

# Guide to Environmental Sustainability Metrics for Data Centers

## White Paper 67

Version 2

### Energy Management Research Center

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#### Revision notice

This paper has been updated as of June 2023 to reflect recent information – see final section of **Appendix** for a detailed list of changes.

### Executive summary

Many companies are now reporting on sustainability as a supplement to financial reporting to demonstrate their commitment to Environmental, Social, and Governance (ESG) programs. For companies in the data center industry or wishing to report on their data center operations, we propose 5 categories for environmental sustainability reporting metrics - energy, greenhouse gas emissions, water, waste, and local ecosystem. Standardizing these metrics will help with adoption, improve benchmarking, and progress sustainability within the industry. We propose 28 key metrics with definitions and applications for data center operators who are in various stages of their sustainability journey, and we also provide published industry-based target values for key metrics.

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## Introduction

As the world becomes more automated and digital, the data center industry is undergoing rapid growth to support this transformation. But growth has to be done in an environmentally friendly way. Data center operators are making commitments on environmental sustainability as part of their Environmental, Social, and Governance (ESG) programs. In addition to social and environmental responsibilities, there are other drivers for reporting progress on sustainability. These drivers covered in White Paper 64, [Four Key Drivers for Colocation Data Centers to Prioritize Environmental Sustainability](#), include customer requirements, impending regulations<sup>1</sup>, adding business value, and attracting or qualifying for ESG investments.

Data center operators should use a standard set of metrics. Without standards, data center operators and those wishing to evaluate data center performance (e.g., investors, regulators, employees, etc.) face the following challenges:

- **Benchmarking** - When organizations use different metrics, it's difficult to compare data center performance. Without benchmarking, it's difficult to establish common criteria and establish leaders that a data center operator can compare against or aspire to. In short, standardized metrics provide a ledger for comparison and benchmarking for companies that aspire to differentiate through sustainability.
- **Alignment** - Lack of standard metrics can make it difficult to identify organizational discrepancies between divisions / operating units and executive management functions (CEO, CFO, COO and CSO - chief sustainability officer). Standardized environmental metrics are needed to set goals & strategies, know where to improve, know what to prioritize, and to show continuous progress, ensuring all players are using the same rulebook.

*Choosing standardized metrics to report sustainability is a key to solving the above challenges.* For example, before [The Green Grid](#) (TGG) proposed power usage effectiveness (PUE) in 2007<sup>2</sup>, there was no standardized metric to measure the energy efficiency of a data center in whole, which led to benchmarking and alignment challenges in the data center industry. While no metric is perfect, if it is standardized and has a clear definition and application, it will be useful and serve to move the industry forward.

The PUE metric was widely adopted and helped drive data center efficiency improvements across the industry. A global [survey](#) conducted by Uptime Institute in 2022 showed the average annual PUE of large data centers improved from 2.5 to 1.55 since 2007. Furthermore, the PUEs of some internet giant data centers such as Google, Facebook, Baidu, and others have been reported to be as low as 1.1. This PUE example demonstrates the importance of standardized and well-understood metrics in reaching an organization's stated sustainability goals. As shown in **Figure 1**, data center operators first set their overarching company goals and then select the metrics, set metric targets, and measure their progress towards the goals year over year. We recommend that data center operators consult frameworks and standards for each of these steps.

We focus on the steps within the blue dotted-line boundary. We propose five metric categories for setting goals and identify a list of standardized metrics with

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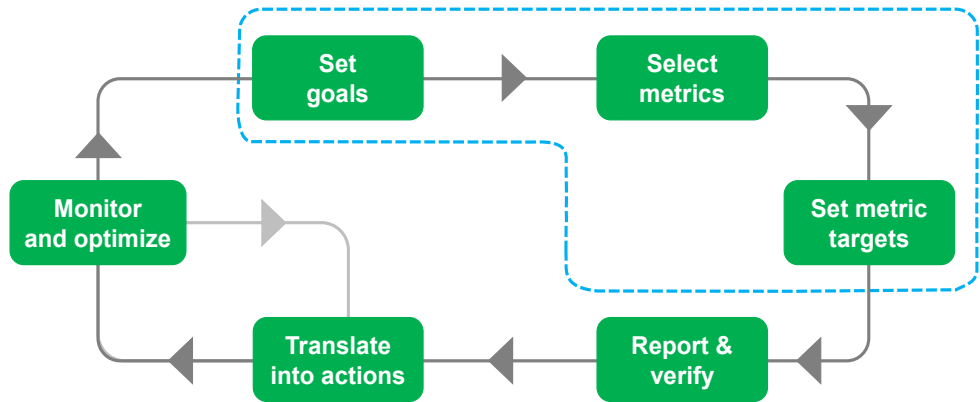
<sup>1</sup> For example, pending directives like Energy Efficiency Directive ([EED](#)) and Corporate Sustainability Reporting Directive ([CSRD](#)) (both from the EU Commission), and [SEC Climate Disclosure Rule](#) (Securities and Exchange Commission SEC - U.S.) will require mandatory reporting for ESG metrics. CSRD [proposed to start](#) in January 2024.

<sup>2</sup> The Green Grid has passed the ownership, development, standardization, and dissemination of PUE to ISO/IEC JTC1 SC39 WG1 [nine years ago](#).

definitions and applications across these five categories, and we also provide published industry-based target values for key metrics.

**Figure 1**

*Steps to optimize a data center's sustainability*



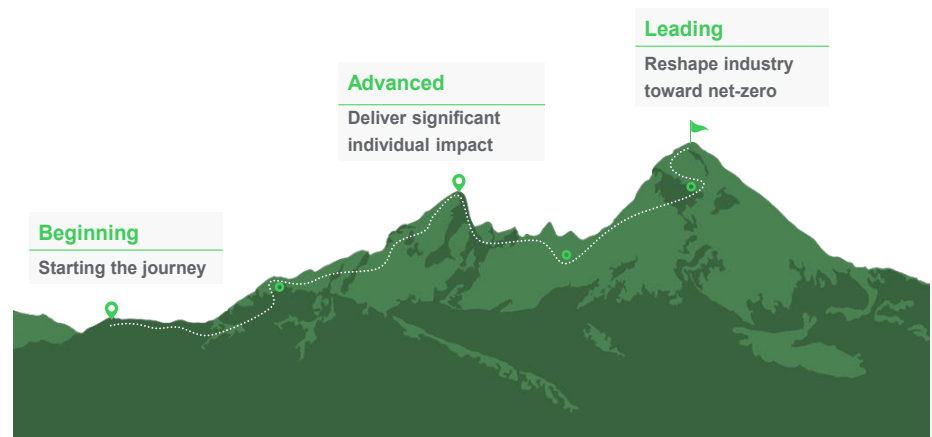
Note, corporate sustainability is made up of three dimensions: Environmental, Social, and Governance (ESG). This paper focuses solely on environmental sustainability and is an update from version 1 released in December 2021 and will be updated as frameworks and metrics evolve.

## Five metric categories used to set goals

Environmental sustainability is about protecting natural resources for future generations. Whether just beginning or more advanced, most data center operators have initiatives around sustainability. The World Business Council for Sustainable Development (WBCSD) identified three stages in the journey towards net-zero (as shown in **Figure 2**). Although these three stages are used as part of WBCSD's guide to net-zero carbon emissions, we've adopted this construct for data center operators to self-identify where they are in their own journey (i.e., stage). We then recommend specific metrics a data center operator can use based on that stage.

**Figure 2**

*Three stages of net-zero carbon sustainability journey*



Source: [SOS 1.5 The road to a resilient, net-zero carbon future](#)

We have identified 28 key sustainability metrics that apply to a data center across five metric categories. These categories represent a holistic approach to addressing environmental sustainability. We describe each of these categories below:

- Energy** - The projected future growth of total data center energy consumption combined with growing distributed renewable energy supply, requires that data center operators have a better understanding of their energy sources. Measuring energy from all sources will determine the carbon-intensity of a data center's energy mix and help operators become more sustainable.

Reporting energy consumption, energy efficiency, and renewable energy use is important for data center operators to show their progress on efforts to minimize their carbon footprint.

