HIOKI

Technical White Paper

Measuring Data Center Infrastructure Efficiency

A practical guide to PUE, DCiE, measurement boundaries, and turning electrical data into actionable insight.



TECHNICAL PAPER | DATA CENTER POWER & EFFICIENCY

Measuring Data Center Infrastructure Efficiency

A practical guide to PUE, DCiE, measurement boundaries, and turning electrical data into actionable insight.

Data centers must manage rising power and cooling demands while maintaining the IT capacity that delivers useful computing. PUE and DCiE provide a common framework for understanding how facility power is distributed between IT equipment and supporting infrastructure. Their value, however, depends on how and where the measurements are made.

This paper focuses on the measurement decisions that make efficiency data useful: defining consistent boundaries, selecting practical measurement points, choosing an appropriate interval, and interpreting changes in context.

Why measure resource efficiency

Efficiency metrics create a baseline for managing power and cooling costs and allow teams to apply a consistent method across facilities. The most important principle is simple: measurement must be repeatable before improvement can be demonstrated.

"If you cannot measure it consistently, you cannot improve it confidently."

Key efficiency metrics

PUE	**What it tells you**
Total Facility Power ÷ IT Equipment Power	Shows the total facility power required for each unit of IT equipment power. Lower values indicate less supporting overhead.
DCiE	**What it tells you**
IT Equipment Power ÷ Total Facility Power × 100%	Shows the share of total facility power used by IT equipment. Higher values indicate a greater share reaching the IT load.

01 | Understand the power boundary

PUE is a boundary problem before it is a calculation problem

PUE compares all power entering the facility with the portion delivered to IT equipment. The numerator includes the power required to operate the entire data center, while the denominator represents the IT load that produces useful computing.

The power path to IT can include UPSs, PDUs, cabling, and switches. Facility power also supports HVAC, lighting, security, generators, switchgear, and other infrastructure. PUE makes that supporting overhead visible — but only when the measurement boundaries remain consistent.

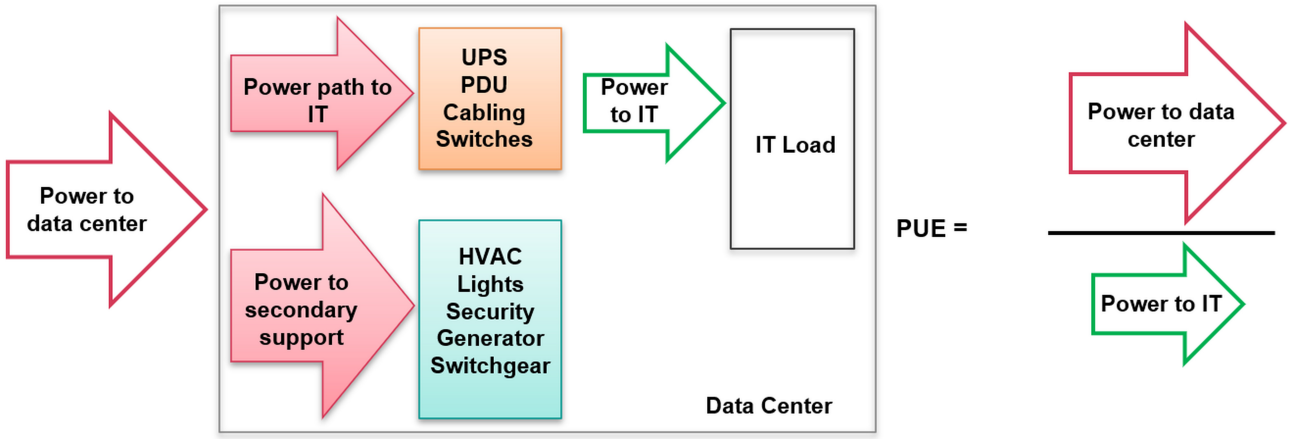


Figure 1. PUE power flow and calculation boundary.

1	2	3
Fix the boundaries	**Keep the interval consistent**	**Interpret in context**
Use the same total-facility and IT measurement points for every comparison.	A result is only comparable when the time basis is comparable.	Relate PUE movement to IT load and supporting facility systems.

A lower PUE is considered better and identifies 1.0 as the ideal value. Its reference values provide a simple interpretation scale for comparing measurements.

Illustrative PUE Reference Values

PUE	Level of Efficiency
3.0	Very inefficient
2.5	Inefficient
2.0	Average
1.5	Efficient
1.2	Very efficient

Measurement locations

The total-facility measurement represents power delivered to the data center. The IT measurement represents the portion consumed by the IT load. At the IT boundary, the point can be selected at the UPS output, PDU output, or IT equipment input depending on the monitoring level and practical access available at the facility.

