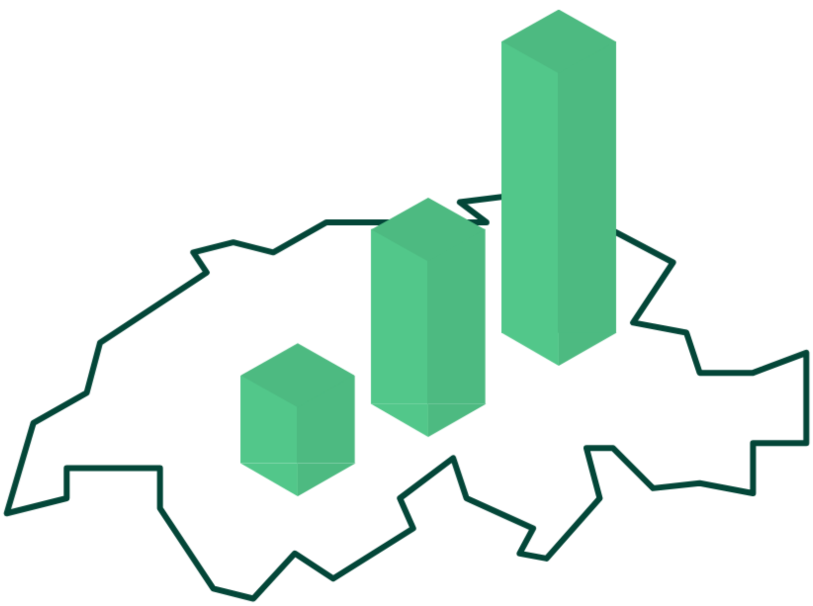
Environmental impacts of the ICT sector in Switzerland

Study report
v1.0 – September 2025



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Study: Environmental impacts of the ICT sector in Switzerland

Version: 1.0

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About us

Resilio supports organisations in reducing the environmental footprint of their digital infrastructures or services. It is a private company that, rather than pursuing profit maximization, is driven by a desire to make a difference by creating significant positive impacts.

Resilio has developed a unique set of tools & methods enabling easier, faster and more accurate Life Cycle Assessment (LCA) of Information and Communication Technologies (ICT) with up-to-date data.

The **Lab team** is dedicated to pushing the boundaries of knowledge in the field. It is carrying research including this study.

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Abstract

Context

Human activities have a profound impact on the world around us, particularly on biodiversity and the environment. The expansion of industries, urbanization and deforestation are altering ecosystems and threatening countless species. Pollution, excessive resource consumption and climate change further accelerate this decline, reducing the planet's ability to regenerate itself.

Switzerland signed in 2016 along with 196 nations the **Paris Agreement**[1]. It aims to limit global warming to well below 2°C above pre-industrial levels, with efforts to cap the increase at 1.5°C. In January 2025, the Federal Council approved new objectives to reduce greenhouse gas emissions by 65 % compared to 1990, which implies an average decrease of 59 % between 2031 and 2035[2]. Despite record growth in renewable installations, current projections indicate a **significant shortfall in meeting this target**. Significant efforts are essential to bridge this gap and fulfil the Paris Agreement objectives.

Parallel to its environmental initiatives, Switzerland has been proactive in embracing the digital transformation. The **"Digital Switzerland" strategy**[3] outlines the nation's vision for a sustainable and responsible digital future, using digital technologies as a tool to emphasize inclusivity and innovation to answer current challenges.

In this context, **digital technology** plays a complex role. While it may seem immaterial at first glance, it is deeply rooted in reality. The extraction of raw materials, the operation of energy-intensive datacentres, and the increasing volume of electronic waste **notably contribute to pollution and resource depletion**.

While these technologies can offer solutions for environmental monitoring, energy efficiency, and sustainable development, they also have a significant ecological footprint which cannot be overlooked. As digital technologies continue to evolve, it is crucial to assess and **mitigate their environmental impacts to ensure a more sustainable future**.

To answer this need, Resilio, in collaboration with many institutions such as the International Telecommunication Union (ITU), the EPFL and many more, has decided to **conduct a study aiming to evaluate the impacts of these technologies in Switzerland**. This allows to identify the main sources of impacts to inform policy-makers an contribute to raising awareness among Swiss citizens.

To fulfil these objectives, this study aims at publishing:

- Up-to-date data on the impacts of Information and Communication Technologies (ICT) in Switzerland in 2024;

[1] https://unfccc.int/process-and-meetings/the-paris-agreement
[2] https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate--international-affairs.html#-1381339056
[3] https://digital.swiss/en/

- Predictions of the impacts of ICT in Switzerland in 2035;
- A rigorous and transparent methodology based on the principles of Life Cycle Assessment (LCA);
- A list of recommendations to comply with the pre-established objectives mentioned above.

Methodology

Life Cycle Assessment (LCA) is a method used to assess the environmental impacts of a system through its different life cycle phases which are here the following:

1. **Manufacturing**: From the extraction of raw materials to the production in a factory;
2. **Transportation**: From the factory to the consumer;
3. **Usage**: Impacts related to the usage of the product or service, mainly its electricity consumption;
4. **End of life**: Treatment of waste, recycling, incineration and/or landfilling of waste.

The perimeter under study is defined as the entirety of **digital equipment and infrastructures** in use in **Switzerland**, for **personal or professional use**. Digital technologies are considered looking at three main tiers:

1. **End-user equipment**: Every digital device used directly by individuals, ranging from smartphones and laptops to printers and connected objects, for private and business use;
2. **Telecommunication networks**: Fixed and mobiles networks throughout Switzerland, including optic fibres, copper cables, etc.;
3. **Data centres**: From smaller and local data centres to bigger data centres dedicated to Artificial Intelligence (AI) and high-performance computing.

Six environmental impact categories are studied in detail to assess the environmental impacts, among them: climate change, fine particles, minerals/metals and fossils resource use. This study aims to adhere as closely as possible to the norms ISO 14040:2006, ISO 14044:2006, ITU-T L.1410 and ITU-T L.1450.

Key results

The key results from this study are the following:

- **Switzerland is a highly digitalised** country. In 2024, 99% of the population regularly accesses the internet and each inhabitant owns an average of 6 digital devices. ICT infrastructures consume 12% of Switzerland's electricity consumption, and half of it is dedicated to data centres.
- ICT consumes **substantial portions of the safe operating space delimited by the planetary boundaries**, particularly for mineral resource use, freshwater ecotoxicity and climate change. Its **footprint is increasing rapidly**, with expected increases ranging from 27% to 151% **until 2035**, depending on the environmental categories. These trends are due to the increase of the population and the growth of new usages (generative AI, virtual reality, etc.).
- **Material resource use plays a critical role**. Digital technologies consume 65% of the annual sustainable budget defined by planetary boundaries in terms of the use of mineral and metal resources. It is expected to increase to 83% by 2035. This is particularly concerning given the **rising**

demand for electronics** in sectors such as health, mobility and renewable energy, which compete for the same critical materials.

- **End-user equipment** are the **main driver of environmental impacts** in Switzerland **in 2024**, mainly due to their manufacturing phase, which involves intensive resource extraction and energy use. However, the trends until 2035 show that data centres and networks footprints are increasing and **data centres are going to concentrate the most impacts by 2035**. Zurich area, is at the heart of this trend as it is the second largest AI development hub in Europe.

Although the development of these technologies and digitalization can be levers to reduce environmental impacts globally, this study highlights the fact that the development of ICT technologies should be carefully considered and regulated. There is a need for targeted mitigation strategies as well as a broader governance framework to **ensure the sustainability of the digital transformation**.

Recommendations

It is essential to act upon these conclusions to address the environmental challenges posed by digital technologies. The recommendations presented in this study are structured around three main objectives. These objectives and some key recommendations are given below:

- **Decrease the need of manufacturing of new devices**:
    - **Extending the lifespan of devices currently in use** by designing more robust and reparable devices, buying second-hand and ensuring proper collection end-of-life devices to recycle or reuse electronic components.
    - **Reducing the number of devices** by mutualising equipment between multiple users or between personal and professional use (BYOD policy).
- **Design and manufacture more efficient equipment and infrastructures**:
    - **Design equipment that are less resource-intensive**: consuming less electricity, recyclable, using recycled material, etc.
    - Create and democratise **standards and labels** for more energy efficient devices.
    - Offer systematic **eco-design training** in engineering schools.
- **Arbitrating digital usage**:
    - **Critically assessing and moderating the use** of digital technologies to ensure they meet genuine needs without excess.
    - **Inform and consult citizens** regarding the environmental consequences of digital technologies, promoting a collective approach to sustainable digital transitions.
    - **Shift** towards **business models** that reduce dependency on the continuous production and sale of new electronic devices, exploring alternatives such as product-as-a-service or refurbishment schemes.

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Glossary

Bring Your Own Device (BYOD): It is a policy that enables employees in an organization to use their personal devices for work purposes. This typically applies to smartphones and laptops.

Life Cycle Assessment (LCA): It is a standardised assessment method for carrying out a multi-criteria and multi-stage environmental assessment of a system (product, service, company or process) over its entire life cycle (design, manufacture, use, end of life, etc.).

Paris Agreement: Signed in 2016 and endorsed by 196 nations including Switzerland, it aims to limit global warming to well below 2°C above pre-industrial levels, with efforts to cap the increase at 1.5°C.

Planetary boundaries: They are critical ecological thresholds that define a safe operating space for humanity. These thresholds aim to quantify the limits within which global environmental systems can continue to function stably and sustainably. Using the planetary boundaries allows an absolute sustainability assessment, and therefore moving beyond simply reducing the environmental impact to ensuring that human activities stay within the absolute limits of the Earth.

Rebound effect: It is a phenomenon characterised by a partial or full offset of expected positive impacts due to unintended changes in behaviour or consumption pattern. A typical example would be an increase in consumption that offset energy savings that were anticipated from efficiency improvements.

Sensitivity analysis: It is a type of analysis that is part of the impact interpretation phase of a life cycle assessment. It consists of varying a parameter (quantity, lifespan, mass, etc.) to study the influence on the results. This makes it possible to determine what the dimensioning parameters are and to estimate the uncertainty on the results and to strengthen the reliability of the study as a whole.

Acronyms

Acronym	Meaning
ADP	Ablation Depletion Potential
BYOD	Bring Your Own Device
CTU	Comparative Toxic Unit for ecosystems
DSLAM	Digital Subscriber Line Access Multiplexer
Epf	Eutrophication, freshwater
FTTH	Fiber To the Home
GWP	Global Warming Potential
HDD	Hard Disk Drive
IC	Impact Category
ICT	Information and Telecommunication Technologies
ISO	International Organization for Standardisation
ITU	International Telecommunication Union
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Analysis
LCS	Life Cycle Stage
OCN	Optical Collection Node
OFCOM / BAKOM	Office Fédéral de la Communication / Bundesamt für Kommunikation
OLT	Optical Line Termination
PEF	Product Environmental Footprint
PM	Particulate Matter
PoP	Point of Presence
SSD	Solid State Drive

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1 Introduction

The role of human activities in environmental crises is now undeniable, as stated in the sixth assessment report of the Intergovernmental Panel for Climate Change[4]. The expansion of industries, urbanization, and deforestation are altering ecosystems, threatening countless species and disrupting the delicate balance of nature. Pollution, excessive resource consumption, and climate change further accelerate this decline, **reducing the planet's ability to regenerate itself**.

The Paris Agreement signed in 2016, endorsed by 196 nations including Switzerland, aim to limit global warming to well below 2°C above pre-industrial levels, with efforts to cap the increase at 1.5°C[5]. Despite record growth in renewable installations[6], **current projections indicate a significant shortfall[7] in meeting this target**. **Significant efforts are essential to bridge this gap** and fulfil the Paris Agreement objectives.

In this context, **digital technology plays a complex role**. While it may seem immaterial at first glance, it is deeply rooted in reality. The extraction of raw materials, energy-intensive data centres, and the growing volume of electronic wastes contribute to pollution and resource depletion. It was estimated in 2015 in Switzerland that digital technologies account for about 3% of the total greenhouse gas emissions of the country[8].

While these technologies can offer solutions for environmental monitoring, energy efficiency, and sustainable development, they also have a **significant ecological footprint** which cannot be overlooked. As digital technologies continue to evolve, it is crucial to **assess and mitigate their environmental impact** to ensure a more sustainable future.

To answer this need, Resilio, in collaboration with many institutions such as the International Telecommunication Union (ITU), Swiss Federal Institute of Technology in Lausanne (EPFL) and many more, has decided to **conduct a study** aiming to **evaluate the environmental impacts of these digital technologies in Switzerland in 2024**.

[4] AR6, IPCC, 2021, https://www.ipcc.ch/assessment-report/ar6/
[5] Paris Agreement, United Nation, 2015, https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[6] Switzerland installs 1.78 GW of PV in 2024, PV magazine, https://www.pv-magazine.com/2025/01/27/switzerland-installs-1-78-gw-of-pv-in-2024/
[7] "Les mesures adoptées par la Suisse sont insuffisantes pour limiter le réchauffement climatique", actu-environnement.com, https://www.actu-environnement.com/ae/news/comite-ministres-decision-mesures-suisse-insuffisantes-limiter-rechauffement-climatique-45744.php4
[8] Hilty, Bieser, 2017, Opportunities and risks of digitalisation for climate protection in Switzerland. University of Zurich, Swisscom, WWF https://www.ifi.uzh.ch/dam/jcr:066776d8-d2b0-4c7c-b75d-6b7283cb5791/Study_Digitalization_Climate_Protection_Oct2017.pdf

2 Methodology

The methodology used for this study is Life Cycle Assessment (LCA). It is described in the section below.

2.1 General principles of LCA

2.1.1 Definition

There exist various environmental assessment methods: material analysis, carbon footprint, etc. **Life Cycle Assessment** (LCA) is one of them. It is a methodology that evaluates the potential environmental impacts of a product or service over its lifespan.

Its key characteristics are the following:

- A **multi-criteria approach**: Several environmental indicators are taken into account, such as global warming potential, depletion of abiotic resources, water, air and soil pollution, etc.

- A **life-cycle perspective**: Taking into account the environmental impacts of all life cycle stages of a system's life cycle: manufacturing, distribution, use and end of life.

- A **quantitative approach**: Each indicator is quantitatively estimated in order to place all external aspects of a product or service on the same scale and to make objective decisions.

- A **functional approach**: The object of study is defined by the function it fulfils in order to compare different technical solutions. Therefore, it is necessary to define a **functional unit**: the reference unit used to relate inputs and outputs as well as the environmental performance of one or more systems that quantify the services or products studied.

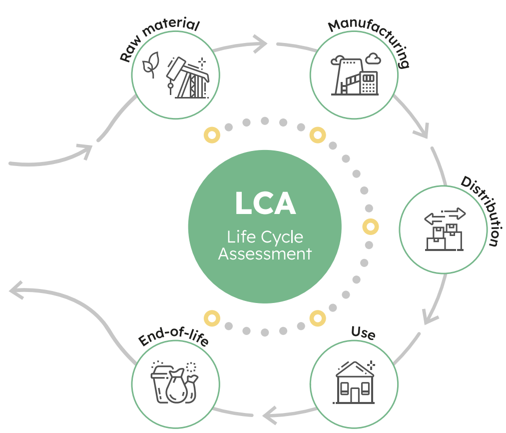

Figure 1 - Diagram of life cycle stages usually considered in LCA.

A Life Cycle Assessment can use two main approaches:

- **Attributional approach**: It describes the potential environmental impacts by partitioning the total impacts depending on life cycle stages, components or another normative rule, using the concept of allocation;
- **Consequential approach**: It describes the consequences in terms of environmental impacts of a decision. It includes the direct and indirect effects of a system, without applying any allocation.

2.1.2 Standards

LCA is mainly defined by two international ISO standards:

1. **ISO 14040: Environmental management - Life cycle assessment - Principles and framework**[9]:

This standard, published by the International Organization for Standardisation (ISO), outlines the **general principles, framework, and requirements for conducting LCA studies**. It provides guidance on defining the goal and scope of the assessment, conducting inventory analysis, assessing the impact, and interpreting the results. ISO 14040 serves as the foundation for LCA methodology and ensures consistency and reliability in LCA practice.

2. **ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines**[10]:

The ISO 14044 standard builds upon ISO 14040 and provides **detailed requirements and guidelines for conducting specific phases of the LCA process**. It offers guidance on data collection, allocation procedures, impact assessment methods, sensitivity analysis, and reporting of results. ISO 14044 helps to ensure the quality and transparency of LCA studies and facilitates comparability between different assessments.

Adhering to ISO 14040 and ISO 14044 is a first step towards **rigorous and standardized LCA studies, enhancing the credibility and reliability of their findings**. Other regional norms and frameworks including but not limited to PEF[11] and the ILCD Handbook[12] (developed by the Joint Research Centre (JRC) of the European Commission) allow for better precision and comparability between studies, refining methods for various industrial and economic domains.

An example of domain-specific standard concerning the ICT domain is **ITU-T L.1410: Methodology for environmental life cycle assessments of information and communication technology goods, networks and services**[13]. The ITU-T L.1410 is an international standard that defines methodologies for assessing the

[9] International Organization for Standardisation (ISO). (2006). ISO 14040: Environmental management - Life cycle assessment - Principles and framework. https://www.iso.org/standard/37456.html

[10] International Organization for Standardisation (ISO). (2006). ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines. https://www.iso.org/standard/38498.html

[11] PEF Method, European Commission, https://green-business.ec.europa.eu/environmental-footprint-methods/pef-method_en

[12] ILCD International Life Cycle Data system, European Commission, https://eplca.jrc.ec.europa.eu/ilcd.html

[13] ITU-T L.1410: Methodology for environmental life cycle assessments of information and communication technology goods, networks and services. International Telecommunications Union (ITU)

environmental impacts of ICT goods, networks, and services using Life Cycle Assessment (LCA). It has been developed by the International Telecommunications Union (ITU). It consists of two parts: first it focuses on evaluating the life cycle of individual ICT products, and then on enabling comparative assessments between ICT solutions and the conventional systems they may replace. While based on ISO 14040 and 14044, it adapts LCA principles to the specific features of the ICT sector, including system complexity, functional performance, and rapid technological change.

In contrast, **ITU-T L.1450, Methodologies for the assessment of the environmental impact of the information and communication technology sector,** focuses on assessing the environmental impact of the ICT sector as a whole, including its future development. This recommendation comprises two main parts. Part I outlines the methodology for calculating the sector's footprint concerning life cycle greenhouse gas (GHG) emissions, while Part II provides a methodology for defining a GHG emissions budget for the ICT sector, considering a 2ºC or lower trajectory in line with global climate goals. The standard is designed for use by governments, international organizations, and ICT sector stakeholders interested in assessing and reducing the sector's overall environmental impact.

2.2 Methodological approach of LCA

2.2.1 The different phases of LCA

The phases allowing to carry an LCA are shown in Figure 2 and described as follow, as an iterative process:

- Goal and scope definition;
- Life cycle inventory analysis;
- Life cycle impact assessment;
- Interpretation of life cycle results.

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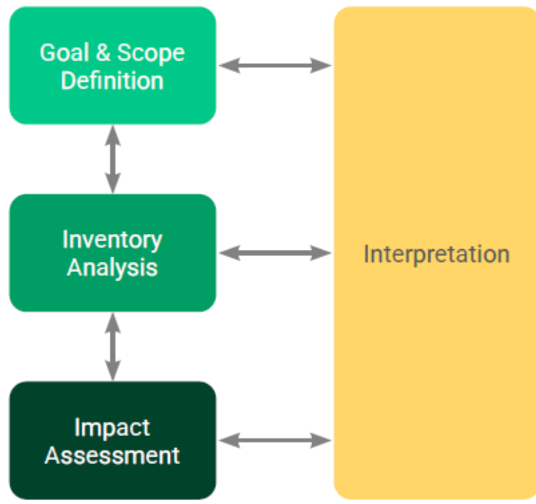

Figure 2 – Diagram of implementation process of an LCA, following ISO 14040:2006

2.2.2 Goal and scope definition

The first phase of conducting an LCA is defining the **goal** and **scope** of the study clearly. This involves:

- Identifying the intended purpose, application audience;
- Defining the system boundaries, inclusions and exclusions, functional unit, level of detail, assumptions and limitations.

2.2.3 Life cycle inventory analysis

In this phase, **data on inputs and outputs** associated with each stage of the product's life cycle stages are **collected** and **quantified**. It is called **Life Cycle Inventory** (LCI).

This includes raw material extraction, transportation, manufacturing processes, distribution, use, and end-of-life disposal. The data collected typically includes energy consumption, material inputs, emissions to air, water, and soil, and waste generation.

2.2.4 Life cycle impact assessment

Once the inventory data is collected, it is converted into **potential environmental impacts** using impact assessment methods. These methods quantify the effects of resource consumption and emissions on various environmental categories such as climate change, acidification, eutrophication, or human health.

During Life cycle impact assessment (LCIA), **cutoff criteria** are applied to exclude processes or inputs with negligible environmental impacts, or those considered outside the system boundaries. Cutoffs streamline the assessment and focus on the most impactful aspects of the life cycle. For example, processes or inputs contributing less than a certain percentage (e.g., 1%) to the total environmental impact may be considered as negligible and excluded from further analysis.

2.2.5 Interpretation of life cycle results

The results of the **impact assessment** are **interpreted** to draw conclusions and identify areas for improvement. This phase involves comparing alternative scenarios or products, identifying hotspots where environmental impacts are most significant, and considering trade-offs between different impact categories.

During results interpretation, **sensitivity analysis** is crucial in LCA to examine the robustness of results to changes in assumptions, parameters, or methodologies. It helps assess the uncertainty and reliability of LCA results and identify key factors driving environmental impacts. Sensitivity analyses involve varying input data, system boundaries, allocation methods, impact assessment models, or other parameters to evaluate their influence on study outcomes boundaries, allocation methods, impact.

2.3 Definition of the goal of the study

2.3.1 Goal definition

The main goal of this study is to assess the **environment impacts of digital technologies** in **Switzerland**.

This objective allows to:

- Identify the main sources of impacts to inform policy-makers and businesses;
- Contribute to raising awareness among Swiss citizens.

2.3.2 Framework

We utilize the **ISO 14040** and **ISO 14044 standards** to establish a robust and internationally recognized framework for conducting Life Cycle Assessments (LCAs) of digital technologies in Switzerland. Adhering to these standards enhances the transparency, consistency, and credibility of our assessments, facilitating informed decision-making and enabling comparisons across different studies and sectors. Moreover, compliance with ISO 14040 and ISO 14044 supports regulatory alignment and strengthens stakeholder trust by demonstrating a commitment to rigorous environmental evaluation practices.

We also employ the **ITU-T L.1410 standard** in our study to ensure a comprehensive and consistent assessment of the environmental impacts of digital technologies in Switzerland. This methodology offers **ICT-specific guidance** that complements the general LCA frameworks outlined in ISO 14040 and ISO 14044, thereby enhancing the credibility and transparency of our evaluations. By addressing **the unique complexities of ICT systems**, such as rapidly evolving technologies, intricate supply chains, and diverse components, ITU-T L.1410 enables us to identify key environmental impact areas across the entire life cycle of ICT goods, networks, and services. Overall, ITU-T L.1410 serves as a vital tool for conducting rigorous and environmental assessments in the ICT sector.

We incorporate the **ITU-T L.1450 standard** into our study to provide a structured and internationally recognized framework for evaluating the environmental impacts of digital technologies in Switzerland. This methodology offers **sector-specific guidance** that complements the general Life Cycle Assessment (LCA) frameworks outlined in ISO 14040/14044 and ITU-T L.1410. This norm enables us to quantify the sector's greenhouse gas emissions and **define a carbon budget aligned with global climate targets**. This facilitates the development of targeted action plans and prioritization of efforts to mitigate greenhouse gas emissions. In general, ITU-T L.1450 is an essential tool for performing thorough and impactful environmental assessments within the ICT sector.

2.3.3 Conduct of the study

The study is divided into the following phases:

- A scoping phase to define its scope and goal;
- A data collection phase to collect all the data about equipment, usage and complementary information, as well as determine the proper hypotheses;
- An impact assessment phase;
- The interpretation of the results;
- A critical review of the results and method.

2.3.4 Intended audience

The intended audience is mainly the following:

- Swiss citizens;
- Swiss policymakers;
- ICT industry leaders.

The final study and final data generated are placed under a **creative commons licence** (CC BY-NC-ND 4.0).

The results are **not intended** to be used in **comparative assertions** for disclosure to the public.

2.3.5 Validity of the results

The results are only valid for the situation defined by the assumptions described in this report: in **Switzerland** in **2024**.

The conclusions may change if these conditions differ. The relevance and reliability of use by third parties or for purposes other than those mentioned in this report cannot therefore be guaranteed by the LCA practitioners.

2.4 Scope of the study

The goal of the study is to provide the latest knowledge about the environmental impacts of the **ICT sector** in **Switzerland**.

The methodology used is **attributional LCA**. It is focused on **direct impacts only**. Indirect positive or negative impacts (rebound effects, etc.), are not taken into account.

2.4.1 System under study

2.4.1.1 Technological boundaries

The perimeter of this study is defined as the entirety of **digital equipment and infrastructures** in use in **Switzerland**, for **personal or professional use**. This covers three different categories of equipment called "Tiers" which can be classified into the following:

1. **Tier I - End-user equipment:** This category regroups all equipment directly used by final users, personal or professional. This category regroups objects such as smartphones, laptops, monitors or connected objects;
   The Tier I has been separated into two categories depending on their nature:
   1. Tier I for **personal usage**: equipment bought and used directly by the user, for his own personal use;
   2. Tier I for **professional usage**: equipment bought or lent by a company, used by the employees in a professional framework.

2. **Tier II - Telecommunication Networks**: This category regroups all equipment used to transmit data between the end-users and the data centres. It is comprised of a fixed network, a mobile network, and a backbone network;

3. **Tier III - Data centres**: This category regroups all equipment dedicated to the hosting and treatment of data (servers, routers, cooling equipment, etc.).

For Tier I, an explicit distinction is made between personal and professional use. For Tier II and III, the distinction is not possible but both uses are considered. More details about the inclusions and exclusions are given in section 2.4.4.

2.4.1.2 Time and geographical boundaries

There are two **temporal perimeters** chosen for this study:

- The **retrospective analysis** is done on **year 2024**. This means that we evaluate all of digital technologies in Switzerland for the year 2024.

- The **prospective analysis** is done on **year 2035**. This means that we estimate all of digital technologies that would exist in Switzerland in 2035.

Considering the **geographical perimeter**, all equipment geographically installed and used in Switzerland are evaluated and accounted for (except for notable exclusions which are outlined in section 2.4.4).

For Tier III, data centres and cloud services are usually more globalized: some data centres installed in Switzerland are used for cloud services consumed outside of Switzerland whereas part of the cloud services consumed in Switzerland are hosted in data centres located outside of Switzerland.

We have therefore chosen two different approaches for Tier III, called “consumption approach” and “production approach”:

- In the “**production approach**” (also called “**location-based approach**”), all data centres equipment geographically installed in Switzerland are evaluated and accounted for. As well, no other equipment or service located or hosted outside of Switzerland are looked at.

- In the “**consumption approach**” (also called “**market-based approach**”), all data centres equipment geographically installed and used in Switzerland are also evaluated and accounted for. Furthermore, the production of cloud services hosted outside of Switzerland but consumed in Switzerland is taken into account. The method to do so is detailed in section 2.8.2.3.3. The goal of this approach is to get the most accurate evaluation of environmental impacts of the Swiss population.

	Data centres installed in Switzerland	**Data centres installed outside of Switzerland**
Cloud services consumed in Switzerland	Included	Excluded
Cloud services consumed outside of Switzerland	Included	Excluded

Table 1 - Scope of the "production approach"

	Data centres installed in Switzerland	**Data centres installed outside of Switzerland**
Cloud services consumed in Switzerland	Included	Included
Cloud services consumed outside of Switzerland	Excluded	Excluded

Table 2 - Scope of the "consumption approach"

The combination of the various temporal and geographical perimeters leads to **three perimeters** for the results:

1. The “production approach” for 2024;
2. The “consumption approach” for 2024;
3. The “production approach” for the projection to 2035.

2.4.2 Functional unit

The **functional unit** of a product or a system is a quantified description of its performances, serving as the reference point for all environmental impact calculations. It ensures comparability between different systems by standardizing the studied function.

In this study, the **studied function** corresponds to:

“The totality of digital equipment and infrastructures related to digital technologies used in Switzerland to consumers, public and private organisations and industries during a year.”

It is very arduous to classify the use of digital technologies in different functional units, due to the multiplicity and diversity of uses. Therefore, we’ll replace the functional unit by a **declared unit**.

In our case, we’ll select two declared units giving information on a global:

“Equipment and infrastructures related to digital technologies used in Switzerland over a year”.

And on an individual scale:

*“Equipment and infrastructures related to digital technologies used in Switzerland over a year **per inhabitant**”*.

2.4.3 Life cycle stages considered

This study evaluates the environmental impacts associated with the following life cycle stages:

1. **Manufacturing stage**: Encompasses raw material extraction, upstream transportation, and manufacturing processes;
2. **Distribution stage**: Covers the transportation of equipment from the manufacturing location to the installation and use site;
3. **Use stage**: Includes the electricity and other resources consumed by the equipment during its operational phase;

4. **End-of-life stage**: Involves the treatment and disposal processes of ICT equipment at the end of its useful life.

This framework aligns with the ISO norm standards typically used in Life Cycle Assessments previously described, as it covers the entire lifespan, and consequently impacts, of a digital product or service.

While the ITU-T L.1410 adapts the LCA methodology to the specificities of ICT, such as virtualization, shared infrastructure, and service-based functional units, it remains coherent to apply the conventional life cycle steps (manufacturing, use, end-of-life) when evaluating ICT goods.

The standard stages adopted, derived from ISO 14040/44, provide a structured and widely accepted framework that allows for comparability across sectors. Although ITU L.1410 refines the modelling of aspects like network energy use, cloud services, and allocation of shared resources, the core life cycle logic remains valid. Using the standard LCA structure ensures consistency, while still allowing for integration of ICT-specific nuances where needed.

2.4.4 Inclusions and exclusions

As presented previously, this study covers the entirety of **digital infrastructures or equipment**, for **personal and professional use**, across Switzerland throughout the three tiers.

This section explains the inclusions and exclusions for each of the Tier. The exhaustive list of included equipment as well as details about the methodology and origin of the data can be found in section 2.8.

2.4.4.1 Tier I: End-user equipment

In Tier I, we have included:

- **Phones**: Smartphones, landline phones, feature phones;
- **Computers**: Desktops, laptops, tablets;
- **Viewing equipment**: Monitors, TV screens and beamers;
- **Other equipment**: Video game consoles, printers, set-top boxes and internet boxes;
- **IoT equipment**: Sensors, automations, video cameras, etc.

Remark: For IoT equipment, only the connectivity and "intelligent" module is taken into account for the assessment of the environmental impacts, not the entire equipment.

The following elements are excluded from the study, because their impacts are considered as negligible:

- Equipment peripherals (mouses, keyboards, USB keys, etc.);
- Chargers and power supply units (PSU);
- Packaging of the products.

The following elements are not taken into account in the study, due to a lack of available environmental data:

- Smart watches;
- GPS phones;
- Payment terminals, cash machines, cash registers;
- Public access points (e.g. in public spaces, cafés, train station, etc.).