- **Greenhouse gases (GHG) emissions** - CO<sub>2</sub> and other gases such as CH<sub>4</sub>, PFCs, HFCs are classified as greenhouse gases<sup>3</sup>. These GHG emissions, also referred to as “carbon emissions”, are a major contributor to climate change and one of the most pressing issues facing society today. According to [GHG Protocol](#) and [ISO 14064](#), there are three categories of GHG emissions: Scope 1, Scope 2, and Scope 3, which are covered in more detail in the **Appendix**. Reporting GHG emissions is important for data center operators to show their efforts on controlling climate change.
- **Water** - Water shortages are becoming a serious problem in many regions. It's important to understand water use within a data center and at power plants. Decreasing water usage is a focus area for many data center operators and local jurisdictions. There are different types of technologies (e.g., dry cooler with adiabatic evaporation, liquid cooling) that are being implemented to reduce direct water usage. As a result, data centers are using less water on average than they used to. Operators are also investing in water replenishment programs to save water indirectly. Reporting water usage / savings is becoming more important as a part of overall sustainability goals.
- **Waste** - Data centers are challenged with a unique waste profile compared to other industrial operations. In order to meet circularity goals / targets, data center operators need to understand their waste profile (especially E-waste and batteries) with tailored data center metrics. Minimizing waste from the supply chain and diverting it out of landfills through reuse and recycling is a key strategy for environmental sustainability. Circular economy design methodologies and processes support improvements in this area. See **Appendix** for more information on circular economy. Reporting waste generation and diversion is emerging in importance for data center operators and is likely to become commonplace in the near future.
- **Local ecosystem** - Data centers have direct and indirect impact on the local ecosystem (i.e., biodiversity) including land, sound level, species, etc. For example, data centers have a direct impact on the land they are built upon and an indirect land impact from their supply chain. Measuring the impacts to land are common in industries like mining but are new to the data center industry. The HVAC equipment (e.g., cooling towers, dry coolers, ducts) and diesel gensets in a data center can produce high levels of noise, which draw attention from local jurisdictions. Greenfield data center construction also impacts the quantity and diversity of species around it. Reporting the impact on the local ecosystem is also emerging in importance for data center operators and likely to become commonplace in the near future.

Making progress on environmental sustainability goals as an industry means adopting standardized metrics for measurement, and making these metrics well understood throughout the market and the data center industry, and publicly reporting<sup>4</sup> them regularly (e.g., semi-annually, annually).

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<sup>3</sup> CO<sub>2</sub> - carbon dioxide, CH<sub>4</sub> - methane, PFCs - perfluorocarbons, HFCs – hydrofluorocarbons

<sup>4</sup> According to the Global Reporting Initiative (GRI), “the term ‘sustainability reporting’ refers to the process of reporting, which starts with an organization determining its material topics based on its most significant impacts and results in the organization publicly reporting information about these impacts.” For guidance on reporting principals (e.g., comparability, verifiability) see [GRI 1: Foundation 2021](#).

## Recommended metrics for sustainability reporting

This section details the specific metrics within each category, and how they map to the stages of maturity. We selected and recommended these metrics based on the following seven criteria:

- Relevant and important to data centers
- Reflects the impact on environment directly or indirectly
- Standardized and quantifiable for benchmarking and alignment
- Actionable (can easily be translated into actions to make improvements)
- Applies to all geographies (i.e., regions, countries, etc.)
- Complies with regulations - voluntary or mandatory
- Eligible for green capital

As a result of following these criteria we identified 28 key metrics for data center operators to report on environmental sustainability in a holistic way (as shown in **Table 1**). Data center operators should use these metrics to set targets and show progress (e.g., year over year).

These metrics should be collected, measured, or calculated based on multiple data points during a reporting period (*twelve-month rolling*). The following subsections provide definitions and applications for each metric listed in the table as Beginning, Advanced, and Leading. The **Appendix** contains explanations on the additional metrics identified for the Leading stage.

### Recommendations on reporting metric priorities

In addition to key metrics, **Table 1** also details their recommended use according to the three stages of the journey. However, regardless of what stage you are in, all data center operators should, at a minimum, report on 6 fundamental metrics (Beginning column). For data center operators in the Advanced and Leading stages, the table shows the set of metrics becoming more comprehensive, which will allow better tracking and improvement for more advanced programs.

**Table 1**

28 key metrics for reporting environmental sustainability

Metric categories	Key metrics	Units	Recommendations		
			Beginning (6)	Advanced (18)	Leading (28)
<b>Energy (6)</b>	• Total energy consumption	kWh	✓	✓	✓
	• Power usage effectiveness (PUE)	Ratio	✓	✓	✓
	• Total renewable energy consumption	kWh		✓	✓
	• Renewable energy factor (REF)	Ratio			✓
	• Energy Reuse Factor (ERF)	Ratio			✓
	• Server utilization (ITEU <sub>sv</sub> )	%		✓	✓
<b>GHG emissions (7)</b>	• Scope 1 <ul style="list-style-type: none"> <li>◦ GHG emissions</li> </ul>	mtCO <sub>2</sub> e	✓	✓	✓
	• Scope 2 <ul style="list-style-type: none"> <li>◦ Location-based GHG emissions</li> <li>◦ Market-based GHG emissions</li> </ul>	mtCO <sub>2</sub> e mtCO <sub>2</sub> e	✓ ✓	✓ ✓	✓ ✓
	• Scope 3 <ul style="list-style-type: none"> <li>◦ GHG emissions</li> </ul>	mtCO <sub>2</sub> e			✓
	• Carbon usage effectiveness (CUE)	kg CO <sub>2</sub> e/kWh		✓	✓
	• Total carbon offsets	mtCO <sub>2</sub> e		✓	✓
	• Hourly renewable supply & consumption matching	%			✓
<b>Water (5)</b>	• Total site water usage	m <sup>3</sup>	✓	✓	✓
	• Total source energy water usage	m <sup>3</sup>			✓
	• Water usage effectiveness (WUE)	m <sup>3</sup> /MWh		✓	✓
	• Water replenishment	m <sup>3</sup>			✓
	• Total water use in supply chain	m <sup>3</sup>			✓
<b>Waste (6)</b>	• Waste generated <ul style="list-style-type: none"> <li>◦ Total waste</li> <li>◦ E-waste</li> <li>◦ Battery</li> </ul>	Metric ton Metric ton Metric ton		✓ ✓	✓ ✓
	• Waste diversion rate <ul style="list-style-type: none"> <li>◦ Total waste</li> <li>◦ E-waste</li> <li>◦ Battery</li> </ul>	Ratio Ratio Ratio		✓ ✓	✓ ✓
<b>Local ecosystem (4)</b>	• Land <ul style="list-style-type: none"> <li>◦ Total land use</li> <li>◦ Land-use intensity</li> </ul>	m <sup>2</sup> kW/m <sup>2</sup>		✓ ✓	✓ ✓
	• Outdoor noise	dB(A)		✓	✓
	• Mean species abundance (MSA)	MSA/km <sup>2</sup>			✓

mtCO<sub>2</sub>e = Metric ton of carbon dioxide equivalent

## Energy

### Total energy consumption (kWh)

**Definition** - The total energy consumed to operate a data center. This is typically the electrical energy drawn from the utility grid but would also include any onsite energy production from generators, solar, or wind. Energy imported in the form of natural gas, steam, or chilled water should also be counted.

**Application** - It allows data center operators to make better decisions on site selection, cooling solutions, etc. during design phase to reduce the operation cost and negative environmental impacts. In many cases, a significant portion of carbon emissions for data centers comes from energy consumption. Understanding the total energy consumption is necessary to track improvement in efficiency and reduce the carbon mix in the supply during both design and operation phases. Data center operators also need to balance energy and water consumption as they impact each other. See total source energy water usage metric section for more details.

### Power usage effectiveness (PUE)

**Definition** - A data center's total energy consumption divided by the IT energy consumption. PUE is defined by [ISO/IEC 30134-2](#)<sup>5</sup> and famously created by The Green Grid (TGG) in 2007. For more information on the definition and calculation of PUE, see TGG White Paper #49, [PUE™: A Comprehensive Examination of the Metric](#), and Schneider Electric White Paper 158, [Guidance for Calculation of Efficiency \(PUE\) in Data Centers](#).

**Application** - PUE is an effective metric to drive facility efficiency during the design and operation phase. Normalized to the IT load, PUE allows comparisons across different data centers. PUE will vary based on % load, resiliency (i.e., Tier), and climate. Although PUE is not a perfect metric, its simplicity has allowed data center operators to minimize their facility's overhead energy use.

