Guide to Environmental Sustainability Metrics for Data Centers

White Paper 67

Version 1

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Executive summary

Many companies are now reporting on sustainability as a supplement to financial reporting. They are communicating their commitment to Environmental, Social, and Governance (ESG) programs. The data center industry has unique characteristics, such as high energy intensity, rapid growth, large power consumption and water usage that require specialized metrics. Standardizing these metrics will help with adoption, improve benchmarking, and progress sustainability within the industry. We propose five categories, which include 23 key metrics for data center operators who are in the Beginning, Advanced and Leading stages of their sustainability journey. We also identify the 17 most relevant sustainability frameworks and standards to guide data center operators in target setting, reporting, and certifying.

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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. As a result, energy consumption and overall environmental sustainability have come into focus. Data center operators are making commitments on 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. White Paper 64, *Four Key Drivers for Colocation Data Centers to Prioritize Environmental Sustainability* covers these aspects.

To report on sustainability, it's important to use a standard set of metrics. Without this, data center owners and operators face the following challenges:

- Benchmarking - When organizations calculate and report impacts on sustainability based on different metrics, it's difficult to compare performance. Given the choice, customers will pick the greener alternatives when all else is equal. Furthermore, within an organization, without appropriate metrics for benchmarking, it's difficult to know where to improve, what to prioritize, and how to show progress year over year.
- Alignment - Organizational silos within the design team, procurement team, facility operations, and sustainability team make it hard to set goals and strategies, and to drive actions.

Choosing standardized metrics to report sustainability is a key to solving the above challenges. Before The Green Grid (TGG) proposed power usage effectiveness (PUE) in 2007[1], 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 a metric might not be perfect, if it is standardized and has a well understood 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 facility efficiency improvements across the industry. A global survey of IT and data center managers conducted by Uptime Institute in 2020 showed the average annual PUE of large data centers improved from 2.5 to 1.59 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 paper proposes a list of standardized metrics for reporting on environmental sustainability. Figure 1 shows a typical improvement process. In this paper we focus on the steps within the blue dotted-line boundary. We propose five categories of metrics for data center operators to set environmental sustainability goals according to the unique characteristics of data centers. And we provide a list of standardized, well-understood metrics with definitions and applications for each category to measure the progress. Finally, we identify a list of the most relevant sustainability frameworks and standards for guidance in target setting, reporting, and certifying.

Note, corporate sustainability is made up of three dimensions: Environmental, Social, and Governance (ESG). This paper focuses solely on **environmental sustainability** and will be updated as frameworks and metrics evolve.

[1] The Green Grid has passed the ownership, development, standardization, and dissemination of PUE to ISO/IEC JTC1 SC39 WG1 several years ago.

