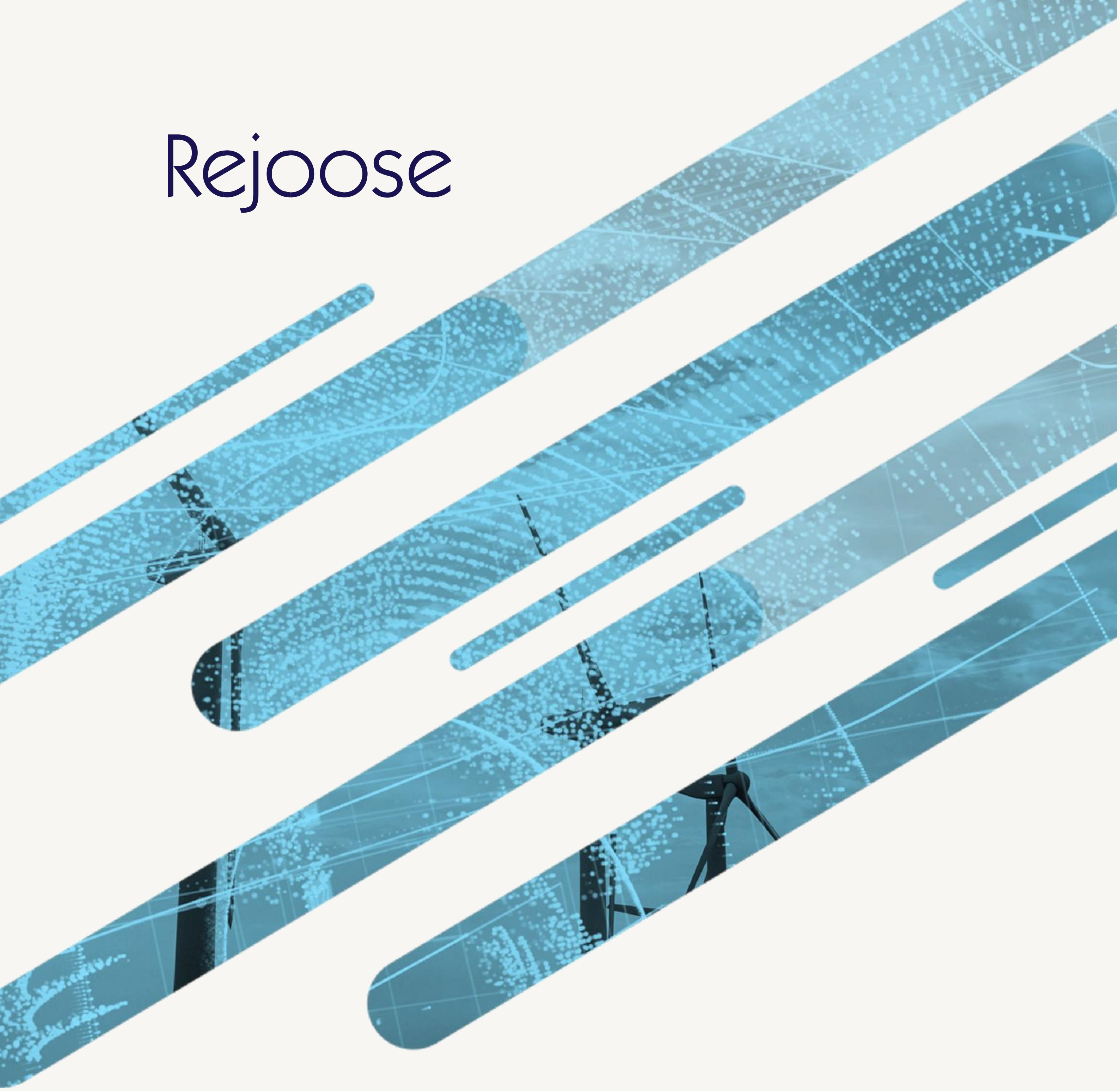
Rejoose



Rejoose White paper - 2025 - LCA General principles

LCA Data for carbon accounting purposes

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Introduction and General Principles

March 2025

This Guidance has been reviewed for conformance with the GHG Protocol Product Standard.

Overview

Executive summary: Introduction and general principles

This ICT LCA White paper provides guidance and accounting methods used in Rejoose for the calculation of GHG (greenhouse gas) emissions for ICT (Information and Communication Technology) products with a focus on ICT products and services. This ICT LCA White paper is built on, and in conformance with, the GHG Protocol Product Standard.[1]

Disclaimer

Rejoose provides carbon emissions data for carbon accounting purposes. Our data supports organizations in measuring and managing their carbon impact.

We align with manufacturers to ensure the correct use of their Product Carbon Footprint (PCF) data. PCF values follow manufacturer-specific methodologies and may not be directly comparable across brands. When using Manufacturer-Specific (MS) data, refer to the original manufacturer documentation.

For Category Average (CA) and Configurable Average (CA+) data, Rejoose follows GHG Protocol guidelines. For further guidance, consult Rejoose whitepapers.

Rejoose assumes no liability for misuse or misinterpretation of PCF figures.

The collection of our 5 detailed ICT LCA White papers includes the following chapters:

- Telecommunications & Network Services
- Desktop Managed Services
- Cloud and Data Center Services
- Hardware (Notebooks, desktop, Smartphones, servers, storage, network etc.)
- Software (coming)

This Introduction gives some context and background to the issues around measuring the GHG emissions of ICT products and discusses some of the reasons for doing this. The methods and standards described here are also the foundation on which Rejoose data is defined and is shared to be transparent about how the Rejoose system works.

As there's no 'single truth' to ICT LCA data, this however, can be considered a standardized and systematic way to approach to scope and account carbon emissions data in ICT. With Rejoose we aim to support a range of possible standardized methods, and this way the companies using this data, can define both baselines and Scope 2+3 GHG emissions.

[1] Greenhouse Gas Protocol, "Product Life Cycle Accounting and Reporting Standard," available at https://ghgprotocol.org/product-standard

It also provides an overview of the other chapters and general guidance on the following topics when assessing ICT products: screening, significance, scope definition, boundary setting, data collection and data quality, allocation, uncertainty, calculating GHG emissions, assurance, reporting.

Assessing the GHG emissions of ICT products presents several challenges because of the nature of ICT, with the complex and extensive features of ICT services, the long and complex supply chains for ICT hardware, and the wide use of shared resources within ICT systems requiring specific allocation techniques. This ICT LCA White paper aims to address these issues by providing the methodologies used in Rejoose, which provide a consistent approach to calculating the GHG emissions from ICT goods and services.

Introduction

Given the growing significance of climate change as a challenge for organizations and governments, it is essential to adopt a comprehensive approach to determine the carbon footprint of products. This approach plays a crucial role in reducing greenhouse gas emissions.

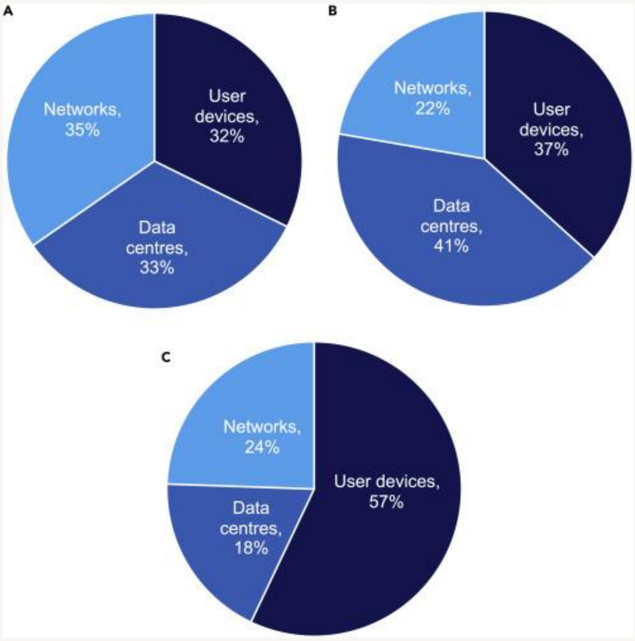

Figure 1 (Freitag, et al., 2021)

The ICT sector is experiencing rapid growth, and this trend is projected to persist, resulting in a significant and potentially expanding carbon footprint. Research suggests that approximately 2.1-3.9% of global greenhouse gas (GHG) emissions can be attributed to the ICT sector. Within this estimate, around 30% of emissions are associated with device production and the remaining 70% with their usage phase (Freitag, et al., 2021).

In order to align with the 2°C trajectory outlined in The Paris Agreement (United Nations, 2015), it is imperative to comprehend the consequences associated with ICT as it contributes significantly to total greenhouse gas (GHG) emissions.

Various peer-reviewed studies have provided estimates for the proportions of impacts attributed to the three primary categories within the ICT sector: networks, user devices, and data centers. The aim is to establish a cost-effective and practical approach that enables manufacturers and resellers to assess the carbon footprint emissions associated with the entire lifecycle of ICT products.

This white paper presents a methodology for generating product-specific Life Cycle Assessment (LCA) results by utilizing industry averages of ICT products. The methodology incorporates product-specific vendor data and incorporates country-specific electric grid greenhouse gas (GHG) emission factors. According to the GHG Protocol Scope 3 calculation guidance, using industry average data can provide higher accuracy compared to relying solely on supplier-specific methods, as data collected directly from suppliers may be less reliable.

> In fact, data collected from a supplier may actually be less accurate than industry-average data for a particular product.
> *Source: GHG Protocol Scope 3 calculation guide – Chapter 1*

At Rejoose, we support both the industry average data method and vendor-specific data, aiming to leverage the benefits of both approaches for a comprehensive analysis. This allows us to provide the best of both worlds in terms of accuracy and reliability.

Primary: Configuration based - Average data method (product category average)
Secondary: Product specific data method (Vendor PCF datasheet) family level.
You can use both in Rejoose today, and there's support for even more standard data connected to each product depending on reporting needs.

Due to the facts presented by this section in the GHG protocol, Rejoose ended up using average data method as the primary dataset but ensure support for vendor/supplier specific.

Box [1.1] The difference between data specificity and data accuracy

Even though the supplier-specific and hybrid methods are more *specific* to the individual supplier than the average-data and spend-based methods, they may not produce results that are a more *accurate* reflection of the product's contribution to the reporting company's scope 3 emissions. In fact, data collected from a supplier may actually be less accurate than industry-average data for a particular product. Accuracy derives from the granularity of the emissions data, the reliability of the supplier's data sources, and which, if any, allocation techniques were used. The need to allocate the supplier's emissions to the specific products it sells to the company can add a considerable degree of uncertainty, depending on the allocation methods used (for more information on allocation, see chapter 8 of the *Scope 3 Standard*).

Source: https://ghgprotocol.org/sites/default/files/standards_supporting/Chapter1.pdf

Scope and purpose of the ICT LCA White paper

1. Expanding manufactures product specific data to include various configuration scenarios and account for geographical representativeness in accordance with the GHG Protocol - Product Life Cycle Accounting and Reporting Standard.

2. Determining scope 2 & 3 emissions for ICT products and create a methodology for transferable products specific data based on industry averages. To allow companies to create product specific scope 2 & 3 emission calculations for their product portfolio when product specific data is not available.

This White paper relates to scopes and category as articulated in GHG protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard.

Scope	Scope 2 + up- and downstream scope 3 emissions
Category	Purchased goods and services.
Product category	ICT products

Product Carbon Footprint (PCF)

ICT product industry averages is often based on manufacturers PAIA PCF's. PAIA (Product Attribute to Impact Algorithm) is used by many manufactures in the ICT sector to assess product carbon footprint of products. PAIA is a streamlined LCA tool developed by MIT's Materials System Laboratory in concert with Arizona State University, and University of California at Berkeley.