### Total renewable energy consumption (kWh)

**Definition** - Total renewable energy that is owned, controlled, or purchased for use at a data center facility. This is the energy obtained from renewable energy sources such as solar energy, wind energy, geothermal energy, bioenergy, hydro, etc.<sup>6</sup>

**Application** - Organizations can reduce their Scope 2 carbon emissions by increasing their share of renewable energy. Replacing fossil fuel-based energy with renewable energy should be a key component of carbon-neutral strategies for energy consumption. This metric allows data center operators to track their Scope 2 reduction plans and is needed for reporting renewable energy use. There are two approaches for data center operators to obtain renewable energy including onsite renewable energy production (self-generated) and purchased renewable energy. You can buy renewable energy through longer-term power purchase agreements (PPAs), green tariffs, or through buying energy attribute certificates (EACs)<sup>7</sup> individually on the open market.

### Renewable energy factor (REF)

**Definition** - Renewable energy owned and controlled by a data center organization divided by the total energy consumption of the data center, according to [ISO/IEC 30134-3](#)<sup>8</sup>. REF accounts for the energy procured through renewable energy certificates (RECs) and consumed by the data center. Achieving an REF=1.0 indicates all of a data center's energy is renewable.

<sup>5</sup> Information technology - Data centres – Key performance indicators - Part 2: Power usage effectiveness (PUE)

<sup>6</sup> According to [ISO/IEC 13273-2](#) Energy efficiency and renewable energy sources – Common international terminology – Part 2: Renewable energy sources, renewable energy source is “energy source not depleted by extraction as it is naturally replenished at a rate faster than it is extracted”. Criteria to categorize an energy source as renewable can differ amongst jurisdictions, based on local environmental or other reasons.

<sup>7</sup> These are called renewable energy certificates (RECs) in the U.S., guarantees of origin (GOs) in Europe, and green electricity certificates (GECs) in China.

<sup>8</sup> Information technology - Data centres - Key performance indicators - Part 3: Renewable energy factor (REF)

Application - This normalized metric allows comparisons across different data centers and allows operators to track renewable energy consumption as data center load changes.

### Energy reuse factor (ERF)

Definition - The ratio of reused energy to total data center energy consumption. This metric is defined under standard [ISO/IEC 30134-6](#). ERF values range from 0 to 1.0 with 0 meaning no heat energy is reused and 1.0 meaning that all of a data center's heat energy is re-used / exported.

Application - The purpose of this metric is to push data center operators and municipalities to find ways to re-purpose waste heat. A use case for data centers is feeding the waste heat into nearby district heating systems. [Facebook's data center in Odense, Denmark](#) is a good example.

### Server utilization (ITEU<sub>sr</sub>)

Definition - The annual average CPU utilization of all servers in a data center, according to [ISO/IEC 30134-5](#)<sup>9</sup>.

Application - The use of this metric allows data center operators to develop a policy to operate servers effectively for the purpose of improving server energy efficiency. For example, reducing the number of active servers while maintaining the same workload or increasing the workload while maintaining the same number of active servers, are two approaches to optimize the server effectiveness. This metric also enables data center operators to improve the data center's energy efficiency or effectiveness.

## GHG emissions

### Scope 1 - GHG emissions (mtCO<sub>2e</sub>)

Definition - Direct emissions that occur from sources controlled or owned by the data center organization. Sources include combustion of fuels from backup gensets, leakage of sulfur hexafluoride (SF<sub>6</sub>) from medium voltage switchgear, hydrofluorocarbons (HFCs) released by cooling systems, transportation of materials, and workers using mobile combustion sources owned or controlled by the organization such as trucks, cars, etc.

Application - During the design phase of the facility, Scope 1 emissions should be considered and solutions to reduce or eliminate this source should be implemented. For example, replacing backup genset with other forms of energy storage is a topic currently under discussion. For more information see White Paper 14, [The Reality of Replacing Diesel Generators with Natural Gas, Energy Storage, Fuel Cells & Other Options](#).

### Scope 2 - Location-based and market-based GHG emissions (mtCO<sub>2e</sub>)

Definition - Location-based GHG emissions reflect the average emissions intensity of grids in the data center location, within a defined geographic area, and a defined time period. Market-based GHG emission considers contractual arrangements under which the data center operator procures electricity from specific sources, such as renewable energy. The [GHG Protocol Scope 2 Guidance](#) identifies these two methods for Scope 2 accounting.

Application - These two metrics are used to measure the indirect emissions from purchased or acquired electricity, steam, heat, and cooling (*as applicable*) that are

<sup>9</sup> Information technology - Data centres - Key performance indicators - Part 5: IT Equipment Utilization for servers (ITEU<sub>sv</sub>)



controlled or owned by a data center organization. The location-based metric can be used to describe the GHG intensity of grids and assess risks / opportunities aligned with local grid resources and emissions. The market-based metric indicates the organization's procurement actions and assesses risks / opportunities with contractual electricity procurement. This dual metric can assess a variety of mitigation options to lower Scope 2 carbon emissions and provides transparency for stakeholders or investors.

### Scope 3 - GHG emissions (mtCO<sub>2</sub>e)

Definition - Other indirect GHG emissions, for example from the value chain (embodied carbon), business travel, and waste management. See **Appendix** for complete definition.

Application - As renewable energy use increases, Scope 3 becomes the largest contributor to carbon emissions. For more information see Schneider Electric White Paper 53, [Recommended Inventory for Data Center Scope 3 GHG Emissions Reporting](#) and White Paper 99, [Quantifying Data Center Scope 3 GHG Emissions to Prioritize Reduction Efforts](#).

### Carbon usage effectiveness (CUE) (kg CO<sub>2</sub>e/kWh)

Definition - The ratio of a data center's annual CO<sub>2</sub> emissions<sup>10</sup> to IT equipment energy demand. It was originally created by The Green Grid and is currently a standard under [ISO/IEC 30134-8](#). The standard describes three categories of measurement: Basic - CUE<sub>1</sub>, Intermediate - CUE<sub>2</sub> and Advanced - CUE<sub>3</sub>. Basic focuses on CO<sub>2</sub> only while Intermediate focuses on CO<sub>2</sub> equivalent. Advanced is reserved for future use. We recommend Intermediate - CUE<sub>2</sub> for data centers. The ideal CUE value is 0.0, which indicates there is no carbon emissions associated with the data center's operations.

Application - This metric allows comparisons of carbon emission intensity across data centers. It can be used in site selection (design phase), as well as in operations to measure the effectiveness of continuous improvement programs.

### Total carbon offsets (mtCO<sub>2</sub>e)

Definition - Total reduced or avoided carbon emissions through financial mechanisms outside of a data center's operation. Carbon offsets are also known as verified emission reductions (VERs), or carbon credits. In essence, a data center operator pays others to not emit carbon and uses that to offset emissions from data center operations. Offsets are recognized by governments, independent 3<sup>rd</sup> party organizations, and non-government organizations (NGOs). They're regarded as a cost effective and credible way of achieving carbon neutrality.

Application - This metric can be used to quantify purchased carbon offsets to address Scope 1 and Scope 3 carbon emissions that are not mitigated or avoided. It provides reporting transparency and visibility into true carbon reduction efforts vs purchased offsets. For example, [Microsoft](#) pledged to become carbon neutral in 2012. "To fund its goal, the company charges an internal fee to business groups based on their carbon output. These fees are then used to purchase carbon offsets, among other solutions, supporting projects around the world including forest preservation, reforestation, energy efficient cooking methods, wind power development, and more." According to SBTi's [Net-Zero Standard](#), offsets can't be counted as emission reductions to meet an organization's science-based targets. But it can be regarded as an option for neutralizing residual emissions or to finance additional

<sup>10</sup> According to Annex C - NOTE Certified renewable energy can originate outside country borders when emission factors are approved by local government in [ISO/IEC 30134-8](#), market-based Scope 2 is used for CUE calculation.

climate mitigation. Long-term science-based targets (SBTs) must cover at least 90% of scope 3 emissions through reduction efforts. In another words, purchased offsets can offset 10% of Scope 3 at most. The other benefits include economic incentives for reducing carbon emissions, or as a policy tool to help stabilize carbon markets. For more information on carbon offsets, see White Paper, [Moving Organizations to Carbon Neutrality: The Role of Carbon Offsets](#).

### Hourly renewable supply & consumption matching (%)

Definition - This metric measures, in percent, the extent that the renewable energy generation matches the energy consumption in real time within a data center organization. This is gaining traction in the industry, for example, internet giants such as Microsoft and Google are piloting this concept.

