Making Data Centers Green

SAP Focuses on Sustainability

THE BEST RUN SAP

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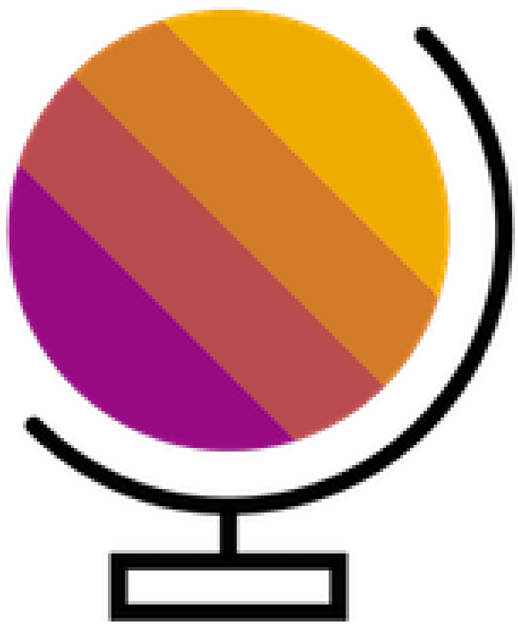
INTRODUCTION

This whitepaper outlines the industry standards and best practices followed by SAP Global Cloud Services (GCS) Data Center Management through design, operation, and end-of-life of data centers across the globe.



SAP's strategic approach and contribution to sustainability

SAP's purpose is to help the world run better and improve people's lives, and sustainability is at the core of our values (see SAP Purpose and Sustainability).

Our objective is to create positive economic, environmental, and social impact within planetary boundaries. We use two strategic levers to achieve this objective:

1) delivering products and services that meet the sustainability challenges and opportunities of our customers and helping businesses achieve sustainable operations (enabler).
2) being a role model in our own sustainable business operations and practices (exemplar).

This dual responsibility allows us to learn from our own experiences while benefiting our customers and giving us credibility to advise them on their sustainability journey.

Climate Change: We must act now.

Climate change is one of the biggest challenges of the 21st century and settling for doing "less harm" is no longer sufficient. It is urgently time to "do more good" (SAP Press release).

The impact of climate change has become so apparent in the last decade that the world community made the milestone commitment in 2015 in Paris to limit global warming to below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (see Paris Agreement).

SAP enables organizations with the solutions and capabilities to run sustainably. These include sustainability-specific solutions for corporate sustainability performance management and reporting, carbon accounting, waste management for circular economy processes, and responsible and inclusive value chain management. SAP's deep reach into business data and processes, combined with an unmatched global partner ecosystem, gives us the unique leverage to help make positive impact at scale.

SAP has 50 years of experience helping companies manage resources, acting as a role-model ourselves with more than 10 years of experience as a leading sustainable enterprise.

We address climate action through a three-fold approach "avoid-reduce-compensate" We have ambitious commitments and actions including:

- Target to achieve net-zero along our value chain in line with a 1.5°C future by 2030.
- Goal to become carbon-neutral in our own operations by the end of 2023.
- Since 2014, we have been using 100% renewable electricity for all data centers and facilities worldwide
- We recently committed to plant 21 million trees by the end of 2025.

Please check the following sources for more details:
SAP Integrated Report, SAP's UN SDG Webbook, SAP's Global Environmental Policy, and Sustainability Solutions, Software and Services | SAP.

The Impact of Data Centers on Climate Change

As more business moves to the cloud, data centers play an increasingly strategic role for SAP as we provide solutions to our customers. Our internal data centers have become a primary focus of our carbon reduction efforts.

Throughout this document, the term "data center" refers to **GCS-managed data centers** (i.e., SAP-owned or managed by a co-location provider).

Running solutions in SAP data centers and using hundreds of cloud solution transactions per day requires processors, memory, storage, and cooling, and electricity – which ultimately results in carbon emissions.

