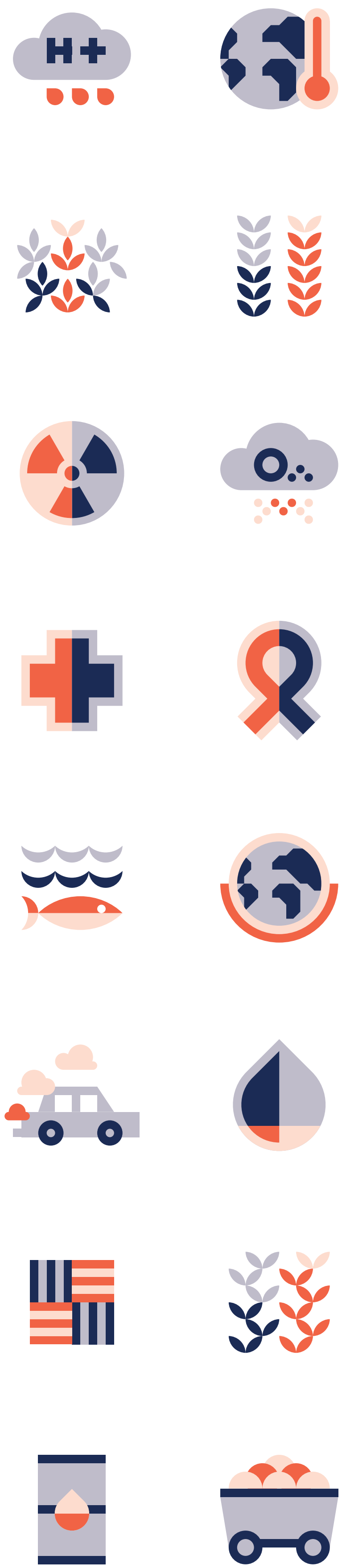

WHITE PAPER

DATA CENTERS

Measuring Impacts for More Effective Actions

Data4
SMART & SCALABLE DATA CENTERS

apl
Pioneering Data Centers

SUMMARY

For many companies in the digital space, data center activity is included in their carbon footprint among scope 3 emissions. Indeed, data centers, the cornerstone of our digital world, are not carbon-neutral. To reduce their environmental footprint, it is important to limit their energy consumption, as well as the amounts of all materials used in their construction.

To help with this, life cycle assessment (LCA) is now considered the most rigorous, comprehensive, and widely recognised evaluation method for auditing all inputs, outputs, and environmental impacts tied to the design and construction of data centers.

In this white paper, we show the real impacts of data centers and all their components on the environment, and specifically on climate change and resource consumption.

Preface

The digital revolution is accelerating; simultaneously, the environmental footprint of the infrastructure underpinning that revolution is growing along with it. Data centers, the backbone of our digital economy, are now in the hot seat: **how can we continue to grow our data centers while responding to environmental imperatives?**

At Data4 and APL Data Center, we decided to take a close look at all of the components that make up a data center. Indeed, while reducing energy consumption and using energy from renewable sources are essential measures, they are not enough on their own.

We have a much higher aim: we want to get a comprehensive, scientific view of our impact. This is where life cycle assessment (LCA) comes in: LCA is a rigorous methodology that allows us to comprehensively evaluate the environmental impacts of a data center, from its construction to its operations, all the way through to the end of the life cycle for its equipment.

Why is this approach essential? Because hiding behind energy consumption are other factors that are often invisible to us, but which weigh heavily on our planet: the mining of metals, water consumption, threats to biodiversity, the production of electronic waste, etc. Given this fact, companies need to recognise these other impacts and take concrete action to mitigate them.

This white paper reveals the results of a life cycle assessment performed on a data center belonging to the European operator Data4. The data center in question is located on the company's Marcoussis campus, near Paris, and began operations in 2023. This LCA is an unprecedented, transparent analysis that sheds light on possible ways of reforming the industry and building a more sustainable digital sector. After all, measuring impacts brings the knowledge of where to take action.

ESG commitments should be backed up with an approach based on hard data. At Data4 and APL Data Center, we've done just that by making LCA the foundation of our environmental commitments.

Linda Lescuyer,
Head of Environment & Sustainable Innovation, Data4

Thomas Martin,
Deputy CTO, Head of Sustainability & Innovation, APL Data Center

CONTENTS

1

Introduction

The purpose of this white paper is to share the results of a life cycle assessment (LCA) of a data center owned and operated by Data4. The data center in question was chosen for being representative of the "hyperscaler" family of data centers and the goal of the LCA was to identify the impacts tied to the different functions of a data center.

Since 2020, Data4 has applied LCA to all its projects to build new data centers. As such, the company has a significant number of studies at its disposal. Thanks to this systematic approach, Data4 has been able to establish a standard profile of the environmental impacts of a hyperscaler data center. Now, in this white paper, Data4 will share its conclusions and publish the LCA results for a representative data center.

FOCUS OF STUDY

This white paper reveals the results of an LCA performed on data center DC 19, located on the Marcoussis campus, near Paris, belonging to the European operator Data4.

This document is intended for the entire data center ecosystem, including users, service providers, and operators, to help them understand and identify the causes of environmental impacts and thus facilitate the emergence of new technical solutions.

- First, we will look at the importance of life cycle assessment for understanding the major environmental concerns before adopting an eco-friendly design approach.
- Then, we will detail the various functions of a data center.
- From there, we will examine the framework for assessing the data center, which is representative of its category, explaining the scope and assumptions applied.
- Finally, we will present the analyses conducted in this study and the suggested opportunities for improvement to reduce environmental impacts, and particularly those actions taken by Data4.

2

Life cycle assessment (LCA)

2.1 What is life cycle assessment?

Life cycle assessment (LCA) is a methodology used to evaluate the environmental impacts associated with all stages in the life cycle of a product or service, from the extraction of raw materials to the disposal of all materials at the end of the life cycle.

This approach accounts for the various phases in the life cycle, such as production, distribution, usage, and waste management, while also identifying the inputs (energy, raw materials) and outputs (emissions, waste) at each stage.

Providing a comprehensive, detailed view, LCA allows a company to assess not only direct impacts, but also indirect or "hidden" impacts throughout the entire value chain of a product or service.

LCA is based on three fundamental principles:

- **Multi-stage:** The assessment accounts for all stages in the product life cycle, from the extraction of raw materials to the end of service life, adding up the impacts produced throughout the entire value chain.
- **Multi-component:** The assessment takes into account all components and subsystems of the system in question.
- **Multi-indicator:** LCA goes beyond merely analysing greenhouse gas (GHG) emissions: it evaluates impacts across multiple indicators, as defined in the methodology.

Moreover, this three-pronged approach allows us to account for overlapping impacts between stages in the life cycle, between components of the system, and between impact indicators. In other words, much like the physics principle of communicating vessels, when you aim to decrease one environmental impact, it can have an effect on other indicators or stages of the product life cycle.

Why is LCA useful for data centers?

Data centers consume large amounts of electricity to power servers, cooling systems, and security systems. Additionally, the construction, operations, and end-of-life management of the buildings and IT equipment generate CO_2 emissions and involve the use of fossil fuels and minerals. LCA helps identify the phases of the life cycle that have the greatest impacts, measure their overall environmental footprint, and implement strategies to reduce the negative impacts.

Life cycle assessment (LCA) has been recognised as **the most rigorous, comprehensive, and widely respected evaluation method for auditing all inputs, outputs, and environmental impacts tied to the design, construction, and operation of data centers.**

Since 2020, Data4 has systematically applied LCA. When carrying out the analysis of DC 19, Data4 had already performed nine previous LCAs, giving the company a solid general understanding and making it easier to extrapolate the results to all data centers.

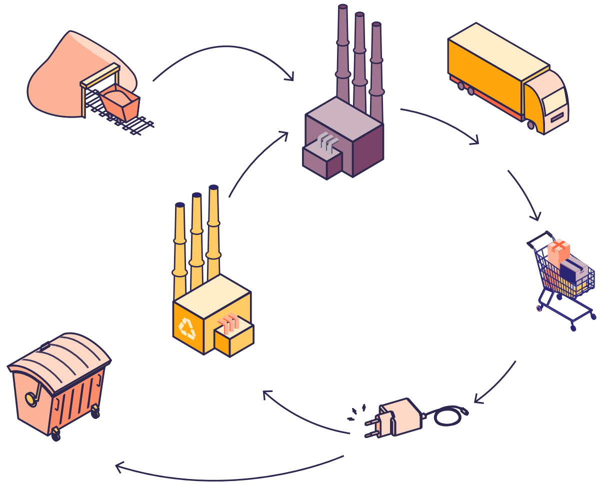

Figure 1 – Life cycle stages (source: MiNumEco, Mission Interministérielle Numérique Écoresponsable)

REMEMBER

LCA offers:

- A multi-dimensional "scan" that takes into account all of the environmental impacts of a product or service. It relies on a three-pronged approach: multi-stage, multi-indicator, multi-component.
- Identification of environmental concerns to be prioritised in order to reduce the environmental impact of the product or service evaluated.

Reminder of the standards and references

Life cycle assessment is based on a series of standards and general references that guarantee the consistency and robustness of LCA methodologies:

- **ISO 14040 standard:** An international standard that lays out the essential steps in LCA, including defining the goal and scope, inventory analysis, impact assessment, and interpreting the results. This standard guarantees that assessments are performed consistently and transparently, facilitating the comparison of results and informed decision-making for environmental management.
- **ISO 14044 standard:** This standard supplements the ISO 14040 standard by laying out the specific requirements and guidelines for performing an LCA. The standard provides the methodological steps, including the collection and evaluation of inventory data, the assessment of environmental impacts, and the interpretation of results. ISO 14044 puts an emphasis on rigour and transparency in the process, ensuring that LCAs are carried out consistently and reliably while enabling critical assessment and the continuous improvement of environmental practices.
- **NF X30-264:** A French standard that provides additional specifications for performing LCAs under the ISO 14040 and ISO 14044 standards. It is intended to ensure rigorous and uniform application of the LCA methodology in France, providing clarification on how to conduct analyses, interpret results, and report conclusions.
- **Recommendation ITU-T L.1410:** A reference developed by the International Telecommunication Union (ITU) that details the specific requirements and guidelines for performing an LCA of information and communication technology (ICT) goods, networks, and services.
- **Product Category Reference (RCP) for cloud services and data centers**[1] *(January 2023, revised April 2025)*: A French reference document, published by ADEME, which provides a methodological framework for LCAs of data hosting services according to their degree of integration. The reference is intended to ensure the consistency of LCAs performed, providing clarifications for the functional unit, overall scope, impact indicators, and allocation rules.

Data4 was a trailblazer, performing its own assessments prior to the publication of ADEME's methodology. For this reason, the LCA presented in this white paper is not perfectly aligned with ADEME's RCP document.

[1] https://librairie.ademe.fr/industrie-et-production-durable/6031-evaluation-environnementale-des-services-d-hebergement-informatique-en-centre-de-donnees-et-de-services-cloud.html

2.2 What environmental indicators do we use?

According to the *Environmental Footprint 3.1* method developed by the European Commission, LCA goes beyond "simply" analysing greenhouse gas (GHG) emissions as it includes as many as 16 environmental impact indicators, including:

Figure 2 – Illustration of the 16 environmental impact indicators under the Product Environmental Footprint (PEF) method

Not all indicators are relevant for every product or service. As such, a methodology is developed and a series of indicators are selected, according to which the results are interpreted to facilitate understanding. The evaluators choose six or seven indicators whose impacts cover 80% of the "single score". The single score is a standardised and weighted aggregation of indicators expressed using a synthetic unit known as a point (Pt).