This Rejoose Whitepaper and ICT LCA White paper is published as an IT LCA White paper built on the GHG Protocol Product Accounting and Reporting Standard (referred to as the *Product Standard* throughout this IT LCA White paper).
The purpose of this IT LCA White paper, which is in conformance with the *Product Standard*, is to provide additional guidance to practitioners who are implementing the *Product Standard* for ICT products (including ICT services). This IT LCA White paper follows a life cycle approach to the assessment of ICT products (including services).

ICT in this White paper follows the OECD definition,[22] which has the following guiding principle: "ICT products must primarily be intended to fulfill or enable the function of information processing and communication by electronic means, including transmission and display."

The OECD definition includes the following 10 broad categories for ICT products:

- Computers and peripheral equipment
- Communication equipment
- Consumer electronic equipment
- Miscellaneous ICT components and goods
- Manufacturing services for ICT equipment
- Business and productivity software and licensing services
- Information technology consultancy and services
- Telecommunications services
- Leasing or rental services for ICT equipment
- Other ICT services.

The *Product Standard* defines products to be both goods and services, thus for the ICT sector it covers both physical ICT equipment and delivered ICT services.

The need for this IT LCA White paper is due to the specific nature of ICT products. ICT equipment is characterized by extensive bills of material (BOM) consisting of hundreds of individual components with long and complex global supply chains, often using multiple and alternative sources. This makes it inherently challenging to execute a detailed life cycle assessment (LCA) for typical ICT equipment. The ICT sector is also characterized by a large number of extensive services.

Rejoose addresses this issue by providing users with access to a vast database of carbon and energy consumption data. By utilizing this database, users can accurately assess the environmental impact of their operations. Additionally, Rejoose incorporates a reporting function that takes into consideration relevant legislation and European Union (EU) requirements. This ensures that users can generate reports that align with regulatory standards and fulfill their compliance obligations.

These services are generally complex solutions including potentially thousands of items of ICT

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[2] Organisation for Economic Co-operation and Development (OECD), "Information Economy Product Definitions Based on the Central Product Classification (Version 2)," In OECD Digital Economy Papers, No.158, 2009, available at: https://www.oecd-ilibrary.org/docserver

equipment and have significant use stages. In other words, understanding the use profile and behavioral aspects of the use of the service are important in assessing the service. Although LCA and the Product Standard are applicable to both goods and services, they are more easily applied to physical goods because services are intrinsically more complex; it is, therefore, more complex to assess services. This IT LCA White paper has a specific objective of addressing the assessment of ICT services. Its primary aim is to offer a practical and consistent approach to conducting greenhouse gas (GHG) assessments for ICT products. While the paper adheres to the Product Standard, it provides additional details and specificity that are relevant to the ICT sector. It emphasizes the importance of aligning the level of precision in an assessment with the goals of the assessment itself, while also considering the context in which the results will be interpreted. By doing so, it ensures that the assessment process is meaningful and relevant to the specific needs of the ICT industry.

Therefore, this White paper introduces and explains the approaches and estimation techniques employed by Rejoose. The choice of a specific approach within these techniques depends on the practitioner's goal for the IT assessment, the desired level of precision, and the availability of data (considering the associated cost of collecting additional data if needed).

The overarching purpose of this ICT LCA White paper is to tackle the inherent characteristics and complexities involved in assessing the environmental impact of ICT products and services. By providing practical guidance and considerations, it aims to support practitioners in conducting meaningful and effective assessments that align with their objectives and constraints.

ICT products and particularly the following points:

- Multiple components for ICT equipment
- Complex and long supply chains for ICT equipment
- Complex nature of ICT services across their life cycle
- Often bespoke and tailored characteristics of ICT services to meet specific customer requirements.
- Allocation of resource use to ICT services, which typically share resources
- Significant in-use stage of ICT products
- Uncertainty surrounding measurement of use stage
- Enabling effect of ICT products

Supporting standards

The White paper correlates with known corporate GHG accounting standards by applying the use of primary data sources to create industry averages.
Primary data sources in accordance with ISO 14025:2010, Product Carbon Footprinting ISO 14067 and the GHG Protocol Product Standard.
Data and results include GHG's whose 100-year GWP values have been identified by the IPCC (CO_2 eq calculation method AR6).

Recommended use:
Using product-level GHG data based on the Product Standard as a source of data to calculate scope 3 emissions associated with selected product types.
Source: GHG protocol Product life cycle accounting reporting standard 1.6.

Functional unit

The functional unit for all category types and sub types is shown as kg CO_2 eq per product.

Limitations

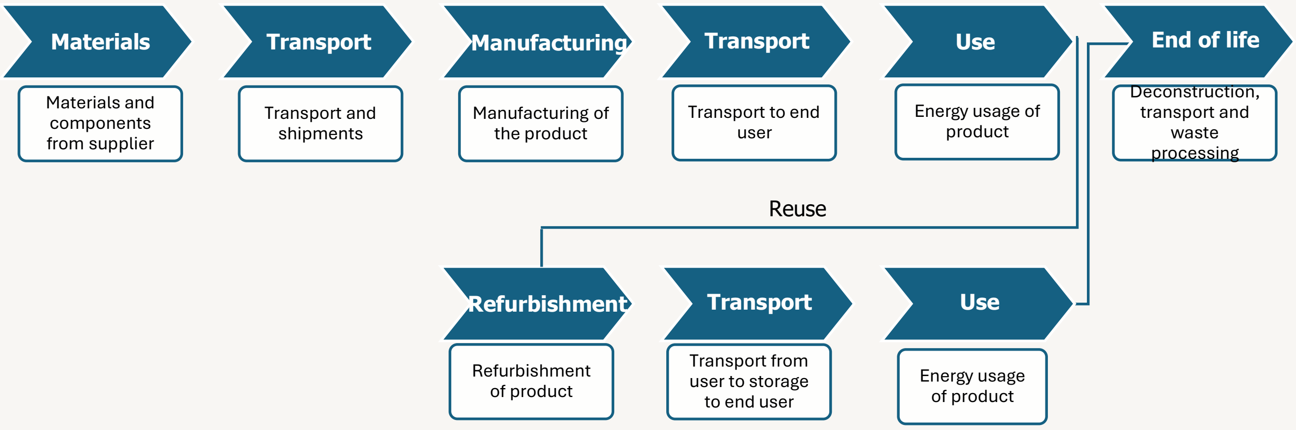
The methodology does not support product specific GHG reduction strategies, including tracking and improving processes and material inputs.

System boundaries

The data analyzed in this study considers the life cycle GHG emissions from both upstream and downstream sources, encompassing the entire product life cycle from cradle to grave. The specific life cycle stages included in the analysis are outlined in the corresponding figure.

To ensure accuracy and relevance, the use phase data is excluded from the data sources. This allows for the recalculation of product-specific energy usage and facilitates the incorporation of country-specific electric grid GHG emission intensities. Further details regarding product-specific energy usage can be found in the Rejoose White paper - Validated Devices.

Regarding calculations and results, the manufacturing stage is categorized to encompass raw material acquisition, processing, assembly, and all other processes related to component manufacturing. This comprehensive approach ensures a thorough assessment of GHG emissions throughout the manufacturing process.



Current state of the art

The ICT industry recognizes the significance of GHG emissions resulting from ICT operations. While some ICT vendors conduct LCAs and GHG assessments on their products, such practices are not yet standard across the industry. Rejoose focuses on addressing this gap by collecting data to provide compliant carbon data required for IT Carbon assessments. This is necessary because reliable and consistent sources of secondary data and emission factors for ICT components are not readily available and the process of acquiring them is time-consuming.

In addition to Scope 3 data, Rejoose provides information on the actual usage phase of ICT products. This data is used to define use case and country-specific Scope 2 carbon emissions. As a result, the data and results obtained from Rejoose for a company operating during a typical workday in Denmark would differ from those for a company operating 24/7 in Sweden. Each dataset is specific to the use case and country, ensuring compliance with reporting requirements.

As the measurement of GHG emissions progresses, Rejoose is committed to continually expanding its datasets to provide increasingly comprehensive information. This ongoing effort aims to facilitate a broader range of GHG assessments and contribute to making such assessments a standard practice within the ICT sector. By offering robust and up-to-date datasets, Rejoose strives to support the adoption of GHG assessments as an accepted and integral part of sustainability practices in the ICT industry.

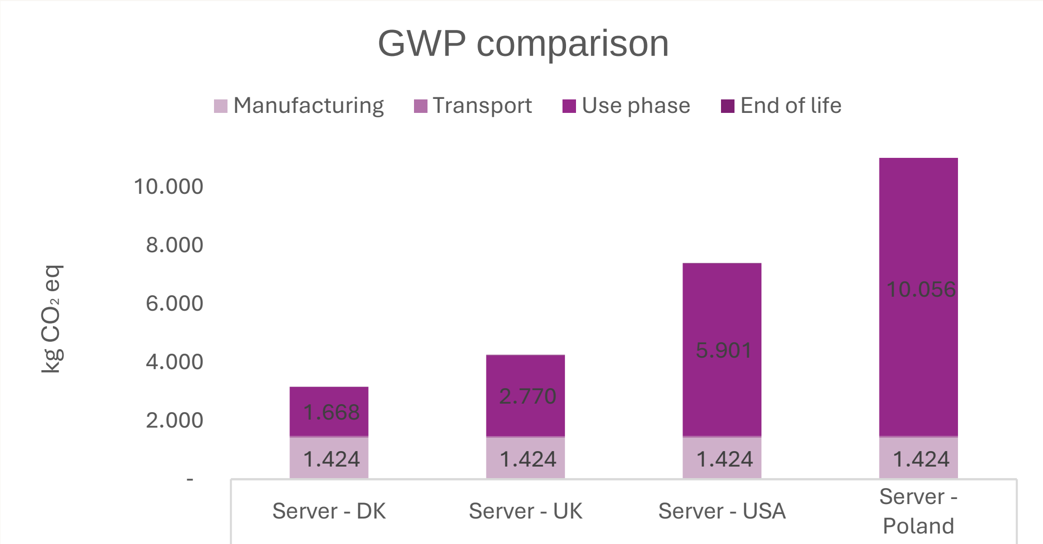
Geographical representativeness

The use phase scenario should always reflect actual geographic location by using regional or country specific electric grid carbon intensity.

Country and use case specific electric grid carbon intensity.

Denmark	0,130 kg CO_2 eq / kWh
United Kingdom	0,181 kg CO_2 eq / kWh
USA	0,356 kg CO_2 eq / kWh
Poland	0,657 kg CO_2 eq / kWh

Above is just examples on the differences.



	Server - DK	Server - UK	Server - USA	Server - Poland
End of life	15	16	19	21
Use phase	1.668	2.770	5.901	10.056
Transport	59	48	55	59
Manufacturing	1.424	1.424	1.424	1.424

Figure 2

The examples provided highlight the significant impact of carbon intensity variations across different countries and emphasize the importance of country and use case-specific reporting.

Operating the same server in different countries can lead to different results in terms of Global Warming Potential (GWP), which measures the greenhouse gas emissions associated with an activity or product. This variation is primarily influenced by the carbon intensity of the electric grid in each country.

In the given example, the scenario involves operating a server for four years in four different countries. The proportion of the use phase in the overall life cycle of the server differs across these operational scenarios. For instance, in Denmark, the use phase contributes to 53% of the server's life cycle impacts, whereas in Poland, it accounts for 87% due to the higher carbon intensity of the electric grid in that country.