Application - This can provide a higher level of transparency into how renewable energy production matches consumption in real time. The goal is to reach 100% match of renewable production and consumption on an hour-by-hour basis.

## Water

### Total site water usage (m<sup>3</sup>)

Definition - Total onsite water usage for the operation of a data center. This water usage is the net value covering water withdrawals, evaporation, and discharge. It includes potable, non-potable, and reclaimed water usage. Reclaimed water can be used for data center cooling towers to save potable water.

Application - This metric is used to report the direct water usage by a data center, similar to Scope 1 GHG emissions. Predicting water use in the design phase will help you select an optimized cooling technology that reduces site water usage. For example, [Vantage's](#) data centers adopt air-cooled chillers instead of conventional water-cooled chillers to reduce site water usage. Reclaimed water can be used for data center cooling towers to save fresh/potable drinking water. For example, [Loudoun Water](#) constructed the first pipeline distribution system to supply reclaimed water for the data center industry in 2010. Finally, tracking water use during operations will identify problems like leaks and create a baseline for continuous improvements.

### Total source energy water usage (m<sup>3</sup>)

Definition - Total water used to produce the energy a data center consumes. This is generally from the utility's electricity production.

Application - Similar to Scope 2 GHG emissions, this metric can be used to illustrate the indirect water a data center organization uses. Data center operators can use this metric as an approach (i.e., utility selection) to optimize the water use related with energy consumption. Sometimes, there is a tradeoff between energy water usage, site water usage, and energy consumption. For example, water use of a data center's evaporative cooling system will save energy consumption, which then saves water usage at the power plant. Understanding water use at the site and energy source provides a holistic view to minimize total water usage.

### Water usage effectiveness (WUE) (m<sup>3</sup>/MWh)

Definition - The ratio of a data center's water consumption to the sum of energy consumed by IT equipment. Created by The Green Grid, this metric has become a standard under [ISO/IEC 30134-9](#)<sup>11</sup> with three categories for WUE measurement: Basic - WUE<sub>1</sub>, Intermediate - WUE<sub>2</sub>, and Advanced - WUE<sub>3</sub>. Basic doesn't consider water reuse while Intermediate considers non-industrial reuse in water output.

<sup>11</sup> Information technology - Data centres key performance indicators - Part 9: Water usage effectiveness

Advanced considers industrial and non-industrial reuse in water output and water consumption of energy production in water input. Non-industrial water reuse is not typical, or at most, insignificant for data centers; therefore, we recommend Basic - WUE<sub>1</sub> for data centers. For more information on WUE, see TGG White Paper #35, [WUE™: A Green Grid Data Center Sustainability Metric](#).

Application - WUE allows comparisons across different data centers and should be considered during the design phases. It's also used in the operation phase to track continued reduction in water use.

### **Water replenishment (m<sup>3</sup>)**

Definition – Total water reduced or saved through financial mechanisms outside of a data center's operation. Investments in water offset programs is also known as water balancing. In essence, a data center operator pays others to return water to eco-systems and uses that to offset water usage from data center operations.

Application - This metric can be used to quantify water replenishment to the eco-system to balance data center water usage. It provides transparency on how much water a data center organization uses and replenishes. For example, [Microsoft](#) reported they had 1.3 million cubic meters of water replenishment in 2021 through investments. [Apple](#) partnered with the city of Prineville, Oregon to build an underground water storage facility to expand the city's potable water supply.

### **Total water use in supply chain (m<sup>3</sup>)**

Definition - Total water consumed in a data center's value chain. This concept is under development and is analogous to upstream Scope 3 emissions.

Application - This metric tracks the water consumed in the value chain, which supplies material, equipment, and services to a data center. We recommend that vendors disclose water usage data through environmental product disclosures (EPDs).

## **Waste**

### **Waste generated - total waste, E-waste, and battery (Metric ton)**

Definition - The weight of each kind material (total / electronic equipment / battery) generated in a data center. Measurement should start from construction and continue through a data center's end of life. Similar to carbon emissions, waste can be measured as direct waste, but also waste generated within the data center supply chain.

Application - These metrics can be used to quantify the organization's waste-related impacts on the environment by reducing the overall, electronic, and battery waste generated. Direct waste should be the focus of reporting, and as reporting improves throughout the industry, indirect waste generation can be added to track supply chain.

### **Waste diversion rate - total waste, E-waste, and battery**

Definition - The total weight of waste recycled (total / electronic equipment / battery) divided by the total weight of waste generated (total / electronic equipment / battery) at a data center site. The waste can be diverted from landfills through circular methodologies including, but not limited to reuse, re-manufacturing, and recycling.

Application - These metrics are ratios, comparable across data centers. They're useful for benchmarking and tracking improvement programs to drive the ratios towards 100%. This circular economy practice is regarded as one of the more impactful levers for reducing waste generation and achieving the goal of zero waste. Equipment no longer suitable for critical infrastructure use can be repurposed or re-

manufactured for reuse and therefore diverted from landfills. Equipment no longer capable of fulfilling its purpose can be recycled. For example, when servers and UPS batteries reach their end of useful life, they can be recycled. In the case of VRLA batteries, the industry has an extremely high rate of material recyclability (99%+), with a highly regulated recycling process at the local, state, national, and international levels. Applying li-ion battery technology to UPS applications has been a growing trend over the last several years, and although battery recycling practices continue to develop, it is anticipated that greater amounts of lithium, cobalt, and nickel will be recyclable in the near future, lowering the demand for mined minerals. See **Appendix** for more information on circular economy practices.

## Local ecosystem

### Land - total land use (m<sup>2</sup>)

**Definition** - Total direct land area consumed to operate a data center. Land use includes the land on which the physical data center building(s) is built, including any land area associated with data center operations such as outdoor power & cooling equipment / modules, parking lots, etc. Any land that has been cleared of vegetation to accommodate drainage, setback, or buffer requirements must also be included in total land use area. If the data center is located on a campus or industrial site with other activities, assign the appropriate proportion of land to the data center for this metric. Your methodology for determining land use should be published.

**Application** - This metric is used to report the direct land usage by a data center operator, similar to Scope 1 GHG emissions. Predicting land use in the design phase results in less impact on the local ecosystem by optimizing data center site selection. For example, re-purposing brownfield sites would have the least impact on the environment while greenfield site selections should avoid pristine forest or soil artificialization. The direct use of land by a data center is comparatively minimal to other industries, but care should be taken during site selection and protection during construction.

### Land-use intensity (kW/m<sup>2</sup>)

**Definition** - The ratio of rated IT capacity to the total land footprint of a data center. Higher values mean better use of the land or less land use.

**Application** - This metric allows for comparisons across different data centers and should be considered in the design phase to measure land usage effectiveness. There are several approaches for data center operators to optimize the effectiveness of land use including building multi-storey instead of one-storey, deploying high-density racks instead of low-density racks, etc.

### Outdoor noise - dB(A)

**Definition** - The sound level measured at the data center (emitter) property line. These values can be estimated during the data center design phase.

**Application** - This metric can help data center operators and local jurisdictions identify whether the sound level complies with local noise ordinances. In some data center locations, local jurisdictions are having ongoing discussions on how to prevent or mitigate sound-related issues. Since noise can impact data center site approval and operation, data center operators can select silent HVAC and genset solutions to avoid these issues during the design phase. Designers may also leverage sound-mitigating systems (e.g., acoustic shrouds, louvers, silencers) to mitigate it.

### Mean species abundance (MSA) (MSA/km<sup>2</sup>)

Definition - [CDC Biodiversité](#)<sup>12</sup> (France) developed this metric as a biodiversity footprint methodology with the objective of creating a global biodiversity score (GBS)<sup>13</sup>. This metric indicates the impact on local species by a data center in units of mean species abundance per square kilometer. This is not yet a standard. For more information on biodiversity, see **Appendix** and Schneider Electric White Paper, [The Why, What, and How of Corporate Biodiversity Action: An Introduction for Manufacturing Companies](#).

Application - This metric makes a data center's impact on species more transparent during all phases of a data center. It can help data center operators assess the effectiveness of their plans to protect the species, through the whole lifecycle of the data center.