OPTIMIZING AND REDUCING THE ENVIRONMENTAL IMPACT OF OUR DATA CENTERS

To reach SAP's ambitious plan to continuously increase sustainability in its own operations, SAP implemented an ISO14001-certified environmental management system (EMS) at more than 50 SAP sites worldwide.

Accordingly, our own data centers in SAP headquarters in Germany and North America are ISO14001-certified, ensuring that SAP manages its data center operations and responsibilities in a systematic and environmentally conscious way, monitors its environmental performance, and aims to continuously improve its impact on the environment.

ENERGY EFFICIENT DATA CENTER FACILITIES

To ensure that our office buildings and data centers operate in an energy-efficient manner and to continuously improve our energy performance, we have implemented an ISO50001-certified Energy Management System in our headquarters in Walldorf / St. Leon-Rot.

Powering our Data Centers with 100% Renewable Electricity

To minimize the negative impact of our internal and external data centers, all SAP-owned, co-located and hyperscaler data centers run with 100% renewable electricity.

We achieve a "green cloud" by:

1) investing in high-quality, EKO energy-certified Energy Attribute Certificates (EACs) to foster renewable energy generation
2) generating on-site renewable electricity through solar panels

This allows us to compensate our data center electricity consumption emissions (one major step towards achieving carbon neutrality by 2023). More importantly, it enables our customers to significantly reduce their carbon emissions by using our green cloud solutions and services.

To achieve low-carbon data centers, SAP is in the process of investigating further renewable electricity concepts such as enhanced investments in its own PV infrastructure and Power Purchasing Agreements.

According to the United States Environmental Protection Agency (EPA), electricity accounts for approximately 25% of the world's greenhouse gas emissions.

In a data center, the majority of the electricity is needed to power up the IT devices, for power provision systems and for supplying energy to air conditioning systems (Energy Innovation).

In 2020, data centers' electricity consumption amounted to about 416 TWh globally (roughly 3% of the world's electricity consumption. (Datacenters.com)

CARBON-FREE VS RENEWABLE ENERGY

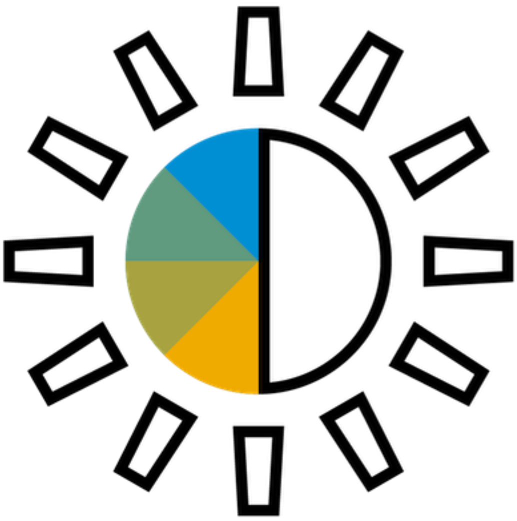
Most kinds of renewable energy are also "carbon-free": they do not emit CO_2 or other greenhouse gases into the atmosphere during their operation. But not all renewable energy is carbon-free, and not all carbon-free energy is renewable.

Examples:

- Biofuels and bioenergy are renewable: we can regrow plants that we burn for fuel. But they are not necessarily carbon-free. Growing plants absorbs CO_2; burning plants releases CO_2. The total impact on CO_2 in the atmosphere depends on how sustainably the bioenergy is produced.

- Nuclear energy is carbon-free: a nuclear power plant does not emit any CO_2, or any other greenhouse gases. But it is not renewable. Nuclear reactors use uranium, and if we run out of uranium, we can never get it back.

As described, the availability of renewable energy is still subject of various factors which is why data centers cannot (yet) rely on them as sole energy source. A growing global movement tackles the decarbonization of the electricity system by aiming at using carbon free energy 24/7. This means that every kilowatt-hour of electricity consumption is met with 100% carbon-free electricity sources, every hour of every day.