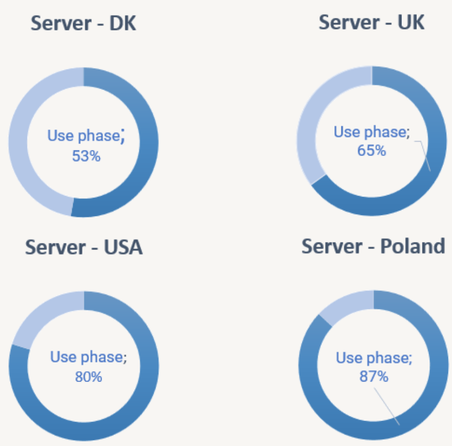


Figure 3

These findings emphasize the significance of considering country-specific factors, such as electric grid carbon intensity, when assessing the environmental impact of electrical devices. By incorporating this information into reporting and analysis, organizations can gain a more accurate understanding of the carbon footprint associated with their operations and make informed decisions to reduce environmental impacts accordingly.

Evolving technology

A further significant issue for the ICT sector is the rapidly changing and evolving nature of the technology. This has several potential effects: development of new products; technology being used in new and unexpected ways; new technologies driving different user and social behaviors; development of more energy-efficient ICT equipment changing underlying assumptions between in-use and "embodied emissions";[3] and development of equipment with built-in measurement capabilities (e.g., device energy consumption, network traffic monitoring and reporting, power saving mode monitoring and reporting). Thus, while this ICT LCA White paper is intended to be standardized in approach, it cannot predict all the potential changes that will happen in the ICT sector in the coming years. However, by using a standardized and approved method and use this until we enhance the system, you will both be able to track your progress and start a steep learning curve and stay ahead of directives and legislation.

Building block approach

This Guidance has a strong focus on the assessment of ICT services, and here the approach is to clearly describe the definition and boundaries of the service and enumerate the constituent elements that make up the service. Each constituent element can be considered as a building block and assessed individually, with the total impact being assessed by summing the impact of all the individual building blocks. This provides for a consistent and efficient approach. Examples of constituent elements are:

- Individual items of ICT equipment
- Use of networks
- Use of shared equipment (e.g., data centers)
- Use of software
- Hardware and software maintenance
- Help-desk support

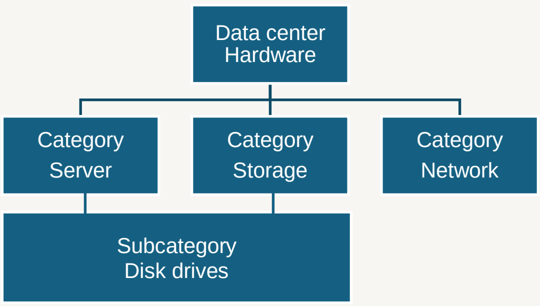
Method overview

The data center hardware is categorized into three main categories, with an additional subcategory consisting of five different types of disk drives. It is crucial to account for the count and type of disk drives in order to improve the accuracy of Life Cycle Assessment (LCA) results. In many cases, different devices can have varying numbers of drives, ranging from 0 to 96. Therefore, considering the drive count and type becomes essential for achieving more precise LCA outcomes.

The data pertaining to manufacturing, transportation, and end-of-life stages is determined through market research on the life cycle Global Warming Potential (GWP) for servers. To enhance calculation efficiency, the Scope 3 data is segregated by excluding the use phase and incorporating the disk drive Scope 3 data separately. This approach specifically addresses the influence of disk drive count and associated Scope 3 data, as outlined in Annex A - Disk drives.

When Scope 3 data is available for specific devices, the total GWP for the sum of devices is calculate by acquiring $M_{Device} + T_{Device} + EoL_{Device}$ data from the relevant product carbon footprint. For devices lacking available product carbon footprint data, Rejoose utilizes the Average data method, and defines comparable units and uses average data to fill out the gap, until the vendor delivers adequate date.

Equation 1 and Equation 2, which yield the total GWP for the sum of devices and individual product carbon footprint, are used repeatedly across all categories within the category methods. This ensures consistency and accuracy in assessing the environmental impact throughout the analysis process.



Server

$$Total\ GWP = \sum GWP_{Device}$$

Equation 1

$$GWP_{Device} = \sum Scope\ 3_{Device} + \sum Scope\ 2_{Device}$$

Equation 2

Where:

$\sum Scope\ 3_{Device}$ Sum of total scope 3 emissions related to a device $[kg\ CO_{2\ eq}]$

$\sum Scope\ 2_{Device}$ Sum of emissions related to use phase of device $[kg\ CO_{2\ eq}]$

$$Scope3_{Device} = M_{Device} + T_{Device} + EoL_{Device} + \sum_{i}^{Number\ of\ drives} (M_{D_i} + T_{D_i} + EoL_{D_i})$$

Equation 3

Where:

M_{Device} Manufacturing GWP for a device $[kg\ CO_{2\ eq}]$

T_{Device} Transport GWP for a device $[kg\ CO_{2\ eq}]$

EoL_{Device} End of life GWP for a device $[kg\ CO_{2\ eq}]$

M_D Manufacturing GWP for a disk drive $[kg\ CO_{2\ eq}]$

T_D Transportation GWP for a disk drive $[kg\ CO_{2\ eq}]$

EoL_D End of life GWP for a disk drive $[kg\ CO_{2\ eq}]$

i Disk drive GWP for each type – see annex A $[kg\ CO_{2\ eq}]$

$$\sum Scope\ 2_{Device} = TEC_{Device}\ x\ L + \sum TEC_{DD}\ \ x\ L\ x\ CI$$

Equation 4

Where:

TEC_{Device} Device typical energy consumptions $[kWh/year]$

$\sum TEC_{DD}$ Typical energy consumption of disk drives $[kWh/year]$

CI Electric grid carbon intensity in operating country/region $[kg\ CO_{2\ eq}]$

L Operating lifetime $[years]$

$$TEC_{Device} = P\ x\ h\ x\ /1000$$

Equation 5

Where:

P Average power consumptions $[W]$

h Operating hours per year $[hours/year]$

$$\sum TEC_{DD} = h\ x \sum_{i}^{Number\ of\ drives} P_i\ /1000$$

Equation 6

Where:

P Average power consumptions $[W]$

h Operating hours per year $[hours/year]$

P_i Power consumption for each drive type

Equations 2 through 6 are utilized to calculate the specific device Global Warming Potential (GWP), with the results then summarized in Equation 1.

Storage

To account for data center storage configuration volatility the disk drives are removed and calculated specifically for the relevant configuration. Furthermore, the study showed a highly consistent result in GWP for $kg\ CO_{2\ eq}\ per\ kg\ product$ diskless device.

$$Total\ GWP = \sum GWP_{Device}$$

Equation 7

$$GWP_{Device} = \sum Scope\ 3_{Device} + \sum Scope\ 2_{Device}$$

Equation 8

Where:

$\sum Scope\ 3_{Device}$ Sum of total scope 3 emissions related to a device $[kg\ CO_{2\ eq}]$

$\sum Scope\ 2_{Device}$ Sum of emissions related to use phase of device $[kg\ CO_{2\ eq}]$

$$Scope3_{Device} = Weight_{Device}\ x\ (M_{WD} + T_{WD} + EoL_{WD}) + \sum_{i}^{Number\ of\ drives} (M_{D_i} + T_{D_i} + EoL_{D_i})$$

Equation 9

Where:

$Weight_{Device}$ Weight of device without disks $[kg]$

M_{WD} Manufacturing GWP per kg device

$[kg\ CO_{2\ eq}\ per\ kg]$

T_{WD} Transport GWP per kg device $[kg\ CO_{2\ eq}\ per\ kg]$

EoL_{WD} End of life GWP per kg device $[kg\ CO_{2\ eq}\ per\ kg]$

M_D Manufacturing GWP for a disk drive $[kg\ CO_{2\ eq}]$

T_D Transportation GWP for a disk drive $[kg\ CO_{2\ eq}]$

EoL_D End of life GWP for a disk drive $[kg\ CO_{2\ eq}]$

i Disk drive GWP for each type $[kg\ CO_{2\ ea}]$

$$\sum Scope\ 2_{Device} = TEC_{Device}\ x\ L + \sum TEC_{DD}\ \ x\ L\ x\ CI$$

Equation 10

Where:

TEC_{Device} Device typical energy consumptions $[kWh/year]$

$\sum TEC_{DD}$ Typical energy consumption of disk drives $[kWh/year]$

CI Electric grid carbon intensity in operating country/region $[kg\ CO_{2\ eq}]$

L Operating lifetime $[years]$

$$TEC_{Device} = P\ x\ h\ x\ /1000$$

Equation 11

Where:

P Average power consumptions $[W]$

h Operating hours per year $[hours/year]$

$$\sum TEC_{DD} = \ h\ x \sum_{i}^{Number\ of\ drives} P_i\ \ /1000$$

Equation 12

Where:

P Average power consumptions $[W]$

h Operating hours per year $[hours/year]$

P_i Power consumption for each drive type

Data center Network

Similar to storage the results from the data showed a consistent GWP kg $CO_{2\,eq}\;per\;kg\;product$ and a highly varying result in regard to scope 2 emissions. The equation below which is without the configurability equation concerning disk drives is used to obtain network device product specific GWP.

$$Total\;GWP = \sum GWP_{Device}$$

Equation 13

$$GWP_{Device} = \sum Scope\;3_{Device} + \sum Scope\;2_{Device}$$

Equation 14

Where:

$\sum Scope\;3_{Device}$ Sum of total scope 3 emissions related to a device $[kg\;CO_{2\,eq}]$

$\sum Scope\;2_{Device}$ Sum of emissions related to use phase of device $[kg\;CO_{2\,eq}]$

$$Scope3_{Device} = Weight_{Device}\;x\;(M_{WD} + T_{WD} + EoL_{WD})$$

Equation 15

Where:

$Weight_{Device}$ Weight of device without disks $[kg]$

M_{WD} Manufacturing GWP per kg device

$[kg\;CO_{2\,eq}\;per\;kg]$

T_{WD} Transport GWP per kg device $[kg\;CO_{2\,eq}\;per\;kg]$

EoL_{WD} End of life GWP per kg device $[kg\;CO_{2\,eq}\;per\;kg]$

$$\sum Scope\ 2_{Device} = TEC_{Device}\ x\ L\ x\ CI$$

Equation 16

Where:

TEC_{Device} Device typical energy consumptions $[kWh/year]$

CI Electric grid carbon intensity in operating country/region $[kg\ CO_{2\ eq}]$

L Operating lifetime $[years]$

$$TEC_{Device} = P\ x\ h\ x\ /1000$$

Equation 17

Where:

P Average power consumptions $[W]$

h Operating hours per year $[hours/year]$

These are the most used categories of products in Rejoose, but this I only a fraction of the total amount of categories and sub-categories.

	Servers	Storage	Network	Cooling	UPS	Cloud services	Desktop PC	Laptop PC	Monitor Displays	Printers MFP	POS / Signage
Energy data											
Energy Efficiency Rating (A-G)	√	√	√	√	√	√					
Power use (Watt)	√	√	√	√	√	√	√	√	√	√	√
Use phase operation (hours)	√	√	√	√	√	√	√	√	√	√	√
Yearly power consumption (kWh)	√	√	√	√	√	√	√	√	√	√	√
Emission data											
Manufactoring	√	√	√	√	√	√	√	√	√	√	√
Transportation	√	√	√	√	√	√	√	√	√	√	√
Use phase	√	√	√	√	√	√	√	√	√	√	√
End of life	√	√	√	√	√	√	√	√	√	√	√
Emission data: kg CO2eq											
Refurbishment data											
Refurbishment value	√	√	√				√	√	√	√	√

Product comparisons

As with the *Product Standard*, the use of Rejoose is mainly intended to do a baseline of your ICT carbon emission and comparing entire solutions, and not to do specific product comparisons.