#### Other considerations on sustainability

Besides the metrics listed in **Table 1**, there are also other metrics which indicate the sustainability of the data centers. For example, the utilization rate of a data center facility including floor space, rack space, and power & cooling system capacities can be internally tracked to drive improvements. These metrics track (and make transparent) how efficiently a data center is used. In another words, the more you utilize an existing data center, the longer you delay data center expansion, lowering your overall Scope 3 emissions, waste, etc. Although this is a straightforward concept, the data center industry does not always perform well in this area. Some examples include under utilized assets and stranded data center capacity or disproportionately used (i.e., run out of space before running out of power & cooling, or vice versa). The most sustainable data center is the one you don't have to build. For more information on this topic, see White Paper 99, [Quantifying Data Center Scope 3 GHG Emissions to Prioritize Reduction Efforts](#).

## Setting metric targets

There are emerging regulations (voluntary or mandatory) on metric targets in some regions of the world to drive the progress of data center environmental sustainability. For example, the European Data Center Association ([EUDCA](#))<sup>14</sup> published time-based and self-regulated target values for several key metrics (e.g., PUE, renewable energy use percentage, WUE) through the Climate Neutral Data Center Pact ([CNDCP](#)), while China published a mandatory national code - [GB 40879 - 2021](#), which stipulates the grades and maximum allowable values for PUE. These regulations could be used increasingly as a reference by more regions in the future.

In order to comply with the regulations, this section identifies some key metrics and provides the published industry-based target values for each metric. We applied the following five criteria to determine which of the 28 key metrics in **Table 1** could have target values that apply to all data centers:

- Regulations are forthcoming
- Measurement approaches have been clearly defined
- Measurement as a ratio or normalized value, not an absolute value
- Not heavily dependent on geography (e.g., land-use intensities in Singapore and Hong Kong will be much different than other countries or cities)

<sup>12</sup> CDC Biodiversité is a direct subsidiary of the Caisse des Dépôts (CDC, the French largest public financial institution).

<sup>13</sup> Berger, J., et al., [Common ground in biodiversity footprint methodologies for the financial sector](#), 2018

<sup>14</sup> EUDCA is an international non-profit organization established in 2011 and registered in Belgium. It represents the interests of the European commercial data center operator community. Their stated mission is: "To provide a platform for European data centre operators, both commercially and politically, with overall aim of promoting and developing growth for the industry".

- Not heavily dependent on local jurisdictions (e.g., outdoor noise level depends on local noise ordinance)

Applying these criteria, we identified four metrics:

- **Power usage effectiveness (PUE)** - The ratio of a data center's total energy consumption to IT energy consumption
- **Renewable energy factor (REF)** - The ratio of renewable energy owned and controlled by a data center organization to the data center's total energy consumption
- **Carbon usage effectiveness (CUE<sub>2</sub>)** - The sum of data center annual Scope 1 and market-based Scope 2 carbon emissions divided by the IT energy consumption with the unit of kg CO<sub>2</sub>e/kWh.
- **Water usage effectiveness (WUE<sub>1</sub>)** - The onsite data center water consumption divided by the IT energy consumption with the unit of m<sup>3</sup>/MWh.

As the values for each metric vary significantly depending on many factors including data center size, redundancy level, location, load ratio, electricity emission factor, value chain activities, etc. Therefore, we relied on surveys, studies, regulations, and industry players to provide published industry target values. **Table 2** summarizes the best-in-class or ideal values and industry target values for these key metrics. The following subsections provide the details for each metric.

**Table 2**

*Industry target values for the 4 key metrics*

Key metric	Defined by	Best-in-class value	Industry target value
PUE	<a href="#">ISO/IEC 30134-2</a>	1.1 (75%-85% load ratio)	1.2-1.3 (75%-85% load ratio)
REF	<a href="#">ISO/IEC 30134-3</a>	1.0	0.75-1.0
CUE <sub>2</sub>	<a href="#">ISO/IEC 30134-8</a>	0.0 kg CO <sub>2</sub> e/kWh	0.0-0.12 kg CO <sub>2</sub> e/kWh
WUE <sub>1</sub>	<a href="#">ISO/IEC 30134-9</a>	0.0 m <sup>3</sup> /MWh	0.3-0.45 m <sup>3</sup> /MWh

## PUE

**Survey** - The 2022 Uptime Institute's [survey](#) shows that the average annual PUE was 1.55, and progress has stalled since 2014.

**Regulation** - [EUDCA](#) published the requirements on PUE for all data centers larger than 50kW of maximum IT power demand: "By January 1, 2025 new data centres operating at full capacity in cool climates will meet an annual PUE target of 1.3, and 1.4 for new data centres operating at full capacity in warm climates. Existing data centres will achieve these same targets by January 1, 2030." In 2021 China published a national code - [GB 40879 - 2021](#), which stipulated the maximum allowable values for energy efficiency and energy efficiency grades for data centers. The maximum allowable PUE value is 1.5. There are three grades - grade 1, 2, and 3, with values - 1.2, 1.3, and 1.5 respectively. [Beijing's local government](#) published requirements on PUE for newly built and retrofitted data centers in July 2021, which stipulated a PUE no higher than 1.3, 1.25, 1.2 and 1.15 for data centers with annual energy consumption of less than 10,000, 10,000-20,000, 20,000-30,000, and greater than 30,000 tonnes of standard coal<sup>15</sup> respectively. Furthermore, the utility will impose a higher power tariff on inefficient (PUE>1.4) data centers. [Singapore](#)

<sup>15</sup> One ton of standard coal equals around 8140 kWh.

Economic Development Board (EBD) and Infocomm Media Development Authority (IMDA) have launched a pilot Data Center - Call for Application Exercise (DC-CFA), which requires that new data centers achieve at least a best-in-class PUE of 1.3 (at 100% IT load) or better.

Industry players - [Google](#) reported 1.1 average annual PUE for their global fleet of data centers in 2021 while [Meta](#) reported 1.09 annual data center PUE in 2021. [CyrusOne](#) reported 1.48 average operating PUE for all their facilities that they built-out and directly managed in 2022, while [Equinix](#) reported 1.48 across their global portfolio in 2021. [Alibaba](#) reported 1.247 average annual PUE for their self-operated data centers in 2022.

Note that PUE values are heavily influenced by cooling system efficiency, climate, and especially load ratio. While the PUE target values mentioned do not provide an average load ratio, it should be stated. **We think a best-in-class PUE is about 1.1 at 75-85% load. Reaching an average annual PUE of 1.2 to 1.3 at 75-85% load is commendable.**

### Renewable energy factor (REF)

Regulation - [EUDCA](#) published requirements on clean energy usage: “Data Centre electricity demand will be matched by 75% renewable energy or hourly carbon-free energy by December 31, 2025, and 100% by December 31, 2030.” [Beijing’s local government](#) published requirements for all data centers built since 2021, with over 5-million kWh annual energy consumption, to increase renewable energy consumption by 10% each year and to reach a 100% renewable energy target by 2030.

Industry players - [Google](#) reported 1.0 REF for five consecutive years in 2021 while [Equinix](#) reported over 0.9 for four consecutive years in 2021. [Apple](#) reported 1.0 REF for their operational electricity consumption while [Amazon](#) reported 0.85 across their operations in 2021. [Alibaba](#) reported 0.216 REF for their cloud in 2022. [CyrusOne](#) reported 0.13 REF for total electricity procured, 0.47 REF for electricity consumed by their customers, and 1.0 REF for their European operations in 2021.

**The best-in-class REF is 1.0. Reaching an REF of 0.75 to 1.0 is commendable.** However, achieving 1.0 with renewable energy purchases doesn’t mean that data centers are actually powered exclusively by renewable sources. [Google](#) and [Microsoft](#) have declared commitments to match 100% of electricity consumption with carbon-free energy on a 24/7 basis for all electricity sources where demand is located by 2030.

### Carbon usage effectiveness (CUE<sub>2</sub>)

Regulation - There are no current CUE requirements. However, we see renewable energy factor requirements as a proxy for CUE requirements because renewable energy plays a significant role in reducing CUE values.

Industry players - Most data center operators reported carbon intensity or GHG emissions intensity differently from CUE (e.g., revenue carbon intensity with units of mtCO<sub>2</sub>e/million US\$, building carbon intensity with units of mtCO<sub>2</sub>e/ft<sup>2</sup>, people carbon intensity with units of mtCO<sub>2</sub>e/monthly active person). This inconsistency makes benchmarking very difficult across data center organizations. Based on available online 2021 ESG reports, we estimated the CUE values using market-based Scope 1 & 2, total energy consumption, and PUE. These calculations resulted in: 0.111 kg CO<sub>2</sub>e/kWh for operator A, 0.003 for operator B, 0.063 for operator C, and 0.141 for operator D.