Optimizing and Reducing Electricity Consumption and Greenhouse Gases

COOLING OPTIMIZATION

During the operation of IT appliances, waste heat is generated. This extra heat can cause malfunction in the devices as the temperature of their environment falls outside their recommended operating range.

There are two ways to treat this extra heat.

1. Accept and create a data center landscape with tolerance on the higher temperature (see Less cooling below)
2. Mitigate and create a data center landscape which makes the most of the existing cooling capacity (see Cooling efficiency increase on the next page)

LESS COOLING

Less cooling means less electricity usage, which indicates not only savings on the energy bill, but also less impact on the environment.

If the data center requires less cooling, that means less energy is used. Because of the cooling reduction, the temperature will rise in the data halls.

SAP has increased the intake temperature to 27 °C in all its data centers, except Newton Square 1. (Newton Square 1 needs further air flow optimization to make sure every racks get the adequate cooling.)

SAP Data Center	Intake Temperature
Colorado Springs 1	27 °C
Colorado Springs 2	27 °C
Newtown Square 1	24 °C
Rot 1	27 °C
Rot 2	27 °C
Walldorf 4	27 °C

Table Intake temperatures in SAP owned data centers

The most prevalent greenhouse gases are,

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (NO_2)

The extent of contribution to climate change as well as the length of persistence in the atmosphere varies between the different GHGs.

To make their impact comparable, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations has defined the so-called "Global Warming Potential".

This index expresses the warming effect of a certain amount of a greenhouse gas over a set period of time (usually 100 years) in comparison to CO_2.

For example, methane's effect on the climate is 28 times more severe than CO_2, but it does only stay in the atmosphere for about a decade while CO_2 persists for 300 to 1,000 years. (Source.)

The table below illustrates why SAP pushed the intake temperature only up to 27 ℃.

Class	Recommended temperature in C	Allowable temperature in C
A1	18 – 27	15 – 32
A2	18 – 27	10 – 35
A3	18 – 27	5 – 40
A4	18 – 27	5 – 45

Table ASHRAE guidelines for Server Intake Temperature

Within the ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) "recommended range" IT equipment will last longer and have fewer failures. SAP is currently looking for manufacturers to support a further increase in the intake temperature.

COOLING EFFICIENCY INCREASE

As indicated earlier in this document, waste heat is not desirable; therefore, we must remove the excessive heat by channeling it into the data hall. However, when cold ambient air mixes with the hot air exhausted from the IT devices, the overall intake temperature will be higher than what is desirable. It is vital to separate the fresh (cold) and return (hot) air as much as possible.

SAP implements various technologies and IT appliances to achieve this goal and to increase cooling efficiency to reduce electricity consumption:

ENERGY EFFICIENT IT APPLIANCES

Energy efficiency and consumption is a critical design element SAP is investigating, by targeting more efficient IT devices in its data centers.

Efficiency can be measured in two ways:

- Performance per watt – used to measure the energy efficiency of servers. In other words, it reflects the compute efficiency for every watt of power consumed by servers. SAP is using this benchmark to determine the standard hardware model that delivers the same - or ideally - more performance per watt of power consumed.

- Purchasing IT devices, which can operate in higher temperature range and therefore, require less cooling.

Optimization of Data Center Cooling

The most widely used and well-regarded technique is the separated cold/hot aisle concept, which is deployed in all **GCS-operated** data centers.

SEPARATED COLD/HOT AISLE CONCEPT

This concept refers to data center layout design, which requires that the devices take cool air from the cold aisle and then release the device exhaust on the other side, into the hot aisle. This ensures that hot and cold air are separated into two distinct areas. The efficiency of the concept can be increased further with having the hot or cold aisle contained.

Some of the approaches SAP uses to increase efficiency within hot and cold aisles are shown in subsequent pages.