For this LCA, three indicators will be analysed in greater detail after we provide an overview and a multi-stage analysis of the life cycle.

2.3 The goal of LCA for Data4: an eco-friendly design approach

Life cycle assessment is used as a tool for eco-friendly design. According to the NF X30-264 standard, eco-friendly design involves the systematic integration of environmental considerations into the design phase when developing products or services. The goal is to reduce environmental impacts throughout the life cycle while obtaining equal or better performance.

Thus, life cycle assessment serves several objectives:

1. **Understand** the issues tied to a product by evaluating throughout the life cycle
2. **Compare** products and solutions for improvement, and thus avoid mistakes
3. **Demonstrate** the eco-friendly design approach and report performance using qualitative data

As figure 3 shows, LCA is useful at every stage in an eco-friendly design approach.

REMEMBER

LCA is a tool for eco-friendly design. It provides a way of understanding environmental concerns, comparing two technical solutions to see if one can improve impacts more than the other, and highlighting the reduction of impact for different stakeholders while complying with regulations on environmental reporting.

Data4 uses LCA as a decision-making tool during the design phase when building a data center. This orients the company's selection of technologies, helping it choose the best technical solutions while considering their entire life cycle and controlling for impact transfers, which might lead to the selection of seemingly good ideas that don't turn out so well.

LCA also allows Data4 to measure its progress towards the goal of achieving carbon neutrality by 2030.

Figure 3 – Diagram connecting LCA with an eco-friendly design approach

3

What is a data center?

Data centers are defined by standard EN 50600-1 as structures or groups of structures dedicated to the hosting, interconnection, and centralised operation of telecommunications equipment, information technologies, and networks, **providing data storage, processing, and transport services**. Data centers rely on energy distribution, environmental control, and security systems to ensure the availability of the provided service.

Data centers provide essential services to meet the daily needs of companies and consumers, hosting massive volumes of strategic data.

Data centers are highly specialised pieces of infrastructure. Each component is designed to ensure the availability, performance, security, and reliability of the digital services provided.

Data centers are made up of multiple parts serving different functions:

- IT equipment (mainly servers);
- and a whole series of infrastructure needed to support that equipment:
  - → a building,
  - → an electrical power system,
  - → a cooling system,
  - → a backup power system.

The LCA aggregates and analyses all of the direct impacts (scope 1) and indirect impacts (scope 2) of all the equipment and materials used to build, maintain, and operate a data center.

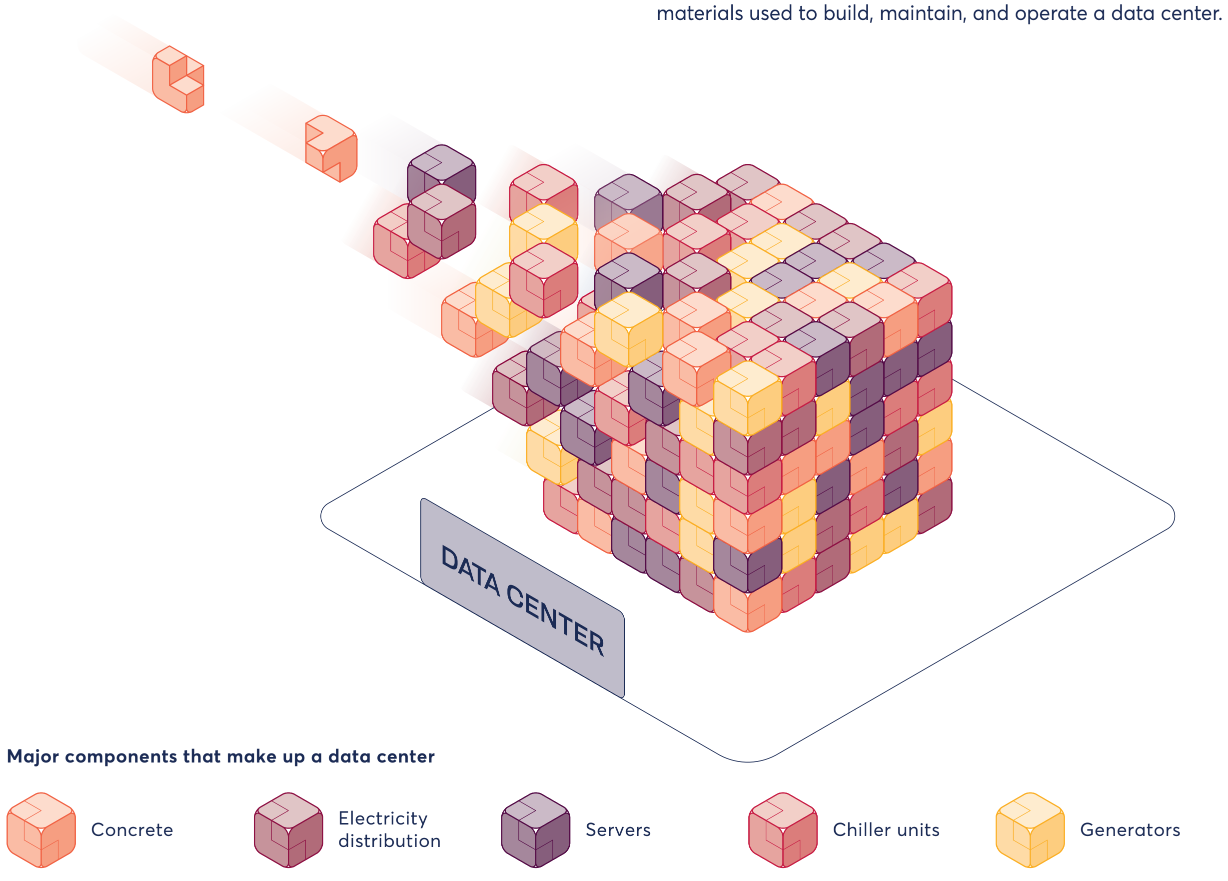

Figure 4 – Simplified representation of a data center

Details of the role played by each component:

Servers

Data is stored in **"racks" of servers**, the **beating heart** of a data center. To optimise space, the servers are installed vertically in racks. Servers are responsible for **hosting artificial intelligence-based applications** and other services, and making them available to end users through a network.

To mitigate the risk of potential failures, data is often duplicated on servers in another data center to ensure continuity of service for end users.

Because of Data4's scope of responsibility, the servers were excluded from the scope of the LCA, both with regard to their manufacturing and the energy that they consume during operation.

A secure building

As a specialist in hyperscale hosting—meaning data centers comprising several thousand square metres of space—Data4 designs and constructs buildings with robust infrastructure specially designed to host IT equipment.

A data center building is made up of three types of rooms: IT equipment rooms, utility rooms, and office spaces.

To ensure the security of the hosted data, DC sites are (sometimes highly) protected to prevent physical intrusion and malicious acts (theft, cutting of power lines, arson, etc.).

A connectivity system

A data center's performance also depends on its connectivity, i.e. its ability to guarantee both connections between internal equipment (servers, routers, network switches, and server racks) and with the outside (via the internet or private networks), with the objective being to allow end users to connect to the data center, or simply to interconnect several data centers.

A multitude of connectivity services are available to create secure and efficient hybrid IT architecture.

An electrical power system

To operate continuously 24 hours a day, seven days a week, a data center needs electricity. Power interruptions can lead to lost data, service outages, and even damage to equipment. As such, a data center's power supply must be stable, redundant, and uninterrupted.

A cooling system[2]

The IT equipment inside a data center, including servers, racks, and network switches, generates a large amount of heat. At the same time, high temperatures can degrade the functioning and overall health of such devices. Installing a **cooling system** removes heat from the building and allows the operators to maintain an optimum temperature to ensure the stability and longevity of the IT equipment. This means temperature control is a key factor in the design and operation of a data center.

There are different cooling technologies available on the market. The designers select cooling systems according to the configuration of facilities, the size of the data center, climatic conditions, requirements for energy efficiency, and more. The main cooling solutions include:

- air cooling
- liquid cooling

The efficiency of the cooling system has a direct impact on the data center's energy consumption. The measurement used to evaluate a system's efficiency is **power usage effectiveness (PUE)**[3]. A PUE close to 1 means that the energy dedicated to cooling is minimal in comparison to the energy consumed by the IT equipment. More efficient cooling solutions not only reduce the data center's carbon footprint, but they also reduce operating costs in the long term.

A backup power system

It is essential to install a **redundant** or **backup power** system to guarantee continuous power if the main electrical grid goes down, the goal being to avoid data loss or service interruptions.

Two **complementary systems exist side by side:**

- **Uninterruptible power supplies** *(UPS)*, coupled with batteries, provide temporary power;
- **Backup generators** (running on diesel or natural gas) provide backup power for a longer period of time.

If the electrical grid fails, then the UPSs instantly kick in. The generators take over when there's a prolonged outage. As such, regular preventive maintenance of the power equipment is crucial to ensure that it will function properly if the main grid has an outage.

[2] https://www.data4group.com/ressources/refroidissement-data-center/

[3] PUE = The total energy used by the data center, divided by the energy used only by the IT equipment.

[4] High availability: provide and guarantee continuous functioning of services or applications by implementing various actions/principles (such as data replication, safeguards, load distribution, redundancy, etc.) to limit the unavailability of an IT system.

[5] Latency: corresponds to the time it takes to send data from a data center to a user's terminal via communication networks.

REMEMBER

Data centers must comply with three complementary levels of requirements:

- **Electrical resilience and technical resilience** to enable uninterrupted operations 24 hours a day, seven days a week;
- **Physical and logical security** to guarantee the integrity of the equipment and the data hosted;
- **Performance**—initially energy performance, but now also environmental performance.

A data center must be designed to operate optimally with **high availability**[4], **low latency**[5], and minimal environmental impacts and operating costs.

4

Life cycle assessment of the data center

Data4 performed its first LCA in 2020, studying one of its data centers in Marcoussis, France, near Paris. Since then, the company has analysed all of its data center projects using the LCA methodology during the design phase. This has allowed management to identify trends in the environmental impacts of data centers.

This white paper aims to present and share the results of a representative LCA conducted for a data center at Data4's campus near Paris.

The technical characteristics of the data center:

- Total floor area: 4,278 m^2
- Floor area for IT equipment: 2,025 m^2
- Electrical power for servers (referred to as IT power): 5 MW IT projected at 70% usage (the average workload).
- A structure made up of 5,200 m^3 of concrete and 500 metric tonnes of steel, along with 3,868 m^2 of insulation and 5,880 m^2 of weatherproofed roofing.
- Main and backup power supplies, with electricity distributed via electrical cabinets (8 general low-voltage electrical panels) and 30,268 metres of wiring.
- A cooling system made up of 20 chiller units dedicated to IT equipment rooms and 3 additional units for the utility rooms.
- A backup power system consisting of batteries (2,800 kg) and four diesel generators.

This section describes the main points of the scope of study used for the LCA of the data center. Note that the evaluation relied on the following:

- the open-source software **openLCA;**
- the database **Ecoinvent (version 3.8)**, known worldwide for its strong geographic and sectoral coverage;
- the **Environmental Footprint 3.0** life cycle impact assessment (LCIA) methodology, provided by the European Commission.

4.1 Functional unit

According to the ISO 14040-44 standard, the functional unit corresponds to the "quantified performance of a product system for use as a reference unit in a life cycle assessment". In other words, the functional unit allows us to quantify the function provided by the products or services studied in the LCA—in this case, the service provided.