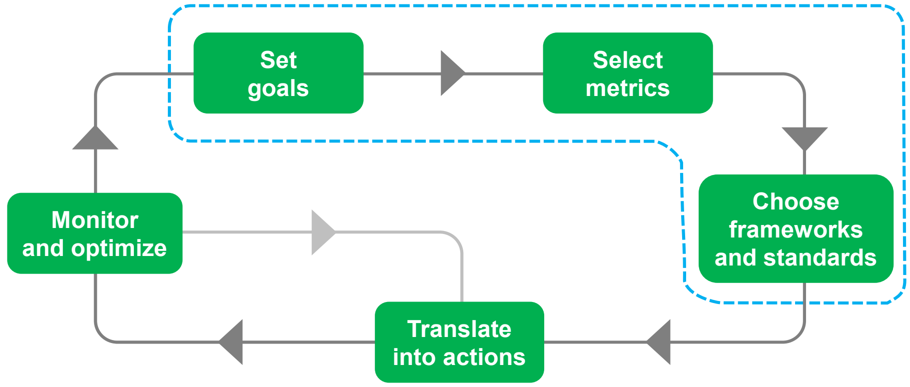
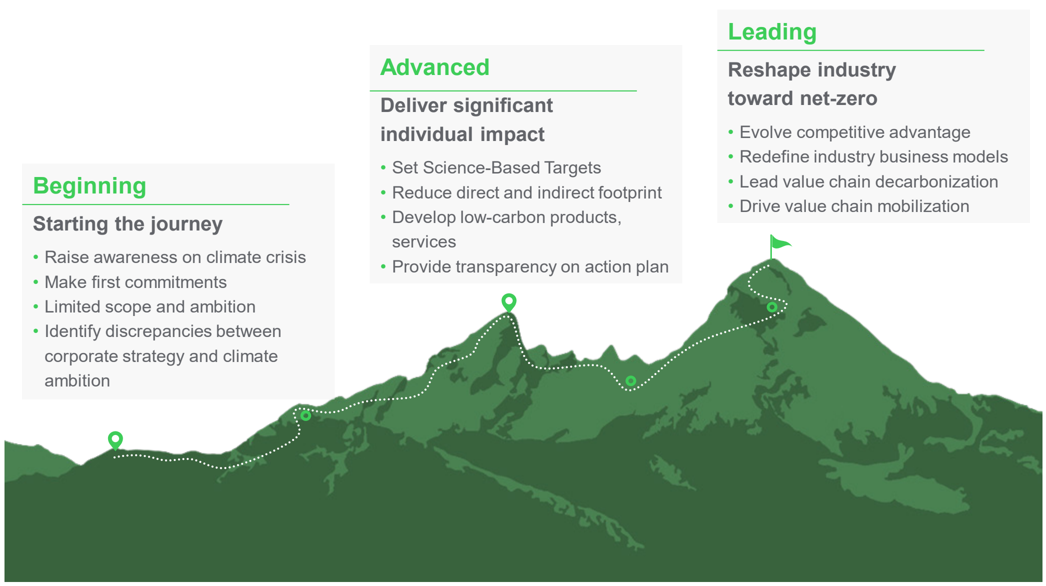


Figure 1
Steps to optimize a data center's sustainability

Five metric categories used to set goals

Environmental sustainability is about protecting natural resources such as the atmosphere, water, and land 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 for net-zero carbon journey, this methodology can also be used for evaluating data center operators toward overall sustainability. We will recommend specific metrics to use based on the data center owner's stage of this journey.



Source: SOS 1.5 The road to a resilient, net-zero carbon future

Figure 2
Three stages of net-zero carbon sustainability journey

We have identified 23 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 - According to some estimates, data center energy consumption represents 1-2% of global energy use, the greatest resource used by data centers. The on-going rapid growth and projected future growth of data centers make energy consumption and efficiency an important focus in a data center's sustainability journey. In addition to reducing consumption through efficient operations, the use of renewable energy helps reduce the greenhouse gases (GHG) emissions represented in electricity consumption. 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_2 and other gases such as CH_4, PFCs, HFCs are classified as greenhouse gases[2]. 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** - Cooling towers and other evaporative cooling techniques are popular heat rejection solutions for data centers because of their high efficiency and large cooling capacity. However, the heat rejection mechanism of these cooling technologies is evaporation, which consumes significant amounts of water. Uptime Institute's research showed that a 1MW data center with traditional cooling methods uses about 25 million liters of water per year. Additionally, traditional electricity generation requires large amounts of water, which is much more than water used for data center cooling. A world water development report from the United Nations showed water usage for electricity generation was 4 times greater than onsite cooling water usage. Water stressed areas have increased the focus by local jurisdictions. Using reclaimed or recycled water instead of fresh water (potable water) helps reduce the pressure on local water resources. Reporting water usage is becoming more important for data center operators as a part of their overall sustainability goals.
- **Waste** - Data centers generate significant waste during construction and operations. Minimizing waste generation from the supply chain and diverting waste out of landfills through reuse and recycling is a key strategy for being more environmentally sustainable. Circular economy design methodologies and processes support improvements in this area. See the **Appendix** for more information on circular economy. Reporting waste generation and diversion is emerging in importance and likely to become commonplace in the near future.
- **Land & biodiversity** - Data centers have a direct impact on the land they are built upon and an indirect land impact from their supply chain. Compared to the total area commercial office buildings use, data centers have a relatively small footprint. However, for data centers with dedicated solar/wind farms, the impact on land and biodiversity can be significant for individual organizations. Measuring the impacts to land and biodiversity are common in industries like mining but are new to the data center industry. See the **Appendix** for more information on these topics.