Due to their high number, their impacts might not be negligible. This is discussed in the limits in section 5.2.

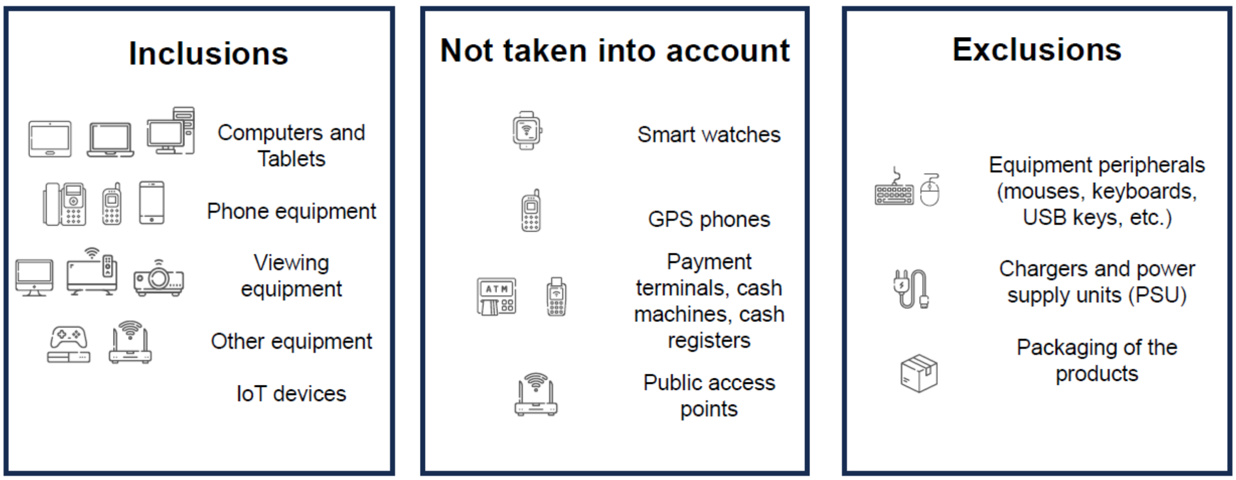

Figure 3 - End-user equipment (Tier I) inclusions and exclusions

2.4.4.2 Tier II: Telecommunication networks

In Tier II, we have included a list of equipment related to **backbone**, **fixed** and **mobile networks** such as:

- **Backbone**: Optic fibre cables;
- **Mobile network:** Passive and active antennas, multi-technology BBU cards and RRU/RRH amplifiers, structural elements (steel and concrete);
- **Fixed network:** Optic fibre and coaxial cable, OCN infrastructure and equipment (building materials, DSLAM, OLT, switches, aggregation and collect routers), alimentation (electric boards), structural elements (steel and concrete).

In the fixed network, modem-routers are excluded as they are already accounted for in the Tier I. International backbone (outside of Switzerland) is excluded from the scope as the geographical perimeter is Switzerland.

Some network technologies are not taken into account in this study, because of a lack of environmental data:

- Satellite communications;
- Private company networks;
- Other specific network technologies, like LoraWAN or Zigbee.

Similarly, some elements in the backbone are not accounted in the scope due to a lack of data, related to the "Trade-secrets" surrounding these infrastructures:

- Points of Presence (PoP);
- Exit points.

In the fixed network the following elements are not taken into account in the study:

- Copper cable network, as these installations are made years ago and no information summarizing or allowing an extrapolation are found regarding this type of network.

Finally, in all network types the following elements are not taken into account in the study, due to a lack of data:

- Installation, maintenance and repair of the equipment and infrastructures;
- Back-up generators.

Their impacts might not be negligible. The lack of these infrastructures and equipment in the scope of the study is discussed in the limits in section 5.2.

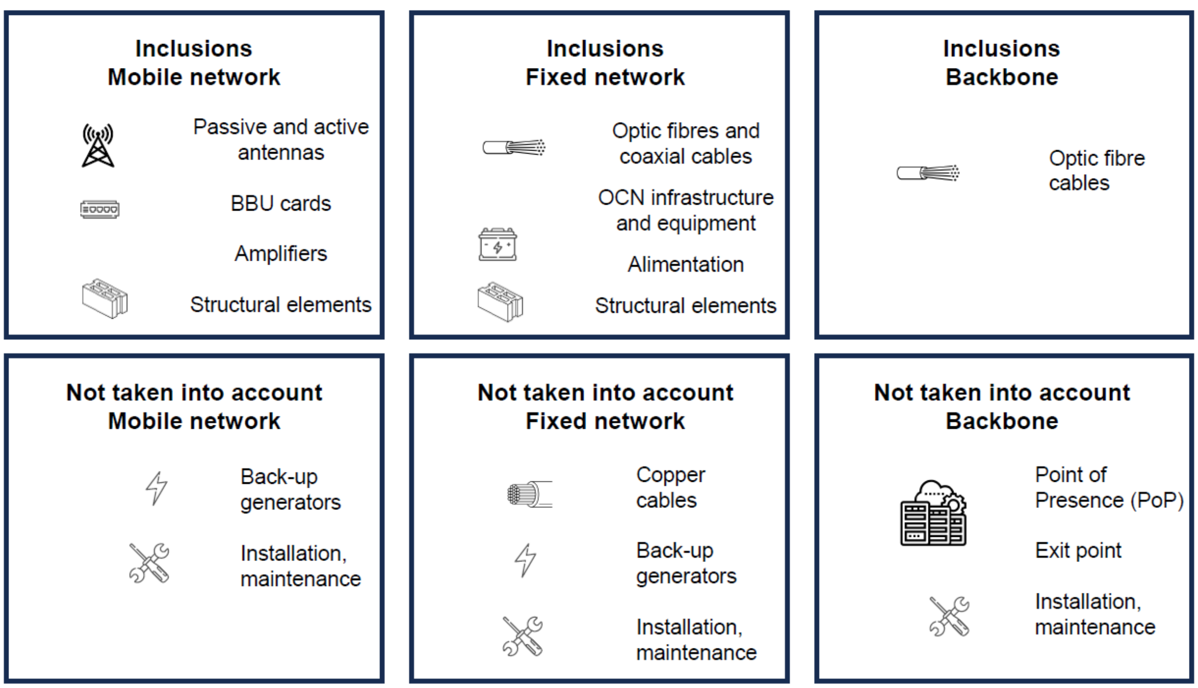

Figure 4 - Telecommunication networks (Tier II) inclusions and exclusions

2.4.4.3 Tier III: Data centres

In the Tier III, we have included:

- **Servers**: classified as classic, high performance and AI-dedicated;
- **Storage equipment**: SDD and HDD storage;
- **Network equipment**: Switches, routers within data centres;
- **Alimentation and cooling**: Three-phase inverters, lead-acid batteries, refrigeration units, refrigerant leaks;
- **Buildings** that host the ICT equipment;
- The **import of cloud services** by Switzerland.

We have excluded from the study, because their impacts are considered as negligible:

- Data centres with an **area inferior to 50 m²**, as these installations are often neglected in all existing evaluations;
- Cables and connectors.

The following elements are not taken into account in the study, due to a lack of available data:

- Maintenance and reparation of the building and equipment;
- Tape storage equipment.

These impacts might not be negligible. The lack of these infrastructures and equipment in the scope of the study is discussed in the limits in section 5.2.

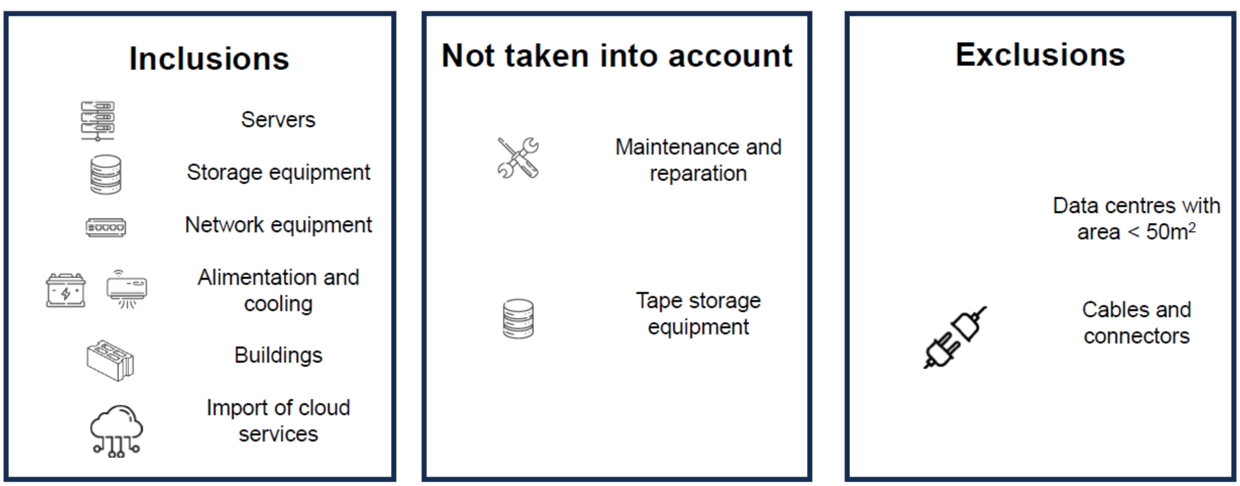

Figure 5 - Data centres (Tier III) inclusions and exclusions

2.4.4.4 Additional exclusions

We have made some additional exclusions that are not directly related to a specific Tier, but are worth mentioning for transparency regarding the compliance with ISO 14040 and ITU-T L. 1410:

- The **impact of employees in the ICT business**: from transportation, desks, meals, etc. These elements are considered out of scope of this study.

The following elements are not taken into account in the study, due to a lack of available data:

- Manufacturing and maintenance of **production equipment**, due to lack of data;
- **Maintenance** and **reparations** of ICT equipment and services, by lack of available data.

These impacts might not be negligible. The lack of these infrastructures and equipment in the scope of the study is discussed in the limits in section 5.2.

2.5 Allocation procedures

Only **temporal allocation** is used in this study, to assign the impacts of equipment to a one-year period. The following formula have been applied throughout the calculations:

$$Impact_{LCS\,;\,IC} = \frac{Impact\ factor_{LCS;\,IC} \times Quantity}{Lifespan}$$

for each independent life cycle step (LCS) and impact category (IC);

With:

- $Impact_{LCS\,;\,IC}$: The total annual impact for an inventory data point (impact/yr);
- $Impact\ factor_{LCS\,;\,IC}$: The impacts of an inventory data point on a given life cycle step (manufacturing, distribution, use, or end-of-life) and on a specific environmental impact category (impact/unit). These values come from environmental databases;
- $Quantity$: The quantity of data of this specific datapoint (number of units, e.g. of smartphones, of computers, amount of electricity consumed, etc.);
- $Lifespan$: The lifespan of the data point, i.e. the considered equipment or flux (yr).

2.6 LCIA methodology

2.6.1 Selection, classification and characterisation of impacts

Life Cycle Impact Assessment (LCIA) phase aims to **assess the significance of potential environmental impacts** based on the results of the life cycle inventory and provides essential information for the interpretation phase.

In our context, the analysis is based on the 16 environmental indicators proposed by the European Commission within the framework of the Product Environmental Footprint[14] (PEF) project, using version **PEF 3.0**. They are listed in Table 3.

Impact category	Acronym (unit)	Assessment method

[14] https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

Acidification	AP (mol H^+ eq.)	Accumulated Exceedance model
Climate change	GWP (kg CO_2 eq.)	Bern model - Global Warming Potentials (GWP) over a 100-year time horizon
Ecotoxicity, freshwater	CTUe (CTUe)	USEtox model 2.1
Eutrophication, freshwater	Epf (kg P eq.)	EUTREND model, as implemented in ReCiPe
Eutrophication, marine	Epm (kg N eq.)	EUTREND model, as implemented in ReCiPe
Eutrophication, terrestrial	Ept (mol N eq.)	Accumulated Exceedance
Human toxicity, cancer effects	CTUh-c (CTUh)	USEtox model 2.1
Human toxicity, non-cancer effects	CTUh-nc (CTUh)	USEtox model 2.1
Ionising radiation, human health	IR (kBq U_{235} eq.)	Human health effect model as developed by Dreicer et al. 1995
Land use	LU (dimensionless)	LANCA model
Ozone depletion	ODP (kg CFC-11 eq.)	EDIP model based on the ODPs of the WMO over an infinite time horizon
Particulate matter	PM (disease incidence)	PM model
Photochemical ozone formation	POCP (kg NMVOC eq.)	LOTOS-EUROS model as implemented in ReCiPe 2008
Resource use, fossils	ADPf (MJ)	CML 2002 v.4.8
Resource use, minerals and metals	ADPe (kg Sb eq.)	CML 2002 v.4.8
Total Primary Energy	TPE (MJ)	- (Not an environmental indicator, it is a flux indicator)
Water use	WU (m^3 world eq.)	Available WAter REmaining (AWARE) as recommended by UNEP, 2016

Table 3 - List of impact categories and the associated acronym, units and assessment methods

For readability purposes and in order to focus the recommendations on key issues, the full set of indicators is typically reduced to a relevant selection. This is achieved through normalisation and weighting. The subset of indicators should be selected to account **for more than 80% of the overall weighted results**, starting from the most significant impact categories.

In this case, the factors used for the normalisation are given in section 2.6.2. No weighting factors are used. The most significant impact categories accounting for at least 80% of the overall result are presented in Table 4.

Remark: In comparison with other studies on the impacts of ICT, the impact category concerning "Ecotoxicity, freshwater" has a much more important weight in the global footprint. This disparity is probably due to the difference in normalisation factors applied in this study.

Impact category	Acronym (unit)	Weight in the total footprint
Resource use, minerals and metals	ADPe (kg Sb eq.)	40%
Ecotoxicity, freshwater	CTUe (CTUe)	23%
Climate change	GWP (kg CO_2 eq.)	14%
Resource use, fossils	ADPf (MJ)	10%
Particulate matter	PM (disease incidence)	8%
Eutrophication, freshwater	Epf (kg P eq.)	2%

Table 4 - List of the six selected impact categories

The definitions of the six selected impact categories are the following:

- Resource use, minerals and metals (ADPe): This indicator measures the depletion of non-renewable mineral and metal resources, such as copper, lithium, and rare earth elements, which are extracted from the Earth's crust. It reflects the potential environmental impact associated with the extraction and use of these materials, considering their scarcity and economic importance.

- Freshwater ecotoxicity (CTUe): This indicator assesses the potential toxic effects of chemical emissions, such as heavy metals, pesticides, or industrial compounds, on freshwater ecosystems (rivers, lakes, etc.). It estimates how these substances may harm aquatic organisms (fish, algae, invertebrates) over time.

- Global Warming Potential (GWP): This indicator measures the contribution of greenhouse gas (GHG) emissions, mainly as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), to global warming over a specific time horizon, typically 100 years.

- Usage of fossil resources (ADPf): This indicator measures the depletion of non-renewable fossil energy resources, such as crude oil, coal, and natural gas. It reflects the long-term reduction in the availability of these energy carriers due to their extraction and use throughout the life cycle of a product or system.

- Fine particles (PM): This indicator quantifies the potential human health impacts caused by the emission of particulate matter (PM) and its precursors, such as nitrogen oxides (NO_x), sulphur dioxide (SO_2), and ammonia (NH_3). These substances can form fine particles (PM_{10} and $PM_{2.5}$) in the atmosphere, which are inhalable and harmful to respiratory and cardiovascular health.

- Freshwater eutrophication (Epf): This indicator measures the contribution to the eutrophication of freshwater systems, caused by the excess loading of nutrients, mainly nitrogen (N) and phosphorus (P). These nutrients can lead to algal blooms, oxygen depletion, and loss of biodiversity in aquatic ecosystems.

An interesting flux category to take into account is the following:

- Total Primary Energy (TPE): Total Primary Energy refers to the sum of all energy inputs required throughout the entire life cycle of a product, process, or service. This encompasses energy used directly and indirectly, from raw material extraction, manufacturing, and transportation to usage and end-of-life disposal. It includes the energy content of raw materials utilized as energy carriers and as feedstocks. This metric is crucial for evaluating the overall energy efficiency and environmental impact of a system.

2.6.2 Normalisation and weighting

The numerical results of the indicators can also be ranked, normalized, grouped, and weighted. This approach **facilitates the interpretation phase**. However, there is currently no scientific consensus on a robust method for conducting such an evaluation.

2.6.2.1 Normalisation with planetary boundaries

In this study, we used as **normalisation factors,** the **planetary boundaries per capita**. Planetary boundaries refer to critical ecological thresholds that define a safe operating space for humanity. These thresholds aim to quantify the limits within which global environmental systems can continue to function stably and sustainably. Using the planetary boundaries allows an **absolute sustainability assessment**, and therefore moving beyond simply reducing the environmental impact to ensuring that human activities stay within the absolute limits of the Earth.

When applied in LCA, planetary boundaries enable the absolute assessment of sectoral impacts and the evaluations of whether a system operates within globally sustainable levels. The nine planetary boundaries are shown in Figure 6.

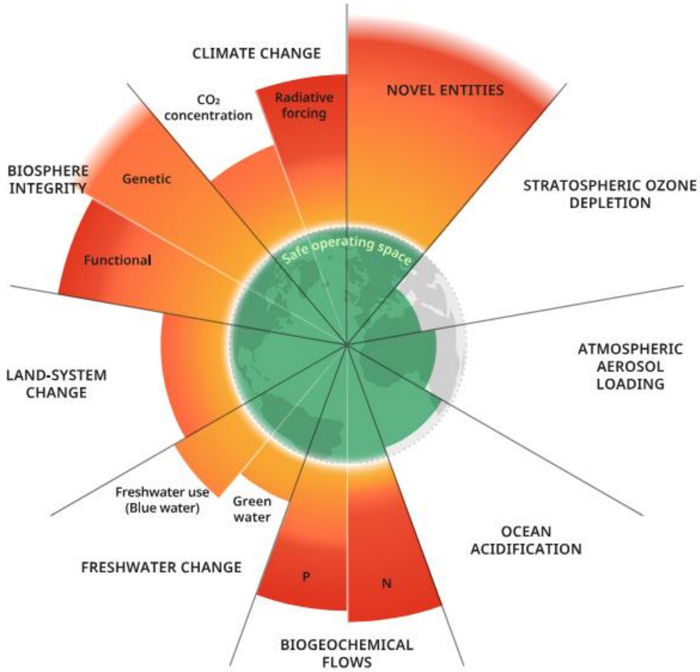

Figure 6 - Illustration of the nine planetary boundaries and their level of exceeding[15]

These planetary boundary values are adapted for their application in the LCIA context, according to the impact categories available in the EF method, provided by the JRC[16]. Table 5 lists the normalisation factors. In line with this normalisation approach, we assume that each indicator holds equal weight in terms of environmental significance. Consequently, a uniform weighting factor of one is applied to all selected indicators.

This methodological choice allows the assessment to focus strictly on environmental relevance, intentionally excluding political, economic, or other external considerations. The normalisation step, which consists of expressing impacts relatively to a reference value, facilitates comparison across impact categories. However, this process may lead to a loss of granularity, as it can obscure the relative contributions of specific components or life cycle stages, thereby limiting the precision of the analysis.

[15] Earth beyond six of nine planetary boundaries. Science Advances, https://www.science.org/doi/10.1126/sciadv.adh2458

[16] Sala S., Benini L., Beylot A., Castellani V., Cerutti A., Corrado S., Crenna E., Diaconu E., Sanyé-Mengual E, Secchi M., Sinkko T., Pant R. (2019) Consumption and Consumer Footprint: methodology and results. Indicators and Assessment of the environmental impact of EU consumption. Luxembourg: Publications Office of the European Union, ISBN 978-92-79-97256-0, doi:10.2760/98570, JRC 113607. https://publications.jrc.ec.europa.eu/repository/handle/JRC113607

Impact category	Acronym (unit)	Normalisation factor
Acidification	AP (mol H^+ eq./person)	1.45E+02
Climate change	GWP (kg CO_2 eq. /person)	9.85E+02
Ecotoxicity, freshwater	CTUe (CTUe/person)	1.90E+04
Eutrophication, freshwater	Epf (kg P eq./person)	7.47E-05
Eutrophication, marine	Epm (kg N eq./person)	8.40E-01
Eutrophication, terrestrial	Ept (mol N eq./person)	2.90E+01
Human toxicity, cancer effects	CTUh-c (CTUh/person)	8.87E+02
Human toxicity, non-cancer effects	CTUh-nc (CTUh/person)	1.39E-04
Ionising radiation, human health	IR (kBq U_{235} eq. /person)	5.93E-04
Land use	LU (dimensionless /person)	7.62E+04
Ozone depletion	ODP (kg CFC-11 eq. /person)	1.84E+03
Particulate matter	PM (disease incidence/person)	7.80E-02
Photochemical ozone formation	POCP (kg NMVOC eq. /person)	5.88E+01
Resource use, fossils	ADPf (MJ/person)	3.24E+04
Resource use, minerals and metals	ADPe (kg Sb eq. /person)	3.18E-02
Total Primary Energy	TPE (MJ/person)	2.63E+04
Water use	WU (m^3 world eq. /person)	1.45E+02

Table 5 - Normalisation factors used to select a subset of impact categories and normalize the results

2.6.2.2 Normalization using the Swiss eco-factors

Another type of normalization is applied in this study, using the **Swiss eco-factors**.

They are based on the **ecological scarcity method**[17], which consists of assessing the impact of the life cycle inventory according to the principle of distance to target. Indeed, the eco-factor of a substance is defined based on the ratio between the current emissions and the maximum tolerated quantity (target set out in the legislation). The higher the emissions, the higher the eco-factor. The units are eco-point (EP or Umweltbelastungspunkte, UBP) per unit of quantity. **Therefore, an eco-factor incorporates three LCA phases in one value: characterization, normalization and weighting**.

The eco-factors have been determined based on Switzerland specific values[18], which makes them relevant in this study as they are adapted to the geographical scope we consider. They are based on the state of the Swiss environment and uses democratically legitimized environmental targets. However, because of this approach they don't directly illustrate the damage potential.

Disclaimer: As the ecological scarcity method is simultaneously a characterization, normalization and weighting method, it is not perfectly adapted to our normalization and weighting case only. Not all the impact categories of this study have a corresponding eco-factor. Furthermore, not all eco-factors can be applied as we implement this step after characterization is already done.

Impact category	Acronym (unit)	Normalisation factor
Climate change	GWP (UBP/kg CO_2 eq.)	1.00E+00
Eutrophication, freshwater	Epf (UBP/g P)	2.01E+08
Eutrophication, marine	Epm (UBP/g N)	8.17E+07
Eutrophication, terrestrial	Ept (UBP/g N)	6.89E+08
Human toxicity, cancer	CTUh-c (UBP/CTUh)	9.30E+11
Ozone depletion	ODP (UBP/g eq. R11)	9.95E+06
Resource depletion, fossils	ADPf (UBP/MJ eq. petroleum)	4.09E+11
Resource depletion, minerals and metals	ADPe (UBP/g eq. Sb)	2.79E+07

Table 6 - Normalisation factors used in this study, from the ecological scarcity method

[17] https://www.mdpi.com/2071-1050/15/23/16515
[18] https://www.bafu.admin.ch/bafu/en/home/topics/economy-consumption/economy-and-consumption-publications/publications-economy-and-consumption/eco-factors-switzerland.html

2.7 Data used

2.7.1 Type and source of data

An LCA calculation requires two different types of data:

1. Data related to the **physical characteristics of the studied system** (such as the number of smartphones used in Switzerland and the amount of electricity consumed by these devices, etc.). For this project, such data is sourced from various public studies, statistical reports and assumptions made.
2. Data related to the **life cycle environmental impacts of ICT equipment** or flows entering the studied system. This data is mostly obtained from two databases: Resilio Database and NégaOctet, as detailed in section 2.7.1.2.

2.7.1.1 Data related to the physical characteristics of the system

We used the diversity of the covered sources of information to obtain both a large and precise coverage of the whole ICT domain: personal equipment, networks, data centres, IoT, etc.

The literature consulted, which was gathered and regularly updated during the data collection phase of our study, allowed us to establish a current inventory (covering the year 2024) detailing the numbers, type of devices, lifespans, etc. associated with digital services in Switzerland.

To ensure robust and precise data collection, we have first prioritized data from Swiss Federal offices or official government supported sources, as they deliver a high reliability degree. For two data points of the same quality, we have always selected the most recent one. For two data points of the same quality and temporality, we have always selected the most “pessimistic” one, in accordance with the norms ISO 14040/44.

These sources served as the basis for conducting the LCA and developing the case studies.

2.7.1.2 Data related to the life cycle impacts

The data related to the life cycle impacts of ICT equipment or other fluxes can be divided into the two following categories:

1. **Primary data**: These are, for example, data collected directly from the manufacturing facility where industry processes are carried out, as well as data related to other life cycle stages that can be traced back to the specific element under study. This includes, for instance, information on materials or electricity supplied by a contracted provider capable of delivering data on the actual services rendered, as well as transport data based on actual fuel consumption and the associated emissions;

2. **Secondary data** are divided into:

a. **Specific data**: These refer to data obtained from commonly available sources that meet the prescribed data quality criteria, namely accuracy, completeness, and representativeness;

b. **Substitution data**: These are data obtained from commonly available sources that do not fully meet the quality criteria required for "specific data."

The data used to model the environmental impacts of the different equipment and infrastructures in this study are **secondary data**. They come from three databases:

- Resilio Database[19], v. 2025.4: most of Tier I equipment as well as Tier III servers;

Resilio Database has not been subject to an external critical review by an independent third party. Resilio Database strives to comply with ISO 14040/44 standards and EF 3.0.

- NégaOctet [20] v1.2: the rest of the equipment.

The NégaOctet database has been subject to an external critical review by an independent third party. The NégaOctet database complies with international standards ISO 14040/44, according to the EF 3.0 format and nomenclature.

- Ecoinvent[21] v3.10, EF3.0 method: electricity mixes for Switzerland.

2.7.2 Data quality

In accordance with the defined goals and system boundaries of the study, the quality requirements for the collected data are established based on several criteria:

- **Technological representativeness**: It is ensured by selecting data that reflect relevant technologies within a recent timeframe, specifically between 2019 and 2024 (mainly IoT and AI);
- **Geographical representativeness:** It is achieved by using data specific to equipment related to digital services used within Switzerland, while acknowledging that certain life cycle stages, such as manufacturing, may occur outside this region. In cases where Swiss data are unavailable, European data are used preferably. Assumptions that are made are appropriately justified;
- **Temporal representativeness**: Data as close to 2024 as possible is selected. If any data from 2024 is missing, we select data as old as 2019 and extrapolate them as much as possible to 2024. When data older than 2024 are used, extrapolations are made using justified assumptions;
- **Exhaustivity**: The application of cut-off criteria proved complex due to the variety of equipment and processes involved. As such, all identified flows are included in the assessment unless otherwise specified in section 2.4.4;

[19] https://db.resilio.tech/
[20] https://codde.fr/nos-marques/negaoctet/base-de-donnees
[21] https://ecoinvent.org/

- **Parameter uncertainty**: Given that, for many parameters, only a single data source is available, a high degree of parameter uncertainty is present. When feasible, data is cross validated using additional sources to mitigate this uncertainty;
- **Consistency and relevance of methodology:** Finally, the study adhered to the principles of methodological consistency and relevance, applying the ISO 14040 and 14044 standards and ensuring a uniform data collection methodology across all components considered.

2.7.3 LCA modelling tool

The assessment of all global environmental impacts for one year is carried out by compiling all data related to the physical characteristics of the system and specific data related to Switzerland (such as the electricity mix, the population, etc.) into **ResilioTech**[22], the proprietary application from Resilio to perform simplified LCA of digital systems.

Furthermore, **Excel** is used as a supplementary tool to gather the LCI data, compute extrapolations and create specific graphics used in this study.

2.7.4 Critical review

The critical review is a procedure for certifying that the Life Cycle Assessment (LCA) complies with standards in order to meet the objectives of the study. It is mainly carried out when the results are intended to be communicated to the public or when comparative claims are made. Its purpose is to limit risks in terms of:

- Inconsistency between the objective and study conclusions;
- Communication of unfounded results, recommendations and conclusions.

In our context, no critical review in the sense of the ISO 14071:2024[23] norm is conducted as no official review panel has been created. However, many reviewers have read and commented the study all along the process.

These reviews aim to:

- Ensure the quality and reliability of the results provided;
- Ensure the relevance of the recommendations provided;
- Identify the important elements and limitations of the study.

The reviewers are the following:

- Dr Thibault Simon, R&D engineer at Resilio - PhD in Computer Science
- Hon. Prof Jean-Pierre Danthine - Entreprise4Society Center, EPFL/Unil/IMD
- Prof Jan Bieser – Berner Fachhochschule (BFH), Universität Zürich (UZH)
- Dr Anders Andrae – International Telecommunication Union (ITU)

[22] https://resilio-solutions.com/fr/services/tech

[23] Environmental management - Life cycle assessment - Critical review processes and reviewer competencies, https://www.iso.org/standard/86264.html

- Prof Michael Zwicky Hauschild – Technical University of Denmark (DTU)
- Mrs Gudrun Gudmundsdottir – Technical University of Denmark (DTU)

The reviews followed these steps:

- Sending the methodology and inventory data to the reviewers (05/05/2025);
- Sending the complete study with results and conclusions to the reviewers (30/05/2025);
- Receiving remarks and comments from the critical review panel (June 2025);
- Consideration of remarks and comments in study (June-July 2025).

