EBOOK

Power Usage Effectiveness (PUE):

What You Need to Know

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Introduction

Since its introduction, Power Usage Effectiveness (PUE) has been widely adopted as a standard metric for evaluating and benchmarking the energy efficiency of data centers worldwide.

The purpose of this eBook is to provide data center professionals with a comprehensive understanding of PUE, why it is important, how it is calculated, how it can be improved, and why it has limitations.

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Understanding PUE

PUE was introduced in 2007 by The Green Grid, a consortium dedicated to advancing energy efficiency in data centers. Since its inception, PUE has been globally adopted and widely reported with its methodology standardized under ISO/IEC 30134-2.2016 and EN 50600-4-2.2016.

PUE is one of the most popular metrics in evaluating the energy efficiency of data center operations. It is expressed as the ratio of total facility energy consumption to the energy consumed by IT equipment. A PUE of 1.0 indicates a perfectly efficient data center in which all of the energy coming into the facility is used by IT equipment and none of it is lost through the power chain or spent on cooling.

Reasons for PUE's Popularity

PUE has reached widespread adoption because it is:

- **Easy to understand.** PUE condenses complex energy consumption data into a simple number that enables stakeholders at all levels to quickly grasp and communicate the efficiency of a data center.
- **Widely applicable.** Most organizations are concerned with energy efficiency as it relates to cost savings, reduced environmental impact, and compliance with regulatory requirements. PUE provides a common metric for assessing energy efficiency across data center environments of all types and sizes.
- **Good for benchmarking.** PUE can be compared across sites or against industry benchmarks to evaluate efficiencies. This enables organizations to set realistic targets, fosters healthy competition, and incentivizes innovation in energy efficiency.
- **Easy to trend.** PUE can easily be measured over time to monitor the effectiveness of energy efficiency initiatives, identify areas for improvement, and reveal how seasonal demand variations and weather patterns impact energy consumption.

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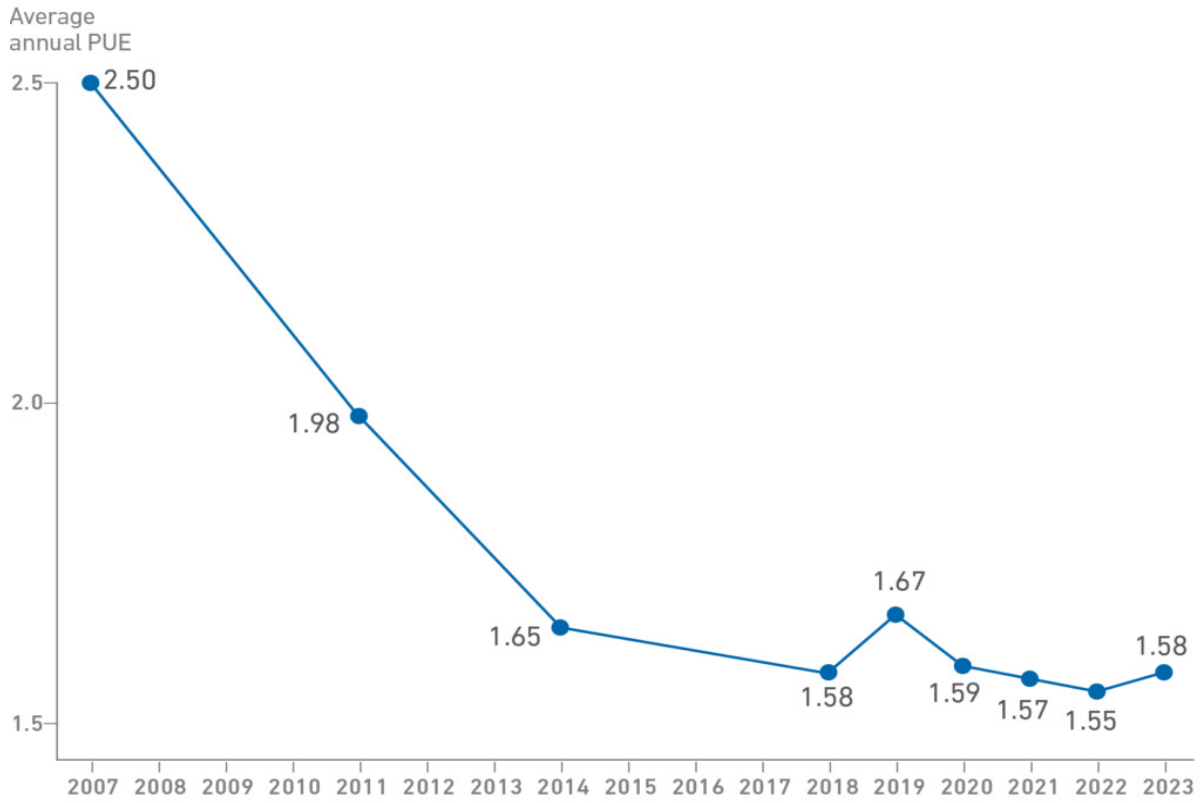
Understanding PUE (continued)

