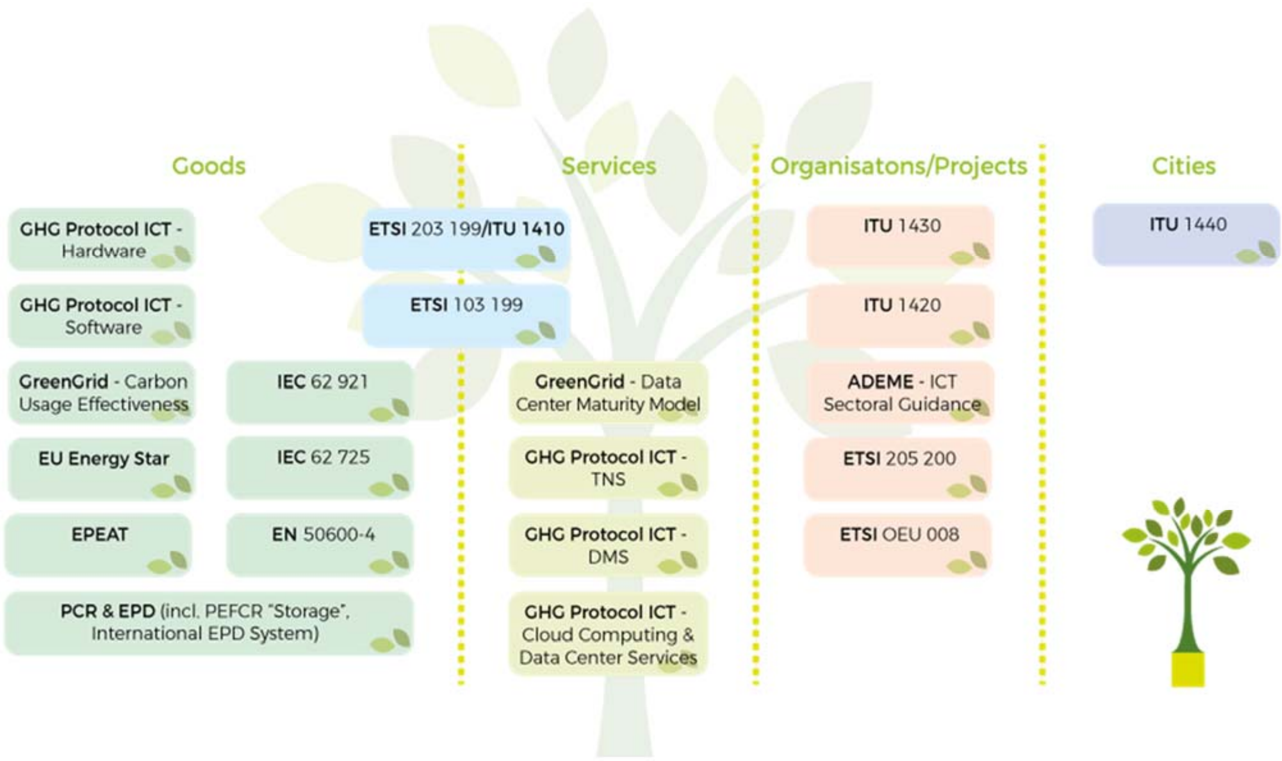

Figure 1. Map of ICT Standards and Guidance for environmental footprint methodologies and other methodologies for the evaluation of sustainability key performance indicators (KPIs) (from www.ictfootprint.eu)

The *ETSI-103199 standard*, developed by ETSI, covers Environmental Engineering and LCA of ICT equipment, networks and services, general methodology and common requirements. The standard provides generic and specific requirements for LCA, assesses environmental impacts of ICT and provides information on comparison of specific ICT on comparative LCA between ICT and reference products systems (e.g. video-conferencing vs. business travel).

The *ETSI-203199/ ITU-1410* standard, developed jointly by ETSI and ITU-T, is a revised version of ETSI-10399 aligned with the ITU-1410 (Construction, Installation and Protection of Cables and Other Elements of Outside Plant).

The other standards considered in the SAT-S development are from the GHG Protocol, focusing on different ICT aspects ranging from general guidance, to software environmental assessment and life-cycle approach, cloud computing and data centre services (quantifying energy and GHG emissions associated with the delivery of cloud services, from a user perspective, provided with the use of data centres) to Desktop Management Services (DMS) and Telecommunication Network Services (TNS) which takes into account service provider equipment (routers, servers) support equipment (cabling and racking), customer premise equipment (telephones, PC, video conferencing systems) and other operational activities associated with telecoms network services, such as installation, maintenance and customer service.