2.8 Life Cycle Inventory

2.8.1 Summarised Life Cycle Inventory for consumption approach

Tier	Parameters	Unit	Stock in 2024	Lifespan (year)
-	Population in Switzerland in 2024	Unit	9,048,900	-
I – Personal use	Smartphones – Entry level	Unit	4,235,538	2.25
I – Personal use	Smartphones – Mid range	Unit	4,069,438	2.25
I – Personal use	Feature phones	Unit	308,700	3
I – Personal use	Landline phones	Unit	2,998,202	8
I – Personal use	Desktops - Basic	Unit	343,763	6
I – Personal use	Desktops - Familial	Unit	343,763	6
I – Personal use	Desktops - Gaming	Unit	516,644	6
I – Personal use	Desktops - Gaming High range	Unit	171,881	6
I – Personal use	Desktops - Power User	Unit	343,763	6
I – Personal use	Laptops – Desk	Unit	1,704,077	5
I – Personal use	Laptops – Notebook	Unit	1,363,262	5
I – Personal use	Laptops – Gaming	Unit	340,815	5
I – Personal use	Tablets – Entry level	Unit	1,062,120	4
I – Personal use	Tablets – Mid range	Unit	3,186,360	4
I – Personal use	Tablets – High range	Unit	1,062,120	4
I – Personal use	Monitors	Unit	4,321,999	6
I – Personal use	Televisions – 45 inches LCD	Unit	4,962,946	7.5
I – Personal use	Televisions – 53 inches OLED	Unit	101,285	7.5
I – Personal use	Video game consoles – Fixed	Unit	914,469	7
I – Personal use	Video game consoles – Mobile	Unit	833,703	7
I – Personal use	TV boxes	Unit	3,395,168	5
I – Personal use	Internet boxes	Unit	4,152,752	5
I – Personal use	Personal printers	Unit	3,597,930	5
I – Personal use	Beamers	Unit	168,200	5
I – Personal use	Connected speakers	Unit	4,051,243	6
I – Personal use	IoT - Cooking	Unit	104,123	9.5
I – Personal use	IoT – Lighting	Unit	1,596,579	7
I – Personal use	IoT – Space conditioning	Unit	150,402	12
I – Personal use	IoT – Water heating	Unit	121,479	12
I – Personal use	IoT – Appliances	Unit	532,193	10.7
I – Personal use	IoT – Security, Control	Unit	32,137	5

I – Personal use	IoT – Security, Video	Unit	163,900	7.5
I – Professional use	Smartphones – Entry level	Unit	1,502,771	2.25
I – Professional use	Smartphones – Mid range	Unit	1,443,839	2.25
I – Professional use	Desktops – Basic	Unit	376,711	6
I – Professional use	Desktops - Familial	Unit	376,711	6
I – Professional use	Desktops – Gaming	Unit	565,067	6
I – Professional use	Desktops – High range	Unit	188,356	6
I – Professional use	Desktops - Power User	Unit	376,711	6
I – Professional use	Laptops – Desk	Unit	1,847,308	5
I – Professional use	Laptops – Notebook	Unit	1,447,846	5
I – Professional use	Laptops – Gaming	Unit	369,462	5
I – Professional use	Tablets – Entry level	Unit	738,923	4
I – Professional use	Tablets – Mid range	Unit	1,447,846	4
I – Professional use	Tablets – High range	Unit	738,923	4
I – Professional use	Monitors	Unit	7,722,948	6
I – Professional use	Televisions – 45 inches LCD	Unit	36,408	7.5
I – Professional use	Internet boxes	Unit	937,786	5
I – Professional use	Multifunction printers	Unit	750,229	6
I – Professional use	Beamers	Unit	16,828	5
I – Professional use	IoT – Industrial sensors	Unit	18,253,968	5
I – Professional use	IoT - Cooking	Unit	11,569	9.5
I – Professional use	IoT – Street lights	Unit	25,710	10
I – Professional use	IoT – Lighting	Unit	177,398	7
I – Professional use	IoT – Space conditioning	Unit	16,711	12
I – Professional use	IoT – Water heating	Unit	13,498	12
I – Professional use	IoT – Appliances	Unit	59,133	10.7
I – Professional use	IoT – Security, Control	Unit	32,137	5
I – Professional use	IoT – Security, Video	Unit	163,900	7.5
II	FTTH subscribers	Unit	1,327,748	-
II	xDSL subscribers	Unit	1,789,240	-
II	Cable-modem subscribers	Unit	1,030,309	-
II	Quantity of data on fixed network	GB	9,110,971,778	-
II	Optic fibre length	km	568,050	25
II	Coaxial cable length	km	309,092	10
II	OCN – OLT	Unit	2,992	7
II	OCN – DSLAM	Unit	6,748	7
II	OCN – Switch/collection routers	Unit	1,622	7
II	OCN – Aggregation routers	Unit	2,223	7
II	OCN – Low voltage distribution boards	Unit	456	5
II	OCN – Air conditioners	Unit	1,824	5
II	OCN – Steel	Ton	28,818	50
II	OCN – Concrete	m³	182,438	50
II	Mobile network subscribers	Unit	9,829,496	-
II	Quantity of data on mobile network	GB	2,097,099,704	-
II	Multi-technology passive antennas	Unit	46,539	7
II	Active 5G+ antennas	Unit	54,539	7
II	Multi-technology RRU/RRH amplifier	Unit	163,617	7
II	Multi-technology BBU card	Unit	54,539	7
II	Pylon – Steel	Ton	13,965	50
II	Pylon - Concrete	m³	38,000	50
II	Terrace – Steel	Ton	28,500	50
II	Terrace – Concrete	m³	95,000	50
III	Total data centre area	m²	261,973	-

III	Mid-range servers	Unit	572,202	5.5
III	High-range servers	Unit	23,072	5.5
III	AI-dedicated servers	Unit	149,819	5.5
III	Switch/routers	Unit	78,031	5
III	SDD	Unit	3,163,873	5
III	HDD	Unit	6,227,568	3
III	Refrigerant leaks	kg	7,593	5
III	Lead-acid batteries	Unit	45,810	8
III	Three-phase inverters	Unit	2,860	5
III	Refrigeration units	Unit	572	15
III	Server bays 42U	Unit	104,789	20

Table 7 - Complete LCI for consumption approach

2.8.2 Detailed Life Cycle Inventory with sources

This section described exhaustively the Life Cycle Inventory (LCI) data points, as well as the sources or assumptions used to obtain this data.

Data are separated by Tier, in sections 2.8.2.1 to 2.8.2.3

Life Cycle Inventory data are given for the three different perimeters of this study:
1. The “production approach” for 2024;
2. The “consumption approach” for 2024;
3. The “production approach” for the projection to 2035.

For each element, the following information is provided:
- The definition of the considered element;
- The number of units in Switzerland in 2024, and the methodology used to extrapolate the information if needed. If relevant, the distinction between the “production” and “consumption” approaches is made;
- The number of units in Switzerland in 2035 (using the “production approach”);
- The average annual electric consumption of a single unit;
- The average lifespan of the equipment;
- The technical characteristics (e.g., screen size, technology, etc.) if there are any. This allows to classify and consider equipment in a more precise manner, refining our modelling of environmental impacts with more granularity.

2.8.2.1 Tier I: End-user equipment

2.8.2.1.1 General methodology

Here is a summary of the methodology applied, for the various cases:
- Year 2024:

- Personal use: The data is obtained from the cited sources. If some treatments are done to the data, there are mentioned and justified (e.g. subtraction of an amount of equipment for professional use);

- Professional use: To estimate the quantity of equipment dedicated to a professional use in Switzerland in 2024, we used data on the number of employees per company size as well as statistics and educated guesses on the amount of equipment per employee;

Number of employees in the company	Primary sector	Secondary sector	Tertiary sector
Less than 10	133,451	237,701	880,526
Between 10 and 49	14,982	397,191	780,988
Between 50 and 249	5,560	398,724	754,190
More than 249	4,634	499,939	1,408,842

Table 8 – Total number of employees in Swiss companies in 2024 depending on the company size and economic sector[24]

Table 8 displays the number of employees depending on the company size and the economic sector. We consider that the employees likely to use professional end-user ICT devices are the ones in companies of more than 10 employees, in the secondary and tertiary sectors. This represents 4,239,874 employees in total, corresponding to 77% of the total number of employees.

- Year 2035:

  - Personal use: We conducted projections of the environmental impacts of ICT up to 2035, using the 2024 stock values as a baseline. Where available, we integrated existing forecasts on the evolution of device stock, both for Switzerland and, when national data are lacking, at the European level. In the absence of detailed stock data, we relied on market growth projections to infer future trends.

  - Professional use: To develop projections for 2035, we utilised forecasts from the Federal Office of Statistics regarding the active workforce and proportionally adjusted the number of devices within companies accordingly.

Given the inherent uncertainty surrounding technological advancements and future usage trends, we assumed that the technical characteristics, lifespan and electrical consumption of devices and infrastructures in 2035 would remain identical to those observed in 2024.

[24] https://www.alexandria.unisg.ch/entities/publication/64db8d56-9a73-4af2-8576-ec8ee256d1df

2.8.2.1.2 Smartphones

- Definition

A smartphone can be described as a mobile communication device that incorporates advanced computing capabilities. It is typically equipped with a touch-sensitive interface, offers connectivity through both wireless networks, includes satellite-based geolocation functionality (GPS), and operates on an operating system that supports the installation and execution of third-party applications.

- Number of units in Switzerland in 2024

For personal use	For professional use
8,304,976 units	1,102,367 units

Personal use: This data is extrapolated from the number of phones in Switzerland in 2022 from the Federal Office of Communication of Switzerland (OFCOM)[25]. The stock for 2024 has been readjusted using the variance in stock between 2021 and 2022 available on the same source. To this number, has been withdrawn a certain number of units dedicated to professional use (see below).

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[26]: a ratio of 0.26 smartphone per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
8,951,651 units	1,151,269 units

Personal use: Using the same penetration rate observed in 2024, considering that this rate already includes only personal equipment, we extrapolated the number of devices to the projected Swiss population in 2035[27].

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

3.65 kWh/year/unit[28]

[25] https://www.bakom.admin.ch/bakom/fr/home/telekommunikation/zahlen-und-fakten/sammlung-statisticher-daten/mobilfunk/anzahl-mobilfunkkundinnen-und-kunden.html
[26] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[27] https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/cantonal-projections.html
[28] https://www.energysage.com/electricity/house-watts/how-many-watts-does-a-phone-charger-use/

- Average lifespan

2.25 years[29]

- Technical specifications

	Entry level	Mid-range
Screen technology	Tactile LCD	Tactile OLED
Screen size (in inches)	6.6	6.6
Repartition (%)	51 %	49 %

Table 9 - Smartphones' technical specifications

According to a study conducted by Counterpoint Research[30], 49% of smartphones sold in the world in early 2023 are equipped with OLED displays. Based on this data, we assumed a distribution of 49% OLED smartphones and 51% LCD smartphones for the purposes of this study.

2.8.2.1.3 Feature phones

- Definition

A feature phone is a category of mobile device that offers more functionalities than a basic phone limited to calls and text messaging, yet does not reach the technological complexity of a smartphone. These devices are capable of handling voice communication, text exchanges, and may include select advanced features typically associated with smartphones.

- Number of units in Switzerland in 2024

For personal use	For professional use
308,700 units	270,298 units

Personal use: The proportion of users who "use a phone but don't use a smartphone" has been found in a study[31] about digital technology uses in Switzerland in 2024. This number multiplied by the population of Switzerland in 2024 gives the stock of feature phones.

[29] https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://cache.pressmailing.net/content/dfb88942-7d46-400b-9686-af3aeb61503b/Comparis_Smartphonestudie_2023_FR.pdf&ved=2ahUKEwiugJeLht-LAxUK1QIHHfcGMDkQFnoECBgQAQ&usg=AOvVaw0IyLrstfuR_ZNNtl9BeLwa
[30] https://www.counterpointresearch.com/insights/smartphone-oled-penetration-q1-2023/
[31] https://datareportal.com/reports/digital-2024-switzerland

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[32]: a ratio of 0.06 feature phone per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
332,737 units	282,289 units

Using the same penetration rate observed in 2024, and considering that this rate already includes only personal equipment, we extrapolated the number of devices to the projected Swiss population in 2035[33].

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

0.6 kWh/unit/year[34]

- Average lifespan

3 years

No specific information about the lifespan of feature phones has been found. We emitted the hypothesis that its lifespan is slightly bigger than a smartphone (which is 2.25 years).

2.8.2.1.4 Landline phones

- Definition

A landline telephone refers to a communication device connected to a fixed-line network. This may include a corded phone physically linked via cables, or a cordless handset which requires periodic charging on a base station.

- Number of units in Switzerland in 2024

For personal use	For professional use

[32] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[33] https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/cantonal-projections.html
[34] https://www.bmwk.de/Redaktion/DE/Downloads/E/entwicklung-des-ikt-bedingten-strombedarfs-in-deutschland-abschlussbericht.html

2,998,202 units	1,695,062 units

Personal use: The number of units in Switzerland in 2022 has been found on a report from OFCOM[35]. The variance from 2021 and 2022 which is -0.1% (meaning there is a negligible decrease in landline phones stock) has been found on the same report. The data from 2022 has been extrapolated to refresh the data to 2024.
Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[36]: a ratio of 0.40 landline phone per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
3,238,132 units	1,770,256 units

Personal use: Using the same penetration rate observed in 2024, and considering that this rate already includes only personal equipment, we extrapolated the number of devices to the projected Swiss population in 2035[37].

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

17.56 kWh/unit/year

This data has been estimated using an active consumption of 2,7W for 10 minutes/day and a stand-by power consumption of 2W for 1420 minutes/day for a single unit on the study "Development of ICT-related electricity demand in Germany" from the Fraunhofer and Borderstep Institutes[38] from 2015.

- Average lifespan

8 years[39]

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35 https://www.bakom.admin.ch/bakom/fr/home/telekommunikation/zahlen-und-fakten/sammlung-statisticher-daten/festnetz/anzahl-festnetzkundinnen-und-kunden.html

36 https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

37 https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/cantonal-projections.html

38 https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.izm.fraunhofer.de/content/dam/izm/de/documents/News-Events/News/2015/IZM-Studie-Strom/entwicklung-des-ikt-bedingten-strombedarfs-in-deutschland-kurzfassung.pdf&ved=2ahUKEwjguY_c

39 https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.izm.fraunhofer.de/content/dam/izm/de/documents/News-Events/News/2015/IZM-Studie-Strom/entwicklung-des-ikt-bedingten-strombedarfs-in-deutschland-kurzfassung.pdf&ved=2ahUKEwjguY_c

2.8.2.1.5 Desktops

- Definition

A desktop computer is a type of computer whose main unit is intended to remain stationary and is not designed for portability. It requires external peripherals, such as a monitor, keyboard, and mouse, to operate effectively.

- Number of units in Switzerland in 2024

For personal use	For professional use
1,718,815 units	1,606,315 units

Personal use: The penetration rate of desktops per household in Switzerland in 2021 has been found on a study from the Federal Office of Statistics (OFS)[40] of 2021. Multiplied by the population of inhabitants in Switzerland in 2024, it gives us the number of desktops in Switzerland. The equipment used in a professional context are subtracted from this total (see below).

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[41]: a ratio of 0.96 desktop per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
2,160,291 units	1,677,572 units

Personal use: To estimate the annual change in desktop computer volumes, we analysed data about imports, exports, and production volumes within the European Union from 2007 to 2020[42]. This allows to derive a trend in net availability, which serves as a proxy for evaluating the evolution of desktop stock over time.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

76.88 kWh/unit/year

[40] https://www.bfs.admin.ch/asset/fr/ind-f-30103
[41] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[42] https://www.indexbox.io/blog/desktop-computer-european-union-market-overview-2024-5/

This metric comes from a study of the Federal Office of Energy[43] (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

6 years[44]

- Technical specifications[45]

	Basic	Family (Mid-range)	Gaming	Gaming (High-range)	Power User
Repartition (%)	20 %	20 %	30 %	10 %	20 %

Table 10 - Desktops' technical specifications

2.8.2.1.6 Laptops

- Definition

A laptop is a computer specifically engineered for a mobile, whether connected to a power source or operating on battery. It features an integrated display and is designed to function independently without the need for peripheral components.

- Number of units in Switzerland in 2024

For personal use	For professional use
3,408,155 units	4,060,555 units

Personal use: The penetration rate of laptops per household in Switzerland in 2021 has been found on a study from the Federal Office of Statistics[46] (OFS) of 2021, and multiplied by the population of inhabitants in Switzerland in 2024, gives us the number of desktops in Switzerland. The equipment used in a professional context are subtracted from this total (see below).

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[47]: a ratio of 0.96 laptop per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use

43 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
44 https://sinfo.hefr.ch/fr/faq/quel-est-le-cycle-de-vie-du-materiel/
45 https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/
46 https://www.bfs.admin.ch/asset/fr/ind-f-30103
47 https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

4,617,890 units	4,240,683 units

Personal use: We applied a direct projection from 2025 to 2035[48], which is likely to provide a more reliable estimate than interpolations based on historical trends, as it better reflects the most recent dynamics of the market and aligns with current technological and policy developments.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

21.84 kWh/unit/year[49]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

5 years[50]

- Technical specifications[51]

	Desk type	Notebook Type	Gaming Type
Screen technology	LCD	LCD	LCD
Screen size (in inches)	14.5	14.5	15.6
Repartition (%)	50 %	40 %	10 %

Table 11 - Laptops' technical specifications

2.8.2.1.7 Tablets

- Definition

A tablet is a portable computing device characterized by its slim design and primary interface through a touchscreen. It typically lacks a built-in physical keyboard, relying instead on a virtual keyboard displayed on the screen. However, many models support the attachment of external keyboards, enhancing their versatility for tasks such as typing and productivity applications.

- Number of units in Switzerland in 2024

48 https://www.indexbox.io/blog/desktop-computer-european-union-market-overview-2024-5/
49 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
50 https://sinfo.hefr.ch/fr/faq/quel-est-le-cycle-de-vie-du-materiel/
51 https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/

For personal use	For professional use
5,310,599 units	1,658,685 units

Personal use: From Statista[52], we found the penetration rate for tablets users in Switzerland in 2021 which we used to estimate the stock for 2021.
Using the variance found in the study from the Federal Office of Energy[53] (BFE) between the years 2019 and 2020, we adjusted the value to find the total number of units in 2024.

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[54]: a ratio of 0.39 tablet per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
5,914,551 units	1,732,265 units

Personal use: To estimate future stock evolution in Switzerland, we used the projected change in device stock in the United Kingdom between 2024 and 2029[55]. From this, we derived an annual rate of variation, which is then applied to the Swiss context.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

6.60 kWh/unit/year[56]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment.
Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

4 years[57]

52 https://www.statista.com/statistics/568671/predicted-tablet-user-penetration-rate-in-switzerland/
53 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
54 https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
55 https://www.statista.com/statistics/553529/predicted-number-of-tablet-users-in-the-united-kingdom-uk/
56 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
57 https://sinfo.hefr.ch/fr/faq/quel-est-le-cycle-de-vie-du-materiel/

- Technical specifications[58]

	Entry-level (< 300CHF)	Mid-range (>300CHF, <900CHF)	High-range (>900CHF)
Screen technology	Tactile LCD	Tactile LCD	Tactile LCD
Screen size (in inches)	10.2	10.3	10.1
Repartition (%)	20 %	60 %	20 %

Table 12 - Tablets' technical specifications

2.8.2.1.8 Monitors

- Definition

A monitor is an electronic output device designed to display visual information processed by a computer. It typically includes a screen and the necessary electronic components to render images, text, and video. Monitors are essential peripherals for desktop computers, thin clients, and as secondary screens for laptops, facilitating user interaction and information display.

- Number of units in Switzerland in 2024

For personal use	For professional use
4,321,999 units	5,935,824 units

Personal use: The number of units in Switzerland for 2020 comes from a study from the Federal Office of energy (BFE) on the electric consumption of ITC equipment in Swiss households[59]. We used the annual variance in stock measured over 5 years from a market study of Cognitive Market Research[60] to extrapolate the total stock of monitors in Switzerland in 2024.

Professional use: The number of internet boxes used in a professional context has been evaluated using the number of employees in Switzerland (Table 8) and Resilio's internal benchmark data: a ratio of 1.4 monitors per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
5,490,912 units	6,199,139 units

[58] https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/
[59] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[60] https://www.cognitivemarketresearch.com/pc-monitor-market-report

Personal use: Based on data for production, imports, and exports, we calculated a Compound Annual Growth Rate (CAGR) for Switzerland over the period 2007 to 2020[61]. This rate is then used to estimate the projected number of devices in 2035. The resulting value is slightly lower than the corresponding estimate for the European market, and significantly below global market projections. This is consistent with the maturity and saturation of the Swiss digital market, which is characterized by stable adoption rates and slower growth compared to emerging economies.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

45.76 kWh/unit/year[62]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

6 years[63]

- Technical specifications

In a study commissioned by the EU in 2020, it has been estimated that, although there is a rise in OLED technology TVs sold, 99% of the stock is comprised of 24 inches LCD screen[64].

2.8.2.1.9 Televisions

- Definition

A television is an electronic device designed to receive and display audiovisual content transmitted via broadcast, cable, satellite, or internet services. It comprises a screen for visual output and integrated speakers for audio, facilitating the reception and presentation of multimedia programming. Modern televisions often incorporate advanced features such as high-definition resolution, smart capabilities for internet connectivity, and compatibility with various digital formats.

- Number of units in Switzerland in 2024

For personal use	For professional use

[61] https://app.indexbox.io/analyze/852841h852851h852861/757/?_gl=1*1600rk1*_ga*MTE4MjQzMzIxNi4xNzM0MzYzMzQ4*_ga_6KCVGEDSJE*czE3NDc4MjIzNjAkbzEwJGcxJHQxNzQ3ODIyMzcyJGowJGwwJGgw
[62] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[63] https://sinfo.hefr.ch/fr/faq/quel-est-le-cycle-de-vie-du-materiel/
[64] https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-11/IA_report-ICT_study_final_2020_(CIRCABC).pdf § Electronic Displays, p. 77

5,064,231 units	2,842,446 units

Personal use: The number of televisions for 2021 in Switzerland comes from a study[65] from the Federal Office of Statistics (OFS). It has been extrapolated to 2024 using the variance measured between 2020 and 2021 by the Federal Office of Energy (BFE) for their document[66] on electric consumption of household ITC equipment in Switzerland.

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[67]: a ratio of 0.67 TV per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
2,333,934 units	2,968,538 units

Personal use: Using data on production, imports, and exports[68], we calculated the Compound Annual Growth Rate (CAGR) for the Swiss television market between 2007 and 2020, which we then used to project the device stock for 2035. Interestingly, despite a notable global CAGR of +3.4% over the same period, the television stock in Switzerland shows a declining trend. This contrast likely reflects the mature state of the Swiss digital market, where device saturation and longer replacement cycles contribute to a stabilization or reduction in stock, in contrast to continued growth in less mature or expanding markets.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

92.16 kWh/unit/year[69]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

7.5 years[70]

65 https://www.bfs.admin.ch/asset/fr/ind-f-30103
66 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
67 https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
68 https://app.indexbox.io/analyze/852580h3/0/?_gl=1*6qkio6*_ga*MTE4MjQzMzIxNi4xNzM0MzYzMzQ4*_ga_6KCVGEDSJE*czE3NDc4MjIzNjAkbzEwJGcxJHQxNzQ3ODIyNjg4JGowJGwwJGgw
69 https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
70 https://www.halteobsolescence.org/hop-lance-un-appel-aux-fabricants-pour-des-televiseurs-plus-durables/

- Technical characteristics[71]

	Configuration 1	Configuration 2
Screen technology	LCD	OLED
Screen size	46.9	58.7
Repartition (%)	98 %	2 %

Table 13 - Televisions' technical specifications

2.8.2.1.10 Video game consoles

- Definition

A video game console is a specialized electronic device designed to output video and audio signals to display and play video games. These consoles typically interface with a television or monitor and are operated using dedicated controllers. They are categorized into two primary types:

  - Fixed consoles: These are stationary units intended for home use, requiring connection to external displays and power sources. Examples include the Sony PlayStation, and Microsoft Xbox.
  - Mobile consoles: These portable units integrate their own display, controls, and power supply, enabling gaming on the go. Notable examples are the Nintendo Switch in handheld mode and the Nintendo DS series.

Modern consoles often serve as multimedia hubs, supporting streaming services, internet browsing, and various entertainment applications, thereby enhancing their utility beyond gaming.

- Number of units in Switzerland in 2024

For personal use	For professional use
1,748,172 units	0 units

Personal use; The number of video game consoles sold in Switzerland for the year 2018 has been found on a study by PWC[72]. Using the lifespan of 7 years and the Compound Annual Growth Rate (CAGR) of the video game console market from 2018 to 2023 available on Statista as a proxy for the variance in stock, we extrapolated a metric for 2024.

- Number of units in Switzerland in 2035

For personal use	For professional use
1,194,903 units	0 units

[71] https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/
[72] https://www.pwc.ch/en/insights/tmt/semo-login/swiss-entertainment-and-media-outlook-2018-2022/video-games.html

Personal use: Using data on production, imports and exports[73], we calculated the Compound Annual Growth Rate (CAGR) for Switzerland over the period 2012 to 2020, which is then used to estimate the number of devices in 2035. The resulting negative CAGR contrasts with global trends, which generally show continued growth. However, applying this projection leads to an estimated device ownership of around 30% per household by 2035, a value that appears to be a reasonable approximation, aligning with the penetration rate reported by DataReportal for Switzerland in 2025. This reinforces the idea of a saturated and stable market in a highly developed digital environment.

- Average electric consumption

103 kWh/unit/year for fixed video game console[74] (ADEME 2025)
5.15 kWh/unit/year for mobile video game console[75]

- Average lifespan

7 years

It is difficult to estimate the actual lifespan video game consoles. The most accepted methodology to follow is to find the average span of time between old and new generations of consoles. For the three main actors of this market (Sony, Microsoft, Nintendo), this span of time is 7 years.

- Technical specifications[76]

	Fixed console	Mobile console
Repartition (%)	52 %	48 %
Stock	914,469	833,703

Table 14 - Video game consoles' technical specifications

2.8.2.1.11 Set-Top boxes

- Definition

A Set-Top box (STB), also known as cable box or TV box, is an external device connected to a television, enabling access to multiple content sources such as cable, terrestrial broadcast, satellite, or internet-based IPTV services. Modern TV boxes integrate streaming platforms like Netflix, Prime Video, and Disney+, consolidating various media channels into a single interface. Advanced models, including Android TV and Apple TV, offer smart functionalities, voice assistant compatibility.

- Number of units in Switzerland in 2024

[73] https://app.indexbox.io/analyze/852580h3/0/?_gl=1*6qkio6*_ga*MTE4MjQzMzIxNi4xNzM0MzYzMzQ4*_ga_6KCVGEDSJE*czE3NDc4MjIzNjAkbzEwJGcxJHQxNzQ3ODIyNjg4JGowJGwwJGgw
[74] https://agirpourlatransition.ademe.fr/particuliers/maison/economies-denergie-deau/electricite-combien-consomment-appareils-maison
[75] https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-11/IA_report-ICT_study_final_2020_(CIRCABC).pdf § Energy p. 91
[76] https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/

For personal use	For professional use
3,395,168 units	0 units

Personal use: The number of TV boxes for 2021 in Switzerland comes from a study[77] from the Federal Office of Statistics (OFS). It has been extrapolated to 2024 using the variance measured between 2020 and 2021 on this same study

- Number of units in Switzerland in 2035

For personal use	For professional use
4,454,755 units	0 units

Personal use: We applied the projected Compound Annual Growth Rate (CAGR) of TV boxes in Europe between 2025 and 2035[78] to the Swiss stock data from 2024, in order to estimate future stock levels. This projection results in a scenario where nearly 100% of Swiss households are equipped with a TV box by 2035, which appears consistent with the high level of digital service adoption in Switzerland.

- Average electric consumption

54.12 kWh/unit/year[79]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

5 years[80]

2.8.2.1.12 Internet boxes

- Definition

An internet box is a networking device that facilitates wireless communication between digital devices and the internet. It serves as a central hub, connecting to a modem to receive internet service and then distributing this connection wirelessly to various devices such as smartphones, laptops, and smart home equipment.

- Number of units in Switzerland in 2024

For personal use	For professional use

[77] https://www.bfs.admin.ch/asset/fr/ind-f-30103
[78] https://www.marketresearchfuture.com/reports/europe-set-top-box-market-21753
[79] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[80] sunrise.ch / salt.ch / swisscom.ch

3,214,966 units[81]	720,779 units

Personal use: This number is provided by the Federal Office of Statistics of Switzerland (OFCOM). It gives the number of connections to a fixed network in Switzerland, which is equivalent to the number of subscriptions to this network. We assumed that each subscriber uses an internet box to access the network.

Professional use: The number of internet boxes used in a professional context has been evaluated using the number of employees in Switzerland (Table 8) and Resilio's internal benchmark data: a ratio of 0.17 internet boxes per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
3,802,970 units	752,753 units

Personal use: To estimate the number of internet boxes in 2035, we used population projections[82] for that year along with the established figure of 95% household coverage by fixed network services (cf. Table 8). Among these connected households, we assumed that 80% have an active subscription and are equipped with a TV box. This assumption reflects both the high penetration of broadband infrastructure in Switzerland and the variability in service adoption rates among households.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

97 kWh/unit/year[83]

- Average lifespan

5 years

To obtain the average lifespan in Switzerland, we observed the announced lifespan of the three main telecom and internet boxes providers: Swisscom, Salt and Sunrise[84]. These three providers announce a lifespan of 5 years.

2.8.2.1.13 Personal printers

[81] https://www.bakom.admin.ch/bakom/en/home/telekommunikation/zahlen-und-fakten/sammlung-statisticher-daten/internet-service-provider.html
[82] https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/cantonal-projections.html
[83] https://agirpourlatransition.ademe.fr/particuliers/maison/economies-denergie-deau/electricite-combien-consomment-appareils-maison
[84] https://www.swisscom.ch/fr/clients-prives/aide/applis-et-services/Consumptionmmation-denergie.html#internet=&acc-internetbox%5Bselected%5D%5B%5D=3

- Definition

A personal printer is a dedicated device designed for producing printed documents. Unlike multifunction printers, it focuses solely on printing tasks, offering high-quality outputs for both text and images. These printers are available in various types, including inkjet and laser models, catering to different printing needs.

- Number of units in Switzerland in 2024

For personal use	For professional use
3,597,930[85] units	0 units

The number of units in Switzerland for 2020 comes from a study from the Federal Office of energy (BFE) on the electric consumption of ITC equipment in Swiss households[86]. We used the annual variance in stock found in the same study to extrapolate this number to 2024.

- Number of units in Switzerland in 2035

For personal use	For professional use
4,098,441 units	0 units

To estimate the number of personal printers, we relied on the projected change in sales volume between 2024 and 2034[87], and assumed a similar trend would continue from 2034 to 2035. This approach provides a consistent basis for extrapolating future stock, in the absence of more granular year-by-year projections.

- Average electric consumption

13.5 kWh/unit/year[88]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment.
Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

5 years[89]

2.8.2.1.14 Multifunction printers

[85] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[86] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[87] https://www.marketresearchfuture.com/reports/pocket-printer-market-32871
[88] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[89] https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-11/IA_report-ICT_study_final_2020_(CIRCABC).pdf, p144

- Definition

A multifunction printer (MFP) is an integrated device that combines multiple office functions into a single unit. Typically, MFPs combine printing, scanning, copying, and sometimes faxing capabilities, thereby simplifying workflow and reducing the need for separate devices. Modern MFPs often feature network connectivity, allowing for shared access across multiple users, and may support wireless communication protocols such as Wi-Fi or Bluetooth.

- Number of units in Switzerland in 2024

For personal use	For professional use
0 units	576,623 units

The number of printers has been evaluated using the number of employees in Switzerland (Table 8) and Resilio's internal benchmark data: a ratio of 0.136 multifunction printer per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
0 units	602,202 units

Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

133 kWh/unit/year[90]

- Average lifespan

6 years[91]

2.8.2.1.15 Beamers

- Definition

A beamer (or video projector) is an optical device designed to process analogue or digital video signals, regardless of their distribution, storage, or network format, in order to modulate a light source and project the resulting image onto an external screen. Audio signals, whether analogue or digital, may also be processed as an optional function of the projector.

[90] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[91] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

- Number of units in Switzerland in 2024

For personal use	For professional use
168,200 units	356,783 units

Personal use: The number of units in Switzerland for 2020 comes from a study[92] from the Federal Office of energy (BFE) on the electric consumption of ITC equipment in Swiss households.
We used the annual variance in stock between 2019 and 2020 from the same study to extrapolate the total stock of beamers in Switzerland in 2024.

Professional use: It is evaluated using the number of employees in Switzerland (Table 8) and data concerning the repartition between professional and personal use of ICT equipment, from one Ademe's study[93]: a ratio of 0.08 beamer per employee.