An increasing number of data center operators are setting goals and declaring commitments on environmental sustainability within these five metric categories. Here are some examples:

- "We are committed to reaching net zero emissions across our value chain in 2030." - Facebook
- "24/7 carbon-free energy by 2030" "By 2030, we aim to be the first major company to operate carbon free." "Achieve zero waste to landfill for our global data center operations." - Google
- "By 2030 Microsoft will be carbon negative, and by 2050 Microsoft will remove from the environment all the carbon the company has emitted either directly or by electrical consumption since it was founded in 1975." "Become water positive for our direct operations by 2030." "Achieve zero waste for Microsoft's direct operations, products and packaging by 2030." "We will take responsibility

[2] CO_2 - carbon dioxide, CH_4 - methane, PFCs - perfluorocarbons, HFCs – hydrofluorocarbons

for the ecosystem impacts of our direct operations by protecting more land than we use by 2025." - Microsoft

- "Any company hoping to become a supplier would have to commit to 'be 100% renewable for their Apple production' within 10 years". - Apple

Table 1 is a summary of the five metric categories mapped to the three stages of the sustainability journey.

Table 1
Summary of recommendations on metric categories for Beginning, Advanced and Leading.

Beginning	Advanced	Leading
• Energy • GHG emissions • Water	• Energy • GHG emissions • Water • Waste	• Energy • GHG emissions • Water • Waste • Land & biodiversity

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 them regularly (e.g. semi-annually, annually).

Recommended metrics for sustainability reporting

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

- Relevant and important to data centers
- Reflects the impact on environment directly or indirectly
- Ease of implementation (i.e. data available, calculation)
- Ease of communication within the organizations
- Ease of benchmarking across different organizations
- Actionable (can easily be translated into actions to make improvements)
- Applies to all geographies (i.e. regions, countries, etc.)
- Standardized and can be quantified

As a result of following these rules we identified 23 key metrics for data center operators to report on environmental sustainability in a holistic way (as shown in Table 2). 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 describe the definition and application of each metric listed in the table for Beginning and Advanced data center operators. The Appendix contains explanations on the additional metrics identified for the Leading stage.

Table 2
23 key metrics for reporting environmental sustainability

Metric categories	Key metrics	Units	Recommendations: Beginning (11)	Recommendations: Advanced (18)	Recommendations: Leading (23)
Energy (5)	Total energy consumption	kWh	✓	✓	✓
	Power usage effectiveness (PUE)	Ratio	✓	✓	✓
	Total renewable energy consumption	kWh	✓	✓	✓
	Renewable energy factor (REF)	Ratio		✓	✓
	Energy Reuse Factor (ERF)	Ratio			✓
GHG emissions (9)	GHG emissions: (Scope 1)	$mtCO_2e$	✓	✓	✓
	Location-based GHG emissions: (Scope 2)	$mtCO_2e$	✓	✓	✓
	Market-based GHG emissions: (Scope 2)	$mtCO_2e$	✓	✓	✓
	GHG emissions: (Scope 3)	$mtCO_2e$			✓
	Location-based carbon intensity (Scope 1+ Scope 2)	$mtCO_2e/kWh$	✓	✓	✓
	Market-based carbon intensity (Scope 1+ Scope 2)	$mtCO_2e/kWh$	✓	✓	✓
	Carbon usage effectiveness (CUE)	$mtCO_2e/kWh$	✓	✓	✓
	Total carbon offsets	$mtCO_2e$		✓	✓
	Hour-by-hour supply and consumption matching	TBD			✓
Water (4)	Total site water usage	m^3	✓	✓	✓
	Total source energy water usage	m^3		✓	✓
	Water usage effectiveness (WUE)	m^3/kWh	✓	✓	✓
	Total water use in supply chain	m^3			✓
Waste (4)	Total waste generated	tons		✓	✓
	Waste landfilled	tons		✓	✓
	Waste diverted	tons		✓	✓
	Waste diversion rate	Ratio		✓	✓
Land & biodiversity (1)	Mean species abundance (MSA)	MSA/km^2			✓

$mtCO_2e$ = Metric tons of carbon dioxide equivalent

Recommendations on reporting metric priorities

Table 2 details the 23 metrics and their recommended use according to the three stages of the journey. However, regardless of what stage you are in, all data centers should, at a minimum, report on the 11 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.