PUE Trends and Benchmarks

When the PUE metric was introduced in 2007, the average PUE industry-wide was 2.5. As PUE became more widely adopted and optimized, it steadily declined down to 1.65. Since then, the average PUE has remained fairly flat, landing at 1.58 in 2023. Many organizations, however, have placed a renewed focus on PUE as sustainability regulations become more stringent.

The average PUE for new, state-of-the-art data centers typically ranges around 1.2 to 1.6. Older data centers or those with less efficient designs and equipment have higher PUEs, sometimes exceeding 2.0.

The most sustainability-minded organizations often target a PUE of 1.2 or less.



Source: Uptime Institute

Factors That Influence PUE

A multitude of factors play a significant role in determining the PUE of a data center. Understanding these factors is crucial for optimizing energy efficiency and minimizing environmental impact.

The key influences that impact PUE are:

- **IT equipment efficiency.** Modern, energy-efficient servers, storage systems, and networking devices consume less power compared to older, less efficient hardware. Upgrading to more efficient IT equipment can lower the overall power consumption of the data center, shaping its PUE.
- **Cooling systems efficiency.** Since cooling accounts for a substantial portion of a data center's energy consumption, the efficiency of cooling systems directly impacts PUE. Implementing strategies such as containment systems, economizers, and optimized airflow management can enhance cooling efficiency and reduce facility energy usage, thereby lowering PUE.
- **Facility design and layout.** The design and layout of the data center facility influence its energy efficiency and, consequently, its PUE. Factors such as the location of air intakes and exhausts, the arrangement of hot and cold aisles, and the use of efficient building materials all contribute to the overall energy performance of the facility. Well-designed data centers that minimize air mixing and optimize airflow patterns tend to have lower PUE values.
- **Power distribution and conversion losses.** Power distribution infrastructure, including uninterruptible power supply (UPS) units and power distribution units (PDUs), introduce inefficiencies through conversion losses and standby power consumption. Minimizing these losses through the use of high-efficiency components and optimizing power distribution architectures can help reduce overall energy consumption and improve PUE.
- **Operational practices.** Efficient utilization of IT resources, such as server virtualization and workload consolidation, can reduce overall power demand. Additionally, implementing energy-saving practices such as adjusting cooling setpoints based manufacturer and industry guidelines can contribute to lower PUE values.
- **Geographic location and climate.** The local conditions surrounding a data center can impact its cooling requirements and energy efficiency. Data centers located in cooler climates may require less mechanical cooling, resulting in lower energy consumption and PUE. Conversely, data centers in warmer climates or regions with high humidity levels may face greater cooling challenges and higher energy costs.
- **Data accuracy.** Accurate metering of IT and facility energy consumption, proper allocation of IT and non-IT loads, and consistent data collection practices are all necessary for accurate PUE calculations.

PUE Measurement and Reporting

Accurate measurement and reporting of PUE are essential for effectively assessing and optimizing energy efficiency in data centers. Plus, PUE reporting may be a component of compliance with regulatory requirements and industry standards. Familiarize yourself with relevant regulations and standards governing energy efficiency reporting in your jurisdiction, such as ASHRAE guidelines or local energy efficiency regulations.