- Number of units in Switzerland in 2035

For personal use	For professional use
173,956 units	372,610 units

Personal use: For beamers, we based our estimate on the projected change in sales volume between 2024 and 2029[94], assuming that this trend would continue similarly from 2029 to 2035.

Professional use: Starting from 2024 data, the data is extrapolated using the ratio between the active population in 2024 and in 2035.

- Average electric consumption

51.5 kWh/unit/year[95]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment. Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

5 years[96]

[92] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[93] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[94]https://www.statista.com/forecasts/1256933/volume-growth-global-pc-monitor-projector-market
[95] https://www.newsd.admin.ch/newsd/message/attachments/69113.pdf
[96]https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-11/IA_report-ICT_study_final_2020_(CIRCABC).pdf

2.8.2.1.16 Connected speakers

- Definition

Connected speakers are external audio devices that interface with televisions to provide access to multiple content sources. These speakers often support wireless connectivity via Bluetooth or Wi-Fi and offer streaming capabilities for services such as Spotify and Deezer. Additionally, many models integrate virtual assistants, enabling voice command functionalities and enhancing user interaction.

- Number of units in Switzerland in 2024

For personal use	For professional use
4,321,999 units	0 units

The prevision for the penetration rate for connected speakers in the UK in 2024 comes from a study[97] from Mediatique. We assumed that the penetration rate from the UK is fairly similar to the one in Switzerland and multiplied it by its population in 2024 to find the total number of units in Switzerland.

- Number of units in Switzerland in 2035

For personal use	For professional use
5,977,859 units	0 units

For connected speakers, we identified a global Compound Annual Growth Rate (CAGR) of 3.6% in stock between 2025 and 2032[98]. We assume this growth rate will persist from 2032 to 2035.

- Average electric consumption

43.8 kWh/unit/year[99]

This metric comes from a study of the Federal Office of Energy (OFEN or BFE) from 2020 about the electric consumption of household ICT equipment.
Although published in 2020, it gives us a precise and reliable indication on the consumption specific to Switzerland.

- Average lifespan

5 years

[97] https://getdigitalradio.com/wp-content/uploads/2021/10/Mediatique-Ownership-and-use-of-audio-enabled-devices-in-2035-June-2021.pdf
[98] https://www.meticulousresearch.com/product/smart-speaker-market-5809
[99] https://www.senat.fr/fileadmin/Fichiers/Images/commission/Developpement_durable/MI_empreinte_environnementale/r19-555-annexe.pdf § p. 112

No detailed information has been found about the lifespan of connected speakers. Considering this equipment runs on a battery, we made a hypothesis of a lifespan of five years.

2.8.2.1.17 Internet of Things (IoT)

- Definition

IoT devices are physical objects embedded with sensors, software, and network connectivity, enabling them to collect and exchange data over the internet or other communication networks. These devices range from consumer products like smart thermostats and wearable fitness trackers to industrial equipment such as manufacturing sensors and medical monitors.

Personal IoT refers to connected smart devices used by individuals in their daily lives to monitor, assist, or enhance personal activities.

Industrial IoT refers to the use of connected sensors, devices, and machines in industrial settings (like manufacturing, energy, or logistics) to monitor processes, collect data, and improve efficiency, safety, and decision-making.

- Number of units in Switzerland in 2024

For both personal and professional use
21,454,840 units

A report[100] from 2023 estimate the repartition of IoT devices given their type of connections worldwide (cellular, Bluetooth, Wi-Fi and fixed). The Swiss Federal Office of Communication (OFCOM) delivered in 2023 another report[101] which indicates the number of cellular IoT subscriptions in Switzerland, which allowed us to estimate a total number of IoT devices in Switzerland.

The repartition of IoT devices into the following categories has been based on a report[102] from IEA from 2024.

Their attribution to either a personal or professional category has been based on the assumptions made by ADEME in their study[103] on the impacts of ICT technologies in France.

Categories of IoT	Stock in Switzerland in 2024 Personal use	Stock in Switzerland in 2024 Professional use
Automation, IoT (Industrial sensors)	0	18,253,968

[100] https://iot-analytics.com/number-connected-iot-devices/
[101] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres.html
[102] https://www.iea-4e.org/edna/tem/
[103] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

Automation, Cooking (ovens, cooktops, range hoods)	104,125	11,569
Automation, Lighting (Wi-Fi and low-energy)	1,596,579	177,398
Automation, Space Conditioning (Smart thermostats, air conditioners)	150,402	16,711
Automation, Street Lights	0	25,710
Automation, Water Heating (water heaters)	121,479	13,498
Automation, Appliances (Refrigerators, freezers, washing machines, clothes dryers, dishwashers, small appliances)	532,193	59,133
Automation, Audio	Already accounted for with connected speaker	
Security, Control for Public (Smart locks)	32,137	32,137
Security, Video for Public (IP cameras)	163,900	163,900

Table 15 - IoT stock amounts in 2024 for personal and professional use

- Number of units in Switzerland in 2035

For both personal and professional use
55,481,944 units

According to Statista[104], the number of IoT connections is expected to increase linearly from the present until 2035. We used these projections to calculate the annual growth in device stock, enabling a consistent estimation of IoT stock expansion over the coming years. The Swiss Federal Office of Communication (OFCOM) delivered in 2023 another report[105] which indicates the number of cellular IoT subscriptions in Switzerland, which allowed us to estimate a total number of IoT devices in Switzerland.

Categories of IoT	Stock in Switzerland in 2024 Personal use	Stock in Switzerland in 2024 Professional use
Automation, IoT (Industrial sensors)	0	47,204,529
Automation, Cooking (ovens, cooktops, range hoods)	269,265	29,918
Automation, Lighting (Wi-Fi and low-energy)	4,128,734	66,485
Automation, Space Conditioning (Smart thermostats, air conditioners)	388,939	458,748
Automation, Street Lights	0	43,215

104 https://www.statista.com/statistics/1403256/global-iot-connections/
105 https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres.html

Automation, Water Heating (water heaters)	314,143	34,905
Automation, Appliances (Refrigerators, freezers, washing machines, clothes dryers, dishwashers, small appliances)	1,376,245	152,916
Automation, Audio	Already accounted for with connected speaker	
Security, Control for Public (Smart locks)	83,107	83,107
Security, Video for Public (IP cameras)	423,843	423,843

Table 16 - IoT stock amounts in 2035 for personal and professional use

- Average electric consumption and lifespan

Lifespan and electric consumption data have been based on the assumptions made by ADEME in their study[106] on the impacts of ICT technologies in France. Only the connectivity and "intelligent" module is taken into account for the electricity consumption, not the entire equipment.

Categories of IoT	Lifespan (year)	Electric consumption (kWh/unit/year)
Automation, Cooking (ovens, cooktops, range hoods)	9.5	21.9
Automation, Lighting (Wi-Fi and low-energy)	7	10.687
Automation, Space Conditioning (Smart thermostats, air conditioners)	12	15.505
Automation, Water Heating (water heaters)	12	17.52
Automation, Appliances (Refrigerators, freezers, washing machines, clothes dryers, dishwashers, small appliances)	10.7	21.9
Security, Control for Public (Smart locks)	5	0.009
Security, Video for Public (IP cameras)	7.5	43.8

Table 17 - Lifespan and electric consumption for IoT

- Limitation

Some sensors that are used in a personal context may not have been accounted for. All sensors used in IoT for which a distinctive role has not been attributed (such as "Street lights") have been regrouped in the IoT category under category "Automation, Industrial sensors".

2.8.2.2 Tier II: Telecommunication networks

2.8.2.2.1 General information

[106] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

Telecommunication networks are systems that enable the transmission of data, voice, and multimedia across distances, facilitating communication between users and devices. These networks are categorized into three types: **fixed**, **mobile** and **backbone network**.

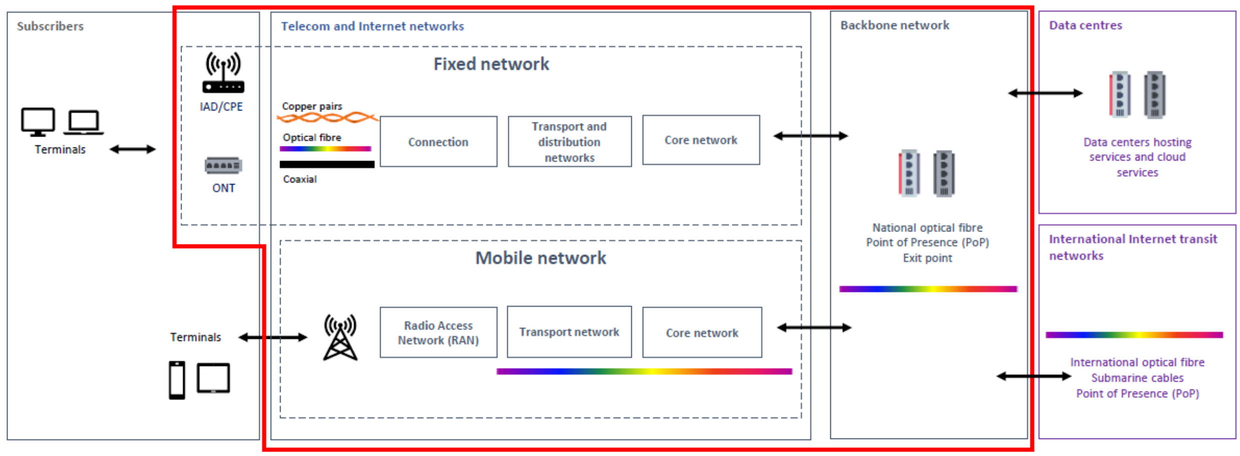

Figure 7 - Diagram of telecommunication networks in Switzerland[107]

2.8.2.2.2 Backbone

A **backbone network** in telecommunications refers to the central infrastructure that interconnects various subnetworks, facilitating high-capacity data transmissions across diverse geographical areas. The backbone network serves as the primary conduit for data flow, linking the mobile and fixed networks to data centres and enabling seamless communication between different parts of the overall network system.

It is mainly comprised of optic fibre cables and Points of Presence (PoP).

PoPs are physical locations where different networks or communication devices interconnect to facilitate data exchange. Due to a lack publicly available data, we had to exclude them from this study.

Additionally, the collected data concerning the length of optic fibre doesn't distinguish optic fibre cables used for the backbone or the fixed network. Therefore, we have decided to include the entirety of optic fibre length into the "Fixed network" section.

2.8.2.2.3 Fixed network

2.8.2.2.3.1 General data

[107] Figure inspired from the study on "Evaluation of the environmental footprint of internet service provisioning in France", https://librairie.ademe.fr/industrie-et-production-durable/7111-evaluation-of-the-environmental-footprint-of-internet-service-provisioning-in-france.html

A **fixed network**, also known as wired or landline networks, rely on physical infrastructure such as OCNs, copper wires, coaxial cables, or optic fibre lines used to establish connections between the backbone network and end-users. They are typically used for services like traditional telephony and broadband internet. Fixed networks are characterized by their high reliability, consistent bandwidth, and low latency, making them suitable for applications requiring stable and high-speed connections. However, their deployment is often limited by the need for extensive physical infrastructure, which can be cost-prohibitive in remote or underdeveloped areas.

The Federal Office of Communication (OFCOM) released in 2023 a report[108] indicating the number of subscribers for each type of connection which are further developed in the following sections. It is interesting to note that the total number of subscribers doesn't add up to the sum of the different technologies. A negligeable amount of the total number is attributed to "Other technologies", which aren't in the perimeter of this study.

Total number of fixed subscribers	4,152,752
FTTH subscribers	1,327,748
xDSL subscribers	1,789,240
Cable-modem subscribers	1,030,309

Table 18 - Number of network subscribers in Switzerland in 2023

The International Telecommunication Union (ITU) released in 2022 a document[109] indicating the total quantity of data exchanged annually in Switzerland through fixed networks:

Total quantity of data exchanged annually: 9,110,971,778 GB
Quantity of data exchanged annually per subscriber: 2,194 GB

Remark: It is important to note that a subscriber does not necessarily mean a single person, as a household or a company can be connected to the fixed network through a single subscription whereas there are more than one internauts.

The total electricity consumption dedicated to fixed networks, is coming from data of key industrial actors (not disclosable) for the year 2023. These figures are extrapolated using the respective market shares (number of subscribers) in order to obtain a consolidated estimate at the national level for Switzerland. It includes the electric consumption required to run all network equipment such as router, switches, active antennas, etc.

Total electric consumption for fixed networks in 2024: 373.75 GWh

To project values for 2035, we adjusted our estimates based on the anticipated evolution of telecommunications technologies, including the deployment of 5G networks and the expansion of optic fibre infrastructure. We also took into account the phasing out of obsolete technologies, ensuring a more accurate reflection of future infrastructure and device usage trends.

[108] https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/internet-service-provider.html
[109] https://www.itu.int/en/ITU-D/Statistics/Documents/DDD/ddd_CHE.pdf

We estimated the change in electricity consumption for the mobile network based on projected data consumption for 2035[110], assuming that electricity usage scales proportionally with data traffic. For the fixed network electricity consumption, no specific projections or proxies for 2035 are available. Therefore, we applied the same proportionality factor (×2.42) derived for the mobile network, assuming that the ratio of electricity consumption to data consumption remains constant between 2024 and 2035.

Total electric consumption for fixed networks in 2035: 905.03 GWh

The life cycle inventory for the fixed network equipment is detailed in the sections below.

Given the inherent uncertainty surrounding technological advancements and future usage trends, we assumed that the technical characteristics, lifespan and electrical consumption of devices and infrastructures in 2035 would remain identical to those observed in 2024.

2.8.2.2.3.2 Cables

A. Optic fibre cable

An optic fibre cable in telecommunication networks is a transmission medium composed of thin strands of glass or plastic that carry data as pulses of light. This technology enables high-speed, long-distance communication with minimal signal loss, making it ideal for broadband internet, telephony, and company networking. Compared to traditional copper cables, fibre optics offer greater bandwidth, enhanced security, and immunity to electromagnetic interference. They are fundamental to modern fixed-line infrastructure, supporting both core backbone systems and last-mile connections such as Fiber to the Home (FTTH), which is the main type of optic fibre installation throughout Switzerland.

The exact length of optic fibre in Switzerland poses a real challenge to estimate, as numerous companies install this type of cable, and no statistics compiling their length exist to this day.

Year 2024: To find the following number of kilometres of single-core optic fibre in 2024, we used data concerning one specific canton, coming from an external non-disclosable source, then extrapolated at the scale of Switzerland.
Year 2035: We use Swisscom as a benchmark for the expansion of fibre optic infrastructure in Switzerland, given that it is the largest FTTH (Fiber to the Home) provider in the country. Swisscom reported covering approximately 50% of households and professional sites in 2024, with plans to increase this coverage to 75–80% by 2030[111]. They also state the goal of enabling almost the entire Swiss population to access fibre networks by 2035. Considering an average growth rate of about 5% coverage per year and the increasing challenges of reaching the last few percent, primarily due to geographical constraints, we estimate a 95%

[110] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/observatoire-statistique/large-bande/donnes-mobiles1.html
[111] https://www.swisscom.ch/en/business/wholesale/ueberwholesale/aktuelles/f2f.html?endless=&srsltid=AfmBOorwzxvEOhlKDeUCI5tARreSkTq6Yl5s4aLpy_mSu0r6-are4Yxs&wcmmode=disabled

FTTH coverage in Switzerland by 2035. With this assumption, we estimate that the length of optic fibre cable will be multiplied by 1.9 from 2024 to 2035.

Length of optic fibre in Switzerland in 2024: 568,050 km
Length of optic fibre in Switzerland in 2035: 965,686 km
Lifespan of optic fibre: 25 years[112]

B. Co-axial cable

A coaxial cable is a type of electrical cable used in fixed networks to transmit high-frequency signals with low loss. It consists of a central conductor, an insulating layer, a metallic shield, and an outer protective jacket, which together minimize signal interference and allow for reliable data transmission. Coaxial cables are commonly employed in applications such as cable television, broadband internet, and telephone trunk lines, often serving as the distribution medium in hybrid fibre-coaxial (HFC) networks. While they offer durability and ease of installation, coaxial cables are gradually being supplanted by fibre-optic cables in scenarios requiring higher bandwidth and longer transmission distances.
The coaxial cable is installed in the last portion of the fixed network, connecting directly end-users to the fixed network.

Year 2024: No relevant data on the total number of coaxial cables has been found regarding Switzerland. We took the educated guess of 300 meters of coaxial cable connection per cable-modem subscriber.

Year 2035: While there are a clear and significant expansion of fibre optic networks in Switzerland, no relevant data or indications suggest any notable growth in coaxial cable infrastructure. Given this lack of development, we assumed that the length of coaxial cable networks will remain unchanged between 2024 and 2035, reflecting its diminishing role in future telecommunications infrastructure.

Length of coaxial cable in Switzerland in 2024: 309,093 km
Length of coaxial cable in Switzerland in 2035: 309,093 km
Lifespan of coaxial cable: 10 years[113]

C. Copper cable

Due to the scarcity and outdated nature of available data, we are unable to obtain reliable information regarding the total length of copper cabling. This lack of current data impedes accurate assessment and analysis of existing copper infrastructure. We decided to exclude it from the impact assessment of fixed network.

[112] https://www.acome.com/en/publications/446-expert-opinions/2963-are-ftth-overhead-optical-networks-reliable-copper-networks
[113] https://tongda-cable.com/comparing-the-lifespan-of-cat-6-network-cables-to-other-types/

According to Swisscom, the entirety of the copper cable network should be dismantled to the profit of FTTH by 2030[114].

2.8.2.2.3.3 OCNs

A. General information

In the context of fixed telecommunications networks, an Optical Connection Node (OCN) serves as a central hub in FTTH infrastructures. It functions as the primary aggregation point where optic fibres from the core network converge before being distributed to subscribers via intermediate nodes such as optical splitters and branch points.

The OCN houses critical equipment, including Optical Line Terminals (OLTs), power supplies, and climate control systems, ensuring efficient signal management and network reliability. Strategically positioned to cover extensive service areas, the OCN is the junction point between the backbone and the fixed network.

Year 2024: To find the number of OCNs, we used data concerning one specific canton, coming from an external non-disclosable source, then extrapolated at the scale of Switzerland.

Year 2035: The value for the number of OCNs has been adjusted based on the projected expansion of fibre optic networks between 2024 and 2035. It is coherent to proportionally adapt the number of OCNs to this metric, as OCNs are positioned between the last mile and the backbone, making their number directly dependent on the total kilometres of fibre optic cable deployed. The number of equipment has been adapted accordingly.

Number of OCNs in Switzerland in 2024: 456
Number of OCNs in Switzerland in 2035: 775

It is notable that the extrapolation we used give a very low number of OCNs in Switzerland compared to the estimations for the number of OCNs in France (approximately one OCN per 20,000 inhabitants in Switzerland against one OCN per 3,000 inhabitants in France according to various governmental and regional sources). However, no other source has been found to challenge this quantity.

The amounts of equipment located in OCNs and the corresponding lifespan are detailed in the following sections.

A. OLT

An Optical Line Terminal (OLT) is a key component of Passive Optical Networks (PONs), located at the operator's central office. The OLT converts electrical signals into optic signals and coordinates data transmission using TDM or WDM. It handles downstream and upstream traffic control, dynamic bandwidth

[114] https://www.swisscom.ch/fr/about/reseau/kupferanschluss.html?srsltid=AfmBOoov5o-T3FaBK8AQC1oHQ74At9nomfLI_dfFGMJKXVkHMH2BzjUK#acc-i3Y5SQ%5Bselected%5D%5B%5D=1

allocation, and network management. OLTs are essential for delivering high-speed broadband in FTTH deployments.

Number of OLTs in Swiss OCNs in 2024: 2,992 units
Number of OLTs in Swiss OCNs in 2035: 5,087 units
Lifespan: 7 years

Year 2024: Quantity and lifespan are coming from an Ademe study[115] from 2023. The quantity has been extrapolated using the ratio between the number of subscriptions in France and in Switzerland.

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

B. DSLAM

A DSLAM is a network device used by telecommunication providers to aggregate multiple Digital Subscriber Line (DSL) connections from end-users into a high-capacity backbone network. Located in telephone exchanges or street cabinets, it connects subscribers to the core network, enabling broadband internet access. The DSLAM separates voice and data signals and supports various DSL technologies. It plays a crucial role in optimizing bandwidth allocation and maintaining signal integrity over long copper loops.

Number of DSLAMs in Swiss OCNs in 2024: 6,742 units
Number of DSLAMs in Swiss OCNs in 2035: 11,005 units
Lifespan: 7 years

Year 2024: Quantity and lifespan are coming from an Ademe study[116] from 2023. The quantity has been extrapolated using the ratio between the number of subscriptions in France and in Switzerland.

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

C. Switch/Collection routers

Switches and collection routers are used to aggregate and forward data traffic from access networks to the core network. These devices ensure efficient data transmission, traffic prioritization, and network scalability.

Number of switches and collection routers in Swiss OCNs in 2024: 1,622 units
Number of switches and collection routers in Swiss OCNs in 2035: 2,757 units
Lifespan: 7 years

[115] https://librairie.ademe.fr/ged/8458/evaluation_impact_environnementale_reseaux_fixes_mobiles_rapport.pdf
[116] https://librairie.ademe.fr/ged/8458/evaluation_impact_environnementale_reseaux_fixes_mobiles_rapport.pdf

Year 2024: Quantity and lifespan are coming from an Ademe study[117] from 2023. The quantity has been extrapolated using the ratio between the number of subscriptions in France and in Switzerland.

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

D. Aggregation routers

An aggregation router is a high-capacity network device used to consolidate data traffic from multiple access routers or switches before forwarding it to the core network. Aggregation routers are crucial in managing large volumes of data, ensuring load balancing, and providing redundancy. They are typically deployed in metropolitan or regional networks, acting as intermediaries between the access and core layers to optimize overall network performance.

Number of aggregation routers in Swiss OCNs in 2024: 2,223 units
Number of aggregation routers in Swiss OCNs in 2035: 3,779 units
Lifespan: 7 years

Year 2024: Quantity and lifespan are coming from an Ademe study[118] from 2023. The quantity has been extrapolated using the ratio between the number of subscriptions in France and in Switzerland.

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

E. Low voltage distribution board

A Low Voltage Distribution Board is an electrical panel used to distribute electrical power to various circuits within a building or facility at low voltage levels, typically below 1,000 volts. It receives power from a transformer or main switchboard and ensures its safe and organized distribution. It includes protective devices such as circuit breakers and fuses to prevent overloads and short circuits. It plays a critical role in electrical safety, operational reliability, and ease of maintenance in both industrial and commercial environments.

Number of distribution boards in Swiss OCNs in 2024: 456 units
Number of distribution boards in Swiss OCNs in 2035: 775 units
Lifespan: 5 years

[117] https://librairie.ademe.fr/ged/8458/evaluation_impact_environnementale_reseaux_fixes_mobiles_rapport.pdf
[118] https://librairie.ademe.fr/ged/8458/evaluation_impact_environnementale_reseaux_fixes_mobiles_rapport.pdf

Year 2024: Quantity and lifespan are coming from the Product Category Rule for Internet Service Provisioning[119].

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

F. Air conditioner

An air conditioner is a device designed to regulate the temperature, humidity, and air quality of an enclosed space by removing heat and moisture from the interior. They are essential for maintaining optimal environmental conditions, ensuring the stable operation of heat-sensitive electronic equipment. Efficient cooling contributes to equipment longevity and overall system reliability.

Number of air conditioners in Swiss OCNs in 2024: 1,824 units
Number of air conditioners in Swiss OCNs in 2035: 3,101 units
Lifespan: 5 years

Year 2024: Quantity and lifespan are coming from the Product Category Rule for Internet Service Provisioning[120].

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

G. Infrastructure

An OCN infrastructure made of steel and concrete provides a durable base for outdoor telecom equipment ensuring stability and weather resistance in network deployments.

Amount of steel for Swiss OCNs in 2024: 26,819 tons
Amount of concrete for Swiss OCNs in 2024: 182,438 m³

Amount of steel for Swiss OCNs in 2035: 45,591 tons
Amount of concrete for Swiss OCNs in 2035: 310,145 m³

Lifespan: 50 years

[119] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
[120] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html

Year 2024: Quantity and lifespan are coming from the Product Category Rule for Internet Service Provisioning[121].

Year 2035: Quantity is obtained by linearly extrapolating the 2024 data using the number of OCNs in 2024 and 2035.

2.8.2.2.4 Mobile network

2.8.2.2.4.1 General data

A mobile networks, also known as cellular network, utilizes wireless technologies to provide connectivity to users on the move. They consist of a network of base stations (which consists of an emission site and its equipment) that communicate with mobile devices using radio frequencies. It operates by dividing regions into "cells," each served by a base station (either a pylon or a terrace emission site) that transmits and receives radio signals, facilitating seamless connectivity for mobile users. The mobile network is what connects the backbone network to mobile end-user equipment.

The Federal Office of communication released the total number of mobile subscriptions in Switzerland[122] in 2023, which we re-adjusted to 2024 using the annual variance between 2023 and 2024 found on a report[123] from DatarePortal.

Number of mobile subscriptions: 9,829,496 subscriptions

It is interesting to note that the number of subscriptions is not fully representative of the number of users, as some people, especially in a professional context, may own two or more subscriptions.

The OFCOM released in 2023 a document[124] indicating the total quantity of data exchanged annually in Switzerland through mobile networks:

Total quantity of data exchanged annually in 2024: 2,097,099,704 GB
Quantity of data exchanged annually per subscription in 2024: 213.35 GB

As well, this is not completely representative of the quantity of data consumed per person, as the number of subscriptions is not equal to the number of subscribers.

[121] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
[122] https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/broadband/mobile-networks1.html
[123] https://datareportal.com/reports/digital-2024-switzerland
[124] https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/broadband/mobile-networks1.html

We obtained data from OFCOM[125] detailing the evolution of mobile data consumption in Switzerland from 2009 to 2023. Observing a linear growth trend from 2016 to 2023, we assume this linear progression will continue consistently from 2024 to 2035.

Total quantity of data exchanged annually in 2035: 5'078'099'704 GB
Quantity of data exchanged annually per inhabitant in 2035: 520.83 GB

As mentioned before, we used this previous estimate to evaluate the electricity consumption on the mobile network, assuming that the evolution in mobile data consumption is correlated to the electric consumption.

Total electric consumption for mobile networks in 2024: 228.3 GWh
Total electric consumption for mobile networks in 2035: 552.82 GWh

The life cycle inventory for the mobile network equipment is detailed in the sections below.

2.8.2.2.4.2 Passive antennas

Passive antennas are radio antennas designed to support multiple wireless communication standards, such as 2G, 3G, 4G, and 5G, within a single physical unit. These antennas are "passive," meaning they do not require an external power source to operate, relying instead on the connected active equipment for signal processing.

Number of passive antennas in 2024: 46,539 units
Number of passive antennas in 2035: 22,780 units
Lifespan: 7 years

Year 2024: The quantity is obtained from a study by OFCOM[126]. The lifespan is obtained from the Ademe's Product Category Rule for Internet Service Provisioning[127].

Year 2035: According to an OFCOM report[128], 2G and 3G networks will begin to be phased out starting in 2025, as Switzerland already has full (100%) coverage of 4G and 5G networks. It is reasonable to assume that 2G and 3G services will be completely discontinued by 2035. We also assume that the number of 4G and 5G equipment will remain stable, given the existing full coverage. Regarding 5G+, Swisscom reported 86% coverage in 2025 with plans to reach 90% by 2030[129]. We therefore projected a further 4% increase from 2030 to 2035, resulting in an estimated 94% coverage, and adjusted the 5G+ equipment numbers accordingly.

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125 https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/observatoire-statistique/large-bande/donnes-mobiles1.html
126 https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/etudes/evaluation-du-marche-des-telecommunications.html
127 https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
128 https://www.comcom.admin.ch/en/mobile-coverage
129 https://www.swisscom.ch/en/about/news/2025/04/16-chip.html?srsltid=AfmBOorihUgEK2U2Mc_7shw-4cSmY5mJdZBZAxUBFm7-uwFYbJZFcJoU

N.B.: No planning or deployment information has been found regarding 6G in Switzerland. We therefore assume that it will not be in place by 2035.

2.8.2.2.4.3 Active 5G+ antennas

Active 5G+ antennas are advanced radio frequency antennas that integrate both the antenna elements and the necessary active components, such as amplifiers and signal processing units, into a single unit. Unlike passive antennas, these antennas require power to operate the integrated components, enabling them to actively boost signal strength, improve coverage, and optimize performance. They are essential for enhancing the performance and efficiency of 5G+ infrastructure.

Number of active antennas in 2024: 8,000 units
Number of active antennas in 2035: 8,744 units
Lifespan: 7 years

The quantity is obtained from a study by OFCOM[130]. The lifespan is obtained from the Ademe's Product Category Rule for Internet Service Provisioning[131].

2.8.2.2.4.4 Multi-technology RRU/RRH amplifier

A Multi-Technology Remote Radio Unit (RRU) or Remote Radio Head (RRH) amplifier supports multiple radio access technologies, such as 2G, 3G, 4G, and 5G, within a single unit. Positioned close to the antenna, they amplify the radio signals before transmission, thereby enhancing network coverage and capacity.

Number of amplifiers in 2024: 163,617 units
Number of amplifiers in 2035: 94,573 units
Lifespan: 7 years

The quantity is obtained from a study by OFCOM[132]. The lifespan is obtained from the Ademe's Product Category Rule for Internet Service Provisioning[133].

2.8.2.2.4.5 Multi-technology BBU card

A Multi-Technology Baseband Unit (BBU) card handles the signal processing functions required for different radio access technologies, such as modulation, demodulation, and error correction.

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[130] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/etudes/evaluation-du-marche-des-telecommunications.html
[131] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
[132] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/etudes/evaluation-du-marche-des-telecommunications.html
[133] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html

Number of BBUs in 2024: 54,539 units
Number of BBUs in 2035: 31,524 units
Lifespan: 7 years

The quantity is obtained from a study by OFCOM[134]. The lifespan is obtained from the Ademe's Product Category Rule for Internet Service Provisioning[135].

2.8.2.2.4.6 Telecommunication pylon

A telecommunication pylon is a tall structure, typically made of steel and concrete, that supports antennas for wireless signal transmission. It ensures wide coverage and clear line-of-sight communication in mobile and radio networks. These pylons are essential for hosting equipment like 4G and 5G antennas.

Amount of steel for pylons in 2024: 13,965 tons
Amount of concrete for pylons in 2024: 38,000 m³

Amount of steel for pylons in 2035: 13,965 tons
Amount of concrete for pylons in 2035: 38,000 m³

Lifespan: 50 years

Year 2024: The number of emission site has been found on an article[136] from 2019. Considering new technologies are mostly built on existing emission sites, this number should not be outdated. The amount and lifespan of steel and concrete for one pylon are obtained from the Ademe's Product Category Rule for Internet Service Provisioning[137].

Year 2035: Since new technologies can be deployed on existing emission sites, the quantity of steel and concrete required for these sites is not expected to change over time.

2.8.2.2.4.7 Telecommunication terrace

A telecommunication terrace is a reinforced platform, typically made of steel and concrete, used to support telecom equipment on rooftops or elevated structures. It provides a stable and secure base for antennas, RRUs, and other components in urban environments.