Moving from the aforementioned standards and guidance, the SAT-S algorithm is based on the basic requirements from the main existing standards and guidance specific to the ICT sector.

The ICTFOOTPRINT.eu Self-Assessment Tool (SAT) is based on some of the ICT standards & methodologies listed in the map. It does not implement one standard in particular, as its goal is to raise awareness and this requires simplicity: Rigorous application of methodologies is out of its scope because this would introduce an excessive level of complexity. However, the SAT was developed based on the main principles of several standards, briefly outlined below.

The result is, indeed, a "non-orthodox" application of such methodologies (which we estimate induces errors in the final figures, which could affect accuracy of predictions to a relevant extent, that could be envisaged in the order of ±30%), but, on the other hand, a significant widening of the range of basic ICT services that the methodology can accommodate for and, in the intentions of the authors, drastic lowering of the access barriers for end-users, which can then perform themselves the assessment, as shown in the next section of the present paper.

4. The ICTFOOTPRINT.eu Self-Assessment Tool (SAT-S)

The Self-Assessment Tool has been designed as tangible and effective means to raise awareness and provide a practical insight to the potential users on:

- What stages may significantly influence the energy and carbon footprint of a product or an organisation;
- The potential difference in results between primary energy footprint and carbon footprint: even if the two indicators are often highly correlated, in some cases, the results can be decoupled;
- The rationale of using ICT-related calculation methodologies to obtain these results.

Additional goals associated with the SAT-S are:

- To allow the user to perform carbon/energy footprints of ICT products/services, i.e. to allow a user to assess the GHG emissions and energy consumption of a given product/service or organization;
- To allow the user to compare the carbon/energy footprint of two products/services providing the exact same function(s) (e.g. a “standard” product and an ecodesigned version of the product).

The current version of SAT-S (Self-Assessment Tool for ICT Services and Products): It is a free on-line service that enables users to get a better understanding of the potential GHG emissions and primary energy consumption of their ICT products and services. The assessment is limited to these two indicators, GHG emissions and primary energy consumption according to the main methodological principles and rules specific to the ICT sector. The tool is currently and openly accessible on the web (https://www.ictfootprint.eu/en/self-assessment-tool) and has been registering encouraging accesses from users within the target of the initiative.

In line with its approach, the SAT-S tool has a simple and intuitive Graphical User Interface: The user is presented with an identification form to provide information about his/her organisation. The identification form (made up of 9 questions) is followed by the technical part of the self-assessment (12 questions overall), which requests information about different aspects of the service or product that needs to be analysed for Life-Cycle Impact Assessment. The information that is collected with the questionnaire is used by the SAT-S engine for the calculation of the carbon footprint. Ultimately, the online tool leverages on its simplified structure to lower barriers to entry for the targeted end-users, notably not accustomed to the rather complex calculation methodologies that are involved. A screenshot of SAT-S, highlighting some of the value points of the tool is reported in Figure 2.

Early validation of an initial prototypical version of the tool resulted in the identification of a terminological barrier that needed to be lowered for non-expert users. Developing a set of relatively simple – but sufficient to provide input to the calculation engine – questions required careful mapping of domain specific terms used in the calculation methodologies onto a user-friendly vocabulary.

Finally the tool generates a report presenting the results of the Life-Cycle Impact Assessment (LCIA). The report illustrates an indicative LCIA for the specified service, both in numeric values and visual representation. In particular the carbon emissions are broken down into the principal phases: from Production, to Operations, Use and End of Life. The resulting impact on Climate Change and Primary Energy are also broken down into “*building blocks*”, i.e. each of the constituent elements of an ICT product or service (end user, transmission network - access network, provider edge, metro networks, long haul networks, datacentres and operations - which includes all activities related to the service/product design, development and distribution provided by the service provider or product manufacturer), showing the relative values for End User, Transmission and Network, Data Centres and Operations.

Finally, user’s results are compared with respect to the average of results from previous SAT-S users (in an anonymous fashion), assessing the same category of ICT services, as shown in Fig. 3 and Fig. 4 below.

The final report includes also a recap of the questionnaire and a glossary of terms, explaining in simple terms the results that are presented.