The standard CUE metric addresses this inconsistency and provides benchmarking for the data center industry. Note that CUE depends heavily on the local power utility's carbon emission factors and renewable energy procurement. **The ideal CUE value is 0.0 kg CO<sub>2e</sub>/kWh, but reaching a CUE of 0.0 to 0.12 kg CO<sub>2e</sub>/kWh is commendable.** Although Scope 1 is only around 1-2% of location-based Scope 1 & 2 emissions according to published ESG reports, some data center operators such as [Microsoft](#) announced their goal to eliminate their dependency on diesel fuel power in their data centers by 2030.

### Water usage effectiveness (WUE<sub>1</sub>)

**Research** - A 2016 Lawrence Berkeley National Laboratory (LBNL)'s [study](#) revealed that the onsite water consumption of data centers in the U.S. was 1.8 L/kWh of total data center site energy use. This applied to all data centers except for closet and room data centers. However, this value is not the average WUE value as it uses total data center energy instead of total IT equipment energy. Based on the WUE definition from [ISO/IEC 30134-9](#)<sup>16</sup>, the actual WUE value from the LBNL study should be about 2.88 L/kWh (m<sup>3</sup>/MWh) assuming an annual average PUE value of 1.6 based on Uptime Institute's [survey](#).

**Regulation** - [EUDCA](#) requires data center operators to conserve water and set ambitious water conservation targets: "By 2022, data centre operators will set an annual target for water usage effectiveness (WUE), or another water conservation metric, which will be met by new data centres by 2025, and by existing data centres by 2030. The water metric target may vary depending on the data center design specification." In July 2022, [CNDCP](#) published a specific WUE target value: "The proposed limit of zero-point-four liters of water per Kilowatt-hour of computer power (0.4l/kWh) takes into account the diverse range of technologies, climates and types of data centre building to ensure that the metric is technology and location neutral. The new metric must be achieved by all data centre operator signatories to the Pact by 2040."

**Industry players** - [AWS](#) claimed: "0.25 liters of water per kilowatt-hour of electricity used on average across AWS data center worldwide" while [Meta](#) reported 0.26 L/kWh WUE for their data center buildings built since 2021. Note that both AWS and Meta used the total energy consumption of the data center instead of IT energy consumption as the denominator to calculate WUE values. The actual WUE values are about 0.28 L/kWh assuming a 1.1 average annual PUE. [CyrusOne](#) reported 0.57 L/kWh WUE for all the facilities built-out and managed by them in 2021.

Note that WUE values are heavily influenced by cooling system types, temperature, and humidity. **While the ideal WUE value is 0.0 m<sup>3</sup>/MWh, reaching a WUE of 0.3 to 0.45 m<sup>3</sup>/MWh is commendable.**

<sup>16</sup> Information technology - Data centres key performance indicators - Part 9: Water usage effectiveness (WUE)



## Conclusion

Before a company can set goals or embed ESG into its business strategy and operations, it must decide on how to measure and report on the metrics. Determining which environmental sustainability metrics a data center business should track is one of the most important issues it faces. Data center operators are facing mounting pressure from investors, regulators, shareholders, customers, and employees to provide greater transparency on the reporting of their data center's environmental impact. Metrics-driven transparency can add value internally by driving sustainability improvements, and externally by increasing stakeholder confidence (e.g., shareholders) and competitiveness.

Not all data center companies are at the same place in their journey. We have outlined 28 metrics across three reporting stages: Beginning, Advanced, and Leading. Beginning stage represents basic reporting for energy, water use, and GHG emissions, in essence, these are the core metrics required for every data center. The Advanced stage adds more detailed metrics for energy, water, GHG emissions, and introduces two new categories including waste and local ecosystem. The Leading stage adds even more detailed metrics to the existing categories.

Data center operators can take advantage of our proposed standardized metrics to develop their own list according to where they are in their sustainability journey. They can then set reasonable metric targets according to industry target values. Data center operators should collect or measure multiple data points during a reporting period (twelve-month rolling) to calculate the metric values. This requires that operators place meters at the right locations for measurement and take advantage of modern digital tools (e.g., [Resource Advisor](#), [DCIM](#)) on the market. Data center operators can then consult frameworks and standards for guidance to report and certify their progress towards their goals, year over year. See **Appendix** for a list of the most relevant sustainability frameworks and standards for guidance in reporting and certifying.



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## Appendix

This appendix provides further explanations of terms and concepts mentioned in the body of this paper.

### GHG emissions

Greenhouse gas (GHG) means “any of the various gaseous compounds that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect”<sup>17</sup>. According to the “[Framework Convention on Climate Change](#)” and “[Kyoto Protocol](#)”, there are six main greenhouse gases: Carbon dioxide (CO<sub>2</sub>); Methane (CH<sub>4</sub>); Perfluorocarbons (PFCs); Hydrofluorocarbons (HFCs); Nitrous oxide (N<sub>2</sub>O); Sulfur hexafluoride (SF<sub>6</sub>).

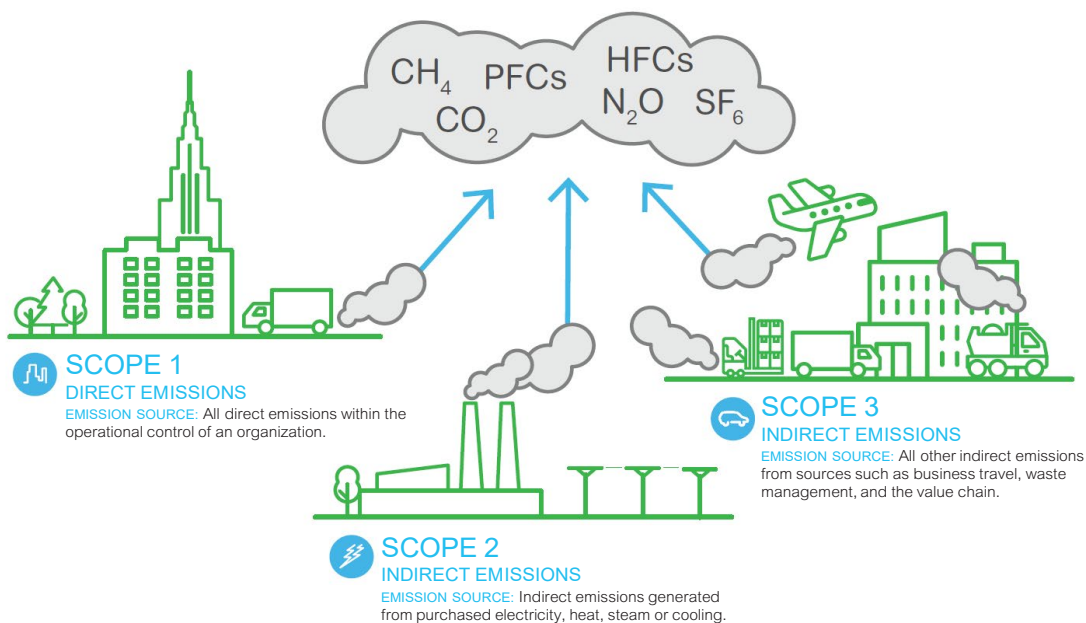
According to the [GHG Protocol](#) and [ISO 14064](#), there are three GHG emission categories including Scope 1, Scope 2, and Scope 3 (as shown in **Figure A1**).

- **Scope 1 - Direct GHG emissions:** All direct emissions within the operational control of an organization.
- **Scope 2 - Energy indirect GHG emissions:** Indirect emissions generated from purchased electricity, heat, steam, or cooling.
- **Scope 3 - Other indirect GHG emissions:** All other indirect emissions from sources such as business travel, waste management, and the value chain.

Scope 1 emissions are the most straightforward to calculate, while Scope 3 data is more difficult to attain. Scope 2 carbon emissions can generally be provided by your utility company. Based on Carbon Intelligence [research](#), over 80% of a company’s emissions are Scope 3. But for data centers, which are energy intensive, Scope 3 emissions are closer to 50% over the lifetime of the data center. As data for Scope 3 is still developing, we have identified this as a Leading metric.