Energy

Total energy consumption

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

Application - 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.

Power usage effectiveness (PUE)

Definition - Total load of a data center divided by the IT load. PUE is a metric defined by ISO/ IEC 30134-2[3] and famously created by The Green Grid (TGG) in 2007. It indicates data center facility efficiency and is a well-understood metric used by most data center operators. For more information on the definition and calculation of PUE metric, 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 phase and while in operation. Normalized to the IT load, PUE allows comparisons across different data center sizes. PUE will vary based on the resiliency required in the design and climate. Although PUE is not a perfect metric, its simplicity has allowed data center operators to minimize the overhead energy use of the facility.

Total renewable energy consumption

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.[4] 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 buying renewable energy credits (RECs)[5] individually on the open market or through longer-term power purchase agreements (PPAs).

Application - Organizations can reduce their Scope 2 carbon emissions by the consumption of renewable energy. Replacing fossil fuel-based energy with renewables from a low or zero carbon emissions source should be a key component of carbon neutral strategies for energy consumption. This metric allows data center operators to develop the plans to mitigate the Scope 2 carbon emissions and it is needed for corporate reporting of renewable energy use.

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[6].

Application - This is a normalized metric that allows comparisons across different data center sizes. It also enables operators to track their renewable energy consumption as the data center load changes. Achieving an REF = 1.0 indicates all the data center power is renewable.

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[3] Information technology - Data centres – Key performance indicators - Part 2: Power usage effectiveness (PUE)

[4] 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.

[5] It is also known as energy attribute certificates (EACs), which is called renewable energy certificates (RECs) in the U.S. and guarantees of origin (GOs) in Europe.

[6] Information technology - Data centres - Key performance indicators - Part 3: Renewable energy factor (REF)

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. The value ranges from 0 to 1.0 with 0 meaning no energy is reused while 1.0 means that all the energy brought into the data center is re-used /exported. A typical 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.

Application - The purpose of this metric is to push data center operators and municipalities to find ways to re-purpose waste heat.

GHG emissions

GHG emissions (Scope 1)

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 (SF6) from medium voltage switchgear and hydrofluorocarbons (HFCs) released by cooling systems, transportation of materials, workers using mobile combustion sources owned or controlled by the organization such as trucks, cars, etc.

Application - Reporting on and tracking Scope 1 GHG emissions helps data centers make operational improvements to reduce this impact. 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.

Location-based and market-based GHG emissions: (Scope 2)

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 procures power from specific sources, such as renewable energy. These two metrics measure the indirect carbon emissions that occur from sources that are not controlled or owned by a data center organization, or result from an organization's activities, such as utility or production of steam or chilled water sold to the organization. The GHG Protocol Scope 2 Guidance identified 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 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 describes the organization procurement actions and assesses risks/opportunities with contractual electricity procurement. This dual metrics can assess a variety of mitigation options to lower Scope 2 carbon emissions and provide transparency for stakeholders or investors.

GHG emissions (Scope 3)

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

Application - Calculating and reporting on Scope 3 is a Leading metric. More information can be found in the Appendix.

Location-based and market-based carbon intensity (Scope 1+ Scope 2)

Definition - Carbon intensity is the sum of Scope 1 and Scope 2 carbon emissions divided by the total energy consumption. Although Scope 1 and Scope 2 carbon intensity can be calculated separately, because data center Scope 1 emissions are much smaller than Scope 2, they are typically combined as one metric: Scope 1 and Scope 2 carbon intensity.

Application - This metric is a ratio and allows for comparisons across data centers and even other industries. It can be used in the site selection, planning and design phase, as well as operations to measure effectiveness of continuous improvement programs.