Following the go-live of the SAT-S service, ICTFOOTPRINT.eu is collecting feedback from users and an improved version will be released in the near future to improve user’s experience. In particular the results will include the indication of ‘equivalents’, to trigger users’ imagination, and motivate them to address the ICT environmental impact issue. Equivalents that are being considered include: emissions produced by 1 average European citizen over 1 year, corresponding to 9.22E+03 kg CO2e/person/year [10]; or 1 km in an average car corresponding to 2.53E-01 kg CO2e/km [11]; or 1 km per person in large plane (more than 250 seats) - World average corresponding to 2.58E-01 kg CO2e/passenger.km [11]; or Housing energy (including heating) consumed by 1 person over 1 year (France average), corresponding to 1.91E+03 kg CO2e/person/year [12].

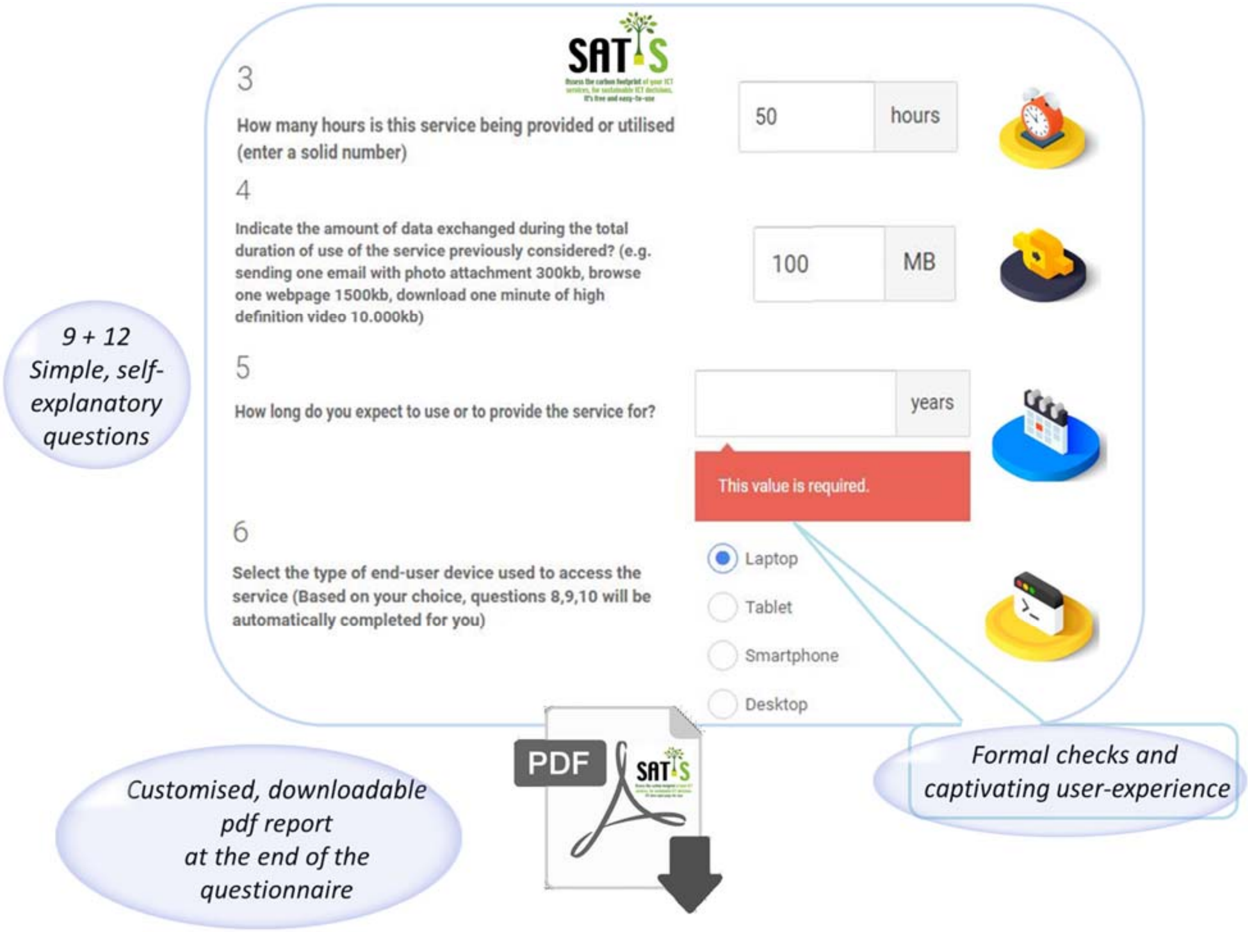

Figure 2. SAT-S barrier-lowering value proposition

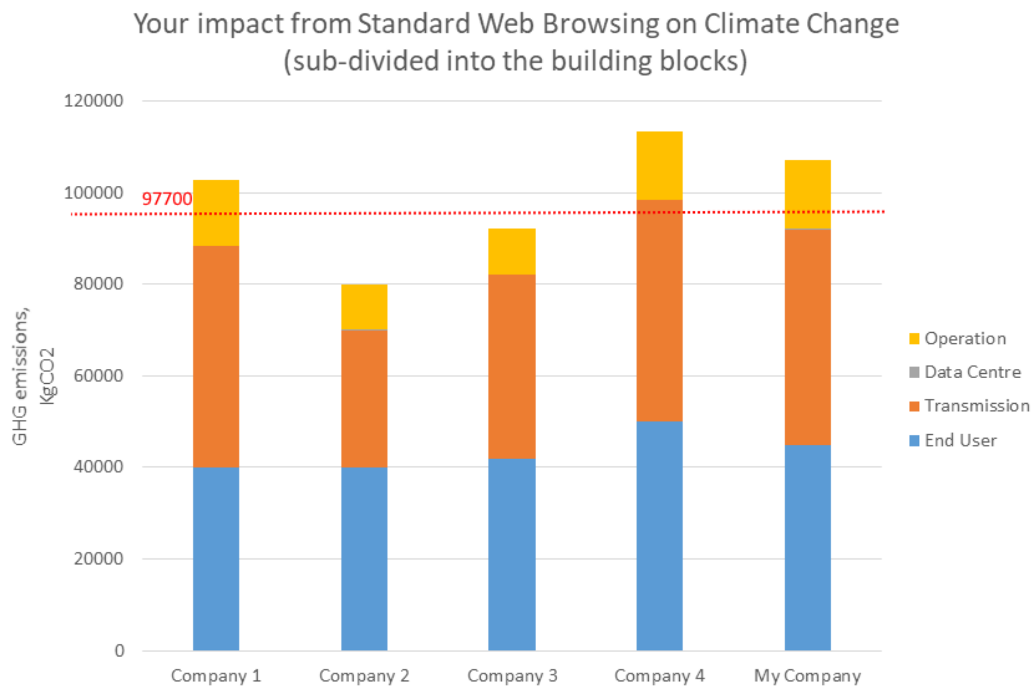

Figure 3. Statistics on Carbon footprint of web browsing emerging from usage of SAT-S
(the red dotted line indicates the overall average score recorded in the ICTFOOTPRINT.eu database)