Thus, the functional unit used for the assessment of the data center is as follows:

To provide hosting services enabling the functioning of the physical IT equipment of the data center located near Paris, representing 5 MW of IT power, over 20 years, i.e. its entire life cycle.

4.2 Scope

The analysis covers all stages in the life cycle of a data center, from the extraction of raw materials to the center's demolition at the end of its useful life, and also including manufacturing, distribution/transport, construction, operations and maintenance, and end-of-life processing, as shown in Figure 5.

This includes all of the equipment needed for the data center's infrastructure to function, **but excludes the manufacturing and use of IT equipment**, as recommended in ADEME's Product Category Reference (RCP) for cloud services and data centers. The emissions from demolition activities are also excluded from the model.

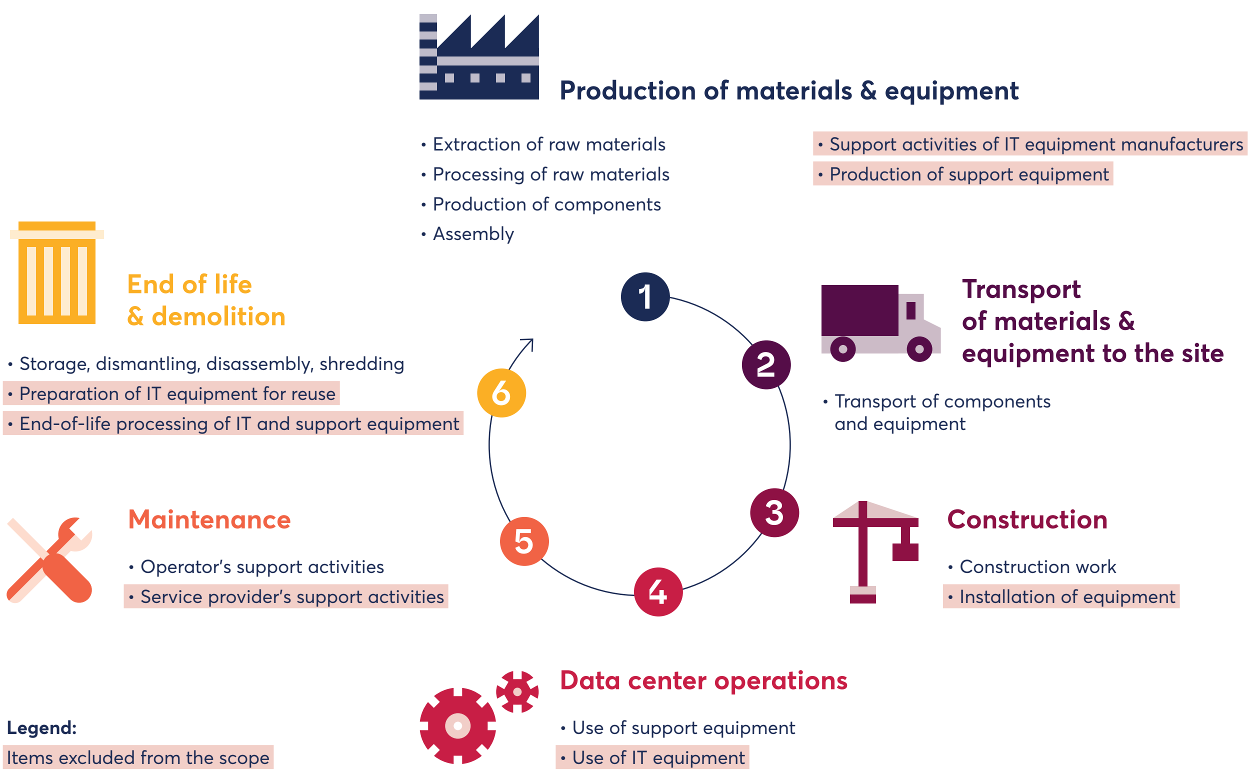

Figure 5 – Scope of the system studied by life cycle stage

Figure 6 provides a diagram of the limits of the system and the major stages included in the model. The data used for the manufacturing stage include the upstream steps of raw-material extraction and transformation.

Direct energy consumption in the construction stage is modelled with diesel combustion and electricity consumption, according to the electrical grid of the data center's country.

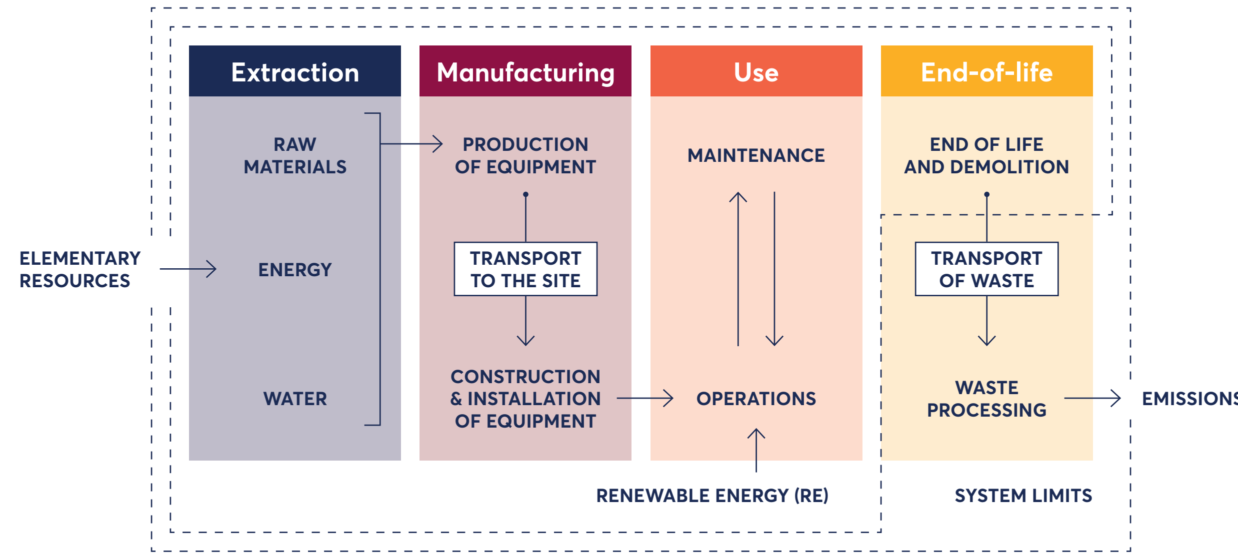

Figure 6 – Diagram of the limits of the system studied

In the presentation of results, the life cycle stages will be presented as in Table 1 below:

LIFE CYCLE PHASES	DESCRIPTION
Production of equipment and materials	Extraction of raw materials and manufacturing of equipment
Transport of equipment and materials to the site	Transport of materials and equipment to the data center's construction site, including all means of transport (road, sea, etc.)
Construction and installation	Construction work, as well as assembly and installation of technical systems (electrical, cooling, structure) until start-up of operations.
Operations	Data center operations: Energy consumption of technical equipment, particularly of the cooling systems, Refrigerant leaks, Combustion of fuel oil during maintenance tests of electrical generators.
Maintenance	Replacement of components and equipment that have lost their efficiency during the data center's operations phase, with the goal of maintaining the center's energy performance and resilience.
End of life	Dismantling of technical equipment and deconstruction of the building. Waste management, including repurposing or recycling of materials and components.

Table 1 – Summary of the life cycle phases studied

In the presentation of results, the data center's functions will be presented as in Table 2 below:

FUNCTIONS	SUB-FUNCTIONS	DESCRIPTION
DC building	*Foundation*	All of the physical structures: foundation, structural and non-structural work, interior walls, and the building envelope. The building provides the physical platform, compartmentalisation, and passive security for the IT equipment rooms and utility rooms.
	Load-bearing structure	
	Envelope	
	Interior construction	
IT cooling	*Cold production*	A series of systems that remove the heat produced by the IT equipment (excluded from scope) via dedicated technical equipment. This includes: cooling units, refrigerant, air-handling units (AHUs), hydraulic circuits (pumps, pipes, valves, exchangers), and climate control units in the IT rooms.
	Cold distribution	
Electrical power	*Conversion*	A chain providing continuous electrical power: transformers, HV/LV panels, wiring. Guarantees the availability and quality of power for critical equipment.
	Distribution	
Backup power system	*Voltage stabilisation and protection*	A series of equipment that ensures the continuity of electrical service in case of an outage on the main electrical grid: electrical generators, fuel oil tanks, batteries, uninterruptible power supplies (UPSs).
	Backup power	
Heating, ventilation, and air conditioning (HVAC) – non-IT	*Ventilation and cooling of utility rooms*	All of the HVAC equipment dedicated to comfort and safety, for non-IT spaces: ventilation of utility rooms and hallways, air conditioning of battery facilities and office space, heating of spaces used by people, smoke extraction, etc.

Table 2 – Summary of functions studied

4.3 Assumptions

To model the data center, Data4 supplied and used data specific to the data center. Several sources of data were used in addition to primary data:

- Environmental Product Declaration (EPD),
- Scientific publications,
- Technical data sheets,
- The Ecoinvent database.

LIFE CYCLE PHASES	DESCRIPTION
Production of equipment and materials	• Several EPDs used and provided by suppliers • Building foundation: an alternative concrete blend using CEM III/A cement • Production of refrigerants with low GHG emissions: modelled according to the EN 15804 standard (in accordance with EPD standards) • Weatherproofing components, modelled using generic tar-based weatherproofing products • Insulation of walls with mineral wool: rock wool was used for modelling with a generic process • Estimated density of the concrete: 2,400 kg/m^3
Transport of equipment and materials to the site	• Transport distances were calculated using the shortest available routes • Refrigerant delivery was included in the transport of the cooling system • Transport of wiring: assumed transport distance of 1,000 km between the manufacturer and the construction site using a EURO 5 diesel lorry
Construction and installation	• Water and energy consumed in the construction phase
Operations	• The data center's lifespan is considered to be 20 years[6] • Non-IT electricity consumption by the data center: 840 kW on average, or 7,358 MWh per year • Renewable energy mix used, mainly consisting of wind, hydroelectric, and solar; model adopted as it corresponds to Data4's policy of purchasing renewable energy • Consumption of diesel for the upkeep and operation of diesel generators: 25,848 litres per year • Water consumption by humidifiers: 14.26 litres per year • Refrigerant leakage: rate of 3% per year throughout the life cycle
Maintenance	• Replacement of batteries every 8 years (conservative assumption taking into account operational practices erring on the side of caution—Product Category Reference (RCP) recommends every 10 years
End of life	• Waste produced by demolition is sent to waste processors • Significant recycling for metals, concrete, and batteries: - Steel: 85% recycled - Copper: 95% recycled - Aluminium: 95% recycled - Reinforced concrete: 20% recycled - Lead-acid batteries: 100% recycled - Mineral wool: 40% recycled

Table 3 - Presentation of the assumptions used for the assessment of the data center

[6] This study was conducted prior to the writing of ADEME's data center and cloud services RCP, which suggests assuming a lifespan of 50 years for a data center.

4.4 Indicators selected

The indicators calculated in Data4's LCAs are actually more extensive than the recommendations provided by the Product Category Reference (RCP), as shown by the table below.

	RCP RECOMMENDATIONS	SELECTION USED BY DATA4
ENVIRONMENTAL INDICATORS TO BE INCLUDED	• Climate change • Depletion of mineral and metal resources • Acidification • Ionising radiation • Emissions of fine particulate matter	• Climate change • Depletion of mineral and metal resources • Depletion of fossil fuels • Acidification • Eutrophication of fresh water • Photochemical ozone formation • Depletion of the ozone layer • Depletion of water resources

Table 4 – Presentation of indicators selected by Data4

In the next section of this white paper, three specific indicators will be analysed as they allow us to draw different and complementary conclusions.