Carbon usage effectiveness (CUE)

Definition - The ratio of the data center annual CO_2 emissions to IT equipment energy demand. This metric is similar to Scope 1 and 2 carbon intensity, but is ratioed to the IT load, like PUE. 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, Intermediate and Advanced.

Application - Similar to carbon intensity, this metric allows comparisons of carbon emission across data centers and other industries. It can be used in the site selection, planning and design phase, as well as operations to measure effectiveness of continuous improvement programs.

Total carbon offsets

Definition - Total reduced or avoided carbon emissions outside a data center organization's operation through purchased carbon offsets. Carbon offsets are also known as verified emission reductions (VERs), or carbon credits. The methodology is to pay others to not emit carbon, which can be used to offset emissions from data center operations. They are recognized by governments, independent 3rd party organizations, and non-government organizations (NGOs), and are regarded as a cost effective and credible way to address an organizational emissions to achieve carbon neutrality. 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.

Application - This metric can be used to quantify the 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. 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*.

Hour-by-hour supply and consumption matching

Definition - This metric measures the extent that the renewable energy generation matches the energy consumption within a data center organization. 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

Definition - Total water usage onsite for the operation of a data center. This water usage is the net value covering water withdraws, evaporation, and discharge. It includes fresh water and reclaimed water usage. Reclaimed water can be used for data center cooling towers to save precious fresh/potable drinking water. For example, Loudoun Water constructed the first pipeline distribution system to supply reclaimed water for data center industry in 2010.

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 result in improved 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. Tracking water use during operations will identify problems like leaks and create a baseline for continuous improvements.

Total source energy water usage

Definition - Total water usage to produce the energy consumed by a data center. Normally, it refers to electricity production from the utility.

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 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 gives a holistic view to minimize the total water usage.

Water usage effectiveness (WUE)

Definition - The ratio of the data center 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 with three categories for WUE measurement, covering aspects of potable and non-potable water use, as well as reuse.

Application - WUE allows for comparisons across different size data centers and should be considered during the planning and design phases and used during operations to track continued reduction in water use.

Total water use in supply chain

This is a concept under development and is analogous to Scope 3 emissions. This metric would track the water consumed in the value chain, which supplies material, equipment, and services to a data center.

Waste

Total waste generated

Definition - Total weight of material waste generated at a data center site. Measurement should start from construction and continue through data center end of life. The amount of waste can be categorized by phase, for example during construction, but also by time frame during regular operations. Similar to carbon emissions, waste can be measured as direct waste, but also waste generated within the data center supply chain.

Application - This metric can be used to quantify the organization's waste-related impacts on the environment and the target is to minimize overall 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 the supply chain.

Waste landfilled

Definition - The weight of waste disposed to landfills.

Application - This metric is used to track waste to landfills and help create programs to reduce the amount.

Waste diverted

Definition - The weight of waste that is diverted from landfills through circular methodologies including, but not limited to reuse, re-manufacturing, and recycling. 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 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 the **Appendix** for more information on circular economy practices.

Application - This metric is used to track recycling and help create programs to improve this number.

Waste diversion rate

Definition - The weight of waste recycled divided by the weight of total waste generated within a data center organization.

Application - This metric creates a ratio that can be compared across data centers. It is useful for benchmarking and creating meaningful improvement programs to drive this towards 100%. This circular economy practice is regarded as one of the more impactful levers for reducing waste generation and achieving the goal of having zero waste. See the **Appendix** for more information on circular economy practices.

Land & biodiversity

Sustainability metrics around land and biodiversity are an emerging area for data centers so we place them in the Leading stage. For more information, see the **Appendix**.

Mean species abundance (MSA)

CDC Biodiversité[7] (France) developed this metric as a biodiversity footprint methodology with the objective of creating a global biodiversity score (GBS)[8]. This metric measures a data center's impact on biodiversity. This is not yet a standard.

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[7] CDC Biodiversité is a direct subsidiary of the Caisse des Dépôts (CDC, the French largest public financial institution).