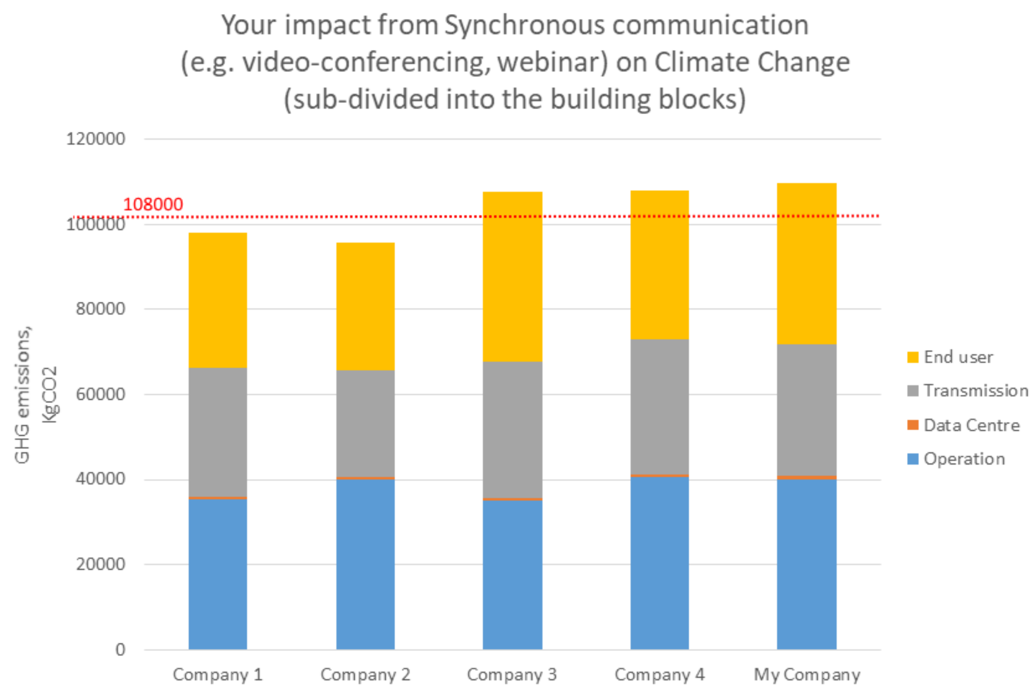

Figure 4. Statistics on Carbon footprint of videoconferencing emerging from usage of SAT-S (the red dotted line indicates the overall average score recorded in the ICTFOOTPRINT.eu database)

At the time of writing of the present paper, the users of SAT-S generated results for their analysed services that indicate, for the use of standard web browsing services a yearly average climate change impact of 9.77E+004 kgCO2/FU and primary energy of 1.68E+006 MJ / FU; use of Synchronous communication (e.g. video-conferencing, webinar) services with an average of 1.08E+005 kgCO2 / FU and primary energy of 1.40E+006 MJ / FU.

5. Future developments: From SAT-S to SAT-O

Deployment of the SAT-S and its initial experimentation is paving the way for the development of a more complete version of the tool addressing the assessment of an organisation as a whole: The SAT-O, which is currently under development, will model a typical ICT-intensive organisation through its founding elements, thereby assessing the environmental impact of its ICT dimension. More in detail, the SAT-O tool will provide an overview of an organisation's carbon footprint taking into account the digital services it provides and uses but also the structural impact of the building and personnel's (heating, commuting etc.).

Providing information about the carbon footprint of an ICT-intensive organisation and its breakdown into components and lifecycle stages will give useful hints on how to reduce environmental impact while increasing energy efficiency. The SAT-O will provide relevant knowledge to its users, and particularly decision-makers, with a cost-benefit viewpoint. This approach will therefore address the final goal of decreasing the environmental impact from ICT through increased awareness, and with a business-oriented perspective, which – from the feedback that the authors are collecting from the ICTFOOTPRINT.eu active community of over 1,600 members – is confirmed to be the main way to engage the large public into "green ICT" themes.

6. Conclusions

One of the biggest challenges for reducing the environmental impact of ICT is the cultural and behavioural change that is required, especially among decision-makers of ICT-intensive SMEs. Despite the scientific and technological progress that has been made in the field of ICT environmental impact analysis, basic knowledge still represents one of the main barriers to the implementation of a more sustainable ICT. Raising awareness on ICT carbon footprint issues and ways to reduce it and democratising access to standards and calculation methodologies is fundamental for achieving meaningful impact, and engaging end-users.

The authors, as part of the pan-European ICTFOOTPRINT.eu initiative, have developed a freely accessible, online service, named SAT-S, that addresses this issue by providing an easy-to-use tool that generates a personalised assessment of a typical ICT service. The tool originates from a mix of the available calculation methodologies, and allows non-specialised end-users to make informed decisions of their ICT solutions, in order to increase their energy & environmental efficiency.

Building upon the SAT-S experience, a new extended version of the tool is being developed, named SAT-O, and will be released on ICTFOOTPRINT.eu in 2018, to provide users with an insight on the ICT environmental impact of their Organisation as whole and potential strategies for improving the organisation's energy efficiency.

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List of abbreviations & acronym

Acronym/ Abbreviation	Description
CSR	Corporate Social Responsibility
CUE	Carbon Usage Effectiveness
DG	Directorate General
DMS	Desktop Management Services
ETSI	European Telecommunications Standards Institute
FU	Functional Unit
GHG	Greenhouse Gas
HW	Hardware
ICT	Information and Communication Technologies
IT	Information Technology
ITU	International Telecommunication Union
ITU-T	ITU's Telecommunication Standardization Sector
KPI	Key Performance Indicator
LCA	Life-Cycle Assessment
LCIA	Life-Cycle Impact Assessment
LCT	Life-Cycle Thinking
PEF	Product Environmental Footprint
OEF	Organisation Environmental Footprint
PUE	Power Usage Effectiveness
RTD	Research and Technological Development
SAT	Self-Assessment Tool
SAT-S	Self-Assessment Tool for Services
SDO	Standards Developing Organization
SME	Small- and Medium-sized Enterprise
SW	Software
TNS	Telecommunication Network Services

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