Data Center Efficiency

EFFICIENCY METRICS · PUE & DCiE · AIRFLOW MANAGEMENT · HVAC EFFICIENCY · MONITORING INSTRUMENTATION

STUDY & REVIEW

01 MUST KNOW

if you remember five things, remember these

01 **PUE is the master metric: Power usage effectiveness (PUE)** = `total power supplied to the data center ÷ IT equipment power consumed`. It is a **unit-less ratio** developed by **Green Grid**, and a *lower* value is better — an ideal facility approaches 1.0, where nearly all power reaches the IT load.

02 **DCiE is PUE inverted: Data center infrastructure efficiency (DCiE)** = `IT equipment power ÷ total power supplied`, the **inverse of PUE**, shown as a *percentage* where *higher* is better. The standard scale pairs them: PUE **1.2** → **83%** (highly efficient) down to PUE **3.0** → **33%** (inefficient).

03 **Airflow drives PUE:** Three airflow-management elements lower PUE when synchronized: **separating returning warm air from supplied cold air**, the **volume of air inflow**, and the **temperature of air inflow**. Always calculate PUE from the *precise IT load*, never the equipment's rated capacity.

04 **HVAC is ~40% of the load:** Cooling runs continuously and consumes almost **40% of total power**. Gauge it with **COP** and the common `cooling power (kW) ÷ cooling load (tons)`; judge **effectiveness** by `IT energy ÷ HVAC energy` (ideal **0.6–3.5**); and monitor its PUE with **SEER, EER, and HSPF**.

05 **Portable vs. permanent: Portable** instruments are temporarily installed by qualified professionals for periodic, as-needed audits — cost-effective for older data centers. **Permanent** instruments are fixed for continuous, real-time monitoring and automatic historical reporting — ideal for new data centers despite a higher initial cost.

02 KEY TERMS

TERM	DEFINITION
Power usage effectiveness (PUE)	Total power supplied to the data center ÷ IT equipment power consumed; a unit-less ratio from Green Grid where a lower value means higher efficiency
Data center infrastructure efficiency (DCiE)	The inverse of PUE (IT power ÷ total power), expressed as a percentage; once called data center efficiency (DCE); higher is better
Green Grid	Non-profit consortium affiliated with the Information Technology Industry Council (ITI) that developed PUE to improve IT and data center energy efficiency worldwide
Corporate average data center efficiency (CADE)	Actual energy effectiveness relative to equipment and server use; the product of facility efficiency and IT asset efficiency
Cooling capacity factor (CCF)	Metric for evaluating inefficiencies in a data center's cooling infrastructure and spotting future cooling-development opportunities
LEED	Leadership in Energy and Environmental Design — green-building accreditation from the US Green Building Council covering materials, location, water, indoor environment, and energy
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers; sets efficiency standards and the feasible operating ranges for IT-equipment temperature and humidity
PAR4	Server power-consumption metric from Power Assure (checks idle, peak, per-watt transactions, total power); tested by UL to standard UL2640
HVAC	Heating, ventilation, and air conditioning — technology that regulates indoor temperature, humidity, and air levels to protect IT equipment from thermal stress
Coefficient of performance (COP)	Output cooling energy (kW) ÷ input electrical energy (kW); indicates heating/cooling-machine efficiency — react quickly if it deteriorates

TERM	DEFINITION
SEER / EER	Ratios of output cooling energy (BTU) to electrical input (Wh); SEER measures a full season of varying temperatures, EER considers only machinery-created conditions
HSPF	Heating seasonal performance factor; same units as SEER but measures the heating mode, so it applies only to heat pumps or reversible units (HSPF × 0.0293 = COP)

03 EFFICIENCY METRICS AT A GLANCE

seven metrics you should recognize

METRIC	WHAT IT MEASURES	KEY DETAIL
PUE	Data center energy efficiency	Total power in ÷ IT power; unit-less ratio; Green Grid; lower is better
DCiE	The same two parameters, inverted	IT power ÷ total power, as a %; higher is better
CADE	Actual effectiveness vs. equipment/server use	Facility efficiency × IT asset efficiency
CCF	Inefficiencies in cooling infrastructure	Flags future cooling-development opportunities
LEED	Green-building credentials	US Green Building Council; materials, location, water, air, energy
ASHRAE	Human well-being + efficiency standards	Sets IT temperature and humidity operating ranges
PAR4	Server power consumption	Power Assure; idle/peak/per-watt/total; UL-tested (UL2640)

04 PUE AND DCIE EFFICIENCY LEVELS

lower PUE ⇄ higher DCiE ⇄ more efficient

PUE	DCIE	EFFICIENCY LEVEL
3.0	33%	Inefficient
2.5	40%	Moderately efficient
2.0	50%	Average
1.5	67%	Efficient
1.2	83%	Highly efficient