[8] https://www.asnbank.nl/web/file?uuid=b71cf717-b0a6-47b0-8b96-47b6aefd2a07&owner=6916ad14-918d-4ea8-80ac-f71f0ff1928e&contentid=2412

Choose the right frameworks and standards for guidance

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.

The landscape of sustainability frameworks can be confusing and complicated. We have identified the 17 most relevant sustainability frameworks and standards for data centers around the world (as shown in **Table 3**). Data center operators can use these for guidance to standardize their environmental sustainability reporting.

Table 3
17 most relevant sustainability frameworks and standards for data centers

Applications	Frameworks and standards	Spectrum	Attributes
Target setting (4)	• UN Sustainability Development Goals (SDGs) • Science-Based Targets Initiative (SBTi) • RE100 • CE100	• Leaders setting sustainability goals • Corporate emissions • Power footprint • Circular economy	Call for action Initiative Initiative Programme
Reporting (9)	• Sustainability Accounting Standards Board (SASB) • Carbon Disclosure Project (CDP) • Global Reporting Initiative (GRI) • Dow Jones Sustainability Indices (DJSI) • Global Real Estate Sustainability Benchmark (GRESB) • Task Force on Climate-related Financial Disclosures (TCFD) • GHG Protocol Accounting and Reporting Standard • ISO/IEC 30134: Information technology- Data centers - Key performance indicators • ISO 14604: GHG Emissions Inventories and Verification	• Corporate ESG indicators • Corporate GHG emissions, water • Climate Change, ESG indicators • Corporate ESG indicators • ESG Benchmark for Real Assets • Corporate climate-related financial • Corporate emissions • Data center operation resource efficiency • Corporate emissions and removals	Standard Framework Framework Benchmark Benchmark Framework Standard Standard Standard
Certifying (4)	• Leadership in Energy and Environmental Design (LEED) • ENERGY STAR • ISO 50001: Energy Management System • Building Research Establishment Environmental Assessment Method (BREEAM)	• Corporate Building Energy Use • Energy use in buildings and plants • Corporate Energy Use • Built Environment Assets	Rating system Framework Standard Standard

These frameworks can be grouped into the following three categories based on their function or purpose:

- **Target setting:** These frameworks are used to set credible, science-based and realistic sustainability targets. Targets can be internal or published externally. For example, the UN Sustainability Development Goals (SDGs) framework comprises of 17 specific goals as a call to action by all countries to promote prosperity while protecting the planet. It provides a great source for organizations to set internal targets.
- **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.

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 smaller list may be overwhelming for some data centers. In these cases, we recommend using third-party consultant services experienced in the sustainability field, preferably with experience in data centers. Based on over ten years of Schneider Electric consultant experience, we provide a matrix to show the relationship between metrics, frameworks, and standards as shown in Table 4.

Table 4
Matrix between 23 key metrics, frameworks, and standards.

Metric categories	Key metrics	Recommended frameworks/standards
Energy (5)	• Total energy consumption • Power usage effectiveness (PUE) • Total renewable energy consumption • Renewable energy factor (REF) • Energy Reuse Factor (ERF)	• SASB • ISO/IEC 30134-2 • RE100 • ISO/IEC 30134-3 • ISO/IEC 30134-6
GHG emissions (9)	• GHG emissions: (Scope 1) • Location-based GHG emissions: (Scope 2) • Market-based GHG emissions: (Scope 2) • GHG emissions: (Scope 3) • Location-based carbon intensity (Scope 1+ Scope 2) • Market-based carbon intensity (Scope 1+ Scope 2) • Carbon usage effectiveness (CUE) • Total carbon offsets • Hour-by-hour supply and consumption matching	• GHG Protocol or ISO 14064 • GHG Protocol or ISO 14064 • GHG Protocol or ISO 14064 • GHG Protocol or ISO 14064 • GHG Protocol or ISO 14064 • GHG Protocol or ISO 14064 • ISO/IEC 30134-8 • N/A, see a White Paper on this topic. • No frameworks or standards available
Water (4)	• Total site water usage • Total source energy water usage • Water usage effectiveness (WUE) • Total water use in supply chain	• ISO/IEC 30134-9 • No frameworks or standards available • ISO/IEC 30134-9 • No frameworks or standards available
Waste (4)	• Total waste generated • Waste landfilled • Waste diverted • Waste diversion rate	• GRI 300: Environmental - 306 • GRI 300: Environmental - 306 • GRI 300: Environmental - 306 • GRI 300: Environmental - 306
Land & biodiversity (1)	• Mean species abundance (MSA)	• N/A, see a White Paper on this topic.