Amount of steel for terrace in 2024: 28,500 tons

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[134] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/etudes/evaluation-du-marche-des-telecommunications.html
[135] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
[136] https://www.radiolac.ch/actualite/telephonie-mobile-les-antennes-deviennent-espagnoles/
[137] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html

Amount of concrete for terrace in 2024: 95.000 m³

Amount of steel for terrace in 2035: 28,500 tons
Amount of concrete for terrace in 2035: 95.000 m³

Lifespan: 50 years

Year 2024: The number of emission site has been found on an article[138] from 2019. Considering new technologies are mostly built on existing emission sites, this number should not be outdated. The amount and lifespan of steel and concrete for one pylon are obtained from the Ademe's Product Category Rule for Internet Service Provisioning[139].

Year 2035: Since new technologies can be deployed on existing emission sites, the quantity of steel and concrete required for these sites is not expected to change over time.

2.8.2.3 Tier III: Data centres

2.8.2.3.1 General information

A **data centre** is a specialized facility designed to house and manage ICT infrastructure. It encompasses a range of components, including servers, storage systems, networking equipment, and security devices, all operating within a controlled environment to ensure optimal performance and reliability. These data centres are engineered to provide continuous power supply, efficient cooling systems, and robust physical and cybersecurity measures to safeguard data integrity and availability.

Data centres serve as the backbone for various digital services, enabling the storage, processing, and dissemination of vast amounts of data essential for business operations, cloud computing, and internet services. Their design and operation are critical to ensuring high availability, scalability, and resilience in the face of growing digital demands.

Data centres are connected to end-user equipment through telecommunication networks: they are first connected to the backbone network, which is then connected to either the mobile or fixed network, to finally reach end-users.

2.8.2.3.2 Assessment of the data centre fleet

To evaluate the surface and types of data centres In Switzerland in 2024, we used the predictions for the total energy consumption dedicated to data centres from the Federal Office of Energy (OFEV) [140] for 2024 based on the data from 2019, considering prospects, transition towards cloud and efficiency increase to

[138] https://www.radiolac.ch/actualite/telephonie-mobile-les-antennes-deviennent-espagnoles/
[139] https://librairie.ademe.fr/industrie-et-production-durable/6008-referentiel-par-categorie-de-produit-rcp-de-la-fourniture-d-acces-internet-fai.html
[140] https://www.newsd.admin.ch/newsd/message/attachments/66075.pdf

come. We selected the high-case scenario for the energy consumption, in accordance with LCA methodologies and the current trends related to AI development[141]. Data is summarised in Table 19.

We selected the data for the total electric consumption dedicated to data centres from the only Swiss source we found regarding this subject. It is a prediction to 2024 of a conjoint report[142] from BFE and Energie Schweiz from 2021. We selected the "High-case" scenario, taking into account the recent advances of AI and a conservative approach in alignment with LCA methodology:

Total data centre electric consumption: 3.503 TWh

Considering that the total electricity consumption in Switzerland is 57 TWh[143], we observe that data centres account for a relatively high share, representing 6.14% of the total consumption.
For comparison, in 2024 in the USA, the part of electricity allocated to data centres is estimated[144] to be between 4.5% and 5.5%. Globally, data centre electricity consumption is estimated to 506 TWh[145] and total electricity consumption around 25,000 TWh[146] which correspond to 2%.

From a report from CBRE dating from 2024[147], we deduced the area of colocation data centres in Switzerland. Using the average consumption for colocation data centres from the study from ADEME on the evaluation of ICT impacts in France[148] in 2021, we deduced the electric consumption of colocation data centres in Switzerland.

From the total electric consumption dedicated to data centres and the one for colocation data centres, we attributed the remaining electric consumption to traditional (companies, public local and national) data centres.

Finally, we used the electric consumption and repartition of traditional data centres found on the same study from ADEME[149] to deduce the total area for each type of data centres

Total data centre area: 262,257 m²

[141] https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf
[142] https://www.newsd.admin.ch/newsd/message/attachments/66075.pdf
[143] https://www.bfe.admin.ch/bfe/fr/home/approvisionnement/statistiques-et-geodonnees/statistiques-de-lenergie/statistique-globale-de-l-energie.html/
[144] https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf
[145] https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/
[146] https://www.iea.org/reports/global-energy-review-2025/electricity
[147] https://mktgdocs.cbre.com/2299/3fd99343-c523-4b58-9dff-72bc2131cf6b-635235536/Data_Center_Market_Switzerland.pdf
[148] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
[149] https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html

We used the PUE of 1.93 indicated on the ICT final study report[150] from 2020 for traditional data centres. We took the assumption that most of the data centres created after 2020 are colocation and cloud dedicated data centres, and that the PUE indicated on this study fits the traditional data centres in Switzerland. For colocation data centres, after discussions with experts in this field and due to the lack of reliable data, we assumed a PUE of 1.30. Therefore, we obtain an **average value of PUE in Switzerland of 1.4**, by weighting the average across the surface.

ICT equipment electric consumption: 2.502 TWh
Non-ICT equipment electric consumption: 1.001 TWh

Finally, an **occupation rates** are taken as indicated by CBRE on their report on the data centre market in Switzerland in 2024[151].

	Public local DC	Public national DC	Company DC	Colocation DC	Importation of Cloud services	Total
Total number	85	69	2,317	98	-	2,569
Total area (m²)	7,589	6,068	29,107	219,200	284	262,257
Occupation rate	40%	35%	50%	80%	-	-
PUE	1.93	1.93	1.93	1.3	-	-
Electric consumption (TWh)	0.062	0.064	0.393	2.981	0.003	3.503

Table 19 - Data centres characteristics

To evaluate the surface and types of data centres In Switzerland in 2035, we found an estimate of the total energy consumption for data centres globally, and a repartition of the workload dedicated to AI for 2035. According to an IEA report on global data centre electricity consumption, under the "Lift-Off Case" scenario, which assumes stronger AI adoption growth compared to the Best Case and aligns with Switzerland's position as an AI pioneer, the electrical consumption of data centres is projected to increase by a factor of 4.25 between 2024 and 2035.

Total data centre electric consumption in 2035: 14.875 TWh

We use the 2035 electricity consumption data for data centres, along with estimates of workload distribution between AI and traditional servers, based on a 2025 McKinsey report[152] indicating that 75% of the workload by 2035 will be dedicated to AI. By combining this with the average power consumption of

[150] https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2020-11/IA_report-ICT_study_final_2020_(CIRCABC).pdf
[151] https://mktgdocs.cbre.com/2299/3fd99343-c523-4b58-9dff-72bc2131cf6b-635235536/Data_Center_Market_Switzerland.pdf
[152] https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-cost-of-compute-a-7-trillion-dollar-race-to-scale-data-centers#:~:text=To%20decide%20how%20much%20to,hinges%20on%20two%20key%20uncertainties

these server types and assumptions drawn from relevant studies[153], reports, and projections, we estimate the actual quantity, not just workload, of servers dedicated to AI and traditional tasks. Additionally, using a 2025 global ICT impact study[154], we classify the remaining traditional servers into two categories with distinct configurations: mid-range and high-range.

Total data centre area in 2035: 573,065 m²

2.8.2.3.3 Consumption and production approaches

As explained in section 2.4.1.2, the Tier III impacts can be assessed using a "**production approach**" (also called "**location-based approach**") or a "**consumption approach**" (also called "**market-based approach**").

Indeed, some data centres installed in Switzerland are used for cloud services consumed outside of Switzerland whereas part of the cloud services consumed in Switzerland are hosted in data centres located outside of Switzerland.

In the consumption approach, the goal is to get the most accurate evaluation of environmental impacts of the Swiss population. Therefore, we consider all the data centres located in Switzerland, and then adjust the results by:

- Subtracting the portion of these data centres that provide cloud services outside of Switzerland;
- Adding a portion of data centres located outside of Switzerland that provide cloud services for Swiss internauts.

This is done using the methodology defined by **Masanet**[155] in 2020. It allows to compute the net change in electricity consumption due to exportation and importation of cloud services in Switzerland in 2024. To do so, it uses electricity consumption and the repartition between traditional data centres and public cloud data centres in the world and in the considered country. The discrepancy between these two repartitions would give the net change due to import and export.

In this study, the repartition between traditional data centres and public cloud data centres in Switzerland is vera similar to the one in the world and therefore the correction to apply a consumption approach is very small: + 3.8 GWh of electricity. This value is very low compared to the total data centres electricity consumption in Switzerland. Therefore, there is no big changes between the consumption and the production approaches.

Electricity consumption correction due to the "consumption approach": + 3.80 GWh

In this case, one limit of the Masanet model is highlighted as it doesn't detail the portion of import versus export of cloud services. Indeed, the majority of environmental impacts of data centres and cloud are generally concentrated in the usage phase, and the environmental impacts of Switzerland's electricity mix

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153 500W for traditional servers and 2000W for AI servers

154 https://www.greenit.fr/wp-content/uploads/2019/11/GREENIT_EENM_etude_EN_accessible.pdf

155 "Recalibrating global data center energy use estimates." de Masanet, E., Shehabi, A., Lei, N., Smith, S., and J.G. Koomey (2020), https://datacenters.lbl.gov/sites/default/files/Masanet_et_al_Science_2020.full_.pdf

are low compared to the neighbouring countries. This can lead to an under-estimation of the impacts if for example Switzerland exports a large amount of cloud services while consuming a similar amount of cloud services coming from abroad.

NB: The "consumption approach" is not applied to the 2035 assessment because the Masanet model is based on 2018 data, already extrapolated to obtain 2024 data. Applied these outdated hypotheses for a prospective analysis for 2035 to lead to a very high uncertainty.

2.8.2.3.4 ICT equipment

The number of IT-equipment and their lifespan is obtained based on the area (useful area dedicated to ICT equipment in data centres, based on the total area times the occupation rate) and the occupation rate of data centres.

For 2035 inventory, we proportionally adjust the quantity of equipment according to the projected change in the number of servers between 2024 and 2035 mentioned above.

Given the inherent uncertainty surrounding technological advancements and future usage trends, we assumed that the technical characteristics, lifespan and electrical consumption of devices and infrastructures in 2035 would remain identical to those observed in 2024.

2.8.2.3.4.1 Servers

Servers are powerful computing machines designed to manage, process, and store large volumes of data. Servers provide essential services such as web hosting, database management, and network traffic control. Servers in data centres are configured to handle specific tasks, such as application processing, storage management, or virtualization.

Servers have been divided into three different categories depending on their usage: 90% mid-range, 4% high-range and 6% AI dedicated servers.

The share of AI dedicated server is found using the ratio between traditional and AI data centres. The repartition between mid-range and high-range is taken from GreenIT world study[156].

A. Mid-range servers

Configuration: *Rack server, 32 RAM 64GB each, 2 SSD Disk 1024GB each, CPU Intel Xeon Platinum 8490H, GPU Custom Dedicated Graphics Card, 1 rack units*

	Production approach	Consumption approach
2024	613,699 units	614,364 units

[156] https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/

2035	815,068 units	-

Lifespan: 5.5 years

B. High-range servers

Configuration: *Rack server, 32 RAM 64GB each, 2 SSD Disk 1024GB each, CPU Intel Xeon Platinum 8490H, 1 rack units*

	Production approach	Consumption approach
2024	25,571 units	25,599 units
2035	33,961 units	-

Lifespan: 5.5 years

C. AI-dedicated servers

Servers dedicated to AI have a special configuration including a Graphic Processing Unit (GPU) to allow more computing capabilities. Their electric consumption can be up to ten times more compared to a standard server[157].

We used a study from Goldman Sachs from 2025 estimating the power demand from AI in Swiss data centres to be around 14% in 2023. Considering the configurations selected for the servers and the electric consumption due to data centres in Switzerland, we extrapolated the number of AI servers in Switzerland

Configuration: *Rack server, 32 RAM 64GB each, 2 SSD Disk 1024GB each, CPU Intel Xeon Platinum 8490H, GPU Custom Dedicated Graphics Card, 1 rack units*

	Production approach	Consumption approach
2024	39,954 units	39,998 units
2035	636,772 units	-

Lifespan: 5.5 years

2.8.2.3.4.2 Switch/router

Switches and **routers** are essential network devices that ensure efficient data flow and connectivity between servers, storage systems, and other network components. Switches optimize internal communication and reduce congestion within the data centre. Routers are responsible for directing data between different networks, such as linking the data centre's internal network to external networks or the

[157] https://news.ucsb.edu/2025/021835/power-ai-data-centers-need-more-and-more-energy

internet. Together, switches and routers are vital for maintaining high-speed, reliable, and secure communication within data centre infrastructures.

The number of switches is obtained from the number of servers. A switch is considered to have 48 ports. A hypothesis of 5 ports per server is used, according to the Masanet study[158].

	Production approach	Consumption approach
2024	78,031 units	78,115 units
2035	170,692 units	-

Lifespan: 5 years

2.8.2.3.4.3 Storage servers

Storage servers are machines that contain multiple disks. Their main goal is to manage and store a load of digital information. The disks can be of two types:

- **Hard Disk Drives** (HDDs) are used primarily for high-capacity storage solutions, where cost-efficiency is a priority over speed. HDDs store data on spinning magnetic platters, and while they offer slower read/write speeds compared to Solid-State Drives (SSDs), they are ideal for archiving and storing large volumes of data that do not require frequent access.
- **Solid-State Drives** (SSDs) are used for high-performance storage applications, providing faster data access, reduced latency, and higher durability compared to traditional HDD. SSDs utilize flash memory to store data, with no moving parts, which allows for quicker read/write speeds and improved reliability.

The number of disks SSD and HDD is obtained using Ademe's data[159] to obtain a ratio of disks per server. By considering storage servers made of 48 disks we obtained the following quantities.

SSDs	Production approach	Consumption approach
2024	65,914 units	65,985 units
2035	144,186 units	-

Lifespan: 3 years

HDDs	Production approach	Consumption approach
2024	129,741 units	129,882 units
2035	283,809 units	-

Lifespan: 5 years

158 https://datacenters.lbl.gov/sites/default/files/Masanet_et_al_Science_2020.full_.pdf
159 https://librairie.ademe.fr/societe-et-politiques-publiques/7880-evaluation-de-l-impact-environnemental-du-numerique-en-france.html

2.8.2.3.5 Non-ICT equipment

The number of non-ICT equipment and their lifespan is obtained based on the area (useful area dedicated to ICT equipment in data centres, based on the total area times the occupation rate) and the occupation rate of data centres. The occupation rate is retrieved from a study[160] from ADEME on the environmental impacts of ICT in France in 2022.

2.8.2.3.5.1 Refrigerant leaks

Refrigerants are substances used in cooling systems to maintain optimal temperature and prevent overheating of servers and other equipment. These cooling systems typically include air conditioning units, chillers, or liquid cooling systems, which rely on the refrigerant to absorb and transfer heat from the interior of the data centre to the external environment.

	Production approach	Consumption approach
2024	7,593 kg	7,601 kg
2035	16,609 kg	-

2.8.2.3.5.2 Batteries

Lead-acid batteries are commonly used in data centres as a backup power source for uninterruptible power supplies (UPS) systems. These batteries provide critical backup power during outages or fluctuations in the electrical grid, ensuring that the data centre's equipment remains operational and avoids downtime.

	Production approach	Consumption approach
2024	45,810 units	45,860 units
2035	100,211 units	-

Lifespan: 8 years[161]

2.8.2.3.5.3 Three phase inverters

A **three-phase inverter** is used to convert DC (direct current) power, typically from battery storage or solar panels, into AC (alternating current) power. It ensures a stable and reliable power supply to critical equipment by efficiently managing the conversion process for three-phase electrical systems, which are common in data centres.

	Production approach	Consumption approach
2024	2,860 units	2,863 units

160 https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://librairie.ademe.fr/societe-et-politiques-publiques/7880-9522-evaluation-de-l-impact-environnemental-du-numerique-en-france.html&ved=2ahUKEwix75bFqvCMAxUx9rsIHUe6Ax8QFnoECBYQAQ&usg=A

161 https://librairie.ademe.fr/industrie-et-production-durable/6031-referentiel-par-categorie-de-produit-rcp-de-services-cloud-et-de-centre-de-donnees.html

2035	6,255 units	-

Lifespan: 5 years[162]

2.8.2.3.5.4 Refrigeration units

A **refrigeration unit** is a crucial component for maintaining the optimal temperature and preventing overheating of critical ICT infrastructure. These units work by circulating refrigerants through cooling coils, absorbing heat from the data centre's air, and releasing it outside the facility.

	Production approach	Consumption approach
2024	572 MW	573 MW
2035	1,251 MW	-

Lifespan: 15 years[163]

2.8.2.3.5.5 Server bays 42U

A 42U **server bay** refers to a standard-sized rack used in data centres to house servers and other network equipment. The "42U" designation indicates that the rack is 42 units high. These racks are typically used to organize and mount servers, switches, storage devices, and other ICT equipment in a space-efficient manner.

	Production approach	Consumption approach
2024	104,789 units	104,903 units
2035	229,226 units	-

Lifespan: 20 years[164]

2.8.2.3.5.6 Infrastructure

The quantity of steel and concrete required to build the surface of data centre has been considered in this study.

[162] https://librairie.ademe.fr/industrie-et-production-durable/6031-referentiel-par-categorie-de-produit-rcp-de-services-cloud-et-de-centre-de-donnees.html
[163] https://librairie.ademe.fr/industrie-et-production-durable/6031-referentiel-par-categorie-de-produit-rcp-de-services-cloud-et-de-centre-de-donnees.html
[164] https://librairie.ademe.fr/industrie-et-production-durable/6031-referentiel-par-categorie-de-produit-rcp-de-services-cloud-et-de-centre-de-donnees.html

3 Presentation of the results

In this section, environmental footprint results for year 2024 are presented, starting from a global overview and moving toward more granular analyses.

A comparative analysis with other similar studies is performed in order to assess the coherence and robustness of the results. This comparison further provides valuable insights into Switzerland's positioning in the broader context of digital environmental impacts. Various sensitivity analyses are also performed.

Finally, environmental footprint projection results for 2035 are shown.

N.B.: In the following sections, the results are sometimes given the notation "E". For example, 4.3E-03, corresponds to 4.3 x 10^{-3} in scientific notation or 0.0043 in decimal notation. Furthermore, in tables showing percentages, the total may not be exactly 100% due to rounding.

3.1 Global evaluation with the "*consumption approach*"

In this section, we focus on the "consumption approach", as this approach gives us the most realistic evaluation of the digital technologies used by of the Swiss population. Results for the "*production approach*" can be found in section 3.1.4.

3.1.1 Quantities of equipment and fluxes

In the subsequent sections, this report analyses the extent of personal digital equipment ownership among Swiss residents, first focusing on end-user devices. Additionally, it examines the supporting infrastructure, including telecommunications networks and data centres, by quantifying the number of devices and assessing relevant metrics.

3.1.1.1 Internet users

As of the 2nd trimester 2024, Switzerland's population is estimated at 9,002,763 individuals[165]. Among this population, 99.0% are active internet users spending an average of 5 hours and 32 minutes per day on the internet[166], reflecting the nation's extensive digital connectivity.

As of December 2024, the number of employed individuals in Switzerland is reported at approximately 5,521,429 individuals, according to data from CEIC Data[167].

3.1.1.2 End-user devices

[165] https://www.bfs.admin.ch/news/fr/2024-0538
[166] Internet users aged 16 to 64, https://datareportal.com/reports/digital-2024-switzerland
[167] https://www.ceicdata.com/en/indicator/switzerland/employed-persons

51,250,956 end-user devices are attributed to personal use. This includes smartphones, laptops, tablets, smart TVs, gaming consoles, as well as personal IoT. On average, **each resident owns 5.7 personal devices**. This high device-to-person ratio reflects the pervasive integration of digital technologies into daily life, encompassing smartphones, tablets, laptops, smartwatches, and other connected devices.

Regarding the **professional users**, it is estimated that they used **20,825,737 ICT devices**, resulting in an average of **3.8 devices per worker**. This figure encompasses a range of equipment, including desktop computers, laptops, mobile devices, and specialized tools essential for various occupational functions (printers, beamers, etc.). The substantial number of devices per worker highlights the critical role of ICT in professional settings and the associated environmental considerations.

Although this number may appear low compared to the average number of personal devices, it is important to note that these are supplementary devices. Indeed, they add to, rather than replace, the personal equipment already owned for personal usage.

It is important to note that industrial Internet of Things devices are excluded from the afore mentioned figures, as their inclusion, due to their exceptionally high numbers, would have significantly skewed the estimates. Indeed, the vast majority of industrial IoT devices are industrial sensors and automated components that are not directly operated by individual workers. Nevertheless, it remains relevant to acknowledge that approximately **18,754,024 industrial IoT devices** are in use across Switzerland in 2024.

Excluding industrial Internet of Things devices, the total number of end-user devices (for personal and professional use) in Switzerland amounts to 72,076,693. This corresponds to a total of **8.0 end-user devices per inhabitant**, highlighting the high degree of digital equipment penetration within the population.

3.1.1.3 Telecommunication networks

This section presents the number of network equipment units deployed for telecommunication networks in Switzerland as of 2024, along with their per-capita equivalents and associated usage metrics such as the number of subscribers and data traffic volumes.

Parameter	Unit	Value for fixed network	Value for mobile network
Number of subscriptions	unit	4,152,752	9,826,496
Amount of data transferred yearly per subscription	GB	2,194	213
Total electricity consumption	GWh	374	228
Network equipment quantity[168]	item	15,866	272,695

[168] Optic fibre and coaxial cables distances have been excluded from this count.

Table 20 - Usage metrics for fixed and mobile networks

As shown in Table 20, this represents a total of **288,561 telecommunications network equipment units in Switzerland**, excluding cables and structural components.

A significant disparity is observed between the number of equipment units deployed in fixed and mobile networks. This discrepancy is primarily attributable to the exclusion of cable infrastructure from the equipment count, despite its substantial contribution to the physical footprint of the fixed network. Furthermore, mobile networks are inherently more spatially distributed, as they rely on a dense network of "cells" comprised of 19,000 emission sites for a total of almost 55,000 multi-technologies antennas, to ensure near-complete national coverage. In contrast, fixed networks typically require fewer relay points, as they serve static access points with more centralized infrastructure. A second explanation could be competition between mobile operators, which leads to duplication of infrastructure such as antennas.

3.1.1.4 Data centres

These facilities operate continuously and are typically optimized for high performance, redundancy, and energy efficiency. As of 2024, the total number of data centre equipment units in Switzerland is estimated at **1,108,205 units, including 679,960 servers**.

While end-users rarely interact directly with this infrastructure, its environmental impact is substantial due to the high electricity demand for both computing and cooling, as well as the material intensity of high-performance hardware.

3.1.1.5 Overall results

Taking into account all three tiers of the digital ecosystem (end-user devices, data centres and networks, excluding industrial IoT) the total number of ICT devices in use in Switzerland in 2024 is estimated at **73,473,459 units**. This corresponds to an average **of 8.5 devices per inhabitant**.

Of this total, approximately 94% are end-user devices, 5.6% are data centre equipment, and only 0.4% are attributed to telecommunications network infrastructure. The number of telecom infrastructure devices is naturally lower than that of end-user equipment because infrastructure is shared across a large number of users. This mutualization leads to a lower device count relative to the population served. Additionally, end-user devices are smaller, more compact, and produced in higher volumes, while infrastructure components are typically larger, more powerful, and less numerous. Therefore, device counts alone may not accurately reflect the scale or impact of the underlying systems and should be interpreted with caution.

Switzerland's total electricity consumption is approximately 57 TWh[169], with **digital technologies collectively consuming around 6.9 TWh**. This represents nearly **12% of the country's overall electricity use**, reflecting the significant demand from the digital sector.

Data centres alone account for a substantial share of this consumption, estimated at about 6.1% of total Switzerland's electricity consumption, almost half of the total electricity dedicated to digital technologies in Switzerland. Indeed, Switzerland has a high density of data centres per capita. This attractiveness can be explained by strict data protection, the country's political stability, its low-carbon electricity mix, and low environmental risks (e.g. seismic activity).

3.1.2 Environmental impacts at the scale of the country

Global environmental footprint results of ICT technologies in Switzerland in 2024 are presented in Table 21.

Impact category	Unit	Global environmental impact	Share of normalized total footprint
Resource use, minerals and metals	t Sb eq.	186	40%
Freshwater ecotoxicity, per capita	CTUe	65,038,535,926	23%
Climate change	t CO_2 eq.	1,985,341	14%
Resource use, fossils	GJ	49,310,506	10%
Fine particles	Disease incidence	86.9	8%
Freshwater eutrophication	t P eq.	207	2%
Total primary energy	GJ	73,402,135	-

Table 21 - Global impact of digital technologies in Switzerland in 2024, with the consumption approach

Taking these impact categories individually:

- Resource use, minerals and metals (ADPe)

This impact category accounts for **40% of the total impact**, highlighting a major contribution from the ICT sector to resource extraction, mainly linked to hardware production. This corresponds **to 186 tons of Sb eq.**, or the equivalent **of 930 million tons of excavated soil**[170]. This also corresponds to **the metals and minerals contained in 62 million smartphones**.

- Freshwater ecotoxicity (CTUe)

[169] https://www.news.admin.ch/en/newnsb/iTP15U0PYP57z2h_7EXJO
[170] Using a value of clarke of 2,00E-04 kg eq. Sb per ton of excavated soil.

It corresponds to **65,038,535,926 CTUe**. In a study assessing the life cycle of a bottle of shower gel, the total freshwater ecotoxicity potential ranged from approximately 49.6 to 64.5 CTUe, depending on wastewater treatment scenarios[171]. The freshwater ecotoxicity result corresponds to the equivalent impact of producing approximately **1.1 billion bottles of shower gel annually,** in other words, enough bottles to cover the consumption of the entire Swiss population for about 50 years[172].

- Global Warming Potential (GWP)

Although it accounts for **14% of the total quantified impact**, climate change remains a central environmental concern due to its systemic and long-term consequences. It is particularly relevant for ICT systems with high electricity consumption or complex supply chains involving energy-intensive manufacturing.

This corresponds to **1,985,341 tons of CO_2 eq**. Considering the consumption-based CO_2 emissions in Switzerland in 2023 are 122 million tons of CO_2[173], that means that **digital technologies are responsible for almost 2% of the total Swiss consumption-based CO_2 emissions**.

- Usage of fossil resources (ADPf)

With **10% of the total environmental impact**, this indicator highlights the significant energy intensity of certain ICT components or services. Despite being a smaller share compared to other impact categories, the depletion of fossil resources remains a critical issue due to its close ties with energy security, economic stability, and environmental degradation.

This corresponds to roughly **49 million GJ of fossil resources energy**. This is the equivalent of burning 1.5 billion litres of automotive gasoline[174].

- Fine particles (PM)

Although it accounts for **8% of the total environmental impact**, this indicator reflects a direct and measurable threat to human health, illustrating the importance of emission control and clean energy strategies in ICT-related systems.

A **disease incidence of 86.9** due to particulate matters emission in the atmosphere corresponds to the number of individuals who contracted the disease per 1,000 people exposed over a one-year period. As a point of comparison, in Switzerland in 2023, there has been 46,913 hospital admissions for respiratory diseases[175]. Then 86.9 cases represent nearly 0.18% of this value. While it may seem numerically small,

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171 https://www.ecetoc.org/wp-content/uploads/2021/10/ECETOC-TR-127-Freshwater-ecotoxicity-as-an-impact-category-in-life-cycle-assessment.pdf
172 https://www.planetoscope.com/hygiene-beaute/435-consommation-de-shampoings-en-france.html
173 https://ourworldindata.org/co2/country/switzerland#consumption-based-accounting-how-do-emissions-compare-when-we-adjust-for-trade
174 https://www.bts.gov/content/energy-consumption-mode-transportation-0
175 https://www.bfs.admin.ch/asset/en/34027730

this proportion is significant, especially considering that these cases are preventable with improved air quality measures.

- Freshwater eutrophication (Epf)

While this indicator represents only **2% of the total environmental impact**, it remains a critical environmental concern due to its regional scale and its potential to harm freshwater resources, which are vital for drinking, irrigation, and biodiversity.

This corresponds to **207 tons of phosphor eq**. leakages annually in Switzerland. The eutrophication can easily be linked to farming which also leaks non-negligible amounts of phosphor into water (1.3kg of P/ha/years in average for pastoral land[176]). The eutrophication due to ICT technologies is equivalent to the eutrophication due to about **1,600 square kilometres of pastoral land**, which is about **26% of all pastoral land in Switzerland in 2023**[177].

- Total Primary Energy (TPE):

This corresponds to **73 million GJ of energy**, or the equivalent to 95 times Switzerland's energy consumption in 2023[178].

3.1.3 Environmental impacts at the individual scale

In this section, we analyse the results on an individual scale. We used the total population reported by OFS[179] to be 9,002,763 people at the end of the 2nd trimester of 2024. It is roughly comparable to the number of internauts in Switzerland, as the proportion of Internet users in 2024 is estimated to be 99.0% by DataReportal[180]. The results are summarised in Table 22.

Impact category	Unit	Footprint per capita
Resource use, minerals and metals	g Sb eq.	20.7
Freshwater ecotoxicity	CTUe	7,224
Climate change	kg CO_2 eq.	221
Usage of fossil resources	GJ	5.5
Fine particles	Disease incidence	9.7E-6

176 https://ballance.co.nz/advice/phosphorus/managing-p-loss
177 https://www.bfs.admin.ch/bfs/fr/home.gnpdetail.2024-0391.html
178 https://www.bfs.admin.ch/bfs/fr/home/statistiques/energie/consommation.html
179 https://www.bfs.admin.ch/news/fr/2024-0538
180 https://datareportal.com/reports/digital-2024-switzerland

Freshwater eutrophication	g P eq.	23
Total primary energy	GJ	8.2

Table 22 - Environmental impacts of digital technologies per capita in Switzerland in 2024

By taking these environmental impact categories individually:

1. Resource use, minerals and metals (ADPe)

This corresponds to **20.7 grams of Sb eq**., or the equivalent of excavated soil[181]. This also corresponds to **buying 7 smartphones per person per year**.

2. Freshwater ecotoxicity (CTUe)

This corresponds to **7,224 CTUe per person** in a year. In terms of ecotoxicity, this would be equivalent to consuming **127 bottles of shower gel[182] per person per year**.

3. Global Warming Potential (GWP)

This corresponds to **221 kg of CO_2 eq**. This the equivalent to **driving 554 km by car[183] in a year** for each resident.

4. Usage of fossil resources (ADPf)

This corresponds to **roughly 5.5 GJ of fossil resources energy** per person. This is the equivalent of **operating a radiator for 4.2 hours a day[184]** for each Swiss inhabitant.

5. Fine particles (PM)

This corresponds to a disease incidence of **6.3E-6,** due to particulate matters in the atmosphere per resident. This corresponds to approximately **1 case of disease due to particulate matter for every 103,618 individuals**.

6. Freshwater eutrophication (Epf)

This corresponds **to 23 grams of phosphor eq.** leakages annually in Switzerland. Discharging 23 grams of phosphorus into a lake with a volume of 1 million litres (1,000 cubic meters) would result in a concentration of 23 mg/L, which is approximately 654 times higher than the 0.035 mg/L threshold to prevent

[181] Using a value of clarke of 2,00E-04 kg eq. Sb per ton of excavated soil.
[182] https://www.ecetoc.org/wp-content/uploads/2021/10/ECETOC-TR-127-Freshwater-ecotoxicity-as-an-impact-category-in-life-cycle-assessment.pdf
[183] Using the equivalence of 398 g CO2 eq. per km (from Ecoinvent database)
[184] Radiator of 1000 W, 365 days per year

eutrophication. This illustrates how even seemingly small quantities of phosphorus can have disproportionate impacts on freshwater ecosystems.