IMPACT INDICATORS	UNIT	TYPE OF SUBSTANCES INVOLVED	DESCRIPTION OF PHENOMENON
Climate change	Kg CO_2 eq.	Greenhouse gases (carbon dioxide, methane, ozone, nitrous oxide, etc.) emitted through the consumption of fossil fuels, from animal farms, etc.	While initially a natural phenomenon, the greenhouse effect has been amplified by human emissions of greenhouse gases, which trap solar radiation and reflect it back at Earth's surface, causing global warming and climate change.
Depletion of mineral resources	Kg Sb-eq.	Metals and rare earth elements	A measurement of the consumption of natural resources such as iron, aluminium, etc., while accounting for resource availability
Depletion of water resources	m^3 deprived	Water	A measurement of water consumption, taking into account available reserves in the location of consumption

Table 5 – Summary of the various impact indicators used

Since 2020, all of Data4's data center projects have been analysed using the methodology laid out above, allowing the company to establish trends for the environmental impacts of data centers. Those trends will be presented in the next section.

5

Results of the data center's LCA and proposed improvements

In this section of the white paper, we present and explain the overall results of the data center's life cycle assessment[7] before detailing three specific environmental indicators.

5.1 Overall results

5.1.1 VIEW OF THE IMPACT THROUGHOUT THE ENTIRE LIFE CYCLE

Analysis of the results shows two phases that have the biggest impact in the entire life cycle:

- The data center's construction phase, including the production of equipment and materials, as well as the building project,
- The operations and maintenance phase.

Figure 7 shows that:

- 40% to 61% of environmental impacts are tied to the operations phase in a 20-year lifespan,
- 31% to 60% of environmental impacts are tied to the manufacturing of the data center's materials and equipment.

The environmental impacts associated with transporting equipment and materials to the construction site, along with the construction project itself, are relatively marginal.

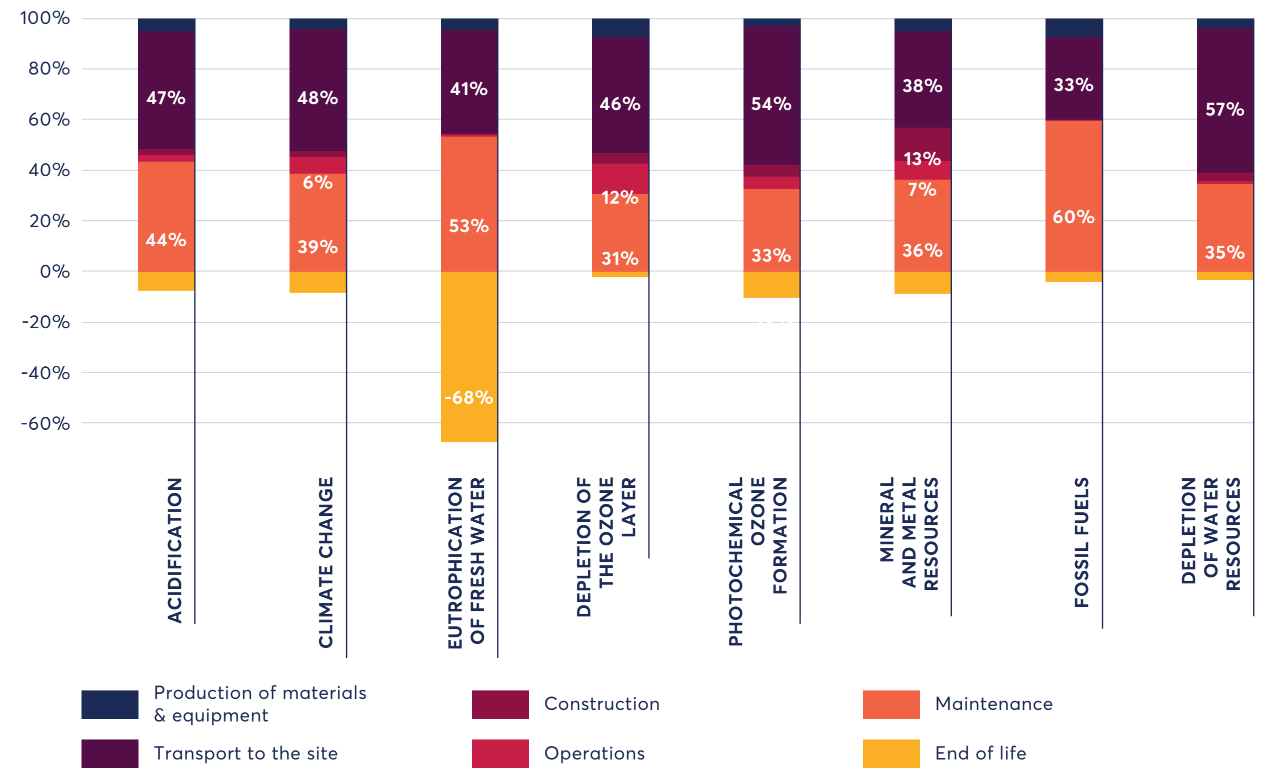

Figure 7 – Impacts of the data center by life cycle phase

[7] This assessment did not include a critical review process as prescribed by the ISO 14040-44 standard, as part of the sharing of results with the general public. However, Data4 and APL Data Center intend to receive and respond to any comments made on this white paper, and remain available to provide any further information.

REMEMBER

The overall environmental impact of a data center throughout its life cycle is mainly tied to two stages:

- The **operations phase** – 50% of impacts, particularly from energy consumption
- The **production of materials & equipment** – 40% of impacts – prior to the data center's construction

5.1.2 FOCUS ON CONSTRUCTION – BREAKDOWN OF IMPACT BY FUNCTION

Given that the transport of equipment and materials, as well as the building project phase, are responsible for relatively small shares of the environmental impacts, our analysis will now focus on the production of equipment and materials.

As such, the sections that follow will provide detailed analysis of this phase, breaking down the environmental impacts according to the main technical functions of the data center.

The breakdown of the impacts of manufacturing materials and equipment according to the data center's major functions in Figure 8 allows us to identify the main contributors, namely:

- The data center building, corresponding to between 17% and 47% of impacts,
- The backup power system, corresponding to between 8% and 29% of impacts,
- The main power system, corresponding to between 14% and 63% of impacts.

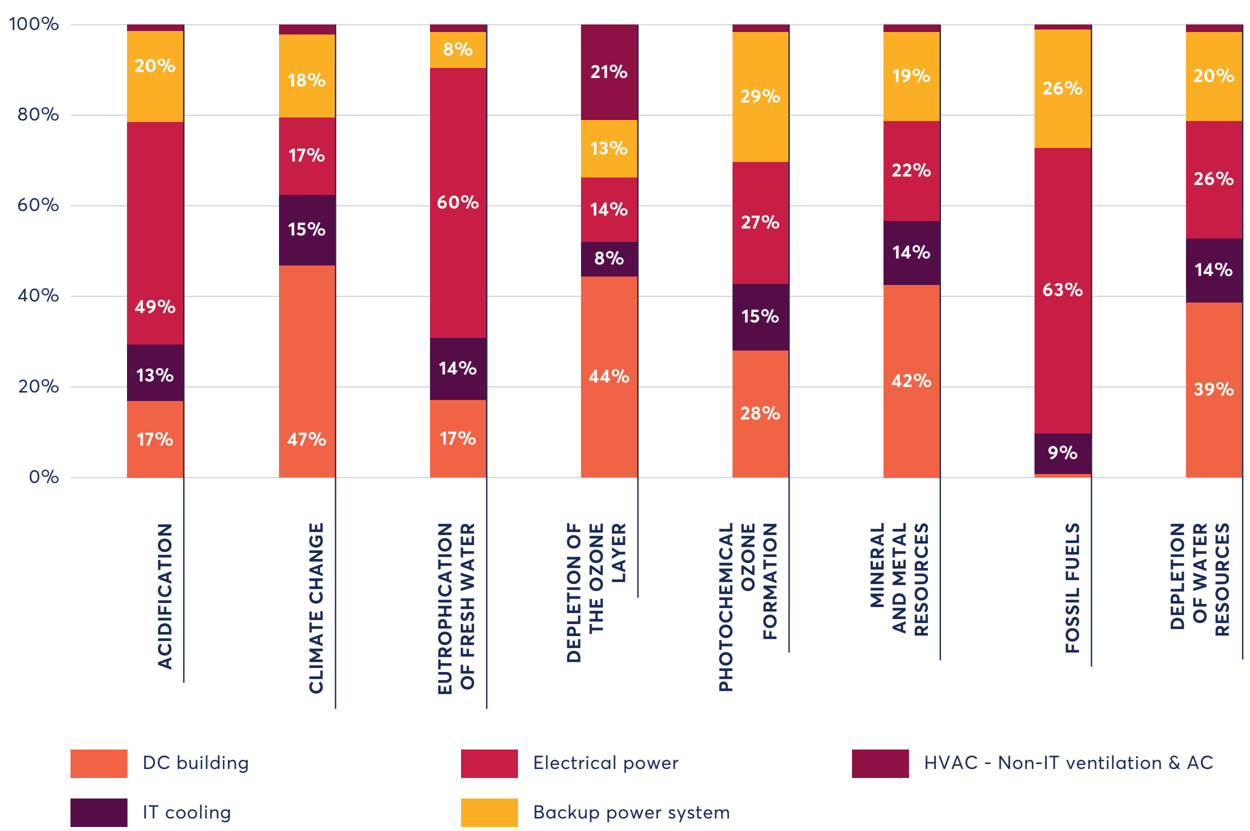

Figure 8 – Impacts of the data center by function

REMEMBER

The environmental impact of manufacturing the data center's equipment and materials comes mainly from the following subsystems:

- The **building**, i.e. the hosting structure, primarily made up of a building envelope of steel and concrete
- The **backup power system**, made up of uninterruptible power supplies, batteries, and electrical generators
- The **electrical distribution system.**

The cooling systems, although largely responsible for the impacts of operations, are less significant in terms of the impact of their manufacturing.

Because of similar interpretations between several indicators and in the interest of simplification, this white paper will detail in particular the data center's contributions to three environmental indicators to offer a complete view of the significant environmental concerns tied to a data center. Those indicators are:

- Climate change,
- The depletion of mineral and metal resources,
- The depletion of water resources.

Climate change

Climate change (a concept commonly tracked in the form of a "carbon footprint") is the most closely tracked environmental indicator. It corresponds to the global warming potential caused by the concentration of greenhouse gases in the atmosphere, which trap solar radiation and reflect it back at Earth's surface. This indicator is measured in kilograms of CO_2 equivalent.

Why track this indicator for a data center?

Throughout its life cycle (extraction of raw materials, production of equipment, construction, operations, end of life), a data center consumes resources, which are extracted, transformed, assembled, transported, and used, before being destroyed. Each of these stages requires the consumption of energy and causes greenhouse gas emissions into the atmosphere, thus contributing to global warming.

Depletion of mineral and metal resources

The depletion of mineral resources is an indicator that reflects consumption pressure on reserves of non-renewable natural resources (iron, aluminium, copper, silicon, etc.). The impact of this indicator is tied to the extraction of resources for the manufacturing of materials and equipment. It is measured in kilograms of antimony (Sb) equivalent.

Why track this indicator for a data center?

Data centers contain a large amount of electronic equipment (such as cooling and network equipment, wires, and batteries), all of which are made up of non-renewable resources like metals and rare earths.