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. Mounting pressures from investors, regulators, shareholders, customers, and employees is driving the need for greater transparency on the reporting of the environmental impact in their data center operations. Metrics-driven transparency can add value internally by tracking and reporting sustainability metrics to help drive improvements, and externally by reporting sustainability metrics to help to increase transparency for stakeholders.

Not all data center companies are at the same place in their journey, we have outlined 23 metrics across three reporting stages: Beginning, Advanced and Leading. Beginning level represents the basic reporting for energy and water use as well as GHG emissions. The Beginning level has core metrics required for every data center company. The Advanced level adds more detailed metrics to the Beginning level for energy, water and GHG and adds a new waste category. The Leading stage adds even more detail to the existing categories and introduces a land & biodiversity category. We recommend these specific metrics at every level for companies to represent their environmental sustainability as clearly as possible and be consistent with the industry.

About the authors

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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"[9]. According to the "Framework Convention on Climate Change" and "Kyoto Protocol", there are six main greenhouse gases: Carbon dioxide (CO_2); Methane (CH_4); Perfluorocarbons (PFCs); Hydrofluorocarbons (HFCs); Nitrous oxide (N_2O); Sulfur hexafluoride (SF_6).

According to the GHG Protocol and ISO 14064, there are three GHG emission categories including Scope1, Scope2, 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 emission can generally be generated by your utility company. Based on the research from Carbon Intelligence, 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.

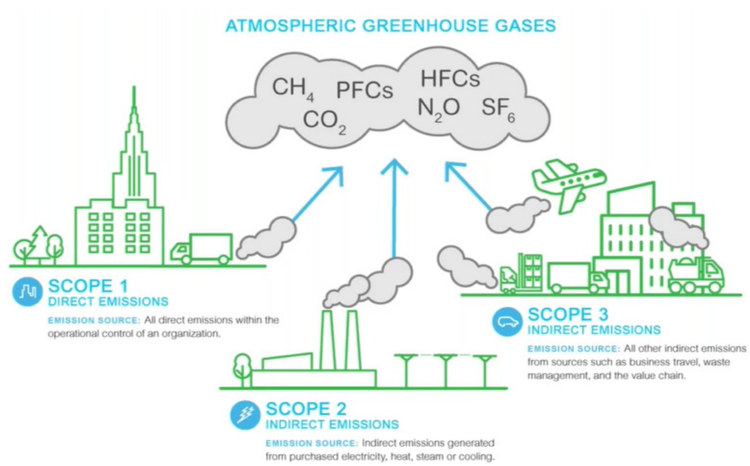

Figure A1
3 categories of GHG emissions from an organization

Based on 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 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.).

[9] https://www.merriam-webster.com/dictionary/greenhouse%20gas

Circular economy

"A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems," According to the Ellen MacArthur Foundation. For data centers, circular economy is one of the most impactful levers to reduce emissions of supply chain in Scope 3 category discussed in Figure A1.

For circular economy, people tend to think of recycling first and regard it as a helpful action to lower supply chain. But there are other considerations:

- What is the plan to maintain and prolong your equipment? The longer it lasts, the lower its carbon footprint.
- 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.