**Figure A1**

*3 categories of GHG emissions from an organization*



Based on the above categories, GHG emissions from a data center are not only from their own operations and electricity consumption, but also from the goods data centers purchase. GHG emissions (Scope 3) may include the indirect emissions

<sup>17</sup> <https://www.merriam-webster.com/dictionary/greenhouse%20gas>

from sources such as travel, waste management, and the value chain of a data center. For example, the emissions may include data center construction (purchased goods and services); employee commuting (cars, buses, etc.); business travel (flight, train, rental cars, hotels, etc.).

## Circular economy

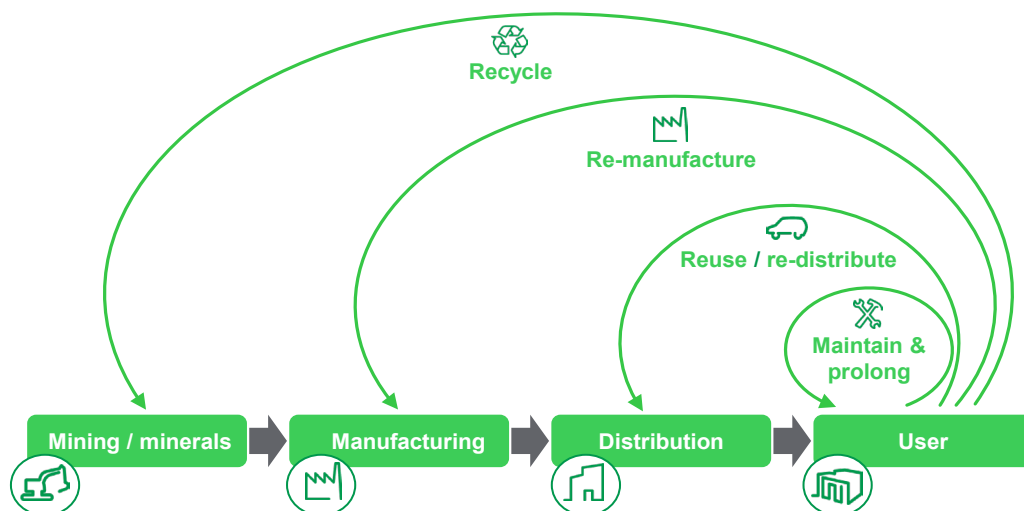
“A circular economy is based on the principles of eliminating waste and pollution, circulating products and materials (at their highest value), and regenerating nature” According to the [Ellen MacArthur Foundation](#). For data centers, circular economy is one of the most impactful levers to reduce Scope 3 supply chain emissions illustrated in **Figure A1**. People tend to think of circular economy as recycling to lower supply chain emissions. But there are other considerations:

- What is the plan to maintain and prolong your equipment? In general, the longer it lasts, the lower its carbon footprint. However, if equipment is very inefficient and your utility emission factor is high, it may actually be better to replace it with more efficient equipment.
- Can it be reused when it can no longer be maintained?
- Can I remanufacture / reuse / redistribute it?

**Figure A2** demonstrates a 4-step process of product design for circular economy.

**Figure A2**

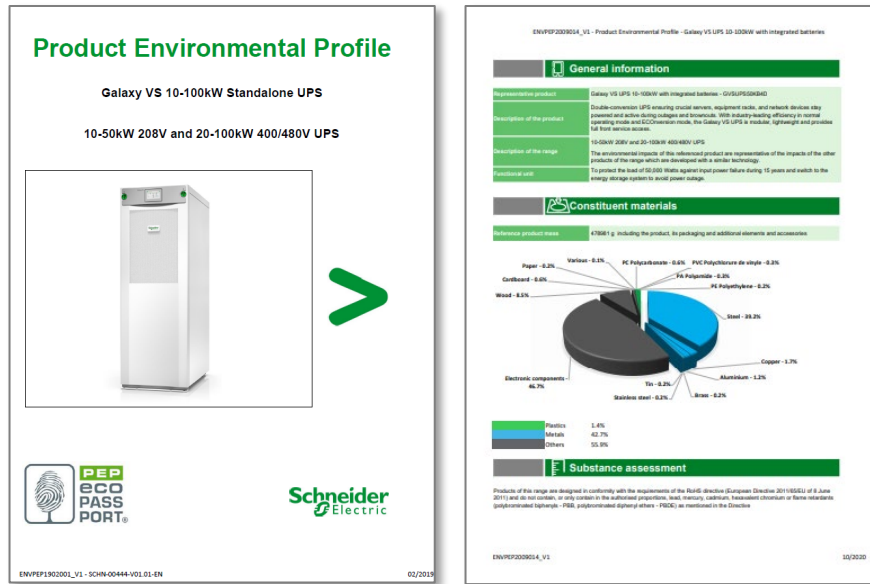
*4 steps in a product design to help lower waste from supply chain*



Gaining visibility into a vendor’s circular economy practices is important for a company’s environmental sustainability program and to determine its Scope 3 emissions. Environmental product declaration (EPD) documents such as Product environmental profiles (PEP), and life cycle assessment (LCA) reports are one approach vendors can provide more transparency. **Figure A3** shows an example of a [PEP](#) document. This is becoming an increasingly important aspect of vendor selection. For more information on this topic, see White Paper 70, [Guide to Assess a Commercial Product’s Sustainability](#).

**Figure A3**

An example of a product environmental profile (PEP) document (Schneider Galaxy VS UPS shown)



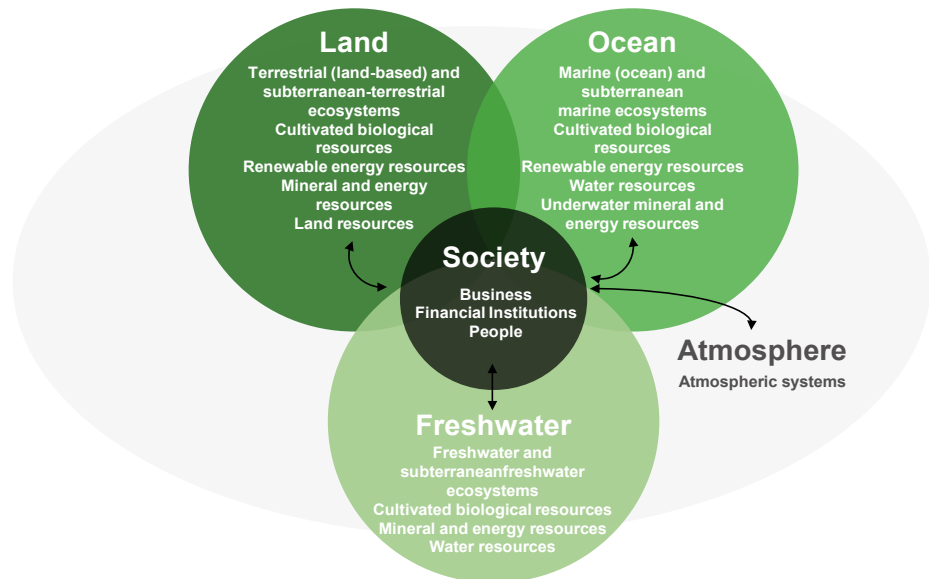
**Biodiversity**

According to World Wildlife Fund (WWF), “Biodiversity is all the different kinds of life you’ll find in one area - the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and support life. Biodiversity supports everything in nature that we need to survive: food, clean water, medicine, and shelter.”<sup>18</sup> Another description of the importance of biodiversity is from GRI 304 Standards, “Ensuring the survival of plant and animal species, genetic diversity, and natural ecosystems. Biodiversity also contributes directly to local livelihoods, making it essential for achieving poverty reduction, and thus sustainable development.”<sup>19</sup> **Figure A4** illustrates four realms of biodiversity: land, ocean, freshwater and atmosphere. Society and economy are embedded within these four realms.

**Figure A4**

The realms of biodiversity

Adapted from the *Task-force on Nature-related Financial Disclosures*



<sup>18</sup> <https://www.worldwildlife.org/pages/what-is-biodiversity>

<sup>19</sup> <https://www.globalreporting.org/standards/media/1011/gri-304-biodiversity-2016.pdf>

As the impacts on biodiversity attract more attention from governmental and non-governmental organizations, we expect reporting to gain in popularity. For example, in 2020 the EU released “Biodiversity Strategy for 2030” to protect nature and reverse the degradation of ecosystems<sup>20</sup>.