3.1.4 Comparison of results with the "production approach"

In this section, we present the results of the "production approach" and highlight how they differ from the "consumption approach". The differences between the two approaches are detailed in section 2.4.1.2.

As the only differences concern the Tier III, Table 23 summarises the amount of equipment and fluxes between the two approaches.

Parameter	Unit	Production approach	Consumption approach
Total number of servers	item	679,224	679,960
Total number of Tier III equipment (including servers)	item	1,107,004	1,108,205
Electricity consumption	GWh	3,500	3,503.8

Table 23 - Comparison of fluxes between production and consumption approaches for Tier III – Data centres

Table 24 shows that, despite a slight increase in impacts with the "consumption approach" due to the net import of cloud services, the results remain largely similar. This suggests that Switzerland is highly developed in terms of data centre infrastructure, with a significant share of digital service demand already being met by domestic facilities.

Impact category	Unit	Footprint per capita - Production approach	Footprint per capita - Consumption approach
Resource use, minerals and metals	g Sb eq.	20.7	20.7
Freshwater ecotoxicity, per capita	CTUe	7,222	7,224
Climate change	kg CO_2 eq.	220	221
Resource use, fossils	GJ	5.4	5.5
Fine particles	Disease incidence	9.6E-6	9.7E-6
Freshwater eutrophication	g P eq.	23	23
Total primary energy	GJ	8.2	8.2

Table 24 - Comparison of environmental impacts between production and consumption approaches

One limitation of this approach lies in the lack of granularity in the method (explained in section 2.8.2.3.3). While it is possible to estimate the **net import and export of cloud services**, we do not have sufficient detail to precisely quantify the bilateral flows of cloud services between Switzerland and other countries. This limitation is particularly relevant given the significant differences in electricity mixes between Switzerland and many of its trading partners. As a result, the associated environmental impacts, especially those linked to energy consumption, are likely to be non-negligible.

3.1.5 Comparison to Planetary Boundaries

Planetary boundaries refer to **critical ecological thresholds** that define a **safe operating space for humanity**. These thresholds aim to quantify the limits within which global environmental systems can continue to function stably and sustainably. It is possible to compare the environmental footprint of digital technologies per capita to the planetary boundaries in order to evaluate whether it stays within globally sustainable levels.

Impact category	Percentage of planetary boundary per capita
Resource use, minerals and metals	65%
Freshwater ecotoxicity	38%
Climate change	22%
Usage of fossil resources	17%
Fine particles	13%
Freshwater eutrophication	3%

Table 25 - Planetary boundary results per capita

Table 25 illustrates the contribution of the impacts to the planetary limits. In 2024, digital technologies in Switzerland consume 22% of the annual per capita sustainable budget to stay below 1.5°C of global warming. Similarly, they consume 65% of the annual sustainable budget in terms of the use of mineral and metal resources, and 38% of the planetary sustainable budget in terms of freshwater ecotoxicity.

The data clearly demonstrate that while the ICT sector does not yet exceed any planetary boundaries per capita in Switzerland, it **already consumes substantial portions of the safe operating space**, particularly for mineral resource use, freshwater ecotoxicity, and climate change.

This leads us to consider how much of the total space within the limits can be occupied by ICT technologies. Indeed, **many other needs must also be taken into account, such as housing, mobility, food, healthcare, etc.** Defining the portion of these planetary boundaries that we can **reasonably allocate to ICT technologies** involves weighing their usefulness and contributions to society against our other needs. In a scenario of digital sobriety, such considerations should be discussed with civil society at the political and philosophical levels.

3.1.6 Normalization using Swiss eco-factors

Another normalization is applied using the **Swiss eco-factors**. They are computed using the **ecological scarcity method**, based on the principle of distance to target. More details about the methodology are given in section 2.6.2.2.

By multiplying the LCA results by the Swiss eco-factors, UBP values are obtained. They are summarised in Table 26. The higher the value of UBP, the greater the contribution of digital equipment and infrastructure to the environmental issue in question.

Impact categories	UBP value	% of total UBP value
Climate change	1.99E+12	54%
Human toxicity, cancer	9.30E+11	25%
Resource depletion, fossils	4.09E+11	11%
Eutrophication, freshwater	2.01E+11	5%
Eutrophication, marine	8.17E+10	2%
Resource depletion, minerals and metals	2.79E+10	1%
Eutrophication, terrestrial	1.93E+10	1%
Ozone depletion	9.95E+09	0%
TOTAL	**3.66E+12**	**100%**

Table 26 - Swiss eco-factors global results

The environmental impact of ICT technologies in Switzerland in 2024 represents a total of **3,665 billion UBP**. It is equivalent to 4.07E+05 UBP per capita.

The impact categories that concentre the most impacts are not the same than the ones selected with the PEF normalization method or the planetary boundaries. Indeed, the criteria used are not the same. The eco-factors are computed based on the ratio between the current emissions and the maximum tolerated quantity, whereas the PEF normalization factors are computed by summing the characterization factors of all flows in one impact category, and planetary boundaries are computed as the ecological thresholds to avoid irreversible damages.

It can be observed that with these three methods, climate change always appears in the three most important impact categories. This tends to show that climate change is one of the most important environmental issues to consider and that decarbonization of digital technologies is essential in the digital transition.

3.2 Repartition of the environmental impacts with the "*consumption approach*"

3.2.1 Repartition of the results per Tier

The environmental footprint of digital technologies in Switzerland in 2024 can be categorized into the three Tiers.

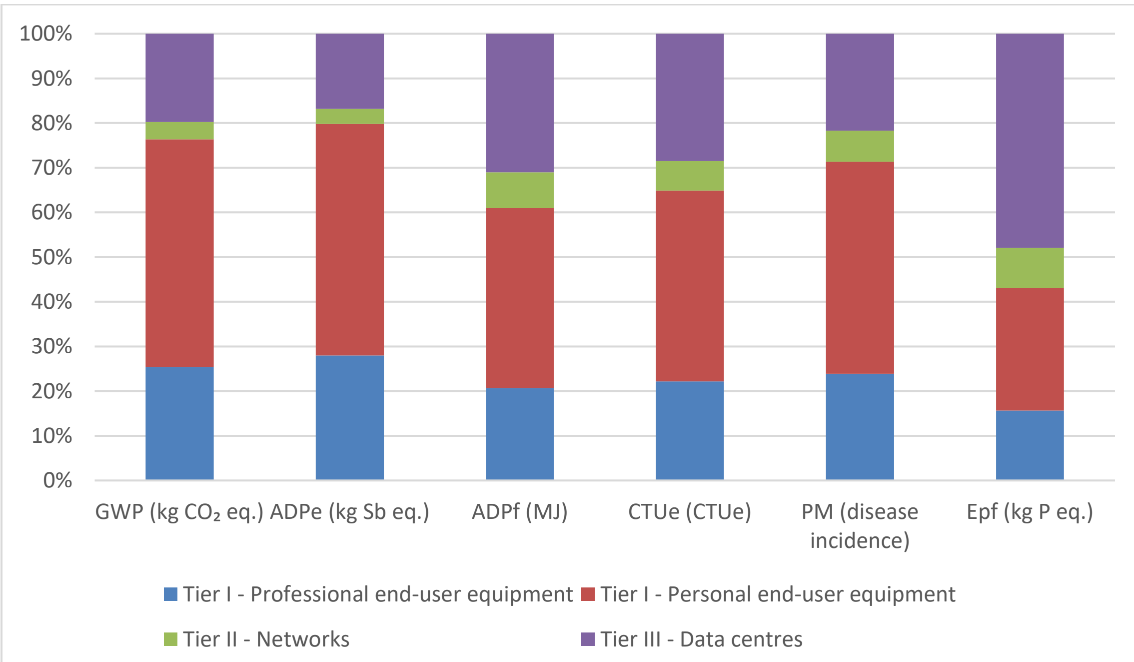

Figure 8 – Global environmental footprint repartition by Tier

As illustrated in Figure 8, personal end-user terminals represent the most significant share, accounting for 51% of the impact on climate change. Professional equipment represents 25% of the environmental footprint. Although less prominent in the public discourse, these assets constitute a critical portion of professional digital infrastructures and are often overlooked in individual assessments. Overall, the **end-user terminal category regroups 76% of the total impact**.

Data centres contribute to 20% of the total digital technologies' footprint on climate change. Finally, **telecommunications networks account for only 4%** of the total environmental impact. Despite their essential role in ensuring digital connectivity nationwide, their relative footprint remains modest.

This repartition on the climate change impact category is similar to the one for the other impact categories. One impact category stands out, freshwater eutrophication, for which data centres concentrate almost 50% of the total footprint.

To better understand the distribution of these impacts, it is necessary to study it according to the life cycle, detailed in the next section.

3.2.2 Repartition of the results per life cycle stage

Figure 9 illustrates the environmental footprint repartition by life cycle stage and Figure 10 illustrates the environmental footprint repartition by life cycle stage and Tier. Overall, two key life cycle stages clearly emerge: manufacturing and usage phases. A divergence in Tier contributions is also visible.

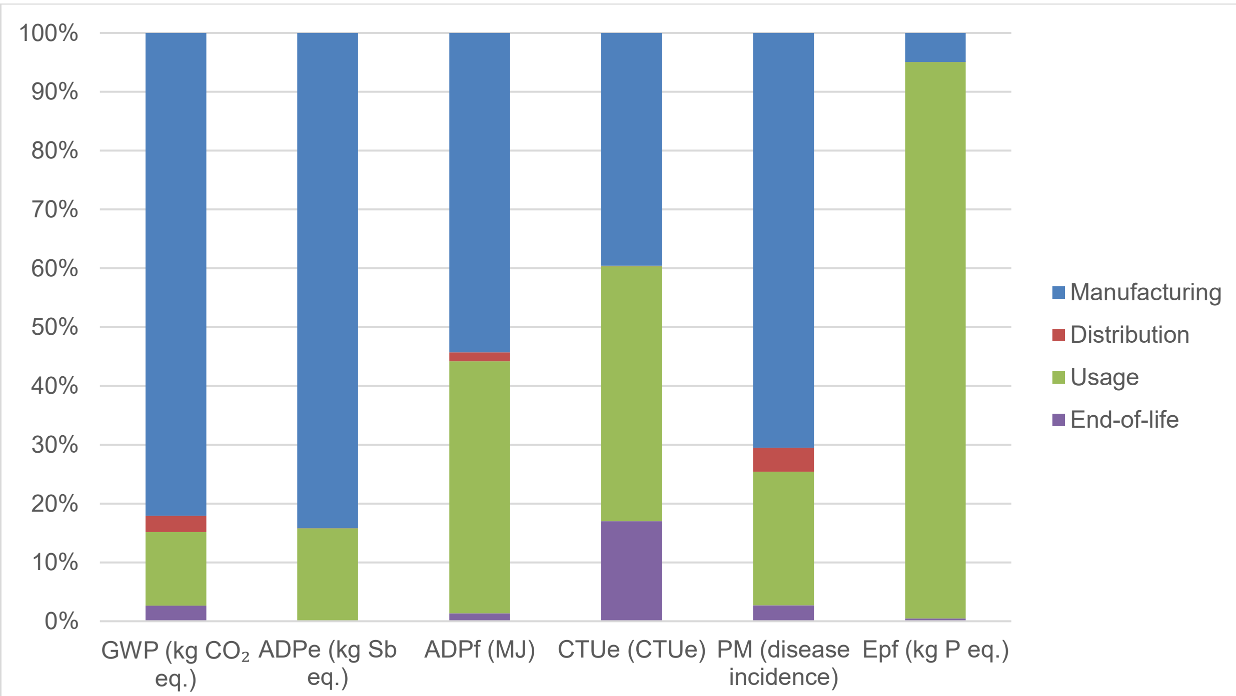

Figure 9 – Global environmental footprint repartition by life cycle stage

The **predominance of manufacturing phase** stems largely from the end-user equipment (Tier I), for which the extraction and transformation of raw materials generate high resource and energy demands. This is primarily attributed to the **high number of end-user devices** in circulation and their relatively **short replacement cycles**, compared to network and data centres equipment.

The **usage phase** follows, with impacts more evenly distributed between end-user equipment and data centres. This highlights the significant **electricity consumption** associated with **datacentres infrastructure**, despite its relatively small number of devices compared to end-user equipment. On the opposite end-user devices are very numerous but their individual electricity consumption is much lower.

The usage phase contributes less significantly to climate change impact category, largely the electricity consumed is coming from an electricity mix that is heavily based on renewable energy sources (mainly hydropower) and nuclear energy[185], which reduces the associated environmental burden. However, as the manufacturing of the devices and electronic components is mainly happening in South-East Asia, the electricity used during this stage has more impact and increases the impact of manufacturing.

The **usage phase** is the **dominant contributor for freshwater eutrophication**. These impacts are closely linked to electricity consumption. More specifically, the **distribution of electricity** through the grid requires substantial amounts of **copper**, and the sulfidic tailings generated during copper mining are a major source of emissions that contribute to this impact category. Indeed, soluble phosphate is added to sulfidic tailings to alleviated acute phytotoxicity[186]. The primary copper mines supplying the global ICT industry are predominantly located in Chile, Peru, and Zambia[187], resulting in a concentration of environmental impacts, particularly those related to resource extraction and freshwater ecotoxicity, in these countries.

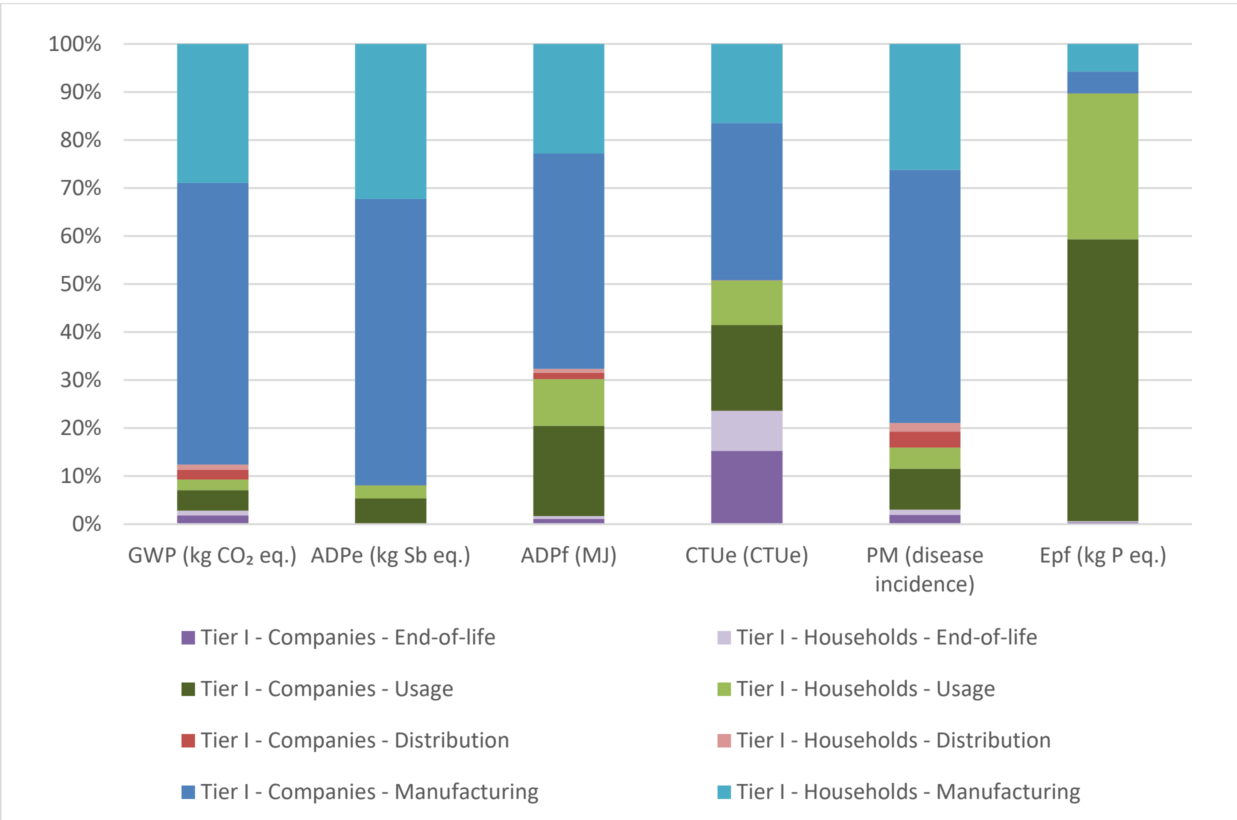

Figure 10 - Global environmental footprint repartition per life cycle stage and Tier

The **distribution and end-of-life phases** have **negligible environmental impacts**, with the exception of end-user equipment's end-of-life stage, which accounts for approximately 15% of the total freshwater ecotoxicity (CTUe). This is due to the high sensitivity of this indicator to the leaking of toxic substances,

185 https://www.news.admin.ch/fr/nsb?id=97643
186 https://www.sciencedirect.com/science/article/abs/pii/S0269749119304920#:~:text=As%20a%20result%2C%20it%20is%20hypothesized%20that,tailings%2C%20improving%20the%20success%20of%20tailings%20phytostabilization
187 https://unctad.org/system/files/official-document/ditcinf2025d2.pdf

such as heavy metals and persistent organic compounds, into the environment. This phenomenon is particularly relevant during the disposal of electronic equipment.

3.2.3 Focus on Tier I – End-user equipment

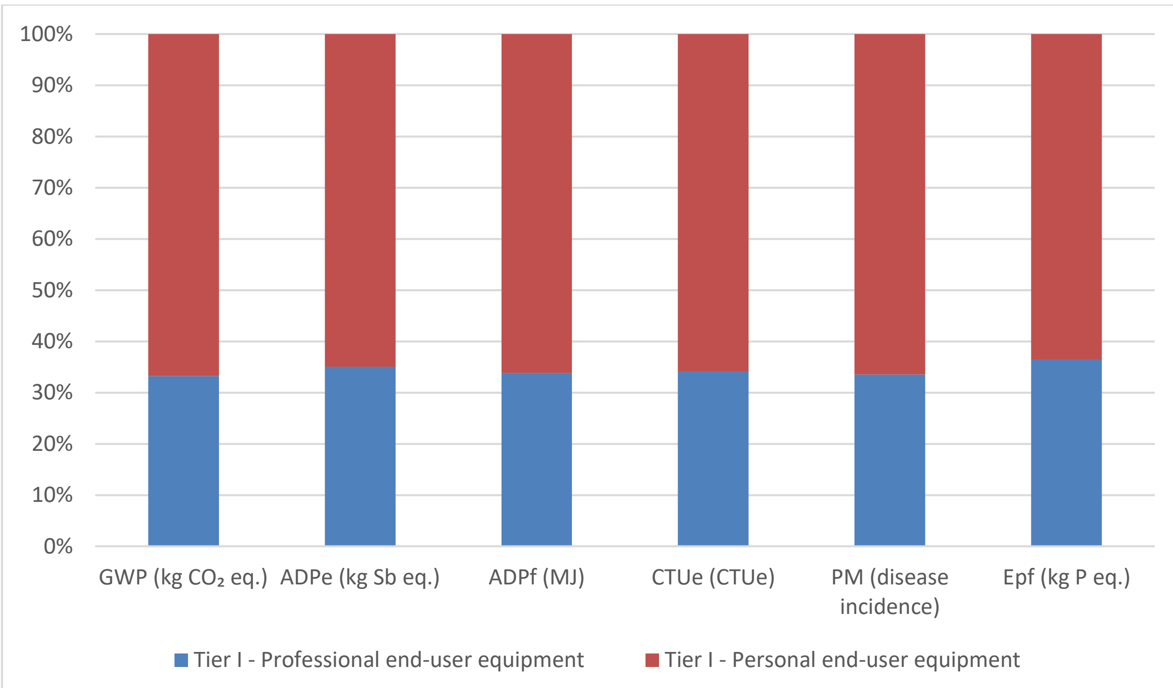

Figure 11 – End-user equipment (Tier I) environmental footprint repartition between personal and professional use

End-user equipment (Tier I) can be categorised between personal and professional use. Figure 11 shows that **households equipment account for around two-thirds of Tier I impacts**. However, the sizes of the populations concerned are not the same. There are about 9 million inhabitants whereas there are about 5 million employed individuals. This is part of the explanation for this repartition of impacts.

Furthermore, the number of professional devices per user is more limited (3.8 devices per worker whereas 5.7 devices per resident as shown in section 3.1.1.2), as they are primarily dedicated to work-related functions, in contrast to household equipment that also supports a wide range of leisure and personal activities

Another noticeable specificity is the consistent split across impact categories. This can be explained by the fact that the types of end-user equipment used in a personal or professional context are similar (c.f. section 2.8 for more details). The repartition of impacts between the impact categories are therefore similar. The split only reveals the repartition in terms of quantities of equipment between professional and personal use.

In the following graphs, we focus on specific categories of end-user equipment.

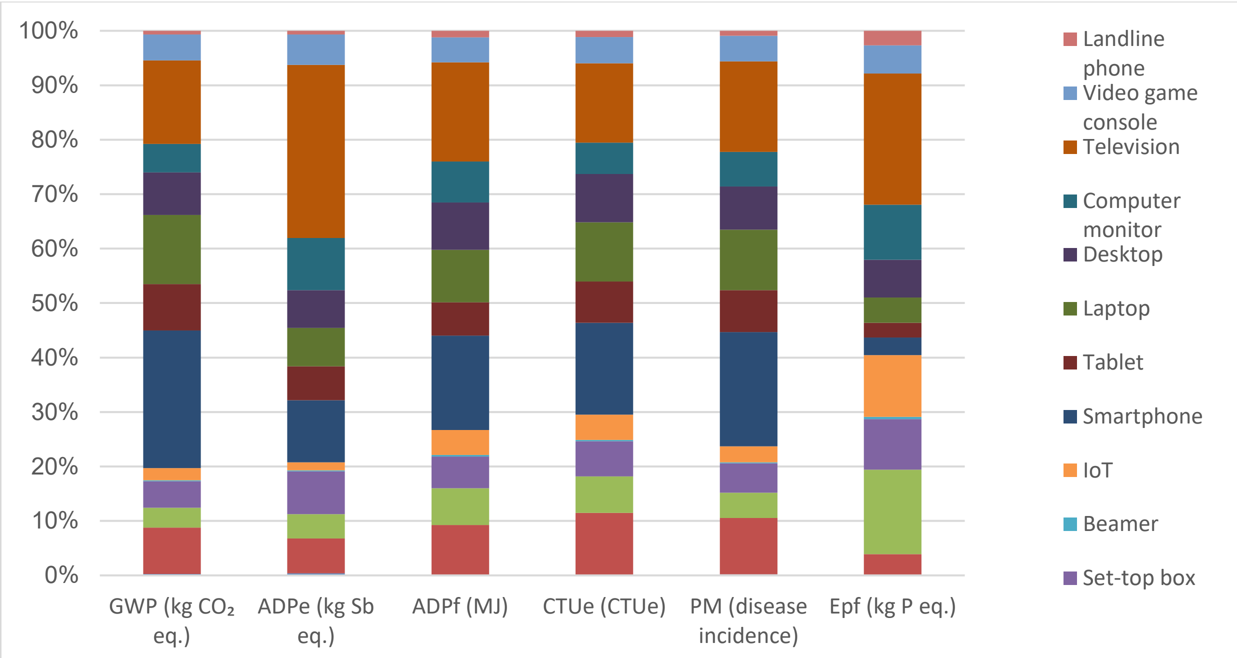

Figure 12 – End-user equipment (Tier I) for personal use environmental footprint repartition by equipment category

Figure 12 above shows that household ICT equipment impacts in Switzerland are **dominated by the environmental impacts of smartphones and televisions**. Smartphones account for 25% of the climate change impacts (GWP) and TVs for 15%, making them the largest contributors. Screens (TVs and computer monitors) also represent 41% of abiotic resource depletion (ADPe) and 33% of eutrophication impacts. This mainly due to their numbers.

Televisions and screens contribute significantly to the environmental footprint of digital equipment, particularly due to their size and energy consumption. Around 98% of the current stock consists of LCD screens, with an average diagonal size of 47 inches. Although OLED models, typically around 60 inches, are increasingly sold, they still represent a small fraction of the installed stock. The manufacturing phase is responsible for the majority of the impact on abiotic resource depletion, due to the extraction and processing of raw materials. Meanwhile, electricity consumption during the use phase remains substantial and is a major contributor to freshwater eutrophication impacts.

Two sensitivity analyses on smartphones and TVs are conducted in sections 6.1.1 and 6.1.2 in order to explore the variability of the overall impacts based on these parameters.

Laptops and desktops contribute 13% and 8% of GWP respectively, while smaller devices like modems, printers, and set-top boxes have more localized impacts, notably in eutrophication (e.g., 19% for modems) and particulate matter emissions (e.g., 11% for laptops and printers). In contrast, IoT devices, projectors, and landline phones have minimal impact (≤2% GWP each), though the rising number of IoT devices may increase their future footprint.

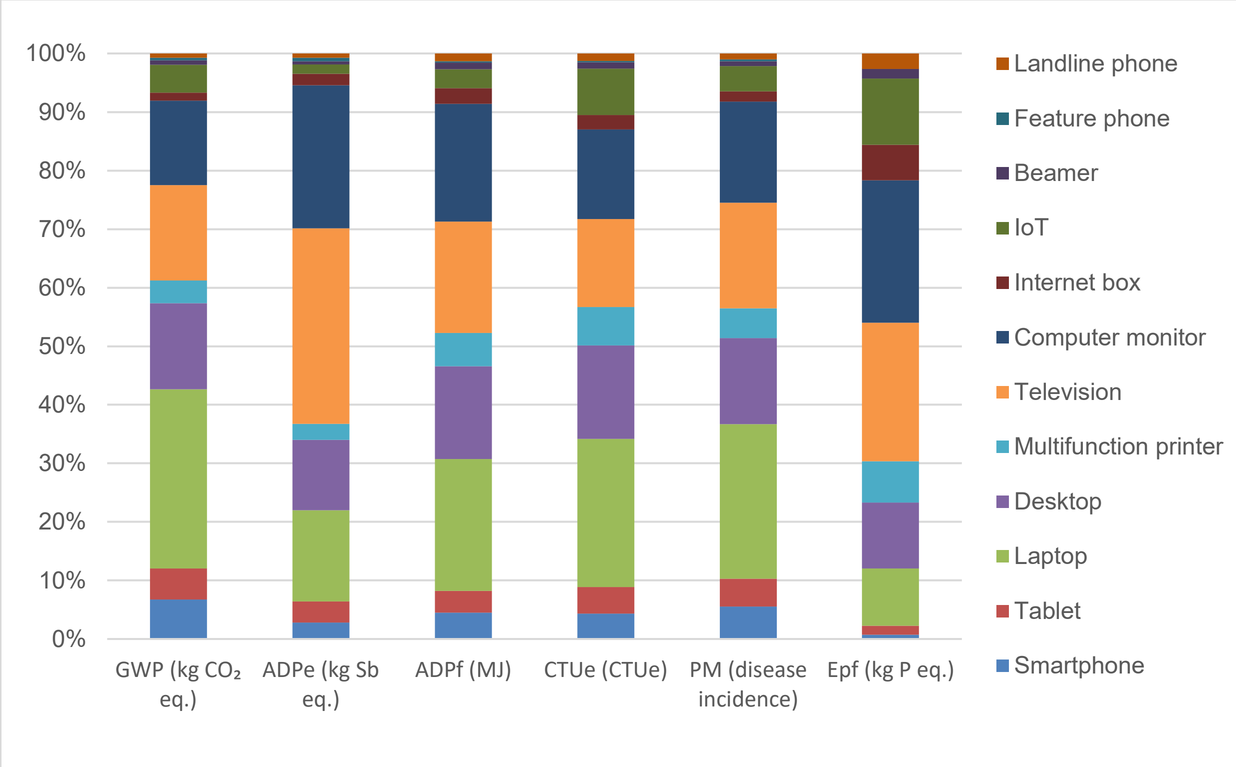

Figure 13 – End-user equipment (Tier I) for professional use environmental footprint repartition by equipment category

Figure 13 shows that concerning **professional end-user equipment, laptops and computer monitors are the primary contributors** to environmental impacts across most categories. Laptops stand out in particular, accounting for 31% of global warming potential (GWP), 19% of fossil resource use (ADPf), and 26% of human toxicity (CTUe). Computer monitors also have a significant environmental footprint, with the highest contributions to mineral resource depletion (25%) and freshwater eutrophication (25%), as well as high impacts on GWP (14%) and particulate matter formation (18%). This is due to the fact that they are now an indispensable part of employees' work tools, specifically in the service sector.

Televisions follow as another major contributor, especially for GWP (16%) and particulate matter emissions (18%). Desktops show a moderate but consistent contribution across all indicators, ranging from 12% to 16%. This is consistent with a shift in recent years towards the use of laptops instead of desktops in companies.

Other devices, such as multifunction printers, IoT equipment, and WIFI hotspots, have lower individual impacts but still play a non-negligible role, especially in categories like eutrophication (e.g., 12% for IoT and 7% for printers).

3.2.4 Focus on Tier II – Networks

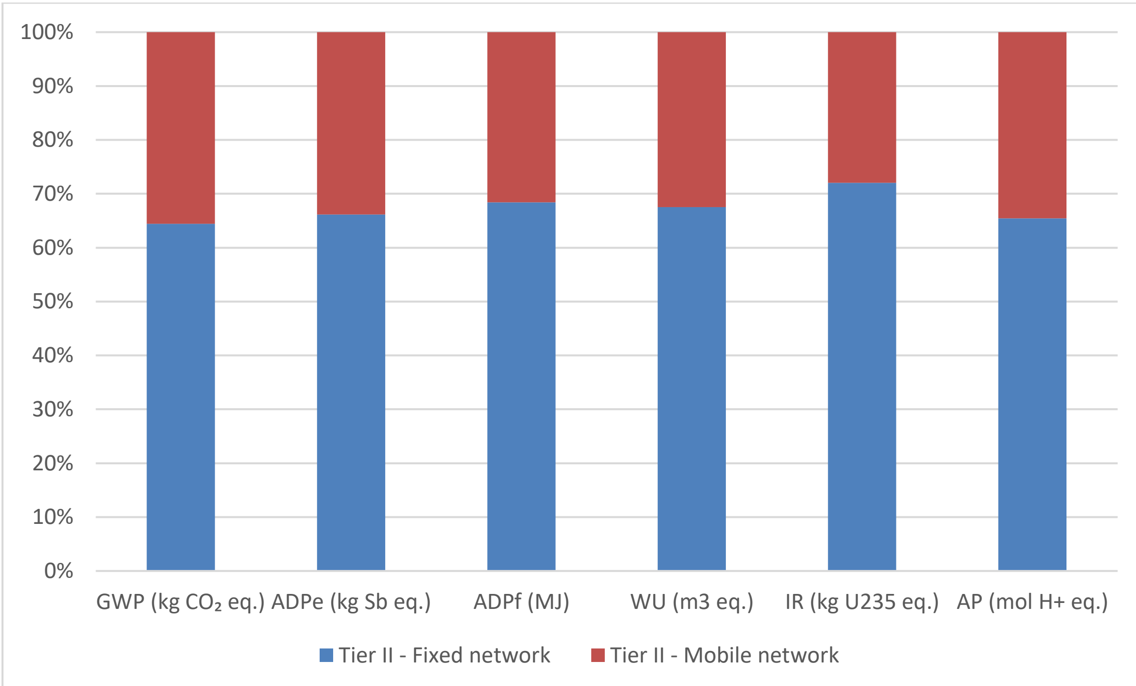

Figure 14 – Networks (Tier II) environmental footprint repartition between fixed and mobile

Figure 14 shows the repartition of the impacts of telecommunication networks between fixed and mobile parts. It can be seen that **most impacts are attributed to fixed network, with 60% to 70%** of the total Tier II footprint. This repartition is very different from what can be observed in other studies, such as the evaluation of the environmental footprint of internet service provisioning in France[188]. In this study, the electricity consumption is more concentrated in the mobile network. The main hypothesis for this discrepancy is differences in the perimeter taken into account for this electricity consumption data. It is possible that small data centres of internet service providers and PoPs are taken into account whereas they are not in the other study.