Note that product comparisons are discussed further in the *Product Standard* (section 1.5). Appendix A of the *Product Standard* provides guidance on product comparison and recommends additional specifications for product comparisons. The *Product Standard* requires additional product rules to be developed to support product comparisons, however product rules are outside the scope of this ICT LCA White paper. See also section 5.3.2 of the *Product Standard* for discussion of Product Rules and IT LCA White paper.

The primary objective for a company is to understand its baseline carbon emissions, establish goals, and track progress over time. By collecting and analyzing relevant data, companies can effectively reduce their carbon footprint. This data-driven approach enables them to identify areas of improvement, implement targeted strategies, and monitor the effectiveness of their initiatives.

Furthermore, the collected data serves a crucial role in reporting, both internally and externally. Companies can transparently communicate their carbon reduction efforts to stakeholders, shareholders, and regulatory bodies. Accurate and reliable data provides credibility to their sustainability claims and allows for meaningful comparisons and benchmarking against industry standards and targets.

Ultimately, the integration of data into carbon management practices empowers companies to drive sustainability, align with environmental goals, and contribute to the global efforts in combating climate change.

Enabling effect of ICT — avoided emissions

An “enabling effect” is the opportunity an ICT solution must avoid GHG emissions in other sectors, which can be attributed back to the ICT solution as the prime cause of that avoidance. The *Product Standard* (sections 11.2 and 11.3.2) states that “avoided emissions shall not be deducted from the product’s total inventory results but may be reported separately. This ICT LCA White paper follows the same approach — that avoided GHG emissions caused by an enabling effect shall be reported separately from the emissions caused directly by a product. Rejoose uses this approach within the Refurbished products report.

Avoided emissions are defined in the *Product Standard* as reductions in emissions caused indirectly by a product, where the product provides the same or similar function as existing products in the marketplace, but with significantly less GHG emissions.

The *Product Standard* does not address accounting of avoided emissions; however it was considered important to include in this ICT LCA White paper a methodology for assessing the avoided emissions caused by the enabling effect of ICT, because of the significant potential that ICT has in this area. As this methodology is different from that for assessing products, it will be included in the Transport Substitution Chapter as a separate appendix (see Section 1.5.2 “Structure of this ICT LCA White paper”).

In summary, the methodology provides a comparison of a business-as-usual (BAU) baseline scenario and an ICT-enabled scenario to demonstrate the benefit of ICT solutions to reduce overall system-level GHG emissions. This involves calculating the emissions in the following three categories.

ICT Product Emissions

The life cycle emissions of the ICT solution that is causing the enabling effect.

Enabling Effects

The avoided emissions due to the activities avoided because of using the ICT solution. These are further subdivided into *immediate* enabling effects and *longer-term* enabling effects.

Rebound Effects

The increased emissions because of using the ICT solution, caused by rebound effects. These rebound effects may be caused by related consequential effects or by unrelated (and sometimes unintended) effects and are often related to human behavioral changes. These effects are further subdivided into *immediate* rebound effects and *longer-term* rebound effects. Because of the nature of rebound effects, assessing them is inherently uncertain as it is difficult to accurately estimate the effects.

Goals for assessing GHG emissions of ICT products

There are several motivations for carrying out a Rejoose GHG assessment of ICT products. It is important to be clear what the goal for carrying out an assessment is, what the results will be used for, and who will use the results. The approach taken for the assessment may well be different depending on the goal.

The *Product Standard* (chapter 2) identifies some common business goals for companies to carry out a product life cycle GHG assessment.

For ICT products (including services) the following are typical goals, which this White paper aims to address:

- Understand emissions through the life cycle of the product, and where in the life cycle the majority of the emissions occur (e.g., understand the proportion of embodied to in-use emissions).
- This can help to direct efforts to reduce emissions of the product such as:
  - Reduction of emissions due to changes in the design of the product. Vendor related.
  - Reduction of emissions due to changes in the manufacture of a good, or provision of a service. Vendor, Reseller and User.
  - Reduction of emissions in the use stage of a product. Vendor: Energy efficiency. User: Operating hours and lifespan.
  - Reduction of emissions in response to behavioral changes in the use of the product. User: Lifespan, use hours, standby and power management.
- Track changes over time, to monitor the impact of product enhancements and new versions of products.
- Respond to customer questions on the GHG emissions of the product offering.
- Public reporting on the GHG emissions of a product (this is required to conform with the *Product Standard*).

Each chapter provides further specific examples of goals for the ICT product(s) covered, and where the Guidance should and should not be used.

Questions and concerns related to ICT

There is a growing interest in ICT with respect to GHG emissions, both because of the significant emissions associated with the manufacture and use of ICT products, and because of the opportunity for ICT products to reduce emissions elsewhere (the “enabling effect”).

The following issues and questions are being raised in relation to ICT’s positive and negative impacts on GHG emissions. This ICT LCA White paper does not aim to directly answer these questions but provides mechanisms and tools with which these issues can be systematically investigated.

- Rapid growth of ICT (e.g., driven by use of social networking, smart phones, mobile data usage, internet usage, internet TV, music, and video streaming)
- Exponential growth in the use of cloud services and the data centers that support them.
- Increasing energy efficiency of computing and telecommunications
- Social changes driven by ICT.
- Opportunities to reduce business-related travel through teleworking, telecommuting and remote collaboration.
- Opportunities to indirectly reduce emissions through the use of various smart technologies.
- Rapid changes in technology and promises of new technology development leading to new opportunities and challenges.
- Knowing the best time to replace ICT equipment, considering the improvements in energy efficiency of new equipment versus the embodied emissions.
- As ICT equipment becomes more energy efficient, its embodied emissions may become proportionately more significant than its use-stage emissions.

How to use this ICT LCA White paper

Who should use this ICT LCA White paper

This ICT LCA White paper is intended primarily for use by practitioners using Rejoose to carry out GHG assessments of ICT products. Typically, this will include practitioners working for a company[9] that supplies the ICT product, or a consultant working on behalf of the company. It may also include researchers carrying out studies in the ICT sector and customers wishing to understand and reduce the emissions from the ICT products they use.

The ICT LCA White paper is a supplement to Rejoose and to the *Product Standard*, and thus assumes that the reader is familiar with the principles and content of the *Product Standard*. Where appropriate, this guidance document summarizes and references the *Product Standard*.

Structure of this ICT LCA White paper

The ICT LCA White paper is organized into chapters as shown in Figure 1.1 and described below. Each chapter covers a specific ICT product (or group of products). Because of the modular (building-block) approach taken, a chapter is likely to refer to other chapters that cover the product's constituent elements. This is particularly true for the chapters covering ICT services.

The chapters in this ICT LCA White paper do not provide exhaustive cover of all ICT products; the approach is to prioritize products that have a significant impact in terms of GHG emissions. This Introduction Chapter (together with the Technical Support chapters) provides generic guidance that can be applied to other areas of ICT products not explicitly covered in this ICT LCA White paper. The structure is designed to allow the addition of more chapters in the future.

This Introduction Chapter provides an overview and general guidance common to GHG assessment of ICT products.

The Annexes provide common references and a glossary, which are relevant to all the chapters.

The Services Chapters cover ICT services that a company might supply, or a customer might purchase. These chapters necessarily refer to the Technical Support chapters.

- Telecommunications Network Services
- Desktop Managed Services
- Cloud and Data Center Services

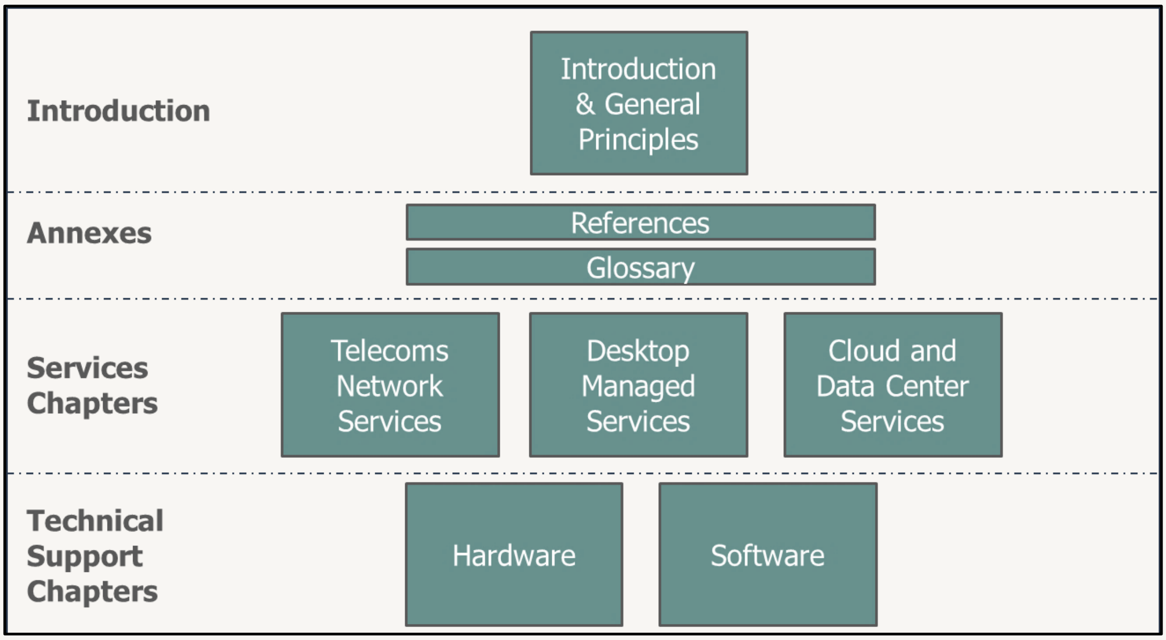
[9] The term company is used in this ICT LCA White paper to represent either a company or an organization that may use the guidance.

The Technical Support Chapters cover the “infrastructure elements” that are common to most ICT services.

- Hardware
- Software (work in progress)

The Appendix covers the use of ICT to avoid GHG emissions in other sectors.

Figure - Chapter structure



As the chapters provide guidance to the *Product Standard*, they follow the structure of the *Product Standard*, using the following headings where appropriate:

- Introduction
- Goal of the chapter
- Business goals for assessing the product
- Scope
- Functional unit
- Boundary setting
- Data collection and data quality
- Allocation
- Calculating inventory results

Key drivers for each chapter

The choice of chapters to include in this guidance has been based on ICT products and services that are widely adopted and/or may have a significant impact in terms of GHG emissions. The following summarizes the key drivers behind each chapter:

Telecommunications network services

Telecommunications networks provide the fundamental support to all modern communications. The rapid growth in the use of the internet, data transfers, mobile communications etc., is leading to significant increases in associated GHG emissions. At the same time, advances in technologies are leading to more energy-efficient networks. The aim of the Telecommunications Network Services (TNS) Chapter is to provide guidance, methodologies, and options to enable practitioners to assess the GHG emissions associated with TNS. This helps to identify the relative size and scale of emission sources within different life cycle stages. Understanding this enables telecommunications providers to communicate and collaborate with suppliers and customers on ways to reduce GHG emissions.