BLANKING PANELS

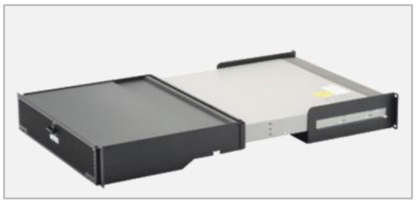
With a single cabinet in the data center, not all U spaces are occupied in the IT equipment. If spaces are open, heat can easily make its way to the cold aisle. Blanking panels are used to prevent this, by blocking off one U space each.

BLANKING SHADES

If there are more than a couple of U spaces, it is recommended to use a blanking shade, which blocks off an entire cabinet if needed. Sometimes a mix of blanking shades and blanking panels is required.

COOL AIR INLET DUCTS

Some network switches do not fill the entire depth of the cabinet (mounted at the back or front). For this, we use inlet ducts, which extend the switch from the front to the back, to keep the cold and hot air separated.



CABINET SIDE PANEL

Every cabinet should have side panels installed as this helps separate hot and cold air and keep it in their respective aisles.

COOL BOOTS

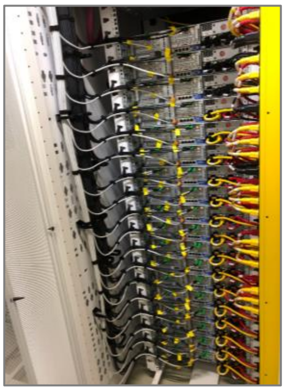
Network cabling runs in and out of the top of each cabinet, which creates another space where hot or cold air can escape to the wrong aisle. Cool boots are used to keep the air from escaping through the top of each cabinet.

SEALED OUTLETS

Just as hot and cold air can leave the top of each cabinet, it can also escape through floor tiles, particularly where power whips are installed. These holes must be closed off to keep the airflow going to the correct aisles.

PROPER IN CABINET CABLING FOR OPTIMIZED AIRFLOW

To make sure air flows through the cabinet without any impediments, the cabling must be installed in such a way that it doesn't block the hot air exhaust. SAP has introduced a process, which separates power and data cable areas with cable managers for power, fiber, and copper cables.

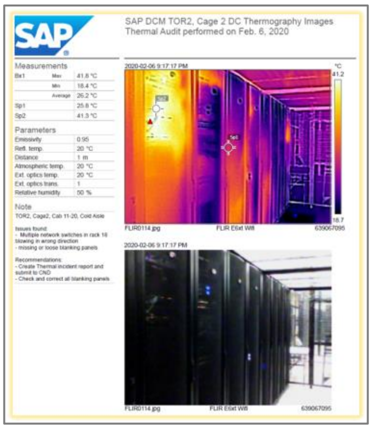


THERMAL CAMERA USAGE

SAP has introduced a thermography process in each of our data centers, which includes using a forward-looking infrared camera to look for hot and cold spots in the data center. Hot and cold spots tell us that we either need to increase the airflow or seal the cabinet more effectively.

Temperatures that are too hot or too cold can cause hardware failures, resulting in customer downtime. The FLIR tool helps us stay ahead of these types of failures.

It also gives SAP the ability to create annual or incident related reports of SAP data centers (both SAP owned and co-locations). Each report is then analyzed and evaluated for corrective actions.



SAP DCM TOR2, Cage 2 DC Thermography Images
Thermal Audit performed on Feb. 6, 2020

Measurements

Bx1	Max	41.8 °C
	Min	18.4 °C
	Average	26.2 °C
Sp1		25.8 °C
Sp2		41.3 °C

Parameters

Emissivity	0.95
Refl. temp.	20 °C
Distance	1 m
Atmospheric temp.	20 °C
Ext. optics temp.	20 °C
Ext. optics trans.	1
Relative humidity	50 %

Note

TOR2, Cage2, Cab 11-20, Cold Aisle

Issues found:
- Multiple network switches in rack 16 blowing in wrong direction
- missing or loose blanking panels

Recommendations:
- Create Thermal incident report and submit to CND
- Check and correct all blanking panels

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Optimizing and Reducing Waste

WASTE

Data centers house thousands of servers to supply the information needs of a data-driven society. These require tremendous amounts of (natural) resources to operate a data center, such as

- electricity
- water
- rare earths for IT equipment

Waste can manifest itself in different formats in a data center.