PUE Measurement Levels

There is a three-level approach to measuring PUE. Each level includes more granular energy consumption data for more accurate PUE calculations.

- **Level 1 (Basic).** The IT load is measured at the UPSs, the facility energy is measured at the utility service, and measurements are manually collected monthly.
- **Level 2 (Intermediate).** The IT load is measured at the floor PDUs or branch circuits, the facility energy is measured at the utility service, and measurements are collected daily.
- **Level 3 (Advanced).** The IT load is measured from outlet-metered intelligent rack PDUs or directly from the devices, the facility energy is measured at the utility service, and measurements are automatically collected every 15 minutes or less.

How often do I measure?		Basic	Intermediate	Advanced
IT Equipment Energy	Required	UPS outputs	PDU outputs	IT equipment input
Total Facility Energy	Required	Utility inputs	Utility inputs	Utility inputs
	Additional recommended measurements*		**UPS inputs/outputs** **Mechanical inputs**	**PDU outputs** **UPS inputs/outputs** **Mechanical inputs**
Measurement Intervals	Required	Monthly	Daily	15 minutes
	Additional recommended measurements*	**Weekly**	**Hourly**	**15 minutes or less**

Source: The Green Grid

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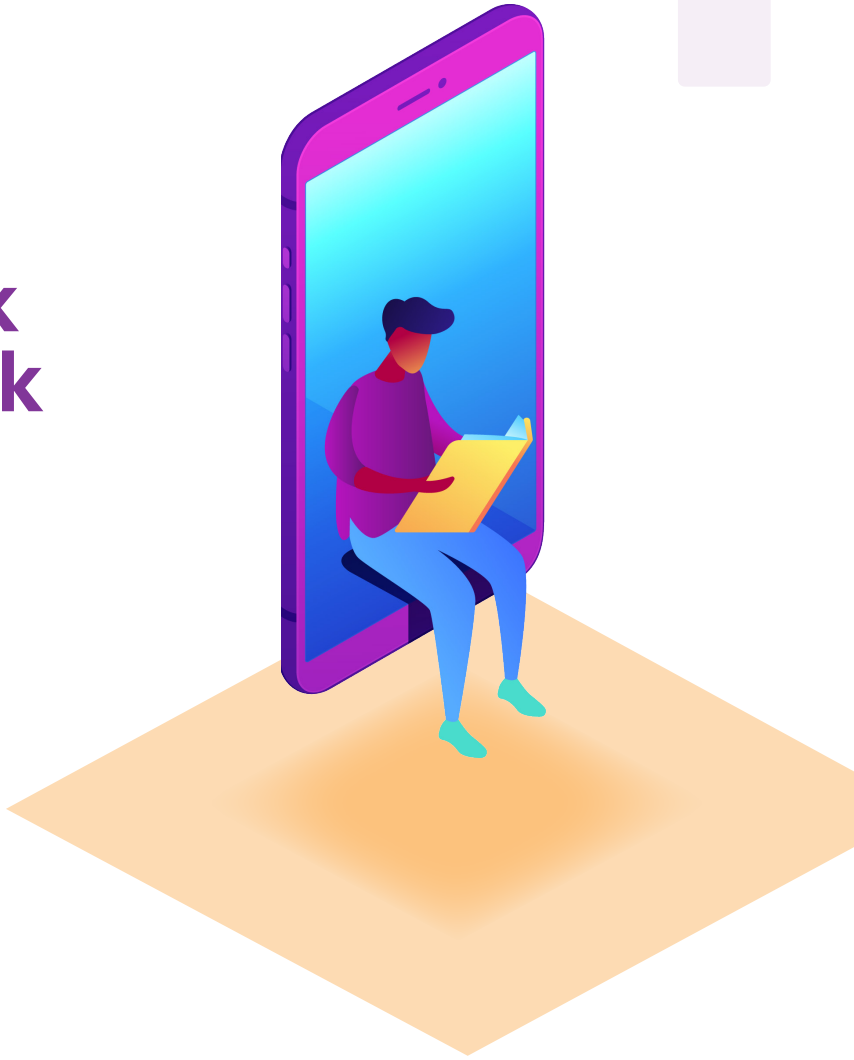

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