Depletion of water resources

The water resource depletion indicator evaluates the consumption of water, taking into account the rarity of fresh water in the place in which it is consumed. It is measured in m^3 of water equivalent.

Why track this indicator for a data center?

This vital resource is increasingly under pressure from human activity. At the same time, water is often essential during material transformation, equipment cleaning, and humidifying and cooling certain data centers.

Table 5 (page 19) summarises the impact indicators presented in this white paper, along with a description of the phenomenon associated with each.

5.1.3 FOCUS ON THE OPERATIONS PHASE

The operations phase is the main source of the data center's environmental impacts for almost all of the indicators studied (with the exception of the depletion of mineral and metal resources).

The breakdown of the operations phase's impacts in Figure 9 shows the main contributors:

- Non-IT energy consumption is responsible for between 45% and 93% of impacts,
- The backup power system, which consumes diesel for the monthly tests of the electrical generators, is responsible for between 1% and 42% of impacts,
- Equipment maintenance, which includes the replacement of batteries after eight years of usage and refilling of refrigerant lost by chiller units, is responsible for between 5% and 18% of impacts.

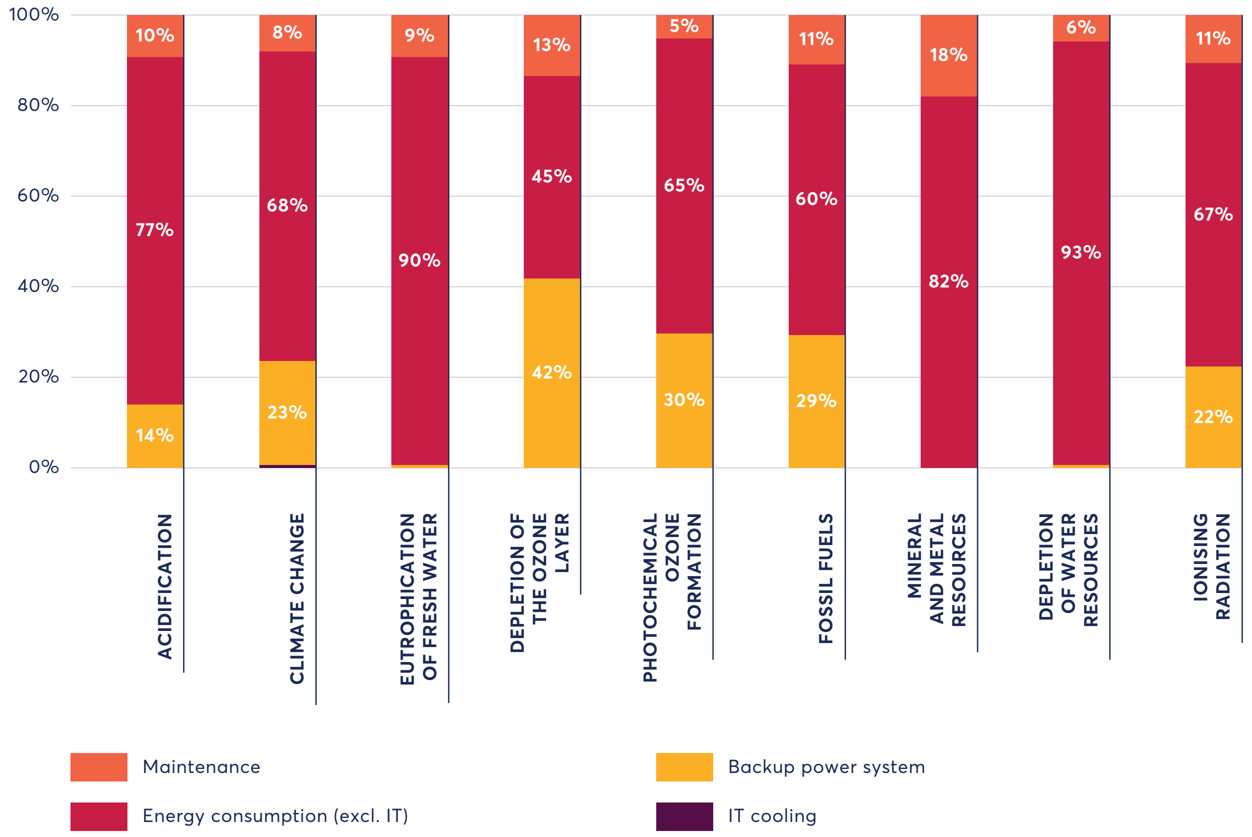

Figure 9 – Impacts of the data center by function

In the operations phase, the environmental impacts are thus mainly tied to the consumption of electricity by technical equipment.

This consumption is generally characterised by the power usage effectiveness (PUE) indicator, which is a ratio of the total energy consumed by the data center to the energy consumed by IT equipment.

For this data center, the average amount of electricity consumed is 4.34 MW[8], with the power profile projecting that amount to break down as follows:

- 3.0 MW for IT equipment (mainly servers),
- 1.34 MW for support systems,

for a PUE of 1.43.

The functions that consume the most energy are as follows:

FUNCTION (EXCL. IT)	ESTIMATED SHARE OF CONSUMPTION EXCL. IT	EQUIV. IN MW FOR DATA CENTER	SHARE OF SITE TOTAL (FOR DATA CENTER)
IT cooling	65–75%	0.55–0.63 MW	12–15%
Electrical power for IT (lost by UPSs, transformers, distribution)	20–25%	0.17–0.21 MW	4–5%
Other (non-IT HVAC and other auxiliary eqpt.: lighting of facilities, security and access control systems)	5–10%	0.04–0.08 MW	1–2%

Table 6 – Functions that consume the most energy

REMEMBER

The environmental impact of the data center's operations mainly comes from the consumption of energy by technical equipment, particularly:

- The **IT cooling system:** chiller units, AHUs, pumps, climate control units
- Losses from equipment in the **electrical distribution system:** UPSs, transformers, distribution panels, etc.

5.1.4 FOCUS ON THE END-OF-LIFE PHASE

The data center's end-of-life phase differs from the others in that it helps reduce the net environmental impacts of the infrastructure[9].

In an LCA, this reduction is represented by environmental credits, referred to as "impacts avoided", associated with the recycling and repurposing of metal and construction materials at the end of the life cycle, thus helping avoid the production of virgin materials.

This "negative value" partially compensates for the impacts generated upstream across all of the indicators studied. As the positive impacts are expected in the distant future, they are by nature very uncertain; as such, we chose to exclude them from our analysis below.

[8] Based on the assumption of needing power to cover the data center operating at an IT workload of 70%.
[9] In Figure 9, the values shown are expressed as a percentage of the total impacts generated by the data center, minus reductions linked to the end-of-life phase.

5.2 DC impacts in terms of climate change

5.2.1 VIEW OF IMPACT BY LIFE CYCLE PHASE

The data center's total net carbon footprint over 20 years is 12,613,538 kgCO_2-eq, approximately equivalent to the emissions of 289 European individuals over the same period[10].

According to Table 7, the two life cycle phases with the greatest impact on climate change are as follows:

- **The operations phase is the greatest contributor, with 6,591,792 kgCO_2-eq, representing 48% of total emissions:** due to the consumption of electricity by equipment producing and distributing the cold needed for the data center to function, and to a lesser extent due to losses in the distribution of electricity. The calculation takes into account France's renewable energy mix (68%), a model used as it corresponds to Data4's policy for purchasing renewable energy.

In addition, the use of diesel during the maintenance of electrical generators contributes 23% of the total.

- **The production of equipment and materials constitutes the second largest source of impact, representing 5,352,830 kgCO_2-eq, or 39% of total emissions.**

This impact is mainly attributable to the manufacturing of materials for the data center's structure and foundations, which are single-handedly responsible for 47% of the emissions tied to the production phase.

The concrete, metal, and other construction materials generate a large amount of greenhouse gas emissions in the course of their extraction and transformation. The cooling, main power, and backup power systems are each responsible for between 16% and 18% of the impact from production, particularly relating to the manufacturing of heavy equipment (chiller units, electrical generators, UPSs, and electrical panels).

PHASE	IMPACT ON CLIMATE CHANGE (KG CO_2-EQ)	PERCENTAGE OF CONTRIBUTION
Production of materials & equipment	5,352,830	39%
Transport to the site	869,047	6%
Construction	370,245	3%
Operations	6,591,792	48%
Maintenance	570,482	4%
End of life	-1,140,858	-8%
Total (gross)	13,754,397	100%

Table 7 – Impacts of the data center on climate change by life cycle phase

[10] Source: Given the annual electricity consumption of an average European was 5,990 kWh in 2023, with a carbon factor of 207 kgCO_2eq/MWh (EAA Europa database)

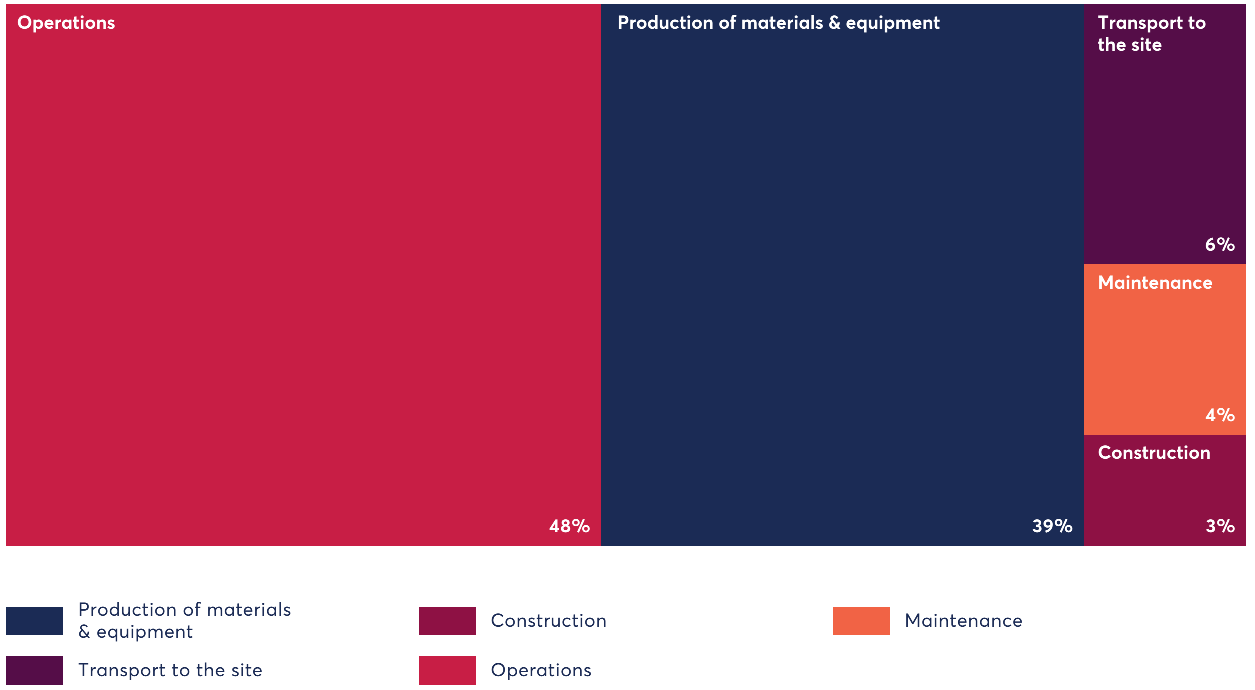

Figure 10 – Impacts of the data center on climate change by life cycle phase

5.2.2 VIEW OF IMPACT BY FUNCTION

According to Table 8, the impacts on climate change are mainly from four functions:

1. The materials used in the **data center building** contribute **47% of the total impact.** This category is heavily influenced by the **load-bearing structure** (32%) and **foundation** (11%), which require large amounts of carbon-intensive materials such as **reinforced concrete** and **steel**.
2. **The backup power system** (generators, UPSs, and batteries) accounts for **18%** of greenhouse gas emissions. This result can be explained by the fact that the electrical generators, UPSs, and batteries are made up of materials that have undergone intense transformation, and thus used a lot of energy in their manufacturing phase.
3. The **main power system accounts for 17%** of emissions, mainly due to the materials that go into the manufacturing of electrical distribution panels.
4. **Similarly, the impacts related to IT cooling represent 16% of emissions in the production phase.** This contribution is mainly tied to the extraction and transformation of the materials needed to manufacture the cold production equipment (chiller units), which account for 6% of emissions, as well as for the many parts involved in cold distribution—such as climate control units, air handling units (AHUs), and fanwalls—responsible for 10% of emissions.