Desktop managed services

Desktop managed services (DMS) is the provision of computing facilities, usually in a corporate environment. It is very broad in scope, encompassing the equipment on the customer's premises (e.g., desktops, laptops, printers), the data center, the local area network (LAN) and the wide area network (WAN), and the supporting human services (e.g., break-fix support, help desk). DMS account for a major part of the ICT sector outsourcing market and a major portion of overall ICT GHG emissions. Customers of DMS are increasingly demanding accurate and transparent information on the GHG emissions of the DMS provided to them for reporting purposes and for identification of areas for potential emissions reduction.

Cloud and data center services

Cloud computing, which is a model for efficiently providing ICT services from a shared pool of remote computing resources (i.e., hardware, data centers, networks, and software applications), can potentially reduce GHG emissions associated with ICT services. This chapter enables cloud and data center service providers and customers to report the GHG emissions from cloud and data center services in a consistent manner and make informed choices to reduce greenhouse gas emissions.

Hardware

ICT hardware is a fundamental component of any ICT system or service. The Hardware Chapter provides guidance on the GHG assessment of ICT hardware. The methodologies described in the chapter cover different calculation methods and provide guidance on different estimation techniques. The chapter also references other standards that cover the GHG assessment of ICT hardware.

Software (work in progress)

Software has a significant impact on the energy used by ICT hardware (because of both the operating system and the applications). Thus, designing software for energy efficiency can reduce the GHG emissions of ICT products (including services). This chapter provides software developers and architects guidance to benchmark and report the GHG emissions from software use in a consistent manner and make informed choices to reduce greenhouse gas emissions. The chapter is in two parts. Part A provides guidance on the full life cycle assessment of software, while Part B relates specifically to the energy use of software and covers the three categories of software: operating systems (OS), applications, and virtualization.

Related standards

Generic product LCA standards

This ICT LCA White paper provides additional guidance for the implementation of the *Product Standard* for ICT products. The *Product Standard* follows a life cycle approach to the GHG assessment of products and builds on the framework and requirements established in the ISO LCA standards: 14040:2006, Life Cycle Assessment: Principles and Framework and 14044:2006, Life Cycle Assessment: Requirements and Guidelines. ISO 14040 and ISO 14044 are considered the base standards for LCA, which other standards are built on.

Two other generic documents for specifying the life cycle assessment of GHG emissions are the PAS 2050 and the ISO 14067. These documents are applicable to any kind of products, but do not give specific guidance for ICT products, hence the need for this ICT specific guidance.

PAS 2050 is a publicly available specification (PAS) for the assessment of life cycle greenhouse gas emissions of goods and services. It was first published in October 2008 by the British Standards Institution (BSI), in partnership with the UK Department of Environment Food and Rural Affairs (DEFRA). A revised edition (PAS 2050:2011) was released in October 2011.

The ISO technical specification 14067 "Carbon footprint of products - Requirements and guidelines for quantification and communication" was published in May 2013.
The relationship between this ICT LCA White paper and these generic product LCA documents is shown in Figure 4.

All three documents (PAS 2050, *Product Standard*, and ISO 14067) address the assessment of life cycle GHG emissions for products, and all are based on ISO 14040 and 14044. Considerable work has been done to ensure alignment on these three standards through the relevant organizations responsible for developing them. The revised version of PAS 2050:2011 allows even closer alignment of the *Product Standard* with the PAS 2050.

Figure - Relationship to generic product LCA standards

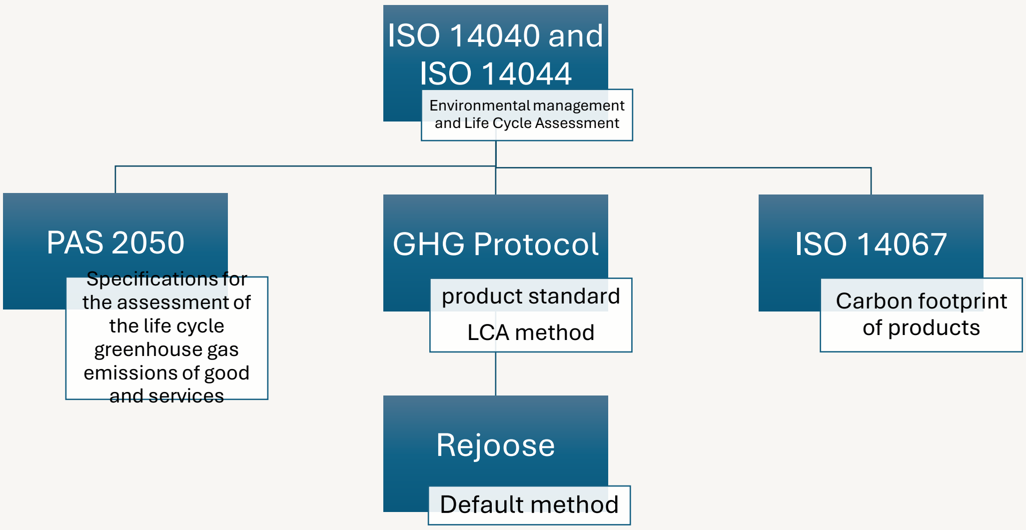


Figure 4'

GHG Protocol Scope 3 Standard

The GHG Protocol Scope 3 Standard and the GHG Protocol Product Standard both take a value chain or life cycle approach to GHG accounting and were developed simultaneously. The *Scope 3 Standard* accounts for value chain emissions at the corporate level, while the *Product Standard* accounts for life cycle emissions at the individual product level (see section 1.6 of the *Product Standard)*. This ICT LCA White paper supplements the *Product Standard*. However, the methodologies in this guidance are also applicable to those categories of the scope 3 standard that relate specifically to products, namely:

1. Purchased goods and services

10. Processing of sold products
11. Use of sold products
12. End-of-life treatment of sold products

ICT-specific LCA standards

Additionally, there are documents published by standards developing organizations (SDOs) that relate to the life cycle assessment of ICT products. These are all based on the ISO 14040 and 14044 standards. They provide general requirements for the assessment of ICT products, generally preferring a detailed approach.

The ICT LCA White paper takes a complementary and more pragmatic perspective to give practitioners more detailed guidance on how to perform LCAs of ICT products and services. It especially focuses on how to prioritize and reduce data collection efforts when a less detailed assessment is needed. Special focus is put on how to define the system boundaries of specific assessment targets.

The ICT-specific LCA standards documents are:

ITU-T L.1410

"Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services"

(International Telecommunication Union [ITU]. Consented September 2011 published March 2012). A revision was published in December 2014, which was developed jointly by ITU-T Study Group 5 and ETSI TC EE. The ETSI Standard ETSI ES 203 199 is technically equivalent to the ITU-T L.1410 and supersedes the previous ETSI TS 103 199.

IEC TR 62725

"Analysis of quantification methodologies of greenhouse gas emissions for electrical and electronic products and systems"

(International Electrotechnical Commission [IEC]. Published March 2013).[3]

[3] ETSI TS 103 199 "Life Cycle Assessment (LCA) of ICT equipment, networks and services: General methodology and common requirements", European Telecommunications Standards Institute [ETSI], published October 2011, superseded by ETSI ES 203 199, December 2014.

General principles of GHG assessments for ICT products

Principles and appropriateness

The principles of product GHG assessments defined in the *Product Standard* (chapter 4) are as follows:

- Relevance
- Completeness
- Consistency
- Transparency
- Accuracy

It is important that the approach taken is appropriate to the product being assessed and to how the results will be used.

Life Cycle Stages

The *Product Standard* (section 7.2) defines five life cycle stages as follows:

- Material acquisition and preprocessing
- Production
- Product distribution and storage
- Use
- End-of-life

These five stages are shown in Figure 1.3 (reproduced from the *Product Standard*).

Note that these stages differ from the standards of ITU and ETSI. Other categorizations of the life cycle are accepted if the significant activities are covered.

For many ICT products the most significant stages (in terms of emissions) are material acquisition, production, and use. Additionally, ICT services may include a stage for "installation" or "service deployment and build," which refers to preparing the ICT service prior to use. This installation stage for ICT services may be accounted for separately or may be included in the standard stage of "distribution and storage."

Figure - Life cycle stages of a product

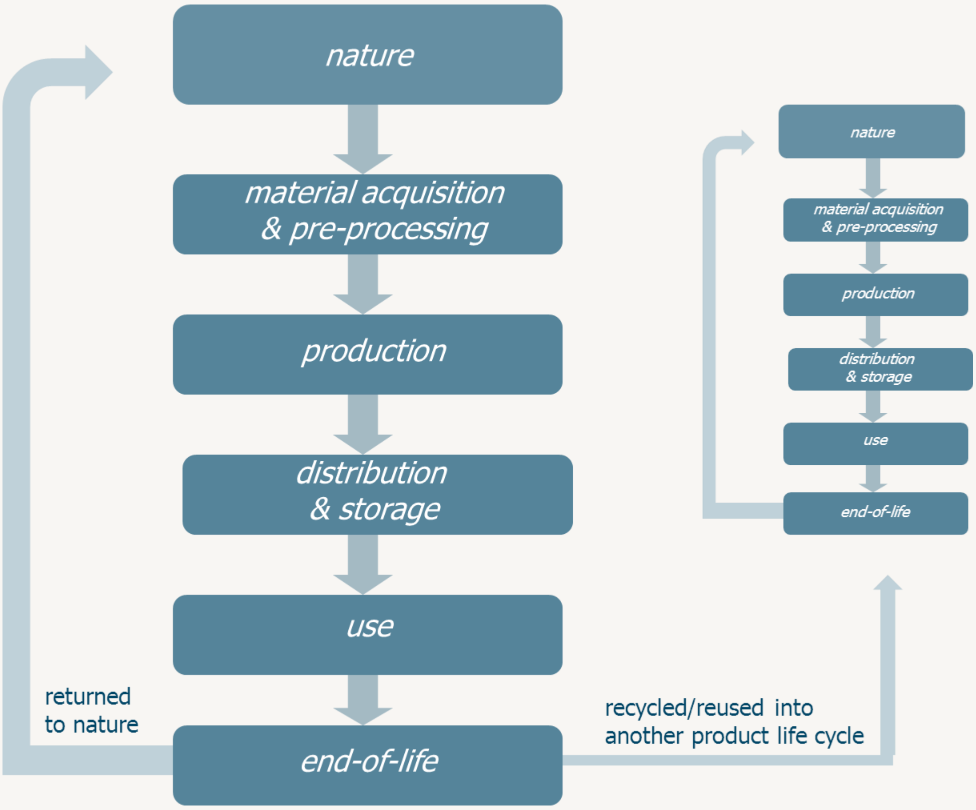


Figure 5

Source: *Product Standard*.

The term "embodied emissions" used in this Guidance combines the emissions from the following life cycle stages: raw material acquisition and preprocessing, production, distribution and transport, installation (by which is meant service deployment and build), and end-of-life treatment (i.e., all life cycle stages other than the use stage). This categorization is for simplicity of reporting, because for many ICT products the use stage is responsible for the majority of the emissions, thus the term "embodied emissions" is often used to refer to all the emissions other than those from the use stage.

Screening assessment

A "screening assessment" is an initial evaluation of a product that aims to identify its significant sources of emissions. This assessment, described in section 8.3.3 of the *Product Standard*, is highly recommended for ICT products. It helps determine the key areas where emissions occur throughout the product's life cycle, enabling a more focused and accurate assessment.

Screening assessments are conducted using readily available data and techniques such as grouping similar elements or employing extrapolation, modeling, and EEIO factors[4]. These methods provide a good enough picture to uncover unexpected emission sources quickly.