[188] https://librairie.ademe.fr/industrie-et-production-durable/7111-evaluation-of-the-environmental-footprint-of-internet-service-provisioning-in-france.html

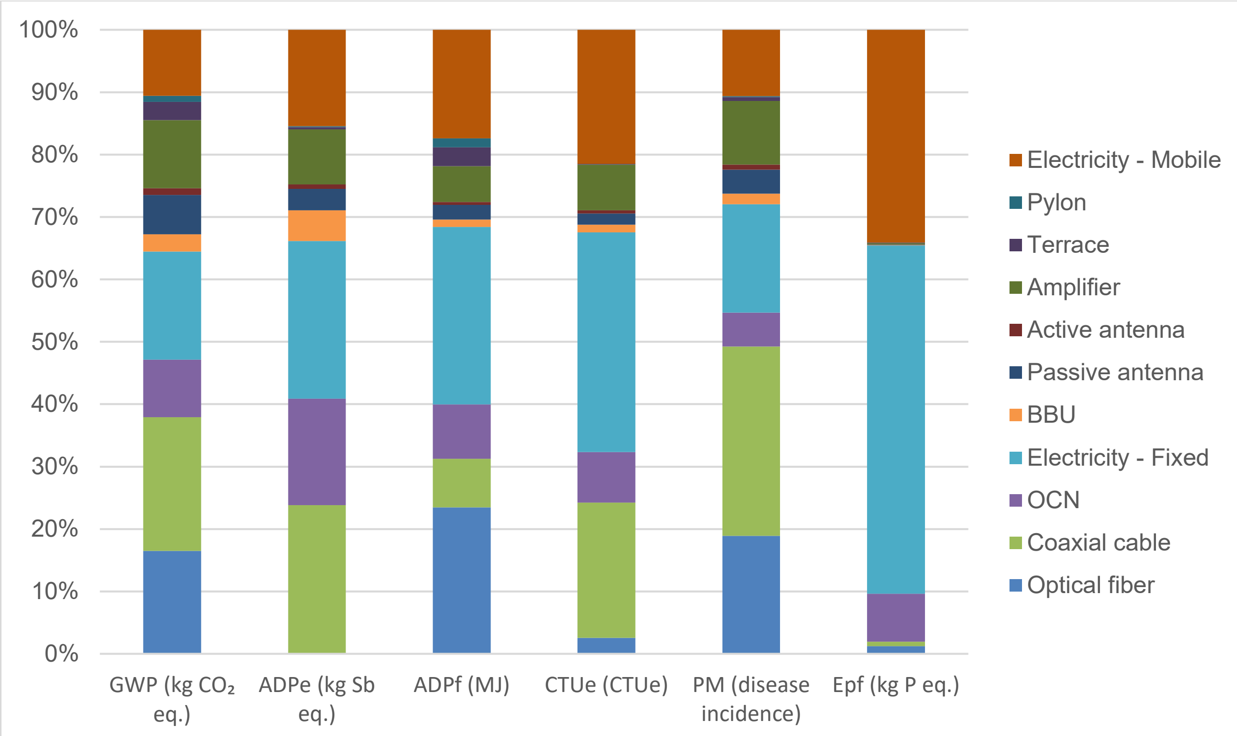

Figure 15 – Network (Tier II) environmental footprint repartition by equipment category

As seen in Figure 15, **electricity use**, especially for fixed networks, is the primary driver of environmental impacts in Tier II, reaching up to 56% of eutrophication and 43% of human toxicity. Mobile electricity also plays a major role across all indicators (14 to 34%).

Among equipment, the majority of the impacts is also attributed to fixed networks. OCNs, coaxial cables and optic fibre stand out with significant contributions, particularly in global warming, resource use, and particulate matter formation. Concerning mobile network, amplifiers and passive antennas are the major contributors.

Figure 16 illustrates the telecommunication networks impacts repartition between the life cycle stages. Compared to Tier I, a higher percentage of impacts is due to electricity consumption during the use phase. As for Tier I, impacts on freshwater eutrophication are almost entirely coming from electricity consumption.

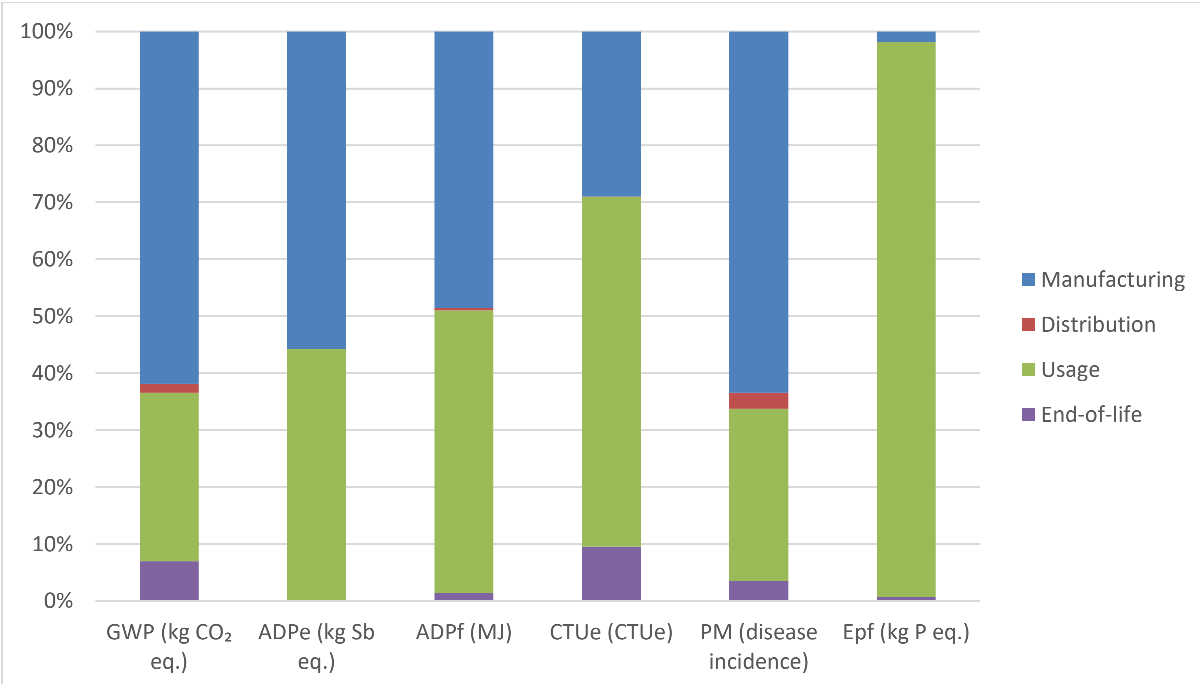

Figure 16 – Network (Tier II) environmental footprint repartition by life cycle stage

Network is the Tier with the **highest incertitude on the results**, due to a considerable lack of data and high uncertainty on the data used. The impacts of this Tier are the smallest ones compared to the others, with 3% to 9% of the total footprint. However, this uncertainty and lack of data is probably inducing an underestimation of the impacts. More detailed discussion can be found in section 5.2.

3.2.5 Focus on Tier III – Data centres

Figure 17 shows the repartition of data centres environmental footprint between the various categories of equipment. Figure 16Figure 18 illustrates the data centres impacts repartition between the life cycle stages.

Electricity consumption (for ICT and non-ICT equipment) dominates most indicators, especially freshwater eutrophication (98% of total) and freshwater ecotoxicity (76% of total). Electricity consumption is separated into electricity for ICT equipment (servers, storage servers, switches) and for non-ICT equipment (cooling, electrical power supply). A ratio of 2.4 can be seen between non-ICT and ICT electricity (corresponding to a PUE value of 1.4).

The **ICT equipment** and their associated electricity consumption represent between 65% and 85% of the footprint. Servers and storage servers come second after electricity consumption. Servers are the largest contributor to global warming potential (43% of GWP footprint), driven by energy-intensive manufacturing processes and operational demands. In comparison, electricity consumption is 22% so twice less important. This repartition is quite different than what could be usually observed for servers. Indeed, as they are power intensive equipment, usage phase is generally the most impactful even for GWP indicator. In this study, Switzerland's electricity mix has a very low carbon impact: 34.6 g eq. CO_2/kWh from Ecoinvent (see section 2.7.1.2).

Among all servers, **storage servers** represent about 50% of the total impact of servers. Mid-range servers are the second most impactful category due to their number. Their impact is 15 times higher than AI-dedicated servers. AI-dedicated servers are the third most impactful category of servers. This is due to their higher unitary impact (due to the presence of a GPU) and the fact that they are a bit more numerous than high-range servers.

The **technical environment** (building, cooling, electrical power supply and associated electricity consumption) **represents 15% to 35% of the data centres footprint**. The impacts are mainly concentrated in the electricity consumption. The ADPe environmental indicator is an exception as batteries account for the majority of the impacts (31% of data centres impacts). This is due to the fact that lead batteries need a considerable amount of minerals and metals for their manufacturing..

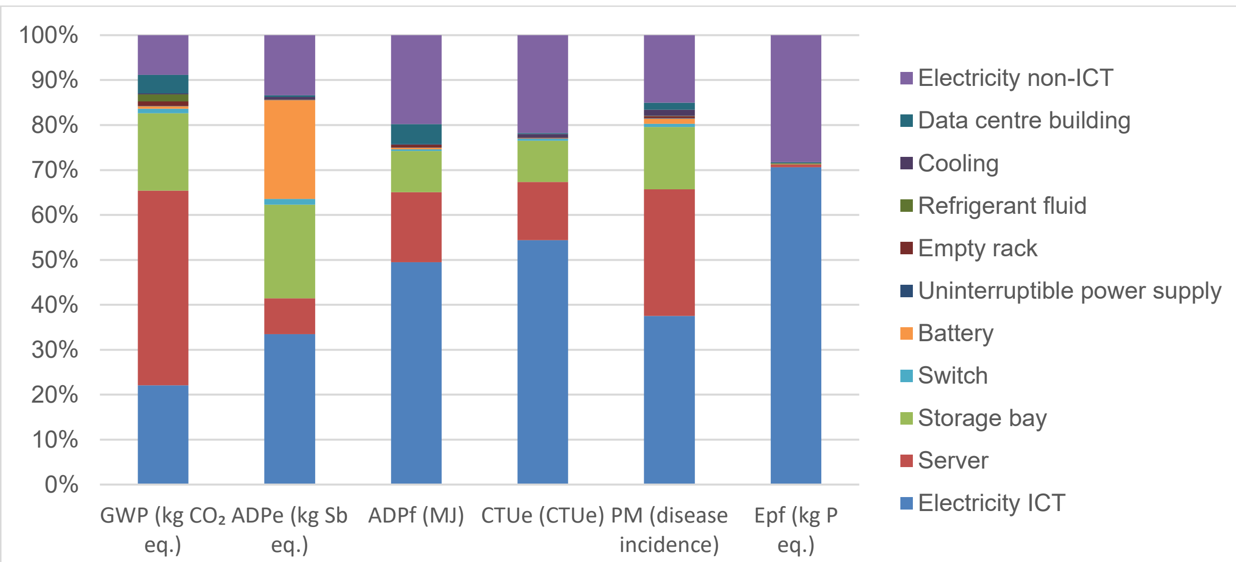

Figure 17 – Data centres (Tier III) environmental footprint repartition by equipment category

The repartition of the footprint between the life cycle stages shows similar pattern with Tier II. In the usage phase, the two fluxes are the electricity consumption and the refrigerant fluid consumption. Electricity consumption accounts for almost all of the impact, refrigerant fluid impact is almost negligible.

The rest of the impact is linked to manufacturing impact for ICT and non-ICT equipment. Distribution and end-of-life represent only a few percents of the total impact.

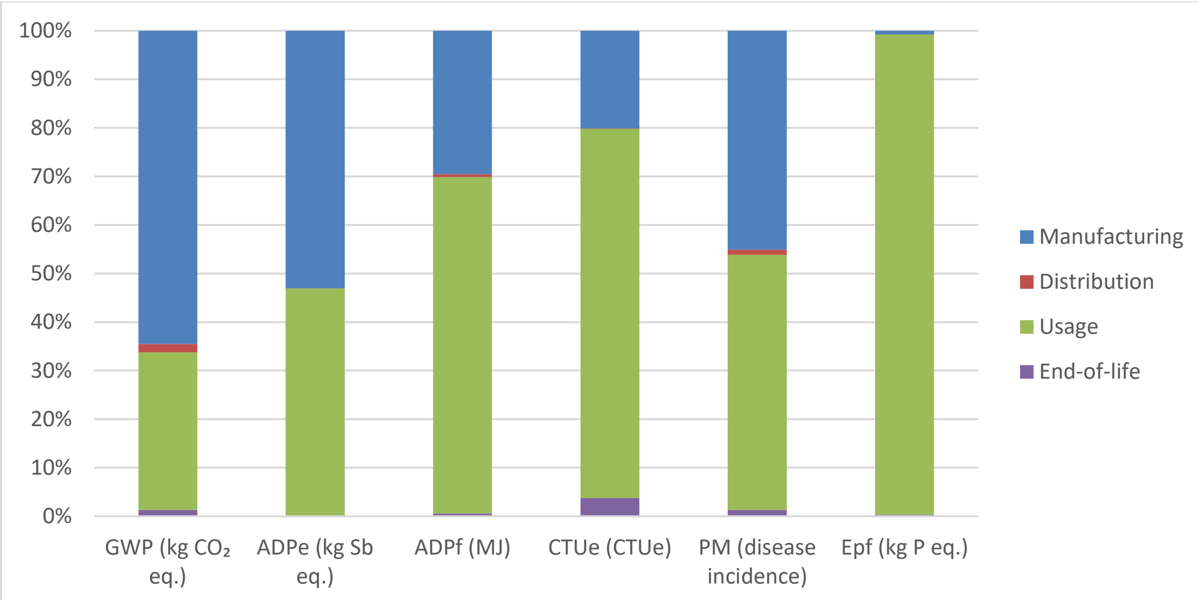

Figure 18 – Data centres (Tier III) environmental footprint repartition by life cycle stage

3.3 Comparison with literature

The objective of this section is to compare the results of the current study (using the "consumption approach") with previous results and already existing scientific literature, for Switzerland or other countries. This allows to challenge and identify differences or similarities between the results.

	Switzerland 2024 (Resilio)	France 2022 (ADEME)[189]	EU 2021 (GreenIT)[190]	World 2025 (GreenIT)[191]	Switzerland 2017 (UZH)[192]
Number of end-user (personal and professional) equipment per internaut (without IoT)	8.5	6.9	N/A	5.7	N/A
Total data consumed per internaut (GB)	1,245	2,711	1,133	3,214	N/A
Total electricity consumption per internaut (kWh)	759	725	551	425	N/A

189 https://librairie.ademe.fr/consommer-autrement/5226-evaluation-de-l-impact-environnemental-du-numerique-en-france-et-analyse-prospective.html
190 https://www.greenit.fr/wp-content/uploads/2021/12/EU-Study-ACV-7-DEC-FR.pdf
191 https://greenit.eco/nos-etudes-et-essais/impacts-environnementaux-du-numerique-dans-le-monde-2025/
192 https://www.wwf.ch/sites/default/files/doc-2017-10/2017-07-study-digitalization-climate-protection-switzerland.pdf

Resource use per internaut, minerals and metals (ADPe) (g Sb eq.)	20.1	14.1	11.2	7.7	N/A
Freshwater ecotoxicity per internaut (CTUe)	7,529	3,930	6,010	2,355	N/A
Climate change per internaut (kg CO_2 eq.)	247	253	361	342	436
Usage of fossil resources per internaut (GJ)	5.7	11.9	7.7	4.7	N/A
Fine particles per internaut (disease incidence)	1.03E-5	1.71E-5	1.56E-5	1.48E-6	N/A
Freshwater eutrophication per internaut (g P eq.)	22.5	N/A	151.5	125.8	N/A
Primary energy per internaut (MJ)	8,200	12,200	8,230	5,352	N/A

Table 27 - Comparison of key results of the current study with previous studies

To place the present results in context, **key indicators are compared** with recent assessments for France (ADEME 2022), the European Union (GreenIT 2021), the world (GreenIT 2025) and an earlier Swiss study (UZH 2017). Methodological boundaries differ across investigations, yet the exercise helps validate overall trends and sheds light on a few notable divergences. The key results of each study are summarised in Table 27. The values are each time given per internaut so the results are comparable even if the geographical scopes are not the same. Overall, a good alignment can be observed. The dimensional metrics that are electricity consumption, data consumption and number of end-user devices are in the same orders of magnitude.

The average Swiss internaut now owns **8.5 end-user devices** (excluding IoT), a figure that **is significantly higher than the global average of 5.7**. Given Switzerland's high level of development, a higher-than-global equipment ownership rate is to be expected. This figure is also slightly higher than the French result. This small disparity may be attributed to differences in temporal perimeter as well as consumption habits, which explain that Swiss internet users in 2024 own more end-user devices than their French counterparts in 2022. Similar discrepancies can be observed concerning the electricity consumption.

For some impact categories, namely climate change, fossil resource use and primary energy, the results are aligned with other recent studies.

It is interesting to note that the impact on climate change by internet user is almost divided by 2 between the 2017 study from UZH and this study. This difference is mainly coming from the impact of the Tier I. This difference is not explained by an actual decrease in the environmental impacts of digital technologies but rather differences in scope, mainly concerning the inclusions and exclusions made in the life cycle inventory.

Furthermore, a handful of indicators still diverge and merit targeted interpretation:

- Minerals-and-metals depletion (ADPe):

The Swiss figure (20 g Sb eq.) exceeds France (14 g), the EU (11 g) and global estimates (8 g). The most plausible explanation is the broader equipment coverage and newer life-cycle inventories used in the present study, which better capture the high material intensity of contemporary premium devices found in Switzerland.

- Freshwater ecotoxicity (CTUe):

Swiss users register a freshwater ecotoxicity value of approximately 7,500 CTUe, which is nearly double that of France and three times the global average, while remaining close to the European average. This indicator is strongly influenced by both the manufacturing phase of end-user equipment and electricity consumption during the usage phase. The observed gap is likely attributable to the **combined effects of a relatively high number of devices per user and elevated electricity consumption in Swiss data centres**.

- Freshwater eutrophication (Epf):

Conversely, the result for Switzerland (23 g P eq.) is markedly lower than the estimates reported for the European Union (152 g) and the global average (126 g). Given that this indicator is heavily influenced by the electricity consumption, the most plausible explanation for this discrepancy, despite Switzerland's higher number of end-user devices, lies in the notably favourable electricity mix assumed for Switzerland in this study concerning eutrophication.

In sum, the updated comparison shows that **most Swiss results fall within the European envelope**, thereby validating the study's core assumptions, whereas remaining differences can be traced to equipment scope, granularity of upstream data, and methodological advances.

3.4 Prospective analysis for 2035

Projecting the environmental impacts of ICT up to 2035 is essential for anticipating future trends in digitalization, infrastructure development, and user behaviour. As the demand for digital services continues to rise, driven by new usages such as AI, IoT, and 5G, understanding the **long-term environmental trajectory** allows policymakers, companies, and researchers to **identify critical impact areas, assess the effectiveness of mitigation strategies, and support the transition toward more sustainable digital systems**.

3.4.1 Environmental impacts at the individual scale

Table 28 summarised the evolution of the environmental impact per indicator between 2024 and the projection in 2035. Population scenarios for Switzerland estimate 9,753.5 million of permanent resident in 2035, following the reference scenario[193]. The total footprint is normalized by this population estimate.

Impact indicator	Unit	Footprint per capita - 2024	Footprint per capita - 2035	Relative change
Resource use, minerals and metals	g Sb eq.	20.7	26.3	+27%
Freshwater ecotoxicity	CTUe	7,222	13,679	+89%
Climatic change	kg CO_2 eq.	220	367	+66%
Usage of fossil resources	GJ	5.4	10.6	+94%
Fine particles	Disease incidence	9.6E-6	1.6E-5	+69%
Freshwater eutrophication	g P eq.	23	57.8	+151%

Table 28 – Projected environmental impacts of digital technologies per capita in Switzerland in 2035

The projections established for 2035 highlight a **significant increase in the environmental impacts** of digital technologies in Switzerland across all environmental indicators. Compared to the baseline year 2024, every environmental impact category shows a substantial rise, reflecting both the expansion of digital infrastructures and the intensification of digital service usage.

One can note that ADPe is the environmental indicator with the smallest increase, 27% between 2024 and 2035. This can be explained because the main increase concerns data centres for which electricity consumption impacts are prominent compared to hardware impacts.

3.4.2 Comparison to Planetary boundaries

Table 29 summarises the percentage of planetary boundaries per capita that is reached in 2024 and in 2035.

Impact indicator	Unit	Percentage of planetary boundary per capita - 2024	Percentage of planetary boundary per capita - 2035
Resource use, minerals and metals	g Sb eq.	65%	83%
Freshwater ecotoxicity	CTUe	38%	72%

193 https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/national-projections.html

Climatic change	kg CO_2 eq.	22%	37%
Usage of fossil resources	GJ	17%	33%
Fine particles	Disease incidence	13%	22%
Freshwater eutrophication	g P eq.	3%	7%

Table 29 - Planetary boundary results per capita projected in 2035

When contextualized within the planetary boundary's framework, the projected environmental impacts of ICT in Switzerland by 2035 raise significant concerns. The most alarming trend appears in freshwater ecotoxicity, which jumps from 38% of the per capita planetary limit in 2024 to nearly 72% in 2035. This indicates that, without intervention, the Swiss digital sector alone could be responsible of a disproportionate share of ecotoxicity.

Other indicators, though less prominent, show similarly concerning trends: metals resource use goes from 65% to 83%, climate change rises from 22% to 37%, fossil resource use increases from 17% to 33%, and fine particulate emissions rise from 13% to 22%, reflecting the growing resource demands and production intensities of digital infrastructure.

Overall, this planetary boundary comparison reveals that the environmental footprint of ICT in Switzerland is on a **trajectory that is incompatible with long-term global sustainability goals**, particularly in terms of material use and toxic emissions. It strengthens the case for targeted actions such as equipment circularity and a more restrained approach to digital growth.

3.4.3 Repartition of the results per Tier

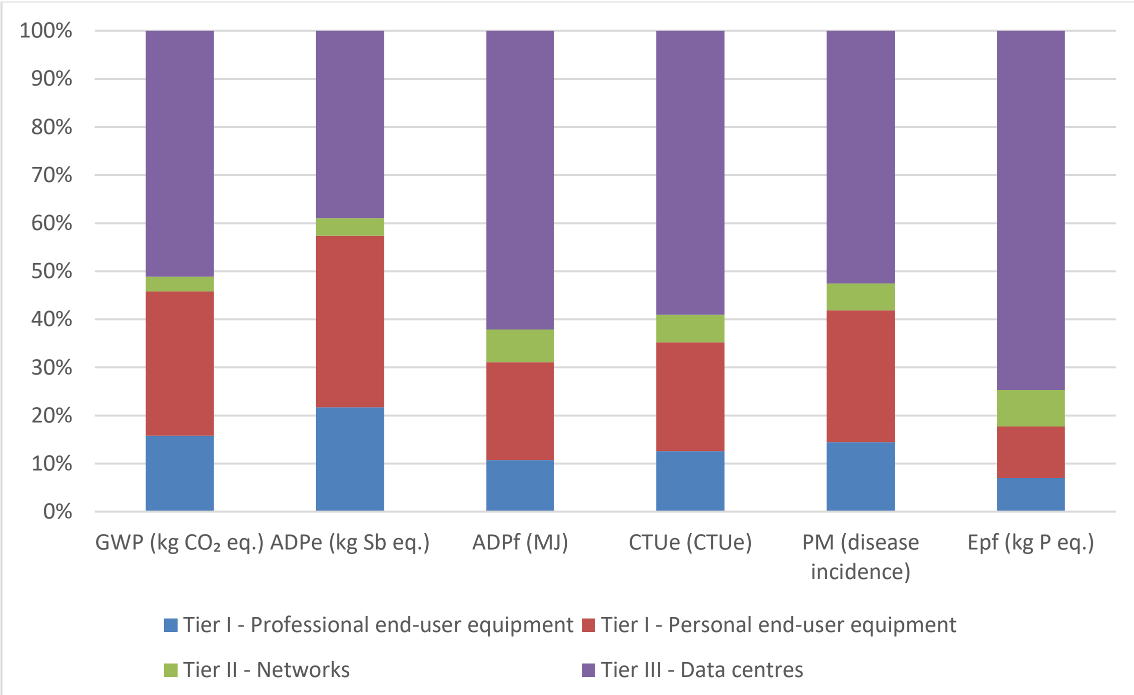

Figure 19 - Global environmental footprint repartition by Tier in 2035

Figure 19 illustrates the repartition of the global footprint in 2035 between the three Tiers. We can observe that the **proportion of impacts of the data centres in the total footprint has drastically increase**: 15%-50% in 2024 to 40%-70% in 2035 depending on the environment indicators. Indeed, the **electrical consumption and the amount of equipment of data centres is projected to increase** by a factor of 4.25 between 2024 and 2035. This is due to the growth of new usages, such as generative AI and high-definition video streaming, amplifying the demand for both computing power and storage capacity, intensifying the load on data centres and networks. Switzerland is at the heart of this trend. Indeed, Switzerland and particularly the **Zurich area**, is the second largest AI development hub in Europe[194].

On the other side, the size of the infrastructure is not increase as fast for telecommunication networks and end-user equipment:

- Tier I - End-user equipment: The penetration rate is already very high in the population in 2024. The increase of the amount of equipment between 2024 and 2035 follows the increase of the population but it is limited. In average, the increase is a factor 1.1.
- Tier II – Telecommunication networks: The expected increase is based on the number of subscribers and amount of data transferred. The increase is approximately a factor 2.

One key limitation of this exercise is the **conservative approach** that is applied, due to the attributional aspect of the study. Indeed, only the amount of equipment and electricity consumption have been updated. The life cycle impacts and lifespan of the equipment are kept the same. Also, the same electricity mix is used. More detailed discussions about the limitations can be found in section 5.2.

[194] https://www.greaterzuricharea.com/en/artificial-intelligence-greater-zurich-area

4 Recommendations

After quantitatively studying the environmental impacts of digital technology in Switzerland between 2024 and 2035, it is necessary to identify the structural elements of the digital footprint. This will then enable us to identify the most appropriate actions and best practices for reducing this environmental footprint. That is the objective of this section.

4.1 Global objectives

Digital technologies have become integral to modern life in Switzerland, offering numerous benefits across various sectors. However, we demonstrate in this study that their environmental impact is substantial and growing. Notably, in 2024, a significant portion of this impact arises from end-user devices, such as smartphones and televisions. The manufacturing phase of these devices is particularly resource-intensive, accounting for a substantial share of the footprint.

However, the results also show that the environmental impact of data centres is likely to increase significantly in the coming years, such that data centres will become the Tier with the greatest impact around 2035. Finally, telecommunications networks appear to have a moderate impact, accounting for no more than 10% of the total footprint. Though the uncertainty of the results for this Tier is very high and the environmental impacts are likely to be underestimated.

Despite the substantial impact associated with end-user equipment in 2024, **responsibility for mitigating the environmental impacts does not rest solely with individual consumers**. **Manufacturers**, **policymakers**, and **organizations** must play crucial roles in shaping sustainable practices and policies. For example, the design choices made by manufacturers can significantly influence a device's durability and reparability, while policymakers can implement regulations that promote both sustainable designs and production, as well as consumption habits.

In addressing the environmental challenges posed by digital technologies, prioritizing **effective and attainable actions** is essential. The three main objectives around which the recommendations should be structured are as follows:

- **Objective n°1: Decrease the need of manufacturing of new devices**: Avoiding manufacturing of new equipment whenever it is possible by extending the lifespan of devices currently in use and reducing their number;
- **Objective n°2: Design and manufacture more efficient equipment and infrastructures**: Manufacture less resource-intensive equipment and infrastructures, by putting into practice sobriety and circularity approach;
- **Objective n°3: Arbitrating digital usage**: Critically assessing and moderating the use of digital technologies to ensure they meet genuine needs without excess.

Implementing these strategies requires a concerted effort across all sectors of society. Public authorities can enact supportive policies and provide educational resources; businesses can adopt sustainable design and production methods; and individuals can make informed choices about their digital consumption. By collectively embracing these recommendations, Switzerland can make significant strides in reducing the environmental impact of its digital landscape.

4.2 Recommendations per Tier

To effectively address the environmental impact of digital technologies in Switzerland, it is essential to examine the three primary components of the digital ecosystem: end-user devices, telecommunication networks, and data centres. Each of these tiers contributes uniquely to the overall environmental footprint, and understanding their specific impacts allows for the identification of targeted strategies to mitigate them. By analysing the life cycle and usage patterns within these domains, we can uncover actionable levers to promote sustainability.

4.2.1 Tier I: End-user equipment

For end-user equipment, the main recommendations focus on decreasing the need of manufacturing of new devices:

- **Extend the operational lifespan of devices**:
  - Apply eco-design principles at the hardware design stage, for more robust and reparable devices.
  - Buy equipment that are second-hand, with high reparability index or relevant label (e.g. TCO, EPEAT), along with warranty extensions.
  - Promote practices that prolong the lifespan of devices, such as regular maintenance, repairs, availability of spare part and software updates, in order to avoid programmed obsolescence.
  - Protect, repair, take care of the equipment all along the lifespan.
  - Give or sell unused equipment if they are reusable. Otherwise, recycle them, in order to given a second life to the equipment, its components or material.
- **Reduce the number of end-user devices:**
  - Mutualise equipment between multiple users. Encouraging the use of fewer devices per individual, and advocating for shared or multifunctional equipment.
  - Share equipment for multiple uses: BYOD (Bring Your Own Device) approach to combine personal and professional use.
  - Reduce the number and sizes of screens.

The second objective concerning the design and manufacturing of more efficient equipment is also relevant:

- Design end-user equipment that are less resource-intensive: consuming less electricity, recyclable, using recycled material, etc.
- Create and democratise standards and labels for more energy efficient devices.
- Offer systematic eco-design training in engineering schools.