FUNCTIONS	SUB-FUNCTIONS	IMPACT ON CLIMATE CHANGE (KG CO_2-EQ)	PERCENTAGE OF CONTRIBUTION
DC building	Foundation	577,143	10.8%
	Load-bearing structure	1,715,145	32.0%
	Envelope	122,265	2.3%
	Interior construction	97,373	1.8%
	Total	**2,511,925**	**46.9%**
IT cooling	Cold production	297,304	5.6%
	Cold distribution	531,554	9.9%
	Total	**828,857**	**15.5%**
Electrical power for IT	Conversion	176,981	3.3%
	Distribution	744,732	13.9%
	Total	**921,713**	**17.2%**
Backup power system	**Generators, UPSs, and batteries**	**982,813**	**18.4%**
HVAC - Non-IT ventilation & AC	Utility room ventilation	36,021	0.7%
	Air handling (excl. IT)	71,500	1.3%
	Total	**107,521**	**2.0%**
Total		**5,352,830**	**100%**

Table 8 – Impacts of the data center on climate change by function

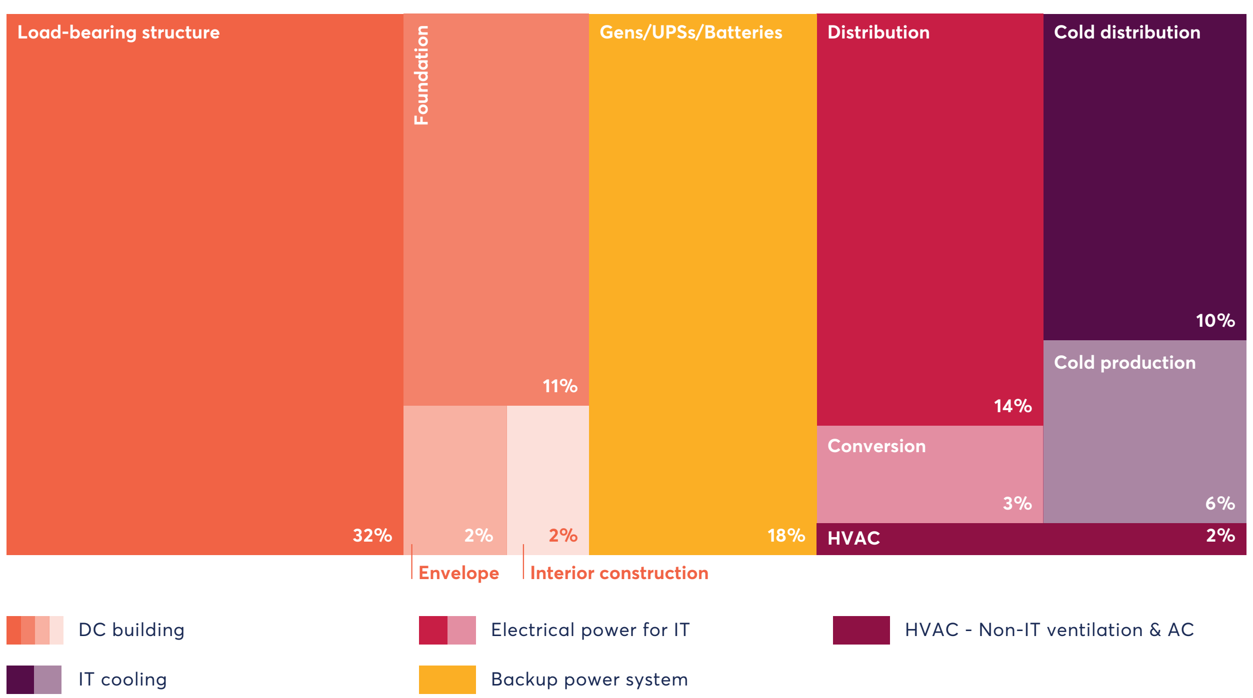

Figure 11 – Impacts of the data center on climate change by function

REMEMBER

PRODUCTION

The production of equipment and materials contributes **39% of the data center's impact on climate change,** or 5,352,830 $kgCO_2$-eq.

Of that 39% of impact:

- 43% is tied to the production of the building's structure
- 8% is tied to the production of backup equipment
- 17% is tied to the production of the building's power supply and distribution systems
- 16% is tied to the production of cooling equipment

For comparison, the construction of a data center with a 5-MW capacity generates a carbon impact **equivalent to the production of four Airbus A320 airliners** (estimated at 1,320,000 $kgCO_2$eq per aircraft[9]).

OPERATIONS

The data center's operations phase represents **48% of the total impact on climate change, or 7,162,274 $kgCO_2$-eq.** Among those emissions, 68% is directly tied to the production of renewable electricity, consumed by the data center's technical equipment.

The annual electricity consumption of an average European was 5,990 kWh in 2023[10], with a carbon factor of 207 $kgCO_2$eq/MWh[11], resulting in annual emissions of 1,240 $kgCO_2$-eq per person. As such, the non-IT operations of the data center (with a capacity of 5 MW IT) over 20 years have a carbon footprint equivalent to the **electricity consumption of 289 European individuals over the same period.**

[9] Vivalda, P.; Fioriti, M. Stream Life Cycle Assessment Model for Aircraft Preliminary Design. Aerospace 2024, 11, 113. https://doi.org/10.3390/aerospace11020113

[10] Source: https://ember-energy.org/data/yearly-electricity-data/

[11] Source: https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1

ACTIONS RÉALISÉES D4 PAR DATA4

5.2.3 ACTIONS FOR IMPROVEMENT

To reduce the impact on climate change in the operations phase, we have:

- **Improved energy efficiency:** improving power usage effectiveness (PUE) by 9% between 2021 and 2024 thanks to real-time management of electricity consumption, optimising management of temperatures in the IT rooms, and optimising cooling technologies, particularly using "free cooling" (using external air).
- **Reused waste heat:** launching a data center pilot project in Marcoussis using bio-circular technology, in partnership with Paris-Saclay University, to reuse the heat produced by the data center to cultivate algae, which is then transformed into biomass for use as bio-based energy and in agro-industry. The expected heat recovery rate is over 20%, which is better than conventional standards.
- **Purchased renewable energy:** beefing up power purchase agreements (PPAs) to guarantee a supply of renewable energy, contributing to the stability of the power grid and reducing the carbon footprint of energy consumed.
- **Used low-carbon fuel for electrical generators:** adopting hyrdrotreated vegetable oil (HVO) fuel for generators, which can reduce overall GHG emissions by 70% compared to conventional fuel oil.
- **Reduced the impact from refrigerants:** gradually replacing older refrigerants that have a high global warming potential (GWP) with low-GWP refrigerants in the chiller units; this initiative covered five data centers in 2024.
- **Reduced the impact of electrical equipment:** installing of a medium-voltage distribution panel free of sulphur hexafluoride (a very powerful greenhouse gas) at data center 8.2 in Milan, reducing the CO_2-equivalent emissions tied to the equipment by 70%.

To reduce the impact on climate change in the construction phase, we have:

- **Used low-carbon construction:** expanding use of low-carbon concrete for foundations and precast hollow-core slabs, reducing the need for concrete by 50% and reducing by 13% the carbon footprint of each new MW IT constructed since 2022. Goal: a 38% lower carbon footprint per MW IT built by 2030.
- **Reduced the usage of resources and transport:** using locally made prefabricated structures to limit the transport distance to 30 km, significantly reducing the carbon footprint tied to transport activities.
- **Reused materials and components:** using second-hand construction materials or reusing certain IT or electrical components to limit the carbon footprint of construction.
- **Systematically adopted eco-friendly design:** incorporating over 50 eco-designed options and solutions at all levels of data center projects in accordance with 56 technical requirements for sustainability.
- **Sought BREEAM environmental certification:** pursuing BREEAM certification for new projects.
- **Implemented carbon offsets:** investing in Label Bas-Carbone certificates to offset residual emissions in scopes 1 and 2, and partnering with Igloo France Cellulose to offset scope 3 emissions by using cellulose insulation (a bio-based insulation made 90% from recycled paper).

5.3 DC impacts in terms of water resource depletion

5.3.1 VIEW OF IMPACT BY LIFE CYCLE PHASE

As Table 9 shows, the **data center's operations phase contributes 57% of the impact on water resource depletion,** with 3,719,482.1 m³ deprived (cubic meters of water depletion per kilogram). This water consumption is directly tied to the use of water in the building and operating of the means of energy production. In this case, the impact is attributable to France's renewable energy mix for the electricity used to power the data center's electrical equipment, a model used as it corresponds to Data4's policy for purchasing renewable energy.

PHASE	DEPLETION OF WATER RESOURCES (M³ DEPRIVED)	PERCENTAGE OF CONTRIBUTION
Production of materials & equipment	2,262,618	35%
Transport to the site	63,522	1%
Construction	213,154	3%
Operations	3,719,482	57%
Maintenance	236,160	4%
End of life	-227,829	-4%

Table 9 – Impacts of the data center on water resource depletion by life cycle phase

In France in 2021, renewable energy was produced by hydroelectric dams (48%), wind farms (30%), and solar panels (12%).

Of the water resource depletion caused by electricity consumption, **78%** can be attributed to solar power installations (51%) and hydroelectric dams (27%).

The consumption of water for the production of photovoltaic energy mostly occurs during the **production of silicon solar cells**.
Regarding the production of hydroelectric energy, although the water is not consumed directly, its **retention by a dam** means that a certain volume of water is constantly subtracted from the natural cycle of water availability.

It is estimated that between 0.04 and 0.1 litres of water evaporates on average for each kilowatt-hour of electricity produced.

A key takeaway from this study is that the data center's direct consumption of water is a relatively minor contributor to the impact on water resources. Indeed, direct consumption represents **less than 0.1% of the total impact of water consumption**, which underscores the idea that **indirect usage of water—particularly tied to electricity generation—is a much more significant contributor to water resource depletion.**

The phase with the second-largest contribution is the production of the data center's materials and equipment, representing 35% of the total impact.

This stage includes the extraction and transformation of construction materials, as well as of the metals used in the electronic equipment. **These processes consume a lot of water**, making this phase an important area for optimising environmental impacts.