In some cases, the screening assessment may provide sufficient accuracy to fulfill assessment goals. For example, if the goal is to identify the life cycle stages with the highest GHG emissions, and the screening assessment clearly highlights those stages, a more detailed assessment may not be necessary. However, it's important to note that to comply with the Product Standard, primary data should be collected for all processes under the ownership or control of the reporting company.

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[4] Environmentally extended input-output (EEIO) models estimate energy use and/or GHG emissions resulting from the production and upstream supply chain activities of different sectors and products within an economy (for further details, see the Product Standard, section 8.3.4).

Significance

Significance is defined in the *Product Standard*, box 7.3 as the size of emissions, removals or GHG intensity. A screening assessment should determine the significance of different elements and stages.

For ICT products the emissions from transport, distribution and end-of-life are often of low significance. If that is the case, it is not necessary to collect detailed primary data on these stages (unless they are under the ownership or control of the reporting company), but rather estimated emissions as determined in the screening assessment can be used.

Similarly for some ICT equipment (e.g., routers) emissions are often dominated by the use stage (this depends on the life of the equipment and the electricity grid factor). If that is the case, it is appropriate to calculate the embodied emissions using modeled data, or sampling techniques, or secondary data (as used in the screening step) rather than performing a detailed assessment of the embodied emissions using measured primary data. Primary data is always required for emissions under the reporting company's ownership or control.

The same approach may be appropriate for complex ICT services, which may include many thousands of similar items of equipment that contribute only a small proportion of the total *emissions of the* service.

For example, for a national telecommunications network of 500,000 individual routers and switches, it would be impractical to carry out a detailed assessment of each equipment item. Rather an estimation approach based on the screening estimate, or some other approach (such as modeling or sampling) would be appropriate, especially where the embodied emissions of the network equipment are likely to be less than 10 percent of the total life cycle emissions for the network.[5]

[5] See the case study in Appendix 2.1 of the Telecommunications Network Services Chapter for a worked example.

Different estimation techniques in cases like this are described in the Hardware Chapter and the Telecommunications Network Services Chapter of this ICT LCA White paper.

Practitioners should apply their expertise to determine which technique or option to use depending on the type of assessment being done and the data that is available. This ICT LCA White paper suggests a number of different techniques.
Because of the rapid changes in the ICT sector (e.g., introduction of new technologies), historical analysis may not always be relevant, and therefore general assumptions may not be reliable to replace a screening assessment.

Depending on the goal and scope of the assessment, a rule of thumb may be used for assessing ICT products where the emissions from a specific life cycle stage or element are determined by the screening assessment to be less than 5 percent of the total emissions. In this case, a detailed assessment for that stage or element is not required. The emissions for that stage or element are then calculated using the percentage determined in the screening assessment. The sum of the emissions calculated in this way (i.e., based on the percentage from the screening estimate) should not exceed 20 percent of the total emissions. It is, of course, always acceptable to do a more detailed assessment if data and time are available.

ICT-specific commentary on the Product Standard

This section follows the chapters of the *Product Standard*, to identify any specific general guidance that is relevant for ICT products.

Scope definition

See also chapter 6 of the *Product Standard.*
It is important to clearly define the scope of the assessment and the period to which the assessment relates. Particularly for ICT services, it is necessary to also provide a definition of the product, which may be an industry standard definition if one exists. The definition will also identify the constituent elements of the product as the "building blocks," which can then be assessed individually. Each chapter of this ICT LCA White paper provides definitions related to the products that it describes.

Functional unit

The functional unit is the quantified performance of the product being assessed and is used as the reference unit against which the product is measured.

The definition of the functional unit should consider the following three parameters:

- The magnitude or quantity of the function that the product fulfills
- The duration or service life (the time required to fulfill the function)
- The expected quality level provided by the product

Some examples of functional units are listed in Table 1 (further examples are given in individual chapters).

Table - Examples of functional units / Climate metrics

Table 1

Product or Service (examples)	Functional unit description (examples)		
	Magnitude	**Duration**	**Quality**
Phone call using a telecommunications network	A minute of voice call over a single carrier's network	One minute phone call	• Listening – e.g., narrow / wideband Mean Opinion Score (MOS) limits • Conversational – e.g., echo / latency limits • Transmission – ITU E-model rating limit
Data transfer using a telecommunications network	• Transfer of 1 megabyte of data • Packet-switched data over a single carrier's network	Extent of time necessary to transfer 1 megabyte of data	• Physical layer net bit rate –10 megabits per second (Mbps) • Includes data link and higher layer overhead
Desktop Managed Service	• 5,000 users (with geographical and service breakdown)	Five year contract	• Service level agreement (SLA), specifying support response times and geographical locations

Boundary setting

See also chapter 7 of the *Product Standard.*

Boundary setting defines what is included and excluded from the assessment. Common guidance is provided here on setting boundary definitions for ICT products, while the individual chapters provide further guidance on boundary setting to provide consistency when assessing similar products.

The *Product Standard* (section 7.2) requires that "the boundary of the product GHG inventory shall include all attributable processes." Attributable processes are defined as any service, material, or energy flows that become the product, make the product, or carry the product through its life cycle.

One of the roles of the IT LCA White paper is to provide sector-specific guidance on the inclusion of specific attributable and non-attributable processes (see section 5.3.2 of the *Product Standard*).

Table 2 and Table 3 provide clarification on some of the key boundary definitions, as recommended by this ICT LCA White paper.

Table - Attributable processes to be included within the boundary definition

Table 2

Attributable process	***Include within boundary***	***Note***
ICT equipment, which is used within the scope of the product (good or service) being assessed	Include the embodied and in-use emissions of the ICT equipment that directly supports or is part of the ICT product that is being assessed	See note 1.
Environmental control (e.g., cooling) of ICT equipment	Include the energy required for the environmental control (HVAC) of ICT equipment, where the equipment directly supports or is part of the service being assessed	See note 2.
Transport of ICT equipment	Include the fuel emissions associated with the transport of ICT equipment	See note 3.
Transport of people	Include the fuel emissions associated with the transport of people, where they are required to deliver or support the ICT product (e.g., maintenance and support engineers)	See note 3.

Table - non-attributable processes that may be excluded from the boundary definition

Table 3

Item	*Exclude from the boundary*	*Note*
Capital goods	Exclude the embodied emissions of capital goods (in alignment with the *Product Standard)*, except where stated otherwise in this ICT LCA White paper.	Except for ICT equipment (see note 1).
Transport	Exclude the embodied emissions of the transport vehicles (but include fuel emissions)	See note 3.
Transport of employees to and from work	Exclude the emissions associated with the transport of employees to and from work.	See also note 4.
Buildings	Exclude the embodied emissions of buildings, due to the building construction (i.e., treat as capital goods).	Except where this is specifically part of the goal of an assessment. See also note 4.

Notes:

1. ICT equipment: A specific issue for assessment of ICT products is the consideration of the ICT equipment itself.

   If the ICT equipment is part of the service being delivered, it is considered an attributable process, and should be included in the assessment. An example is a telecommunications network service, where the emissions of the routers that are part of the physical network should be included in the assessment, as the routers provide the capability to deliver the network service. Both the embodied and the in-use emissions of the routers should be included.

   If the ICT equipment is not part of the product or service being delivered, it should not be included in the assessment. Examples are where computers are used to design the product, or where computers are used for financial accounting of the product.

2. Environmental control (HVAC) of ICT equipment: If environmental control or HVAC (heating, ventilation, and air conditioning) is specifically provided for ICT equipment, such as in a data center or computer server room or cabinet, then the energy required for the HVAC should be included in the assessment. However, for end user ICT equipment in an office environment it may be difficult to separate the HVAC required for ICT equipment from the general office HVAC, thus it is not recommended to include it. Indeed, in this case, heat output from office equipment can, during colder ambient temperatures (e.g., during winter), reduce the need for general heating, whereas during warmer ambient temperatures it can increase the need for air conditioning.

3. Fuel emissions should be for the full life cycle, including upstream emissions caused by extraction and transportation of the fuel.

4. Specific assessments: There are cases where the goal of an assessment may require including or excluding an item in a different manner to that recommended by the guidance in these tables. In all cases it is important to clearly report the boundary definitions chosen for a specific assessment.

Data collection and data quality

See also chapter 8 of the *Product Standard*.

The Product Standard has the following key requirements regarding data collection: “Rejoose collect data for all processes included in the inventory boundary.” “Companies shall receive primary data for all processes under their ownership or control.”

Additionally, the *Product Standard* requires companies to carry out a data quality assessment and provides a suggested framework for this (section 8.3.7 of the *Product Standard*).

The *Product Standard* defines primary data as data from specific processes in the studied product’s life cycle. Secondary data is defined as data that is not from specific processes in the studied product’s life cycle.

For ICT products, data collection usually relates to collecting activity data and emission factors, (the alternative being to directly measure the emissions released from a process). Activity data is the quantitative measure of a level of activity that results in GHG emissions. Activity data can be measured, modeled, or calculated. For ICT products it is often necessary to use modeling techniques (e.g., based on sampling methods) when collecting activity data. (See sections 8.3.4 to 8.3.6 of the *Product Standard* for further clarification of data types and data collection).

This IT LCA White paper recommends adopting a pragmatic approach to data collection, by matching the effort of the data collection for any specific process or item to the expected significance of the related emissions. In the individual chapters, several methods are provided with varying levels of precision. Practitioners are expected to use their judgment in choosing the most appropriate method for a specific product assessment.

Because of the complex nature of ICT products, it may sometimes not be possible to obtain primary data outside the reporting companies' ownership or control or it may not be cost effective to collect the data, and therefore data gaps may exist. The *Product Standard* (section 8.3.10) specifies what may be done to fill data.

Gaps where primary or secondary data cannot be obtained that are sufficiently representative (in order of preference):

- Use proxy data
- Use estimated data

Rejoose operates differentiated data methods, ranging from the standard Average data method to the Vendor specific data.

The purpose of the data quality assessment is to review the quality of data used in the product GHG assessment, and whether the data quality is appropriate for the goal of the product assessment, considering the significance of the different elements of an assessment. Thus, for example, if only "fair" or "poor" quality data is available for a significant element of the assessment, then the data quality assessment should identify steps that will improve the data quality in the future.

Allocation

See also chapter 9 of the *Product Standard.*

Allocation refers to the partitioning of emissions among products where more than one product shares a common process.

Allocation can refer to two situations:

- Allocation of emissions between two or more co-products produced by the same process. A co- product is where one co-product can only be produced when the other co-product(s) is also produced: for example, a soya bean processing plant produces both soy meal and soy oil; a petroleum refinery produces multiple output products (e.g., diesel fuel, heavy oil, petrol) from the one material input (crude oil).
- Allocation of emissions among independent products that share the same process: for example, multiple products sharing the same transport process (vehicle); multiple telecommunication services sharing the same network; multiple cloud services (email, data storage, database applications) sharing the same data center.

The first type of allocation (for co-products) is not common for ICT products, but the second type is very common.

ICT goods often share common manufacturing facilities in their production. ICT services use shared infrastructure (e.g., shared data centers, shared servers and other hardware, shared networks) and shared support arrangements (e.g., service centers, engineers, designers). The advent of cloud computing and desktop virtualization has accelerated this trend. Sharing can happen in various ways (e.g., between different services used by the same customer or between the same type of service used by different customers).

The most appropriate allocation method for ICT services involves prorating the *usage* of the shared component. The method chosen should most closely reflect the underlying use of the shared component, based on the limiting or constraining factor.

The individual chapters provide more specific guidance on allocation methods. Some examples are:

- Use of network: Allocation based on volume of data traffic, number of ports used, or number of subscribers
- Use of software: Allocation based on processing time, or quantity of data processed
- Use of data center: Allocation based on processing time, quantity of data processed, or number of servers used

Note that the ITU-T recommendation L.1410 (see section 5.2.3.3) provides guidance on allocation for ICT equipment, ICT networks, and ICT services.