4.2.2 Tier II: Telecommunication networks

The main recommendations concerning telecommunication networks are the following, to meet the objective n°1:

- Optimise the number of equipment: Coordinate inter-operator collaborations to avoid useless redundancy on network infrastructures and share equipment and infrastructure, particularly in less densely populated areas.

The main recommendations concerning objective n°2 are:

- Enhance energy efficiency of new network equipment.
- Implement smart network management systems to optimize energy usage dynamically.

The main recommendation concerning objective n°3 is:

- Question the environmental cost and expected benefit of new technologies such as 6G.

4.2.3 Tier III: Data centres

The main recommendations concerning data centres are stated below.

Concerning the objective n°1, the goal is to extend the operational lifespan of devices. Detailed actions are similar to what is detailed in section 4.2.1.

Concerning the objective n°2, the recommendations are the following:

- Improve energy efficiency of new infrastructure, therefore enhancing the PUE.
- Improve energy efficiency of new ICT equipment.
- Regulate the development of new data centres by prioritising energy-efficient solutions, such as heat reuse.

The main recommendation concerning the objective n°3 is:

- Regulate and slow down the spread of new usages, particularly the use of AI.

4.3 Recommendations per actors

Building upon this analysis, the subsequent recommendations are structured to engage all stakeholders, public authorities, businesses and organizations, and individual citizens. Each group holds **distinct responsibilities and opportunities to drive change**. Public authorities can implement policies and regulations that set the framework for sustainable practices. Businesses and organizations are positioned to innovate and adopt eco-friendly operations. Meanwhile, citizens can make conscious choices that collectively lead to significant environmental benefits. By organising recommendations for each group, we aim to **encourage everyone to work together** to lessen the environmental impact of digital technologies in Switzerland.

4.3.1 Public authorities

The main recommendations for public authorities are:

Objective 1	**Action 1:** **Implement e-waste collection and recycling programs**	Enhance e-waste collection infrastructure and recycling programs to ensure the proper disposal and recovery of valuable materials from obsolete electronic devices.
Objectives 1 et 2	**Action 2:** **Ensure the framework conditions that will enable a longer service life and a better energy efficiency**	Create and maintain the framework conditions to promote practices that prolong the efficiency and longer functional life of devices. e.g. Impose availability of spare part. Develop new labels and standards.
Objective 2	**Action 3:** **Ensuring the democratisation of knowledge and skills in eco-design**	Systematise eco-design trainings in science and engineering schools and universities
Objective 3	**Action 4:** **Enhance public awareness and participation**	Inform and consult citizens regarding the environmental consequences of digital technologies, promoting a collective approach to sustainable digital transitions.
Objective 3	**Action 5:** **Regulate digital technology usage**	Implement clear environmental standards and usage limitations, particularly in high-impact domains such as artificial intelligence, to mitigate environmental impacts.

Table 30 - Recommendations to reduce the impacts of digital technologies for public authorities

4.3.2 Businesses and organisations

The main recommendations for businesses and organisations are:

Objective 1	**Action 6:** **Implement sustainable purchasing practices**	Prioritise the purchase of equipment that are second-hand, with high reparability index or relevant label (e.g. TCO, EPEAT).
Objective 1	**Action 7:** **Optimise the number of equipment**	Deploy BYOD (Bring Your Own Device) approaches for employee devices and reuse equipment internally whenever it is possible. Mutualise devices to avoid useless redundancy on infrastructures (e.g. telecommunication networks)
Objectives 1 & 2	**Action 8:** **Adopt eco-design principles**	Integrate eco-design in the development of digital services and hardware, for more robust, reparable and energy efficient devices.
Objectives 1 & 2	**Action 9:** **Ensure environmental transparency**	Maintain transparency concerning environmental impacts of digital infrastructures, equipment and services.
Objective 2	**Action 10:** **Support local and low-impact hosting solutions**	Incentivize the use of environmentally optimized data centres powered by renewable energy and located within Swiss or European jurisdictions to reduce data transmission distances and associated emissions, and profit from the low-carbon energy mix.
Objective 3	**Action 11:** **Transform business models**	Shift towards business models that reduce dependency on the continuous production and sale of new electronic devices, exploring alternatives such as product-as-a-service or refurbishment schemes.

Table 31 - Recommendations to reduce the impacts of digital technologies for businesses and organisations

4.3.3 Citizens

The main recommendations for citizens are:

Objective 1	**Action 12:** **Extend current device lifespan**	Prolong the lifespan of electronic devices through proper maintenance, protective measures, repairs, and opting for used equipment when replacements are necessary.
Objective 1	**Action 13:** **Allowing the best end-of-life scenario for end-user equipment**	Give or sell unused equipment if they are reusable. Otherwise, recycle them, in order to given a second life to the equipment, its components or material.

Objective 1	**Action 14:** **Limit the number of personal digital devices**	Reduce the number of personal digital devices by prioritizing the acquisition of second-hand or refurbished electronics, and sharing equipment between multiple users.
Objectives 1 & 2	**Action 15:** **Prioritise the purchase of more sustainable equipment**	Buy equipment that have a high reparability index, good energy efficiency or relevant label (e.g. TCO, EPEAT, Energy Star)
Objective 3	**Action 16:** **Stay informed and critically assess digital habits**	Reflect on personal digital consumption patterns and seek information on the environmental implications of digital usage.

Table 32 - Recommendations to reduce the impacts of digital technologies for citizens

5 Conclusion

5.1 Key findings

This study provides a detailed examination of the environmental impacts of the **Information and Communication Technology** (ICT) sector in Switzerland, and reveals a reality that is often underestimated: digital technologies have a significant environmental impact throughout the entire **life cycle** of devices and infrastructure. Far from being immaterial, the digital sector is heavily dependent on physical resources and produces significant emissions and waste.

In this study, the ICT sector encompasses all the **digital equipment and infrastructures** in use in Switzerland, for personal and professional use. This covers three different Tiers: end-user equipment, telecommunication networks and data centres.

The first observation is that **Switzerland is a highly digitalised** country. Indeed, in 2024, 99% of the population regularly accesses the internet and each inhabitant owns an average of 6 digital devices. Furthermore, ICT infrastructures consume 12% of Switzerland's electricity consumption, and half of it is dedicated to data centres. Digital technology is therefore central to the personal and professional lives of Swiss residents, as well as being essential to the smooth functioning of all sectors of the economy.

This omnipresence of digital technologies has a significant environmental footprint. **ICT consumes substantial portions of the safe operating space delimited by the planetary boundaries**, particularly for mineral resource use, freshwater ecotoxicity and climate change. Its **footprint is increasing rapidly**, with expected increases ranging from 27% to 151% **until 2035**, depending on the environmental categories. These trends are due to the increase of the population and the growth of new usages (generative AI, blockchain, NFTs, web3, virtual reality, etc.). Although often perceived as a modern tool for energy savings and dematerialization, ICT is currently on a growth trajectory that contradicts climate and sustainability goals.

Moreover, this study highlights the **critical role of material resource use**, particularly rare earth elements and strategic metals, in the environmental burden of digital technologies. Digital technologies consume 65% of the annual sustainable budget defined by planetary boundaries in terms of the use of mineral and metal resources, and is expected to increase to 83% by 2035. This is particularly concerning given the **rising demand for electronics** in sectors such as health, mobility, and renewable energy, which compete for the same critical materials.

Another insight from this study is that **end-user equipment**, including smartphones, laptops, televisions, and connected devices, **remains the main driver of environmental impacts in Switzerland in 2024**. These devices dominate the sector's footprint, particularly through their production phase, which involves intensive resource extraction and energy use. However, the trends until 2035 show that data centres and networks footprints are increasing and **data centres are going to concentre the most impacts by 2035**.

All these observations underscore the need for **targeted mitigation strategies** as well as a broader governance framework to ensure the sustainability of the digital transformation. As a highly connected and technologically advanced nation, Switzerland's role is pivotal, both in setting national policies and in influencing global digital sustainability efforts.
Responsibility for mitigating the environmental impacts must not rest solely with individual consumers. Manufacturers, policymakers, and organizations must play crucial roles in shaping sustainable practices and policies. The three main objectives that structure the recommendations are as follows:

- **Decrease the need of manufacturing of new devices**: Avoiding manufacturing of new equipment whenever it is possible by extending the lifespan of devices currently in use and reducing their number;
- **Design and manufacture more efficient equipment and infrastructures**: Manufacture less resource-intensive equipment and infrastructures, by putting into practice sobriety and circularity approach;
- **Arbitrating digital usage**: Critically assessing and moderating the use of digital technologies to ensure they meet genuine needs without excess.

In summary, digital sobriety, doing less and doing better, must be at the heart of Switzerland's digital policy. Technical efficiency alone will not be sufficient. A sustainable ICT future will depend on managing demand, extending product lifespans, and redesigning digital services to serve societal needs without overshooting planetary boundaries.

5.2 Limits of the study

While the results, conclusions, and recommendations presented in this study provide a robust and structured understanding of the environmental impacts of the ICT sector in Switzerland, they must be considered in light of certain **methodological and data-related limitations**. These constraints **do not call into question the overall validity of the findings** but rather **clarify the conditions under which they should be interpreted**. In particular, two key sources of limitation are identified: those stemming from the scope defined at the outset of the study, and those inherent to the life cycle inventory data and modelling assumptions. Addressing these aspects transparently is essential to support a critical reading of the study and to guide improvements in future assessments.

These limitations do not undermine the study's findings, but they emphasize the need for continuous monitoring, methodological refinement, and policy flexibility to adapt to a rapidly evolving digital landscape.

5.2.1 Limitations due to study scope

This study aimed to assess the environmental impacts of the ICT sector in Switzerland through a life cycle approach. However, several constraints related to the scope of the analysis must be acknowledged. Firstly, **certain categories of equipment and infrastructure are not taken into account due primarily to the lack of sufficient and reliable inventory or environmental data**. An exhaustive list of excluded elements is provided in Section 3.4.2.2. As a result, the total environmental impact of the ICT sector may be slightly underestimated, especially in relation to niche or emerging technologies for which environmental data are not yet available. This concerns more specifically telecommunication networks for which a few technologies were not taken into account, such as **satellite communications and private company networks**.

A recent model estimates the environmental impact of launching satellites for certain mega-constellations[195]. In terms of climate change, estimates of the annual impact per subscriber range from 95 kg CO_2 eq. to around 600 kg CO_2 eq., depending on the scenario. The impacts vary depending on the mega-constellation in question, which will use different launchers and fuels, and whose number of users varies. However, this study focuses only on the life cycle of the launcher and fuel and does not take into account the satellite itself and its life cycle.

On one hand, despite these limitations, these partial results show that the impacts would be between 8 and 50 times higher than those of the classic mobile and fixed networks. On the other hand, the number of satellite internet subscribers is very limited, about 0.1% of the population in 2023[196], due to the particularly wide mobile coverage. Thus, the exclusion of satellite internet access from this study might results in a consequent underestimation of the impacts of Tier II, limited by the small number of subscribers concerned. However, the expected increase in the number of subscribers to these services in the coming years could make it crucial to characterize these impacts in order to obtain a comprehensive overview.

Secondly, the **definition of the ICT sector with three Tiers** is very specific to LCA methodology and doesn't match the economic definition of ICT sector that encompasses in addition the service industries. Furthermore, this approach tends to separate the environmental footprint of the ICT sector as such from its effects on other economic sectors (e.g. rebound effect). It is therefore always essential to check the definition of the scopes taken into account when comparing two studies dealing with ICT.

Furthermore, **not all life cycle stages are fully accounted for**. While the study focused on the production, use, and end-of-life phases, other relevant stages such as maintenance, refurbishment, and upgrades are omitted. These phases, although often less significant than manufacturing in terms of direct energy consumption, are increasingly relevant in scenarios that promote circular economy strategies and longer device lifespans. This slack might induce a slight underestimation of the environmental footprint.

Finally, **indirect impacts** related to the operation of digital services, such as the energy use and commuting of employees, or infrastructure-related overheads, were not included in the modelling. Incorporating these elements in future analyses would provide a more complete and nuanced understanding of the sector's total footprint.

[195] https://www.researchgate.net/publication/373715821_Sustainability_assessment_of_Low_Earth_Orbit_LEO_satellite_broadband_mega-constellations
[196] https://www.bakom.admin.ch/bakom/fr/page-daccueil/telecommunication/faits-et-chiffres/observatoire-statistique/fixe/les-services-par-satellites.html

5.2.2 Limitations associated with life cycle inventory and data collection

In addition to scope-related exclusions, this study is also subject to a number of limitations inherent to the underlying life cycle inventory (LCI) data and associated modelling assumptions. One of the key challenges is the **uncertainty surrounding technical specifications**, energy consumption, and product lifespan. For each category of equipment, a single average value is used for both lifespan and energy use, with a few additional technical configurations in some cases. While this approach allows for simplified and consistent modelling across diverse device types, it introduces uncertainty regarding how well these values reflect the full diversity of equipment available on the Swiss market. As such, the results should be interpreted as **indicative of average or typical use cases**, rather than precise reflections of all real-world scenarios.

Specific challenges also arise at the level of individual tiers. In Tier I, a lack of detailed subcategory data for **Internet of Things** (IoT) devices led to simplified groupings that may obscure the wide variability in form, function, and impact across the IoT ecosystem. In Tier III, although Switzerland has relatively low net import/export flows for digital services, the country is still deeply embedded in global data exchanges. The difference between the Swiss electricity mix and the one of countries hosting external data infrastructure introduces an environmental impact that could not be quantified within the current methodological framework.

Moreover, the representation of the **Swiss electricity mix** itself could be improved, as this study uses an annual average value that does not fully reflect the dynamic nature of electricity generation and importation throughout the year. In addition, the representativeness of this average itself has been subject to criticism in existing literature.

Together, these limitations highlight the inherent trade-offs between model simplicity, data availability, result accuracy and rigorous methodology.

5.2.3 Specific limitations of the prospective analysis

Other limitations are added to the **prospective approach**, which estimates the impacts in 2035. The extrapolations made to the year 2035 are based primarily on historical trends and linear assumptions, which may not adequately capture technological disruptions, shifts in consumption behaviours, or major policy interventions. Therefore, these forward-looking estimates should be treated with caution and understood as plausible scenarios rather than predictions. One good example is the stock of feature phones and landline phones. We could expect these stocks to decrease in 2035 compared to 2024. However, as projections for Tier I are based on population growth, these more subtle trends are not visible. This example illustrates a possible overestimation of the impacts. In general, life cycle inventory data for 2035 have greater uncertainty, leading to greater uncertainty of the resulting impacts.

The biggest limitation of this exercise is probably the **conservative approach** that is applied. Indeed, the projections are limited by the **attributional aspect** of the study. Only the amount of equipment and infrastructure (networks and data centres) electricity consumption have been updated. We don't take into account the replacement of current infrastructure. In addition, the technical specifications, life cycle impacts and lifespan of the devices in 2035 are kept identical to those observed in 2024. In reality, for the smallest technologies, we observed that the manufacturing impact seems to be increasing exponentially. This example illustrates a potential underestimate of the impacts of the manufacturing phase, therefore especially for the end-user devices.

Another example concerns the **electricity mix**. The same electricity mix as 2024 is used for 2035 whereas energy production sources and electricity trades are evolving relatively quickly. By 2035, Switzerland aims to significantly increase its renewable energy production, particularly from solar, as well as wind and biomass[197]. Hydropower energy should still play a significant role, but the potential for further expansion is limited. The results presented above might therefore overestimate the impacts, notably for data centres and networks for which the electricity consumption is predominant.

5.2.4 Possible improvements

While this study offers a robust and informative first step toward understanding the environmental impacts of the ICT sector in Switzerland, several solutions could be pursued to improve the precision and relevance of future assessments.

First, a significant improvement would involve refining the scope and inclusivity of modelled equipment and infrastructure. In the current study, **several categories of digital equipment and ICT infrastructure are not taken into account** due to limited or unavailable data, particularly niche or emerging technologies such as certain Internet of Things (IoT) devices, peripheral equipment, and industrial ICT systems. Expanding the scope to include these overlooked elements would offer a more holistic estimate of the sector's environmental footprint.

Another key improvement lies in the representation of life cycle stages. While the study focuses on the most impactful phases, as dictated by LCA methodology, it **does not include intermediate stages such as maintenance, upgrades, and refurbishment**. These phases, though often minor in terms of impacts, can have substantial implications in strategies promoting circularity, repair, or reuse. Including them would allow a more accurate assessment of policies aimed at extending product lifespans and enhancing the reparability and upgradeability of devices.

From a methodological standpoint, one of the core improvements would be the transition from static to dynamic modelling. Currently, **fixed assumptions** are made about device lifespan, average energy consumption, and technological performance. These assumptions are necessary to simplify the modelling process and ensure comparability between equipment categories. However, this simplification limits the

[197] https://www.bfe.admin.ch/bfe/en/home/policy/energy-strategy-2050/documentation/energy-perspectives-2035.html

capacity to reflect real-world variability and future trends. Future versions of the study could integrate **dynamic life cycle modelling**, which allows parameters such as energy mix, usage behaviour, and technological efficiency to evolve over time, particularly in projections to 2035 and later. This would enable more realistic scenarios and help changing user practices on environmental sobriety.

There is also room to improve the **data representativity and uncertainty management**. While the study used the best available average values for key parameters (e.g., energy consumption per device, lifespans, manufacturing impacts), the underlying data is sometimes drawn from heterogeneous sources and generalized international databases. Engaging even more closely with Swiss manufacturers, operators, and public agencies to collect primary data, particularly for telecom networks and data centres, would significantly improve the accuracy of the results.

In this study, a specific effort is made to **distinguish between personal and professional** equipment within Tier I (end-user devices), in order to better reflect the diversity of usage contexts. However, this distinction is not applied to Tier II and Tier III infrastructures, which are currently considered as aggregated systems. For future improvements, it would be valuable to further refine the analysis by **differentiating professional infrastructures across various sectors**, such as the primary (agriculture, mining), secondary (industry), and tertiary (services) sectors. Such granularity would enable the formulation of more targeted and sector-specific recommendations for reducing the environmental impacts of digital technologies.

Furthermore, future iterations of this study could better address international and trade-related interactions. Although Switzerland is a relatively small digital market, it participates in a global ICT supply chain and exchanges digital services (such as cloud storage or AI services) across borders. A more granular model of imported and exported digital services, and the associated energy and emissions implications, would allow for a more complete assessment, especially given the differences between Swiss and global electricity mixes.

Finally, for the **prospective analysis**, it would be more interesting to look at **different deployment scenarios**, with varying degrees of digital sobriety or growth, which aim for carbon neutrality or not, etc. It is crucial for understanding the possible trajectories, more or less probable, of the environmental footprint of ICT. Trend scenarios provide a framework for testing the robustness of different strategies. By examining how strategies respond in different scenarios, it is possible to assess their relevance and effectiveness. In future version of this prospective analysis, another good improvement would be to use prospective LCA. By doing so, it is possible to take into account future developments in centralised infrastructures for example.

In summary, future improvements should aim for more comprehensive equipment coverage, more detailed modelling of all life cycle phases, incorporation of time-evolving parameters, stronger local data inputs, and a better accounting of Switzerland's digital interdependencies with the rest of the world. The prospective analysis should define various trend scenarios. These steps would increase the precision, policy relevance, and foresight capacity of environmental impact assessments in the digital sector.

6 Annexes

6.1 Sensitivity analyses

Several **sensitivity analyses** are carried out on elements with a strong impact on the overall result and based on data with a high uncertainty. Indeed, a sensitivity analysis makes it possible to study how the variation of an input parameter influences the final result.

The 5 sensitivity analyses carried out in this study focus on:

- The quantity of TVs;
- The quantity of smartphones;
- The electricity consumption of networks;
- The electricity consumption of data centres;
- The carbon intensity of the electricity mix.

The justifications for each of the sensitivity analyses are detailed in the following sections.

6.1.1 Sensitivity analysis on TV quantities

TV screens are the most impactful type of equipment of Tier I. However, no information about screen size and other technical specifications are found for Switzerland specifically.

To perform this sensitivity analysis, a 20% increase and decrease in the **number of TVs** is simulated, taking into account both Tier I – Households and Tier I – Companies equipment.

Indicator	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Base case	100 %	100 %	100 %	100 %	100 %	100 %
-20% difference	99 %	96 %	99 %	99 %	98 %	99 %
+20% difference	101 %	104 %	101 %	101 %	102 %	101 %

Table 33 - Results of the sensitivity analysis on the quantity of TVs as a proportion of the total impacts

In the table above, the sensitivity analysis on the quantity of televisions in Tier I shows that a ±20% variation in their number has a very limited effect on overall environmental indicators. The changes across all categories remain within a narrow range of ±4%, with most variations under 2%. This suggests that the total environmental impact of digital technologies in Switzerland is not highly sensitive to moderate fluctuations in the quantity of TVs.

6.1.2 Sensitivity analysis on smartphones quantities

Smartphones are the second most impactful type of equipment of Tier I, after TVs. Similarly, very little technical specifications are found for Switzerland specifically.

To perform this sensitivity analysis, a 20% increase and decrease in the **number of smartphones** is simulated, taking into account both Tier I – Households and Tier I – Companies equipment.

Indicator	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Base case	100 %	100 %	100 %	100 %	100 %	100 %
-20% difference	97 %	98 %	98 %	98 %	97 %	100 %
+20% difference	103 %	102 %	102 %	102 %	103 %	100 %

Table 34 - Results of the sensitivity analysis on the quantity of smartphones as a proportion of the total impacts

Table 34 shows that a ±20% variation in the number of smartphones changes the total impact by only ±3% for most indicators, with no effect on phosphorus emissions (Epf). This indicates a relatively low sensitivity of the overall environmental footprint to fluctuations in smartphone quantities.

6.1.3 Sensitivity analysis on electricity consumption of networks

To perform this sensitivity analysis, a 20% increase and decrease in the **electricity consumption of networks** is simulated.

Indicator	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Base case	100 %	100 %	100 %	100 %	100 %	100 %
-20% difference	100 %	100 %	99 %	99 %	100 %	98 %
+20% difference	100 %	100 %	101 %	101 %	100 %	102 %

Table 35 - Results of the sensitivity analysis on electric consumption network as a proportion of the total impacts

In Table 35, varying the electricity consumption of fixed and mobile networks by ±20% has a negligible effect on the overall environmental indicators. The global warming potential (GWP) remains unchanged, while the other indicators shift by only 1–2 percentage points at most, confirming that this parameter has a limited influence on total impacts at the global level.

6.1.4 Sensitivity analysis on the electricity consumption of data centres

The **electricity consumption of data centres** is a key parameter for Tier II inventory. Furthermore, only one source is found concerning this data. Thus, the uncertainty concerning the impacts of Tier III is quite high.

To perform this sensitivity analysis, a 20% increase and decrease in the **electricity consumption of data centres** is simulated, therefore impacting the quantities of equipment of Tier III too.

Indicator	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)

Base case	100 %	100 %	100 %	100 %	100 %	100 %
-20% difference	95%	97%	94%	94%	95%	91%
+20% difference	105%	104%	107%	107%	106%	111%

Table 36 - Results of the sensitivity analysis on electric consumption data centres as a proportion of the total impacts

In Table 10, varying the electricity consumption of data centres by ±20% results in a global impact variation ranging from -9% to +11% across most indicators. The Epf (phosphorus emissions) indicator shows the highest sensitivity, ranging from 91% to 111% of the base case. This is explained by the fact that this impact is largely driven by the impacts of the electricity consumption, which is the highest for the data centres.

6.1.5 Sensitivity analysis on the Swiss electricity mix

The electricity mix is a key parameter for this type of study as this will change the impacts of the electricity consumption in the usage phase. The environmental impacts of the Switzerland electricity mix are coming from Ecoinvent database v3.10. The climate change indicator is around 35 g eq. CO_2 /kWh, which seemed very low compared to other sources providing impacts around 100 g eq. CO_2 /kWh. For example, the data from the confederation is 125 g eq. CO_2 /kWh[198]. The Ecoinvent data was nevertheless chosen for its multi-criteria approach.

The most probable hypothesis to explain theses discrepancies is the methodology to estimate the impacts of imported electricity. Last versions align more closely with national energy statistics and Guarantees of Origin. Imports from the ENTSO-E grid, which carries a high carbon intensity, are not considered anymore, in order to take into account more precisely the energy source and country from which the electricity is coming from.

However, due to the high discrepancy between the two data, it would be interesting to get an idea of the order to magnitude of the change that using one data or the other would imply on the total impacts.

To perform this sensitivity analysis, the GWP indicator of the **electricity mix used** is set to 0.125 kg/kWh. An intermediate analysis is also performed with an electricity mix used set to 0.075 kg /kWh.

	Total GWP impact (kg CO2 eq.)	Percentage of base case
Base case	1.99E+09	100%
GWP = 75 g eq. CO_2 / kWh	2.38E+09	113%
GWP = 125 g eq. CO_2 / kWh	2.72E+09	130%

Table 37- Results of the sensitivity analysis on electricity mix as a proportion of the total impacts

In Table 37, increasing the electricity mix to 75 g eq. CO2 / kWh make the total impacts increase to 13% and the electricity mix at 125 g eq. CO2 / kWh induces an increase of 30%.

Remark: As this analysis is a thought exercise and only applied on climate change indicator, it is not taken into account in the cumulative sensitivity analysis.

[198] https://backend.kbob.admin.ch/fileservice/sdweb-docs-prod-kbobadminch-files/files/2024/12/03/f331074f-1f32-485a-8028-1705895cca48.xlsx

6.1.6 Cumulative sensitivity analysis

Sensitivity analyses are then combined to determine the maximum and minimum magnitude of possible variations around the impacts assessed in this study.

Indicator	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Base case	100 %	100 %	100 %	100 %	100 %	100 %
-20% difference	95%	96%	94%	94%	95%	91%
+20% difference	105%	104%	107%	107%	106%	111%

Table 38 - Overall results of the sensitivity analyses

With Table 38, we obtain an average interval of -5% to +5% around the baseline value. Epf is the indicator most sensitive to variations, from -9% to +11%. The **majority of this uncertainty** is due to uncertainty related to the electricity consumption of data centres (Tier III).

6.2 Additional results

This section contains various tables that present supplementary results.

		Tier I – Personal use	Tier I – Professional use	Tier II - Networks	Tier III – Data centres
Manufacturing	GWP (kg CO_2 eq.)	27%	55%	3%	16%
	ADPe (kg Sb eq.)	31%	57%	2%	11%
	ADPf (MJ)	26%	50%	7%	17%
	CTUe (CTUe)	27%	54%	5%	14%
	PM (disease incidence)	27%	53%	6%	14%
	Epf (kg P eq.)	50%	39%	3%	7%
Distribution	GWP (kg CO_2 eq.)	31%	55%	2%	12%
	ADPe (kg Sb eq.)	31%	55%	2%	12%
	ADPf (MJ)	31%	55%	2%	13%
	CTUe (CTUe)	28%	52%	2%	18%
	PM (disease incidence)	32%	58%	5%	5%
	Epf (kg P eq.)	31%	55%	2%	12%
Usage	GWP (kg CO_2 eq.)	14%	26%	9%	51%
	ADPe (kg Sb eq.)	14%	27%	9%	50%
	ADPf (MJ)	14%	27%	9%	50%
	CTUe (CTUe)	14%	27%	9%	50%
	PM (disease incidence)	14%	27%	9%	50%
	Epf (kg P eq.)	14%	27%	9%	50%
End-of-life	GWP (kg CO2 eq.)	29%	51%	10%	10%

	ADPe (kg Sb eq.)	31%	55%	5%	9%
	ADPf (MJ)	27%	50%	9%	14%
	CTUe (CTUe)	32%	58%	4%	6%
	PM (disease incidence)	28%	52%	9%	11%
	Epf (kg P eq.)	19%	34%	14%	33%

Table 39 – Environmental footprint of digital technologies in Switzerland in 2024 using the "consumption approach", detailed by life cycle stage and Tier

	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Feature phone	0%	0%	0%	0%	0%	0%
Personal printer	9%	6%	9%	11%	10%	4%
Internet box	4%	4%	7%	7%	5%	16%
Set-top box	5%	8%	6%	6%	5%	9%
Beamer	0%	0%	0%	0%	0%	0%
IoT	2%	2%	5%	5%	3%	11%
Smartphone	25%	11%	17%	17%	21%	3%
Tablet	8%	6%	6%	8%	8%	3%
Laptop	13%	7%	10%	11%	11%	5%
Desktop	8%	7%	9%	9%	8%	7%
Computer monitor	5%	10%	7%	6%	6%	10%
Television	15%	32%	18%	15%	17%	24%
Video game console	5%	6%	5%	5%	5%	5%
Landline phone	1%	1%	1%	1%	1%	3%

Table 40 - Environmental footprint of Tier I personal equipment in Switzerland in 2024, detailed per category of equipment

	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Smartphone	7%	3%	5%	4%	6%	1%
Tablet	5%	4%	4%	5%	5%	2%
Laptop	31%	16%	23%	26%	27%	10%
Desktop	15%	12%	16%	16%	15%	12%

Multifunction printer	4%	3%	6%	7%	5%	7%
Television	16%	34%	19%	15%	18%	24%
Computer monitor	14%	25%	20%	16%	18%	25%
Internet box	1%	2%	3%	3%	2%	6%
IoT	5%	2%	3%	8%	4%	12%
Beamer	1%	1%	1%	1%	1%	2%
Feature phone	0%	1%	0%	0%	0%	0%
Landline phone	1%	1%	1%	1%	1%	3%

Table 41 - Environmental footprint of Tier I professional equipment in Switzerland in 2024, detailed per category of equipment

		GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Fixed network	**Optical fibre**	12%	0%	12%	1%	9%	1%
	Coaxial cable	15%	12%	4%	11%	15%	0%
	OCN	7%	9%	4%	4%	3%	4%
	Electricity	12%	13%	14%	18%	9%	28%
Mobile network	**BBU**	2%	2%	1%	1%	1%	0%
	Passive antenna	5%	2%	1%	1%	2%	0%
	Active antenna	1%	0%	0%	0%	0%	0%
	Amplifier	8%	4%	3%	4%	5%	0%
	Terrace	2%	0%	2%	0%	0%	0%
	Pylon	1%	0%	1%	0%	0%	0%
	Electricity	8%	8%	9%	11%	5%	17%

Table 42 - Environmental footprint of Tier II - Networks in Switzerland in 2024, detailed per category of equipment

	GWP (kg CO_2 eq.)	ADPe (kg Sb eq.)	ADPf (MJ)	CTUe (CTUe)	PM (disease incidence)	Epf (kg P eq.)
Electricity	31%	47%	69%	76%	52%	99%
Server	43%	8%	16%	13%	28%	1%
Storage bay	17%	21%	9%	9%	14%	0%
Switch	1%	1%	0%	0%	1%	0%
Battery	1%	22%	0%	0%	1%	0%
UPS	0%	0%	0%	0%	0%	0%
Empty rack	1%	0%	1%	0%	0%	0%
Refrigerant fluid	2%	0%	0%	0%	0%	0%
Cooling	0%	1%	0%	1%	1%	0%

Data centre building	4%	0%	5%	0%	2%	0%

Table 43 - Environmental footprint of Tier III – Data centres in Switzerland in 2024, detailed per category of equipment

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