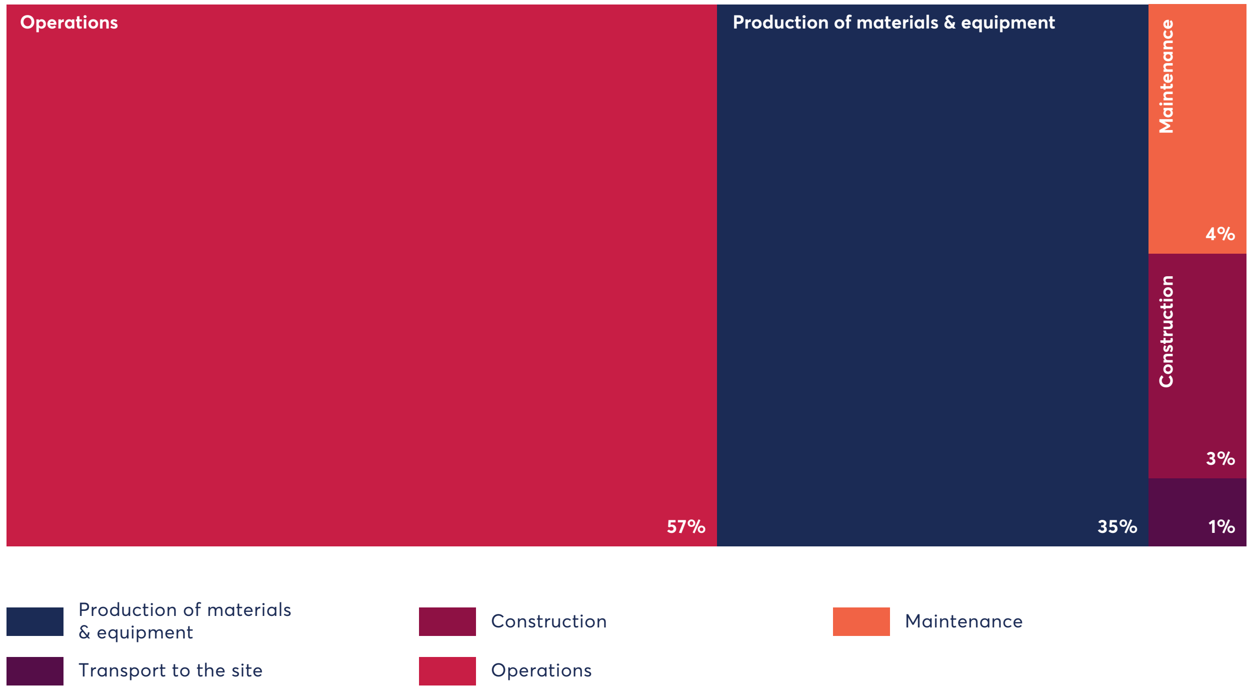

Figure 12 – Impacts of the data center on water resource depletion by life cycle phase

5.3.2 VIEW OF IMPACT BY FUNCTION

According to Table 10, water consumption is mostly tied to four functions:

1. The **DC building**, representing 39% and corresponding to the materials (concrete, steel) needed to build the load-bearing structure.

   The production of steel uses a large amount of water, which is used in particular to cool high-temperature equipment (blast furnaces, rolling mills, converters), but also for industrial operations such as extinguishing coke, gas scrubbing, slag granulation, and descaling of sheet metal.

   The production of concrete (a mixture of sand, gravel, and cement) requires a large amount of water to activate the cement.

   Water is also used in thermal power plants to operate steam turbines.

2. The **electrical power system for IT**, representing 26%, whose contribution to impacts is associated with the copper present in the electrical wiring, transformers, and electrical panels.

   The production of copper requires large amounts of water throughout its process. The extraction, grinding, flotation, and refining steps are all water-intensive and are necessary to isolate the copper from ore with low concentrations. These processes are often carried out in regions already experiencing water stress and put further pressure on local water resources.

3. The **backup power system**, representing 20%, attributable to the production of electrical equipment, including UPSs and batteries, which also contain metals whose production processes require water.

4. The **IT cooling system**, representing 14%: this impact is mainly tied to the **extraction of copper, but also the use of iron** in the manufacturing of steel. These industrial processes consume a particularly large amount of water, which explains their weighting in the life cycle assessment.

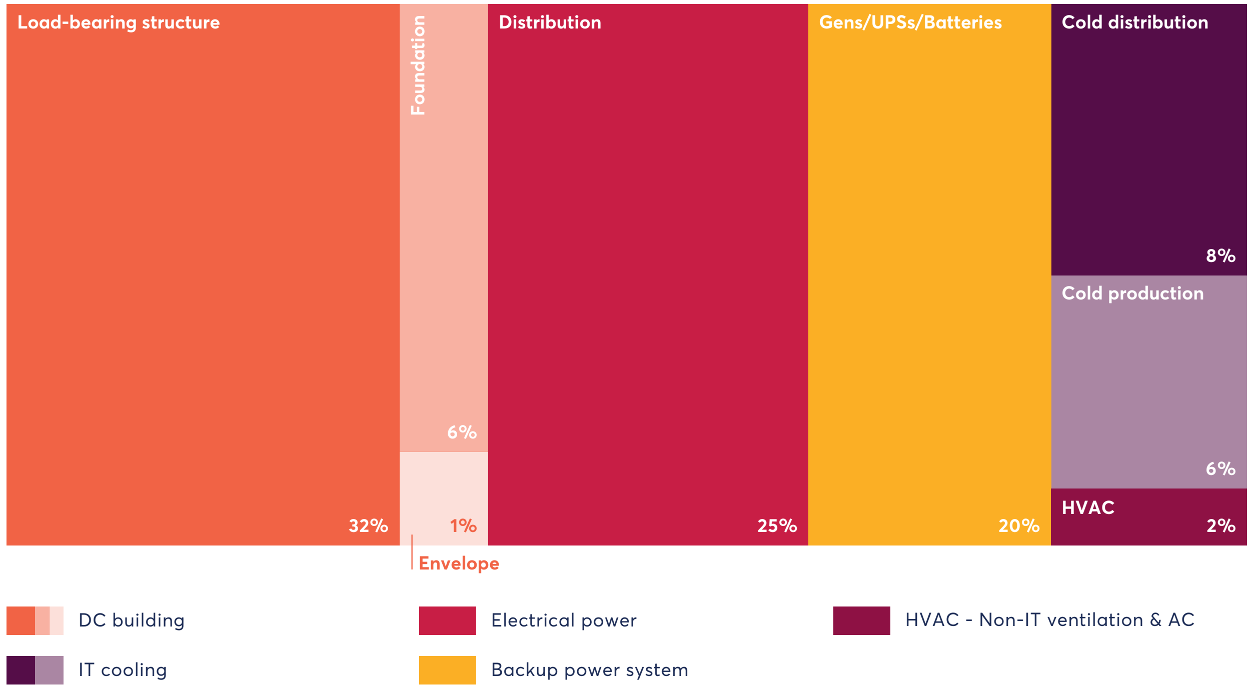

Figure 13 – Impacts of the data center on water resource depletion by function

FUNCTIONS	SUB-FUNCTIONS	DEPLETION OF WATER RESOURCES (M³ DEPRIVED)	PERCENTAGE OF CONTRIBUTION
DC building	Foundation	134,654	6.0%
	Load-bearing structure	715,921	31.6%
	Envelope	27,429	1.2%
	Interior construction	727	0.0%
	Total	**878,731**	**38.8%**
IT cooling	Cold production	141,376	6.3%
	Cold distribution	179,134	7.9%
	Total	**320,510**	**14.2%**
Electrical power for IT	Conversion	11,819	0.5%
	Distribution	572,191	25.3%
	Total	**584,010**	**25.8%**
Backup power system	Generators, UPSs, and batteries	442,376	19.5%
HVAC - Non-IT ventilation & AC	Utility room ventilation	12,881	0.6%
	Air handling (excl. IT)	24,111	1.1%
	Total	**36,992**	**1.7%**
Total (gross)		2,262,618	100%

Table 10 – Impacts of the data center on water resource depletion by function

REMEMBER

OPERATIONS

The data center's operations over 20 years are responsible for **57% of its impact on the depletion of water resources,** or 3,695,328 m³ deprived. This amount corresponds to the volumes of water used **in the production of electricity.**

In comparison, the data center's direct water consumption is very limited, representing just 0.1% of the total water used.

Thus, while the data center's direct water consumption is negligible, the indirect impacts tied to the energy consumed are quite significant.

In 20 years of operating, data center DC 19 will result in water consumption equivalent to that of 3,422 French people[12] over the same period.

If we focus on the data center's direct water consumption over the same period, it is equivalent to the consumption of 11 to 12 French people.

PRODUCTION

The production of materials and equipment needed to build the data center contributes **36% of the impact on the depletion of water resources,** or 2,262,618 m³ deprived, attributable to the manufacturing of the building's load-bearing structure (steel and concrete) and of the technical equipment (extraction of minerals for the production of copper and steel, and energy used in the manufacturing process).

[12] The average French person consumes 54 m³ of potable water per year (https://www.notre-environnement.gouv.fr/themes/societe/le-mode-de-vie-des-menages-ressources/article/consommation-domestique-en-eau-potable)

ACTIONS RÉALISÉES D4 PAR DATA4

5.3.3 ACTIONS FOR IMPROVEMENT

To optimise the building's structure and materials, we have:

- Used low-carbon concrete: In 2023, Data4 began using low-carbon precast slabs, which, thanks to their honeycomb design and optimised fabrication, reduce the need for concrete by 50%, enabling an overall reduction not just of the carbon footprint tied to construction, but also of the impact on water resources. Indeed, this innovation allows Data4 to use less cement and thus enables less indirect water consumption.

To optimise water consumption in the data center's operations phase:

- Data4 does not use cooling towers or adiabatic cooling systems, which are known for their water consumption. This enables the company to achieve a high level of water use efficiency (WUE). **In 2024, our WUE was 0.039 litres/kWh IT across the entire company, as compared to 0.061 litres/kWh IT in 2021 (the average WUE in the industry is around 1 L/kWh IT).**

- **Data4 plans to explore innovative solutions aiming to further reduce the use of water** fit for human consumption by instead using grey water, rainwater, or industrial waste water.

5.4 DC impacts in terms of mineral and metal resources

5.4.1 VIEW OF IMPACT BY LIFE CYCLE PHASE

The data center's total impact on the depletion of mineral and metal resources is 1,820 kg Sb-eq. According to Table 11, the two life cycle phases with the greatest impact are as follows:

- The production of construction materials and equipment is the greatest contributor to this impact, with 1,090 kg Sb-eq, or 60% of the total impact: this is mainly attributable to the manufacturing of the electrical power distribution equipment (63% of the impact) and of the backup power systems (26% of the impact).

Copper, rare earths, and critical metals are limited resources used in the production of electrical infrastructure such as cables, UPSs, and batteries. Aluminium, tin, and silver, which are used in several components, are metals whose extraction has a strong impact on this indicator.

- The operations phase is the second biggest contributor, with 594 kg Sb-eq, or 33% of the total impact: This impact is indirectly tied to the consumption of resources in the manufacturing of equipment to produce and distribute electricity on the public electrical grid.