Assessing uncertainty

See also chapter 10 of the *Product Standard.*

The term "uncertainty assessment" refers to a systematic procedure to quantify or qualify the uncertainty in a product inventory, where uncertainty refers to the range of values for a specific parameter, or more generally to the lack of certainty in data or methodology such as incomplete data, or non-representative factors.

The *Product Standard* requires that "companies shall report a qualitative statement on sources of inventory uncertainty and methodological choices." It also states that "identifying and documenting sources of uncertainty can assist companies in understanding the steps needed to improve inventory quality and increase the level of confidence users have in the inventory results."

The *Product Standard* describes three types of uncertainty in section 10.3.2: parameter uncertainty, scenario uncertainty, and model uncertainty. The relevant table from this section is reproduced here as Table.

Table - Types of uncertainty and corresponding sources

Table 4

Types of uncertainty	Sources
Parameter uncertainty	• Direct emissions data • Activity data • Emission factor data • Global warming potential (GWP) factors
Scenario uncertainty	• Methodological choices
Model uncertainty	• Model limitations

Uncertainty can be a significant issue when assessing ICT products because of, for example:

- the complex and extensive nature of some ICT services
- the long and complex supply chains for manufacture of ICT hardware
- the difficulty in obtaining precise measurements of the use stage
- shared use of ICT resources

It is therefore important to have techniques to reduce the level of uncertainty.

The following approaches are recommended:

- Appropriate sampling techniques
- Sensitivity analysis
- Reporting of the estimated uncertainty

For extensive ICT systems (e.g., with many components, covering multiple geographies, or using a wide range of different hardware), it may not be possible to obtain data for all the individual elements of the system. In this case, a suitable statistical sampling method should be used.

To reduce the uncertainty caused by assumptions or lack of data, carrying out a sensitivity analysis is recommended. This involves adjusting parameters of the assumptions or parameters that affect the data estimates and recalculating the results. Repeating this process for a range of values for several parameters will provide an indication of which parameters have the most significant effect, as well as the likely range for the results. Consider, for example, an ICT service that involves 1,000 users of PCs. Because it is not possible to get accurate measurements on the number of hours per week that the PCs are used, a range of scenarios are analyzed for different use profiles. By changing the number of users for each profile, it is possible to build up a sensitivity analysis. Typically, a sensitivity analysis will involve building an automated model to investigate different scenarios.

Calculating inventory results

See also chapter 11 of the *Product Standard.*

This section describes the general approaches for calculating the GHG inventory results. In the chapters in this ICT LCA White paper, specific calculation and estimation techniques are described.

Calculating GHG emissions

Carbon dioxide equivalent (CO_2e) is used to provide a common figure for measuring the impact of different greenhouse gases. It is determined by multiplying the mass of a given greenhouse gas by its global warming potential (GWP). GWP is a factor describing the radiative forcing impact of 1 kilogram of a given greenhouse gas relative to a kilogram of carbon dioxide over a given period.

The *Product Standard* (section 11.2) requires using a GWP for a 100-year time period and recommends that “Companies should use GWP values from the Intergovernmental Panel for Climate Change (IPCC) Sixth Assessment Report, published in 2022, or the most recent IPCC values when the Fifth Assessment Report is no longer current.”[6]

The general approach for calculating GHG inventory is to multiply the activity data by the appropriate emission factor:

$GHG\ Impact$ (kg CO e) = $Activity\ Data$ (unit) × $Emission\ Factor$

Activity data refers to the quantified measure of an activity that gives rise to GHG emissions. It can refer to the quantity of a physical material or substance, or to the amount of activity. The following two examples are given to illustrate:

1. A server casing weighs 700g and is made of sheet steel. Using an emission factor for steel of 2.51 kg CO_2e per kg of steel, the GHG impact is calculated as follows:
   $GHG\ Impact$ = 0.7 (kg) × 2.51 (kg CO_2e/kg) = 1.76 (kg CO_2e)
2. A router draws 800W and is on for 24 hours, thus uses 0.8 x 24 = 19.2 kWh per day. Using an emission factor for electricity of 0.60 kg CO_2e per kWh, the GHG impact is calculated as follows:
   $GHG\ Impact$ = 19.2 (kWh per day) × 0.60 (kg CO_2e⁄kWh) = 11.5 (kg CO_2e per day)

[6] The IPCC Sixth Assessment Report was published in 2022 with updated GWP values.

Chapter 7 Supplementary Material https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07_SM.pdf

Calculating GHG emissions from the use stage

For many ICT goods and services, the use stage dominates the total emissions. Use stage emissions are primarily caused by the ICT hardware's use of electricity. The five steps below provide an overview of how Reoose calculate GHG emissions from the use stage.

Measure or calculate the power consumption

Obtain power usage for the ICT hardware in different power modes (e.g., full power, low power, standby)

Measure or define the company use profile

The use profile reflects the amount of time that the hardware is in the different power modes (or switched off). This should be established over a representative time period. Where direct measurements are not possible, sampling or surveys should be used, or a set of use-profile scenarios may be used.

Calculate the energy used

The energy used is calculated by multiplying the power by the use profile.

Allocate overhead energy

Overhead energy is typically the energy used for cooling the ICT equipment, but may also include heating of the building, diesel fuel used for generators, energy used in backup systems such as UPS (uninterruptible power supply) and ICT infrastructure. The preferred approach is to calculate the total overhead energy and then allocate a proportion based on a usage factor; an alternative approach is to multiply the energy used by a power usage effectiveness (PUE) ratio. (Refer to the Cloud and Data Center Chapter for a more detailed description of allocating overhead energy). In some cases, it is possible to measure directly the energy used to provide cooling for a specific item of hardware (for example cabinets for ICT equipment that have a separate power supply for cooling).

Convert energy used into GHG emissions

The GHG emissions are calculated by multiplying the energy used by the appropriate country specific emission factor.

Electricity grid emission factors

The emission factor for the electricity used should be appropriate for the country where the electricity is consumed. Electricity grid emission factors are updated in Rejoose and can be chosen for each solution you add or when receiving data from Data integration its automatically using an emission factor from the country of use. Because of the potential high impact on the result, Rejoose ensures the most up-to- date emission factors are used.

Electricity grid emission factors should be used that include the full life cycle of the energy source (i.e., include emissions from extraction and transportation of the fuel, as well as generation and transmission).

For guidance on selection of electricity emission factors see the *Product Standard* section 8.3.4 and box 8.3, which states that "When an electricity supplier can deliver a supplier-specific emission factor and these emissions are excluded from the regional emission factor, the supplier's electricity data should be used.

Note also that the GHG Protocol Scope 2 Guidance[7] has been published since the *Product Standard* was published; this provides additional guidance for scope 2 accounting to clarify the treatment of green power. The Scope 2 Guidance defines two methods for determining emission factors: the location-based method, which reflects average emissions of the grids where the emissions occur (typically using grid-average emission factors); and the market-based method, which reflects the emissions of the electricity purchased (using emission factors derived from contractual instruments). It is important to state which factors are used, and best practice is to report using both location-based and market-based methods. Where on-site generation of electricity occurs then the emission factors should reflect this, and again this should be clearly stated. It is also recommended to report both energy consumed and GHG emissions.

[7] GHG Protocol, "Scope 2 Guidance", 2015. Available at http://www.ghgprotocol.org/scope_2_guidance

Calculating GHG emissions due to transport

Although transport is not specific to ICT, and usually it is not a large proportion of the total emissions, it is a common process, thus the following general guidance is provided:

Transport of goods

Either of two methods may be used to calculate the GHG emissions from transportation of goods:

- **Fuel-based method**: involves determining the amount of fuel consumed and applying the appropriate emission factor for that fuel.

  $= Quantity\ of\ fuel\ consumed\ (liters) \times emission\ factor\ for\ the\ fuel\ (kg\ CO_2e/liter)$

  Where fuel data is available, this is the preferred method.

  Note fuel emission factors should be for the full life cycle, including upstream emissions caused by extraction and transportation of the fuel.

- **Distance-based method**: involves determining the mass or volume, distance, and mode of each transport leg, then applying the appropriate mass-distance emission factor for the vehicle used.

  $$= \sum \{Quantity\ of\ goods\ (mass\ or\ volume\ ) \times\ distance\ travelled\ in\ transport\ leg\ (km) \times emission\ factor\ of\ transport\ mode\ or\ vehicle\ type\ (kg\ CO_2e/(mass\ or\ volume)/km)\}$$

For the distance-based method, the load utilization of the vehicle should be considered (i.e., percentage full).

For both methods, where the vehicle is shared with other goods, allocation of the emissions among goods should be made. This allocation is based on either mass or volume, depending on which is the constraining factor, for example, mass is usually the constraining factor for road, rail, and air (except for goods with a low density).

For both methods, the calculation should consider the emissions caused by empty backhaul (i.e., where the vehicle returns empty or partly empty).

Transport of people

Most ICT services include the transport of personnel to deliver the service. The calculation of the emissions uses the distance traveled and an appropriate emission factor for the mode of transport (e.g., train, car, air).

$= distance\ traveled\ (km) \times emission\ factor\ of\ transport\ mode\ (kg\ CO_2e/passenger \cdot km)$

Where the emissions from transport (of both goods and people) are a small proportion of the total emissions, it is appropriate to use an estimation approach to calculate the transport emissions. The screening assessment will help to determine the significance of the transport emissions.

Sources of emission factors

Commonly used emission factors cover the following:

- Electricity emission factors
- Fuel and transport related emission factors
- Process emission factors
- EEIO emission factors

References to third party databases are available from the GHG Protocol website: http://www.ghgprotocol.org/Third-Party-Databases

Discussion of emission factors is in section 8.3.4 of the *Product Standard.*
Further discussion and examples of sources of emission factors are in the References annex of this ICT LCA White paper.

Assurance

See also chapter 12 of the *Product Standard.*
The *Product Standard* (section 12.2) requires that "the product GHG inventory shall be assured by a first or third party." It states that "assurers are defined as person(s) providing assurance over the product inventory and shall be independent of any involvement in the determination of the product inventory or development of any declaration. Assurers shall have no conflicts of interests, such that they can exercise objective and impartial judgment."
The assurance can be achieved through two methods:

- Verification, or
- Critical review

Critical review can be performed either by an internal or external expert, or by a review panel of interested parties (where the panel should be comprised of at least three members).
ICT products are often characterized by a short life because of rapid changes in technology and, for services, by the bespoke nature of those services. It is recognized that for rapidly changing and bespoke products, there is potentially a proportionately higher overhead to carrying out a GHG assessment and assurance than for longer-life, standard products.
It is therefore appropriate to choose the method of assurance relative to the type of product, and to how the results are to be communicated.

For example, for a one-off bespoke ICT service to be delivered to a single business customer, where the results are to be communicated only to the customer, it would be appropriate to use critical review by an internal expert or an internal panel. Conversely, for a major consumer-facing product, where the results are to be made publicly available, it would be more appropriate to use verification by a third party.

When selecting a competent assurer for ICT products, in addition to the qualities listed in the *Product Standard* (section 12.2), it is important that the assurer has a good technical understanding of the product that is being assessed.