1. Waste heat
2. Electrical and electronic waste, e.g., as a byproduct of the refresh initiatives within the data centers

WASTE HEAT

The return air (from server rooms) exchanges its heat load to water. This heat can still be utilized for various heating purposes.

- residential heating
- office heating
- greenhouse heating
- swimming pool heating
- etc.

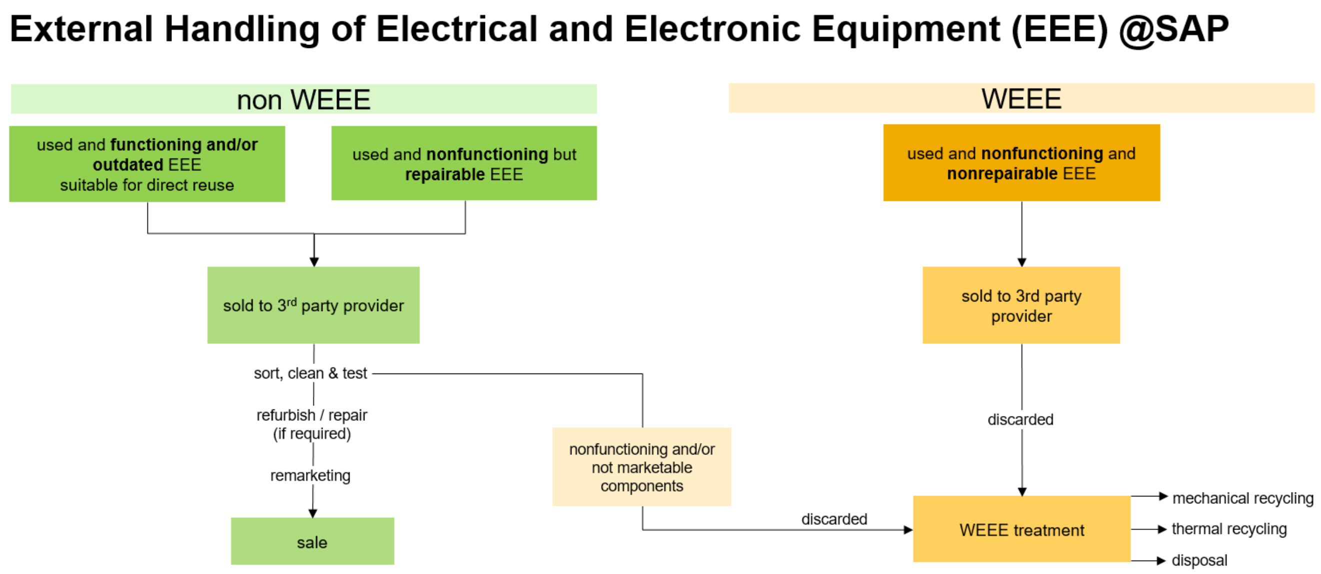
In our St Leon Rot data center, SAP is using a CHP (Combined Heat and Power) plant to produce power and heat for the campus and to use the waste heat from this process to drive absorption chillers that cool the data center—this is a highly efficient transformation of energy.

ELECTRICAL AND ELECTRONIC WASTE

The amount of waste from electrical and electronic equipment (widely known as WEEE or e-waste) generated every year is increasing rapidly. A record 53.6 million metric tons (Mt) of electronic waste was generated worldwide in 2019, up 21 per cent in just five years, according to the UN's Global E-waste Monitor 2020. Considering the prediction that global e-waste will reach 74 Mt by 2030, it represents the fastest-growing domestic waste stream.

SAP cooperates with international and local IT asset lifecycle partners, to:

- refurbish functioning / repairable electrical and electronic equipment (EEE)
- recycle and dispose of malfunctioning / non-remarket able equipment (WEEE).