PHASE	DEPLETION OF MINERAL AND METAL RESOURCES (KG SB-EQ)	PERCENTAGE OF CONTRIBUTION
Production of materials & equipment	1,090	60%
Transport to the site	3	0%
Construction	2	0%
Operations	594	33%
Maintenance	131	7%
End of life	-75	-4%
Total	1,820	100%

Table 11 – Impacts of the data center on the depletion of mineral and metal resources by life cycle phase

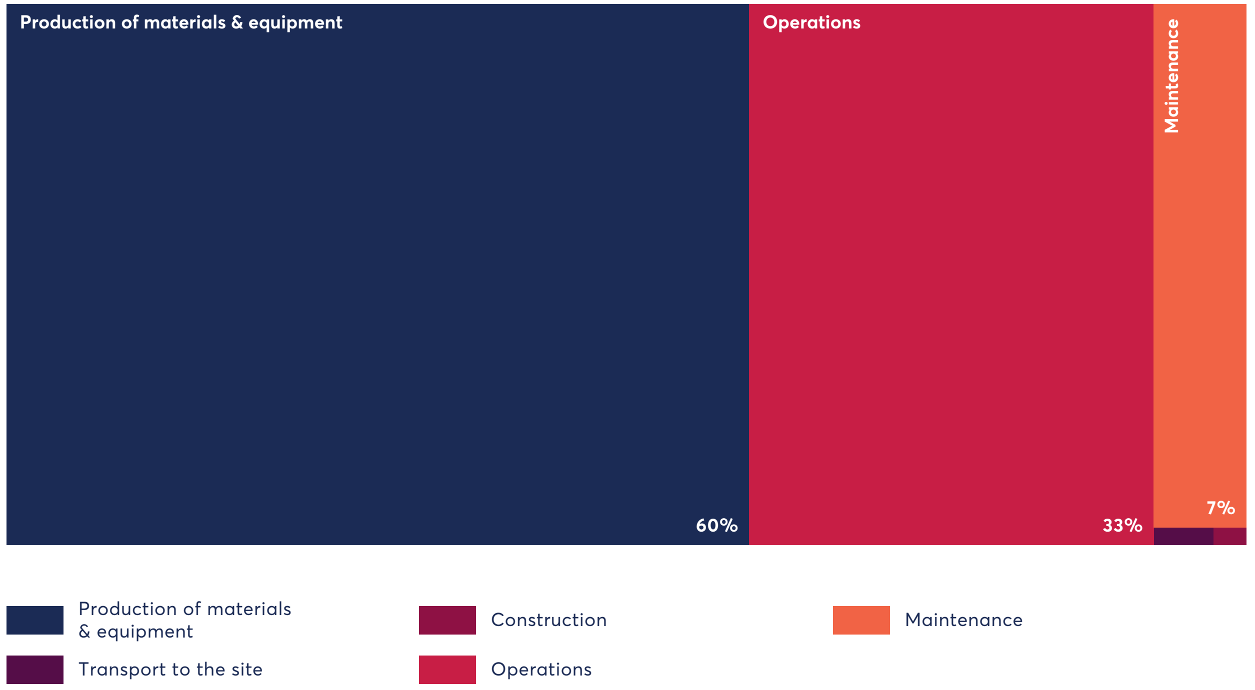

Figure 14 – Impacts of the data center on the depletion of mineral and metal resources by life cycle phase

5.4.2 VIEW OF IMPACT BY FUNCTION

According to Table 12, the impacts relating to the depletion of mineral and metal resources are mainly tied to three functions:

1. The **IT power system**, representing 63% of the impact: the cables, followed by the distribution panels, are the biggest contributors to the depletion of mining resources due to the significant usage of critical metals, namely copper and aluminium.

2. The **backup power system**, representing 26% of the impact: the uninterruptible power supplies, which contain copper, and the batteries, which are typically made using a lead-acid chemistry, have a heavy impact on the depletion of resources.

   This impact is largely due to the extraction of copper, galena, and antimony ores, resources that are considered critical because of their scarcity.

3. The **IT cooling system**, representing 9% of the total impact: once again, the equipment used to produce cold is made with materials such as copper that are non-renewable and over-exploited resources.

Overall, the resources required to produce a data center's equipment are available in limited amounts, are often imported.

FUNCTIONS	SUB-FUNCTIONS	DEPLETION OF MINERAL AND METAL RESOURCES (KG SB-EQ)	PERCENTAGE OF CONTRIBUTION
DC building	Foundation	2	0.2%
	Load-bearing structure	5	0.5%
	Envelope	2	0.2%
	Interior construction	1	0.1%
	Total	**10**	**0.9%**
IT cooling	Cold production	83	7.6%
	Cold distribution	14	1.3%
	Total	**97**	**8.9%**
Electrical power for IT	Conversion	1	0.1%
	Distribution	687	63.1%
	Total	**688**	**63.2%**
Backup power system	**Generators, USPs, and batteries**	**285**	**26.1%**
HVAC - Non-IT ventilation & AC	Utility room ventilation	8	0.8%
	Air handling (excl. IT)	2	0.2%
	Total	**10**	**1.0%**
Total		**1,090**	**100%**

Table 12 – Impacts of data center DC19 on the depletion of mineral and metal resources by function

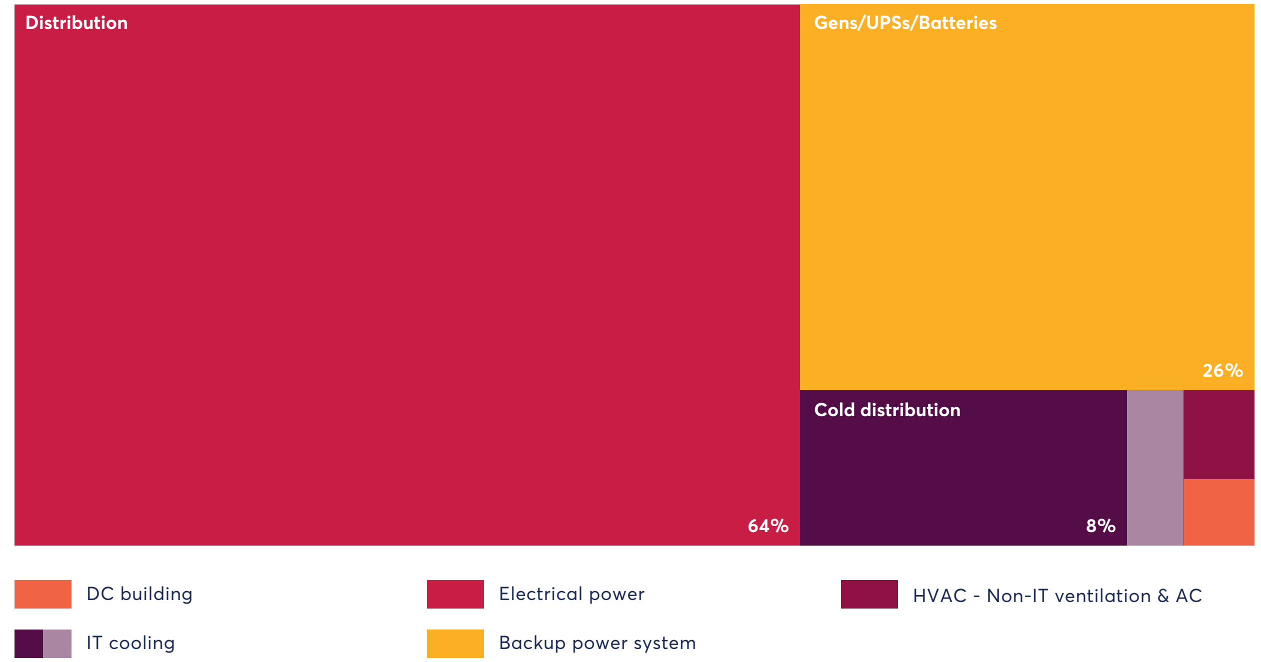

Figure 15 – Impacts of the data center on the depletion of mineral and metal resources by function

REMEMBER

PRODUCTION

The production of the data center's materials and equipment contributes **60% of its impact on the depletion of mineral and metal resources**, or 1,090 kg Sb-eq. The functions contributing the most to the total impact are the main electrical power system, with 63%, and the backup power system, with 26%, as the equipment in these systems contains metals that have often already been heavily mined.

The impact on the depletion of mineral and metal resources from the production of the data center's materials and equipment is equivalent to building 12.4 km of railway[13].

OPERATIONS

The data center's operations phase contributes **33% of its impact on the depletion of mineral and metal resources,** or 594 kg Sb-eq., attributable to the manufacturing of the equipment for producing and distributing electricity on the grid.

5.4.3 ACTIONS FOR IMPROVEMENT

To limit the consumption of resources in the structure and electrical equipment:

- **Data4 implemented a new responsible purchasing policy** that asks our main suppliers to provide environmental product declarations (EPDs) for equipment such as UPSs, chiller units, generators, and CDUs[14].
- **Data4 chooses transformers, UPSs, and batteries with FDESs or EPDs (environmental impact documents) and extends their lifespans.** This can reduce how often they are replaced and thus reduce the consumption of new resources.
- **Data4 guarantees that each kWh of energy is generated from a renewable source,** either via certificates of origin or via power purchase agreements (PPAs).
- Since 2024, Data4 has concluded Power Purchase Agreements (PPAs) with major European players in the renewable energy sector.

6

Conclusion

Conscious of the environmental concerns in its industry, in 2020, Data4 decided to engage in a comprehensive initiative to analyse and understand the real environmental impact of its data centers in Europe, particularly by carrying out life cycle assessments in collaboration with APL Data Center.

Serving as a valuable decision-making tool, LCA is Data4's preferred evaluation method, helping us design our data centers and choose any new technologies. Indeed, life cycle assessment is a powerful tool that can be used for eco-friendly design. Not only does it help provide understanding of the environmental concerns tied to a product or service, but it can also guide choices and decisions for an eco-friendly approach in the design phase. Although having zero impact is impossible, our goal is to reduce our impacts as much as possible and to avoid pollution (of water or air) throughout our value chain with a view to achieving zero net emissions.

The life cycle assessments we have carried out since 2020 have allowed us to target and understand the environmental issues tied to data centers. When analysing the life cycle of a data center (excluding server manufacturing and use), the results show that the construction and operations phases are the biggest contributors to impacts across all environmental indicators, and particularly climate change, water resource depletion, and the depletion of mineral and metal resources.

These impacts are directly related not just to the manufacturing of materials for the data center's infrastructure (construction materials such as concrete and steel) and electrical equipment (usage of copper and other metals), but also to the consumption of electricity for the data center's operations. The production of these materials and energy requires a lot of water, mineral and metal resources, and fossil fuels. What's more, the production processes release greenhouse gases into the environment, contributing to global warming.

Life cycle assessment is a powerful tool that can create greater understanding of where to take action to reduce business impacts.

In conclusion, our goal in this white paper has been to share what we believe to be the key indicators for the data center industry and to offer values that can be extrapolated to all data center infrastructure in the "hyperscaler" family so as to encourage eco-friendly design approaches.

With life cycle assessment, Data4 systematically measures its progress towards reducing its environmental impacts. **In light of its efforts towards the eco-friendly design of its data centers, Data4 projects that it will reduce the carbon footprint of each new MW IT constructed by 38% by 2030,** setting a positive example for players in the digital sector.

This white paper is also a tool for transparently communicating about the actual impacts of data center activities, in hopes of orienting public policy towards actions that will produce tangible benefits.

In this study, the environmental analysis of the data center life cycle allowed us to identify the major environmental issues in the data hosting industry. Conducting a similar study using a social approach—i.e. a social LCA—would enable the identification of social issues as well.

INDICATOR	VALUE FOR THE CONSTRUCTION OF 1 MW IT (SPREAD OVER THE DC'S LIFESPAN)	VALUE FOR 1 YEAR OF OPERATIONS AND PER MW IT
Climate change (kg CO_2-eq)	1,318,424	65,918
Depletion of water resources (m^3 deprived)	507,859	37,195 with less than 1% consumed directly by the data center
Mineral and metal resources (kg Sb-eq)	219	5.9

Table 13 – Impacts tied to building 1 MW of data center capacity and operating for one year

LIST OF FIGURES

LIST OF TABLES

GRAPHICS BY:
coupecoupe.studio

Data4
SMART & SCALABLE DATA CENTERS

apl
Pioneering Data Centers