The assurance process should:

- Ensure that the methods used in the assessment are consistent with the *Product Standard* and with this ICT LCA White paper
- Review data sources and data quality
- Check calculation methods
- Review documentation

Reporting requirements

See also chapter 13 of the *Product Standard.*

The *Product Standard* (section 13.2) specifies the general reporting requirements for a GHG assessment. The following additional specific requirements relate to ICT products:

- For reporting on ICT hardware by life cycle stage, if it is not possible to separate the raw material and production stages, they may be reported as a combined stage.
- For complex ICT services, if the service has been defined as separate constituent elements (following the guidance in this ICT LCA White paper), the emissions associated with each element should be reported separately.
- For the use stage, both energy consumed (kWh) and equivalent GHG emissions (kg CO_2eq) should be reported. The electricity emission factor(s) used should be clearly stated.
- For ICT products that have an enabling effect, the "avoided emissions" shall not be included in the product's total inventory results but should be reported separately.

Appendix:

References and Glossary

August 2022

This Guidance has been reviewed for conformance with the GHG Protocol Product Standard.

References - Sources of Emission Factors

The following provides references to some common sources of emissions factors: Commonly used emission factors cover the following:

- Electricity emission factors
- Fuel and transport related emission factors
- Process emission factors
- EEIO emission factors

References to a number of third-party databases are available from the GHG Protocol website: There is also discussion of emission factors in section 8.3.4 of the *Product Standard.*
Table 1 below references some commonly used sources for emission factors.
Global electricity emission factors for different countries are provided in a comprehensive and accessible format by the following three sources: GHG Protocol, Defra, Carbon Trust. Note that all of these derive the data from information from the International Energy Agency (www.iea.org).

Table 1 Sources of Emission Factor data

Organization	*Type of data*	*Link*
GHG Protocol	Calculation tools and Emission Factors	http://www.ghgprotocol.org/calculation-tools/all-tools
Defra, UK Government	Emission Factors	https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
ELCD	Emission Factors	http://eplca.jrc.ec.europa.eu/ELCD3/
Ecoinvent	Emission Factors	https://ecoinvent.org/
GaBi	LCA tool and databases	http://www.gabi-software.com/databases/gabi-databases/
Carnegie Mellon University, Green Design Institute	EIO LCA model	https://engineering.cmu.edu/caces/tools-results.html

Glossary of Terms

Term	***Term Type***[1]	***Definition***
3GPP	Standard	The 3rd Generation Partnership Project[2] (3GPP) unites six telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TTA, TTC).
Activity data	GHG	Quantitative measurement of activity from a product's life cycle that, when multiplied by an emission factor, determines the GHG emissions arising from a process. *Examples of activity data include the amount of energy used, quantity of material used, quantity of service used or provided.*
ACPI	ICT	Advanced Configuration & Power Interface.
Allocation	GHG	Allocation refers to the partitioning of emissions between products where more than one product shares a common process. [See also Introduction Chapter 1.8.4 and the *Product Standard* Chapter 9].
API	ICT	Application programming interface.
Assessment	GHG	As used in this Guidance, refers to the assessment of the GHG emissions over the life cycle of a product. [See also LCA].
ATIS	Standard	Alliance for Telecommunications Industry Solutions.
Attributable process	GHG	Attributable processes are any service, material and energy flows that become the product, make the product, and carry the product through its life cycle. [See also Introduction Chapter 1.8.2 and the *Product Standard* 7.2].
Avoided emissions	GHG	Avoided emissions are reductions in emissions caused indirectly by a product. This is where a product provides the same or similar function as existing products in the marketplace, but with significantly less GHG emissions. [See also Introduction Chapter 1.1.5 and the *Product Standard* 11.2 and 11.3.2].
B2B	Other	Business to Business.

[1] GHG Emissions reporting terminology, ICT terminology, Standards Body, or other terminology

[2] http://www.3gpp.org/

Term	Term Type[1]	Definition
B2C	Other	Business to Consumer.
BSI	Standard	British Standards Institution.
CAPEX	Other	Capital Expenditure.
Cloud	ICT	Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
CO_2e	GHG	Carbon dioxide equivalent. This is the unit of measure used for comparing the radiative forcing of a GHG to carbon dioxide. [See also GWP].
Colo (Colocation Data Center)	ICT	A colocation data center is an independently owned and run building where multiple data or telecommunications carriers locate their connections next to one another, enabling customers in the building to interconnect to them with a minimum of cost and complexity[4].
CPE	ICT	Customer Premises Equipment (also known as Customer Domain Equipment).
CPU	ICT	Central Processing Unit.
CRAC	ICT	Computer Room Air Conditioning.
DEFRA	Other	UK Government Department for Environment Food and Rural Affairs.
DHCP	ICT	Dynamic Host Configuration Protocol (DHCP) is a network protocol.
DMS	ICT	Desktop Managed Services. (Services provided by specialist ICT companies to businesses to manage their desktop environments (such as PCs, laptops, tablets and smartphones). [see DMS Chapter 3.2]
DNS	ICT	Domain Name System.

Term	Term Type[1]	Definition
DSLAM	ICT	Digital subscriber line access multiplexer. (DSLAM is a network device, which connects multiple customer digital subscriber line (DSL) interfaces to a high-speed digital communications channel using multiplexing techniques).
EEIO	GHG	Environmentally extended input-output. EEIO models estimate GHG emissions for different product sectors, by allocating national GHG emissions to groups of products based on economic flows. [see Box 8.2 in the *Product Standard*]
Embodied emissions	GHG	The term "embodied emissions" used in this guidance combines the emissions due to the following life cycle stages: raw material acquisition and preprocessing, production, distribution and transport, installation and end-of-life treatment (i.e. all life cycle stages other than the use stage). [See also Introduction Chapter 1.7.2].
Emission	GHG	Releases to air and discharges to water and land that result in GHGs entering the atmosphere.
Emission factor	GHG	Amount of greenhouse gases emitted, relative to a unit of activity.
Enabling effect	GHG / ICT	An "enabling effect" is the opportunity an ICT solution has to avoid GHG emissions in other sectors, which can be attributed back to the ICT solution as the prime cause of that avoidance. [See also 'avoided emissions'].
ERP	ICT	Enterprise Resource Planning.
ETSI	Standard	European Telecommunications Standards Institute.
FTE	Other	Full Time Equivalent.
Functional unit	GHG	The functional unit is the quantified performance of the product being assessed, and is used as the reference unit against which the product is measured. [See also Introduction Chapter 1.8.1 and the *Product Standard* 6.3.2].
GHG	GHG	Greenhouse gas.
GHG emission	GHG	Release of GHGs to the atmosphere.

Term	*Term Type*[1]	*Definition*
GWP	GHG	Global Warming Potential. GWP is a factor describing the radiative forcing impact of one kg of a given greenhouse gas relative to a kg of carbon dioxide over a given period of time. [See also Introduction Chapter 1.8.6 and the *Product Standard* 11.2 and 11.3.1].
HVAC	ICT	Heating, ventilation, and air conditioning.
I/O or IO	ICT	Input Output.
IC	ICT	Integrated Circuit.
ICT	ICT	Information and Communication Technology. This guidance document follows the OECD definition, which has the following guiding principle: “ICT products must primarily be intended to fulfill or enable the function of information processing and communication by electronic means, including transmission and display.” [see also the Introduction Chapter 1.1]
IEC	Standard	International Electrotechnical Commission.
IEEE	Standard	Institute of Electrical and Electronics Engineers.
IH	ICT	ICT Hardware.
IMAC	ICT	“Installs, Moves, Adds and Changes” – term related to activities of maintenance engineers supporting DMS.
iNEMI	ICT	International Electronics Manufacturing Initiative.
Inventory Results	GHG	The GHG impact of the studied product per unit of analysis. [See also Introduction Chapter 1.8.6 and the *Product Standard* chapter 11].
IP	ICT	Internet Protocol.
ISO	Standard	International Organization for Standardization.
IT	ICT	Information Technology.

Term	Term Type[1]	Definition
ITU	Standard	International Telecommunication Union.
LAN	ICT	Local Area Network.
LCD	ICT	Liquid Crystal Display.
LCI	GHG	Life Cycle Inventory.
LCIA	GHG	Life Cycle Inventory Assessment.
Life cycle	GHG	Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end-of-life.
Life cycle assessment (LCA)	GHG	Compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its lifecycle.
Materiality	GHG	Materiality is the condition when individual or aggregate errors, omissions, and misrepresentations have a significant impact on the GHG inventory results and could influence a user's decisions. [See the *Product Standard* 12.3.3]
MME	ICT	Maximum Measured Electricity.
MPLS	ICT	Multi-Protocol Label Switching. (A protocol in telecommunications networks that directs data from one network node to the next).
Network	ICT	A telecommunications network is a series of points or nodes interconnected by communication paths[6]. Networks allow the transfer of data and sharing of computing resources through groups of interconnected computers and peripherals.
NIST	Standard	National Institute of Standards and Technology.
Non-attributable process	GHG	Processes and services, materials and energy flows are not directly connected to the studied product because they do not become the product, make the product, or directly carry the product through its life cycle. [See also Introduction Chapter 1.8.2 and the *Product Standard* 7.2].

[6] This definition is from http://searchnetworking.techtarget.com. Other definitions of networks include "Any thing reticulated or decussated, at equal distances, with interstices between the intersections" (Dr. Samuel Johnson, author of the 1755 Dictionary and owner of Hodge).

Term	*Term Type*[1]	*Definition*
OEM	ICT	Original Equipment Manufacturer.
OS	ICT	Operating System.
PAIA project	ICT	Product Attribute to Impact Algorithm, project run by the Massachusetts Institute of Technology (MIT).
PDU	ICT	Power Distribution Unit.
Primary data	GHG	Data from specific processes in the studied product's life cycle.
Product	GHG	A product is defined as "any good or service". This Guidance includes both "networks" and "software" in the definition of products, as ICT services.
Proxy data	GHG	Data from a similar activity that is used as a stand-in for the given activity. Proxy data can be extrapolated, scaled up, or customized to represent the given activity.
PUE	ICT	Power Usage Effectiveness. PUE[7] is a metric which represents the ratio between the total facility power and the IT equipment power of a data center.
PWB	ICT	Printed Wiring Board (also referred to as Printed Circuit Board).
RPP	ICT	Remote Power Panel.
Screening Assessment	GHG	A screening assessment is an initial assessment of a product to understand what the significant and relevant sources of emissions are. [See also Introduction Chapter 1.7.3 and the *Product Standard* section 8.3.3].
Secondary data	GHG	Data that is not from specific processes in the studied product's life cycle.
Significance	GHG	Significance is defined in the *Product Standard* (box 7.3) as the size of emissions, removals or GHG intensity. [See also Introduction Chapter 1.7.4].

[7] The Power Usage Effectiveness (PUE) ratio was developed as a key data center efficiency metric by The Green Grid consortium http://www.thegreengrid.org/

Term	*Term Type*[1]	*Definition*

SLA	ICT	Service Level Agreement.
SNMP	ICT	Simple Network Management Protocol.
SPC	ICT	Storage Performance Council.
SPEC	Standard	Standard Performance Evaluation Corporation.
TNS	ICT	Telecommunications Network Services.
TPC	ICT	Transaction Processing Performance Council.
TPCF	ICT	Typical Power Consumption Factor.
Uncertainty	GHG	Uncertainty refers to the range of values for a specific parameter, or more generally to the lack of certainty in data or methodology such as incomplete data, or non-representative factors. The term uncertainty assessment refers to a systematic procedure to quantify or qualify the uncertainty in a product inventory. [See also Introduction Chapter 1.8.5 and the *Product Standard* chapter 10].
UPS	ICT	Uninterruptable Power Supply.
VM	ICT	Virtual Machine.
VMM	ICT	Virtual Machine Manager.
VoD	ICT	Video on Demand.
WAN	ICT	Wide Area Network.