SAP is working on various fields to have a better e-waste mix, including:

- avoiding e-waste (for example switching from static UPS to dynamic UPS to reduce the environmental load caused by recycling the static UPS batteries)
- increasing remarketing shares
- increasing mechanical recycling share
- decreasing disposal and thermal recycling

Optimizing and Reducing Water Consumption

EFFECTIVE USE OF WATER

Climate change will affect the availability, quality, and quantity of water for basic human needs, threatening the effective enjoyment of the human rights to water and sanitation for potentially billions of people. In light of the potential adverse impact on both the environment and society, a data center's water consumption must be considered when talking about sustainable operations.

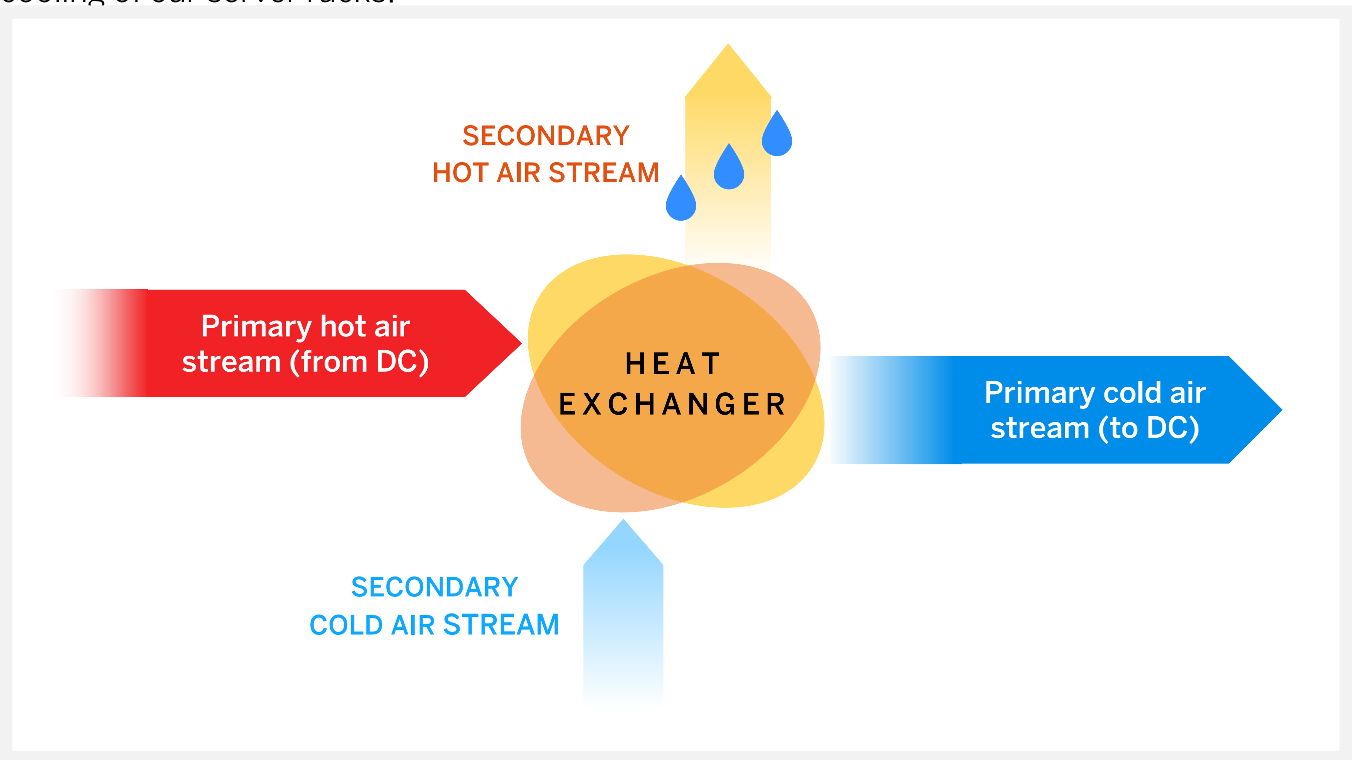
Water is used in the cooling systems of data centers. For example, when water evaporates it drains heat from the environment. 1 MW of traditional data center cooling can consume up to 26 million liters of water per year. (Heslin, 2016) This evaporated water must be backfilled. With modern cooling technologies (adiabatic cooling) the amount of this evaporated water can be decreased.