## Frameworks and standards for reporting and certifying

Frameworks and standards are used to help organizations measure and report on sustainability. Frameworks provide general guidelines and are typically non-obligatory, while standards can be adopted by jurisdictions and become obligatory.

Based on over ten years of Schneider Electric consulting experience, we have identified the 10 most relevant sustainability frameworks and standards for data center environmental sustainability reporting and certifying around the world (as shown in Table A5).

- **Reporting:** Similar to financial reporting, data center operators can use these frameworks as guidance to provide qualitative and quantitative nonfinancial information to assess their sustainability performance. For example, the Carbon Disclosure Project (CDP) is a popular framework to help large companies integrate environmental information and business impacts into financial reporting.
- **Certifying:** These frameworks provide a means for organizations to certify their sustainability improvements by meeting a minimum number of requirements or points. For example, LEED is a well-known rating system for buildings to evaluate the environmental performance and encourage sustainable design.

**Table A5**

*10 most relevant sustainability frameworks and standards for data center reporting and certifying*

Applications	Frameworks and standards	Spectrum	Attributes
Reporting (4)	<ul style="list-style-type: none"> <li>• <a href="#">Sustainability Accounting Standards Board (SASB)</a></li> <li>• <a href="#">Task Force on Climate-related Financial Disclosures (TCFD)</a></li> <li>• <a href="#">Carbon Disclosure Project (CDP)</a></li> <li>• <a href="#">Global Reporting Initiative (GRI)</a></li> </ul>	<ul style="list-style-type: none"> <li>• Corporate ESG indicators</li> <li>• Corporate climate-related financial</li> <li>• Corporate GHG emissions, water</li> <li>• Climate Change, ESG indicators</li> </ul>	<ul style="list-style-type: none"> <li>Standard Framework</li> <li>Framework Framework</li> </ul>
Certifying (6)	<ul style="list-style-type: none"> <li>• <a href="#">Science Based Targets initiative (SBTi)</a></li> <li>• <a href="#">ENERGY STAR</a></li> <li>• <a href="#">ISO 50001: Energy Management System</a></li> <li>• <a href="#">ASHRAE</a></li> <li>• <a href="#">Leadership in Energy and Environmental Design (LEED)</a></li> <li>• <a href="#">Building Research Establishment Environmental Assessment Method (BREEAM)</a></li> </ul>	<ul style="list-style-type: none"> <li>• Corporate emissions</li> <li>• Energy use in buildings and plants</li> <li>• Built environment assets</li> <li>• Energy standard for building</li> <li>• Corporate building energy use</li> <li>• Corporate energy use</li> </ul>	<ul style="list-style-type: none"> <li>Initiative Framework Standard Standard Rating system Standard</li> </ul>

## Mapping metrics to frameworks and standards

Without this paper’s guidance, it can be difficult for data center operators to choose the right guidelines for their organizations because no single Framework or standard covers all the metrics. This section simplifies the complexity of the many frameworks available by mapping the metrics to the most relevant frameworks and standards. Even this shorter list may be overwhelming for some data center operators. In these cases, we recommend using third-party consultant services experienced in

<sup>20</sup> [https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030\\_en](https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en)

the sustainability field, preferably with experience in data centers. Based on over ten years of Schneider Electric consulting experience, we provide a matrix in **Table A6** showing the relationship between metrics, frameworks, and standards.

**Table A6**

*Matrix between 28 key metrics, frameworks, and standards*

Metric categories	Key metrics	Recommended frameworks / standards
<b>Energy (6)</b>	<ul style="list-style-type: none"> <li>Total energy consumption</li> <li>Power usage effectiveness (PUE)</li> <li>Total renewable energy consumption</li> <li>Renewable energy factor (REF)</li> <li>Energy Reuse Factor (ERF)</li> <li>Server utilization (ITEUsv)</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">SASB</a></li> <li><a href="#">ISO/IEC 30134-2</a></li> <li><a href="#">RE100</a></li> <li><a href="#">ISO/IEC 30134-3</a></li> <li><a href="#">ISO/IEC 30134-6</a></li> <li><a href="#">ISO/IEC 30134-5</a></li> </ul>
<b>GHG emissions (7)</b>	<ul style="list-style-type: none"> <li>Scope 1 <ul style="list-style-type: none"> <li>GHG emissions</li> </ul> </li> <li>Scope 2 <ul style="list-style-type: none"> <li>Location-based GHG emissions</li> <li>Market-based GHG emissions</li> </ul> </li> <li>Scope 3 <ul style="list-style-type: none"> <li>GHG emissions</li> </ul> </li> <li>Carbon usage effectiveness (CUE)</li> <li>Total carbon offsets</li> <li>Hour-by-hour supply and consumption matching</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">GHG Protocol</a> or <a href="#">ISO 14064</a></li> <li><a href="#">GHG Protocol</a> or <a href="#">ISO 14064</a></li> <li><a href="#">GHG Protocol</a> or <a href="#">ISO 14064</a></li> <li><a href="#">GHG Protocol</a> or <a href="#">ISO 14064</a></li> <li><a href="#">ISO/IEC 30134-8</a></li> <li>N/A, see a <a href="#">White Paper</a> on this topic</li> <li>No frameworks or standards available</li> </ul>
<b>Water (5)</b>	<ul style="list-style-type: none"> <li>Total site water usage</li> <li>Total source energy water usage</li> <li>Water usage effectiveness (WUE)</li> <li>Water replenishment</li> <li>Total water use in supply chain</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">ISO/IEC 30134-9</a></li> <li>No frameworks or standards available</li> <li><a href="#">ISO/IEC 30134-9</a></li> <li>N/A, see a <a href="#">White Paper</a> on this topic</li> <li>No frameworks or standards available</li> </ul>
<b>Waste (6)</b>	<ul style="list-style-type: none"> <li>Waste generated <ul style="list-style-type: none"> <li>Total waste</li> <li>E-waste</li> <li>Battery</li> </ul> </li> <li>Waste diversion rate <ul style="list-style-type: none"> <li>Total waste</li> <li>E-waste</li> <li>Battery</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> <li><a href="#">GRI 300: Environmental - 306</a></li> </ul>
<b>Local ecosystem (4)</b>	<ul style="list-style-type: none"> <li>Land <ul style="list-style-type: none"> <li>Total land use</li> <li>Land-use intensity</li> </ul> </li> <li>Outdoor noise</li> <li>Mean species abundance (MSA)</li> </ul>	<ul style="list-style-type: none"> <li>No frameworks or standards available</li> <li>No frameworks or standards available</li> <li>No frameworks or standards available</li> <li>N/A, see a <a href="#">White Paper</a> on this topic.</li> </ul>



## Changes made to White Paper 67 Version 1 as of June 2023

### Section 1: Introduction

- Updated **Figure 1** - removed “Choose frameworks and standards” and added “Set metric targets”.
- Updated content of several paragraphs

### Section 2: Five metric categories used to set goals

- Updated **Figure 2** - removed bullets under each stage
- Replaced “Land & biodiversity” with “Local ecosystem”
- Updated content for each category
- **Removed Table 1**

### Section 3: Recommended metrics for sustainability reporting

- Replaced eight rules with seven criteria
- Updated **Table 2** - Number of metrics increased from 23 to 28, and “Beginning” metrics reduced from 11 to 6. Specific metric changes include:
  - Added “Server utilization (ITEUsv)” in energy category
  - Added segmentation for GHG emissions metrics by scope
  - Removed “Location-based carbon intensity (Scope 1+ Scope 2)” and “Market-based carbon intensity (Scope 1+ Scope 2)” metrics
  - Updated metric “Hour-by-hour supply and consumption matching” with “Hourly renewable supply & consumption matching”
  - Added “Water replenishment” metric to water category
  - Removed “Waste landfilled” and “Waste diverted” metrics
  - Added “E-waste” and “Battery” metrics to “Waste generated” and “Waste diversion rate”
  - Added “Total land use”, “Land-use intensity”, and “Outdoor noise” metrics to “Local ecosystem” category

### Section 4: Choose the right frameworks and standards for guidance

- Moved this section to the appendix. Updated guidance content and renamed the section “Frameworks and standards for reporting and certifying”

### Added new section “Setting metric targets”

- Provided quantitative targets for a subset of metrics - PUE, REF, CUE<sub>2</sub>, & WUE<sub>1</sub>.

### Section 5: Conclusion

- Updated the content of several paragraphs

### Appendix

- Updated Biodiversity section