05 HVAC EFFICIENCY & EFFECTIVENESS FORMULAS

know which ratio measures what

MEASURE	FORMULA	NOTE
HVAC efficiency	cooling-system power (kW) ÷ cooling load (tons)	Most common method
COP	output cooling (kW) ÷ input electrical (kW)	React fast if it drops
HVAC effectiveness	IT energy (kWh/yr) ÷ HVAC energy (kWh/yr)	Ideal range 0.6–3.5
Airflow efficiency	gross fan power (W) ÷ gross fan airflow (cfm)	Low-pressure drops help
SEER	seasonal output cooling (BTU) ÷ input (Wh)	Over a varying season; higher = better
EER	output cooling (BTU) ÷ input (Wh)	Machinery only; residential
HSPF	SEER units, but in heating mode	Heat pumps only; × 0.0293 = COP

06 PORTABLE VS. PERMANENT INSTRUMENTATION

two ways to measure efficiency

PORTABLE INSTRUMENTATION	PERMANENT INSTRUMENTATION
temporary · as-needed · older data centers	*fixed · continuous · new data centers*
— Temporarily installed, then removed after the audit	— Fixed for permanent, continuous use
— Run by qualified professionals on an as-needed basis	— Real-time data from live circuits, no human involvement
— Cost-effective where permanent install is impractical	— Automatic historical and real-time reports
— Measures actual power consumption and demand	— Higher initial cost; ideal for new data centers
— Troubleshoots input issues — harmonics, surge, fluctuation	— Read via computerized monitoring and management software

07 EXAM TRAPS

where the knowledge check gets you

- × “A higher PUE is better.” — Backwards. **Lower** PUE means higher efficiency: PUE 1.2 (DCiE 83%) is highly efficient, PUE 3.0 (DCiE 33%) is inefficient, and every overhead watt adds cost.
- × “PUE and DCiE are the same measurement.” — DCiE is the **inverse** of PUE. PUE is a ratio ≥ 1 (total ÷ IT power); DCiE is a percentage (IT ÷ total power).
- × “PUE is expressed in watts or some other unit.” — PUE is **unit-less** — that is exactly what makes it easy to clarify, compare, and adapt.
- × “Use the equipment's rated power capacity to compute PUE.” — Use the **precise IT load value**, not rated capacity, or the number is wrong.
- × “SEER and EER are interchangeable.” — Both divide output cooling (BTU) by electrical input (Wh), but **SEER** measures a whole season of varying outdoor temperatures while **EER** ignores seasonal conditions and reflects only machinery-created conditions.
- × “HSPF rates cooling efficiency.” — HSPF measures the **heating** mode, so it applies only to **heat pumps or reversible units**, never cooling-only equipment (HSPF × 0.0293 = COP).
- × “HVAC is a minor part of the power budget.” — Cooling runs continuously and accounts for almost **40%** of a data center's total power consumption.
- × “Permanent instruments are installed only temporarily.” — Reversed: **portable** instruments are temporarily installed and removed; **permanent** instruments are fixed for continuous, real-time monitoring.

08 SELF-QUIZ

answers are upside-down below

Q1 Write the formula for power usage effectiveness (PUE).

Q2 How does DCiE relate to PUE, and in what form is it expressed?

Q3 A data center reports a PUE of 1.2 — what is its DCiE and efficiency level?

Q4 Which organization developed PUE, and what property makes it easy to compare?

Q5 Name the three elements that link PUE to airflow management.

Q6 CADE is the product of which two efficiencies?

Q7 Approximately what percentage of a data center's total power does the HVAC system consume?

Q8 Which three ratings are used to monitor an HVAC system's PUE?

Q9 What is the ideal range for HVAC effectiveness (the IT-energy to HVAC-energy ratio)?

Q10 Which instrumentation type is used on an as-needed basis by qualified professionals, and which provides automatic real-time and historical data?

ANSWER KEY (rotate the page)

Q1 PUE = total power supplied to the data center ÷ IT equipment power consumed **Q2** It is the inverse of PUE (IT power ÷ total power), expressed as a percentage **Q3** DCiE 83%, highly efficient **Q4** Green Grid; PUE is a unit-less ratio **Q5** Separating returning warm air from supplied cold air, the volume of air inflow, and the temperature of air inflow **Q6** Facility efficiency and IT asset efficiency **Q7** Almost 40% **Q8** SEER, EER, and HSPF **Q9** 0.6 to 3.5 **Q10** Portable is used as-needed; permanent provides real-time and historical data