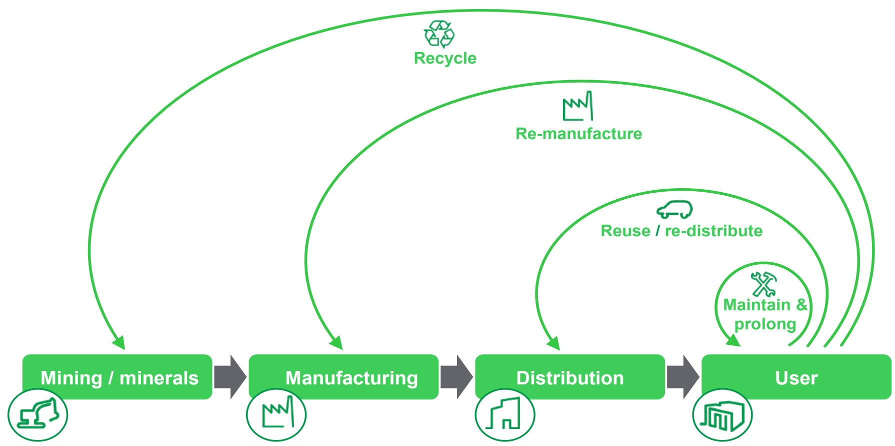

Figure A2
4 steps in a product design to help lower waste from supply chain

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. Product environmental profile (PEP), environmental product declaration (EPD) and life cycle assessment (LCA) documents are one way for vendors to provide more transparency. Figure A3 shows an example of a PEP document. This is becoming an increasing important aspect of vendor selection.

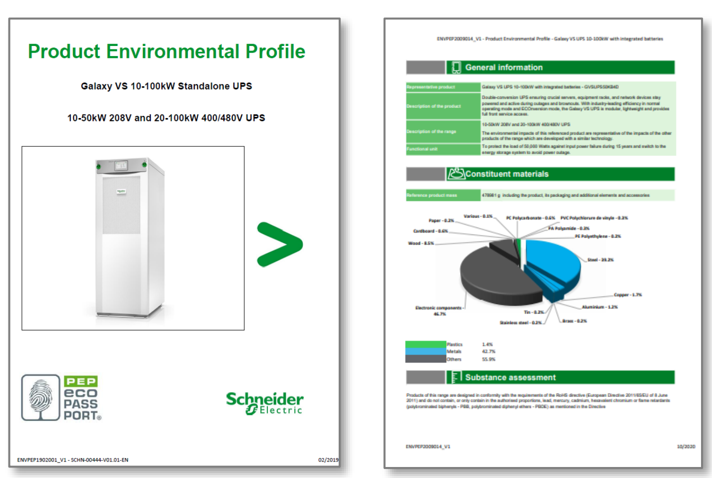

Figure A3
An example of a product environmental profile document (Schneider Galaxy VS UPS shown)

Land & biodiversity

Land - The direct use of land by a data center is comparatively minimal, but care should be taken during site selection and protection during construction. Re-purposing brownfield sites would have the least impact on the environment. Greenfield site selections should avoid pristine forest or soil artificialization. Another consideration is the indirect land impact data centers can have for building solar farms for renewable energy. The land footprint of solar farms could be several times bigger than data center footprint due to its low power density[10]. However, renewable energy usage is a major approach to minimize Scope 2 carbon emissions of data centers. In the lifetime of a data center, carbon emissions from embodied construction and supply chain represent a very small portion of the total carbon emission. Carbon emissions from energy consumption (i.e. electricity) are normally the biggest portion[11]. As a result, the GHG emissions savings from a solar farm typically outweigh the negative impact on land.

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."[12] Another description of the importance on biodiversity from GRI 304 Standards is "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." [13] As the impacts on biodiversity attract more attention from governmental and non-governmental organizations, we expect reporting to gain in popularity. For example, the EU released "Biodiversity Strategy for 2030" in 2020 to protect nature and reverse the degradation of ecosystem[14].

[10] Based on estimation from Schneider Electric, solar farm used to supply renewable energy for a data center can use around 10 times land compared with data center land footprint.

[11] Based on estimation from Schneider Electric, carbon emissions from embodied construction of a data center only represent around 1% of total carbon emissions in a data center lifetime while carbon emissions from energy consumption can represent over 90%.

[12] https://www.worldwildlife.org/pages/what-is-biodiversity

[13] https://www.globalreporting.org/standards/media/1011/gri-304-biodiversity-2016.pdf

[14] https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en