SAP uses indirect adiabatic cooling in all their owned data centers, as well as a closed water circuit to minimize water consumption for cooling of our server racks.

Adequate cooling is crucial to make sure IT devices work in the recommended ASHRAE recommended range. Air cooling systems have lower efficiency at warmer temperatures, while simple evaporative cooling consumes tremendous amounts of water and requires costly maintenance.

The indirect adiabatic cooling system incorporates the advantages of both. (Mechanical cooling is still used when the evaporation-based cooling is not effective, as the intake air is more humid.)

In the picture below, the primary hot air enters the heat exchanger from the data center on the left. Then, in the heat exchanger, it exchanges its heat load with the air in the secondary airflow. If the ambient air (secondary air flow) is warm, the additional water sprayed onto the heat exchanger increases the cooling efficiency with evaporation.



Appendix

KEY PERFORMANCE INDICATORS AND RELEVANT MEASUREMENTS

Setting up the right measurements helps to

- track the performance towards our sustainability objectives,
- determine new requirements,
- identify barriers,
- prevent irrelevant actions from being implemented,
- reward excellence.

For example, by tracking the overall power consumption of the data centers, a company can recognize that it serves more customers with a unit of energy, reflecting an increase in operating efficiency.

The following are some widely used measurements and formulas in data centers to achieve sustainability over the lifetime of a data center.

PUE (POWER USAGE EFFICIENCY)

This measurement determines how efficiently the data center uses available energy.

$$\text{PUE} = \frac{\text{Total Facility Consumed energy}}{\text{IT Equipment Consumed Energy}}$$

This is the most popular method to measure data center effectiveness developed by Green Grid.

PUE is expressed as a ratio, with overall efficiency improving as the quotient decreases towards 1. The most efficient data centers have a PUE lower than 1.07.

WUE (WATER USAGE EFFICIENCY)

This measurement shows how effectively the data center uses water as a resource.

$$\text{WUE} = \frac{\text{Total Facility water consumption}}{\text{IT Equipment Energy}}$$

Nowadays, due to modern cooling technologies, an average data center will consume as much as a golf course. Global warming is making water scarce, therefore we must ensure that our Data Center operations consume as little water as possible.

AEU (AIR ECONOMIZER UTILIZATION)

This measurement shows at what percentage the DC runs with free cooling.

$$\text{AEU} = \frac{\text{Air Economizer Hours}}{24 * 365}$$

Also, full compressor-based cooling hours can be monitored as well. The remaining time is when the Air Economizer is partially working. The theoretical maximum is limited mainly by the geographical location of the Data Center (e.g., data centers in a cooler climate can use more free cooling) and the ASHRAE class compliancy of the used devices (see next page).

ENERGY INTENSITY (POWER CONSUMPTION PER REVENUE)

Defining a decrease in power consumption as a sustainability goal by itself does not make any sense, because companies are always trying to grow and serve a larger and more diverse customer base. So, the ideal KPI would consider this business growth metric.

$$\text{EI} = \frac{\text{Consumed Energy in kWh}}{\text{Cloud Revenue in mEuro}}$$

TOTAL AMOUNT OF E-WASTE GENERATED

Measuring the absolute weight of e-waste exclusively is not expedient as it does not consider the way e-waste is handled. To accelerate the shift towards a circular economy, companies must aim to prevent waste from being created in the first place, to increase the ratio of remarketing and mechanical recycling of e-waste and eliminate thermal recycling and disposal.

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