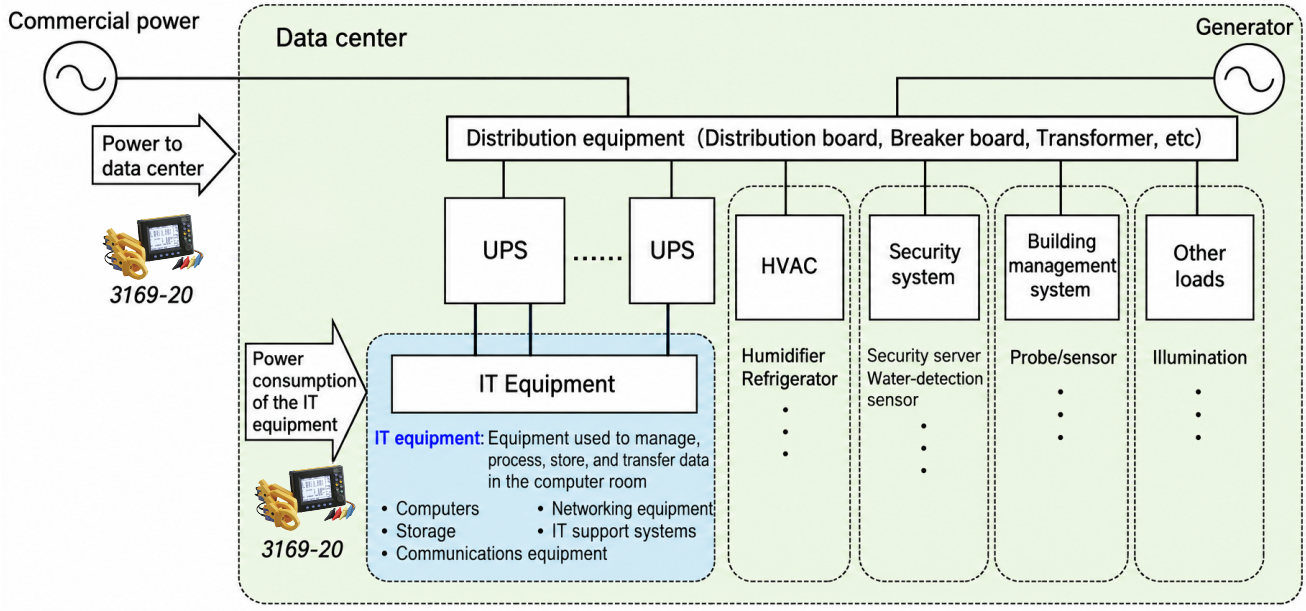


Figure 2. Example PUE measurement points and PQ3198 placement.

02 | Choose the measurement level

Match measurement detail to the decision you need to make

PUE monitoring can be approached at three levels. Each level moves the IT measurement point closer to the load and increases the measurement frequency, while maintaining the utility input as the total-facility energy boundary.

Measurement	Level 1 Basic	Level 2 Intermediate	Level 3 Advanced
IT equipment energy	UPS outputs	PDU outputs	IT equipment input
Total facility energy	Utility inputs	Utility inputs	Utility inputs
Measurement interval	Monthly or weekly	Daily or hourly	Continuous, 15 min or less

How to use the levels

- Level 1 provides a basic view using UPS outputs and monthly or weekly measurements.
- Level 2 moves the IT measurement point to PDU outputs and increases the frequency to daily or hourly data.
- Level 3 measures at the IT equipment input and uses continuous intervals of 15 minutes or less.

More measurement is not automatically better. Higher monitoring levels provide more detail, but may be costly or impractical in existing facilities. The objective is sufficient accuracy and resolution to support the engineering decision.

Use the result to investigate what changed — not just to report a number

With consistent measurement points and intervals, teams can estimate energy efficiency, compare results across data centers, and determine whether efficiency improvements should be investigated. The measurements become most useful when a change in PUE can be related to a change in IT load or in a supporting system that affects total facility power.

Design & manufacturing	Validate how power conversion and supporting equipment affect total facility energy use.
Commissioning	Confirm measurement boundaries, establish a baseline, and compare operation under defined conditions.
Owners & operators	Trend efficiency over time and investigate changes that may be associated with IT load or supporting infrastructure.

PQ3198 for PUE and DCiE evaluation



The PQ3198 power quality analyzer can support PUE and DCiE evaluation by providing long-term electrical measurements at defined facility and IT boundaries. Used consistently, these measurements help teams understand where energy is consumed and investigate changes in facility efficiency.

- Measure at total-facility and IT-side locations
- Capture long-term electrical data at consistent intervals
- Support comparison and troubleshooting when PUE/DCiE changes

Conclusion

PUE and DCiE give data center stakeholders a common language for evaluating how electrical energy is used across IT equipment and supporting infrastructure. Their value depends on disciplined measurement: consistent boundaries, appropriate intervals, and enough context to explain why the result changed. With that foundation, efficiency metrics become a practical tool for design validation, commissioning, operational troubleshooting, and continuous improvement.