

# Measuring Data Center Productivity

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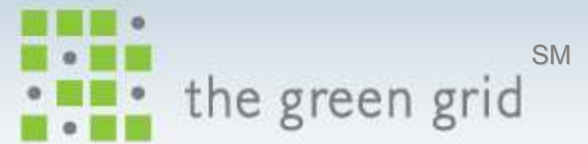
Metrics and Measurements Work Group

# Agenda



- What is Data Center Productivity (DCP)?
- Why DCP?
- The Green Grid's approach to measuring DCP
- DCP Task Force current status
- First Data Center energy Productivity (DCeP) test results
- Next steps / long term vision
- Q&A

# What is Data Center Productivity (DCP)?



- Methodology for quantifying the useful work that a data center produces relative to the quantity of any resource that it consumes to produce this work
- Mathematically expressed:

$$\text{DCP} = \frac{\text{Useful Work Produced by Data Center}}{\text{Resource Consumed Producing the Work}}$$

- With this generalization, DCP becomes a family of metrics each with a different quantity in the denominator
- Although a comparative metric is desired and still our goal, our immediate goal was to provide a tool that would allow a data center operator to baseline their own data center and compare its productivity today with yesterday
- Useful work is defined as completed tasks that have value to the end user or business supported by the data center.
  - Work output someone is willing to pay for has value

# Why DCP?



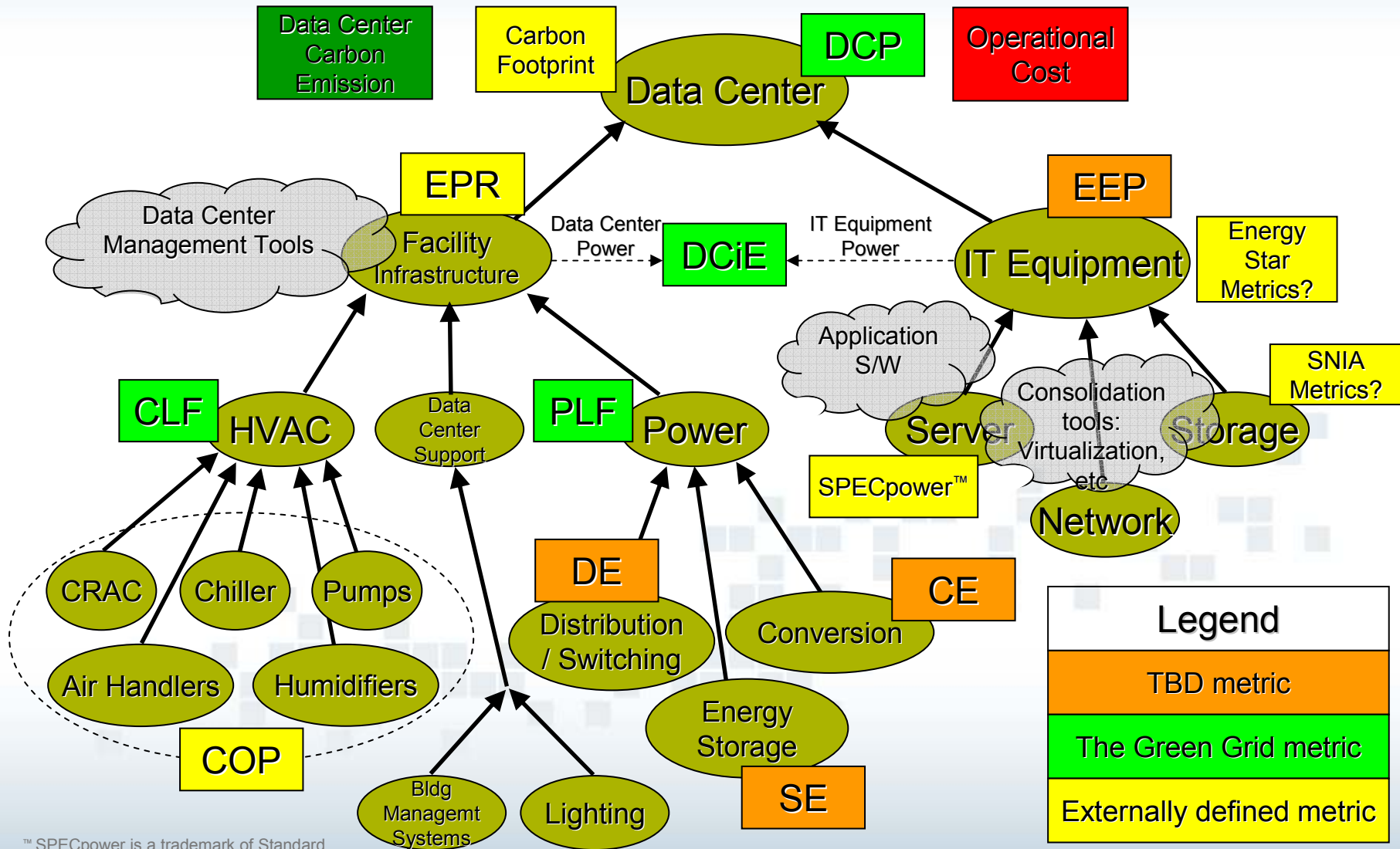
- Builds on the metrics Power Utilization Effectiveness (PUE) and Data Center infrastructure Efficiency (DCiE)
- DCiE works well for assisting in optimizing power consumption of infrastructure equipment
- DCiE not intended to measure the work output of IT equipment
- Actions taken to improve IT productivity may actually result in a *decrease* in DCiE if they reduce power utilized by the IT equipment
- To address both infrastructure and IT productivity needs, we need one or more metrics to complement PUE / DCiE
- Establish a baseline to measure improvement
  - Ultimate goal is to enable comparison of disparate data centers
- Further Green initiatives
- DCP has been recognized by many as the "*Holy Grail*" of data center metrics
  - Data centers are *information factories* that typically measure the input but not the output

# The Green Grid's Approach to Measuring DCP

Metrics and Measurement Work Group Metrics Taxonomy

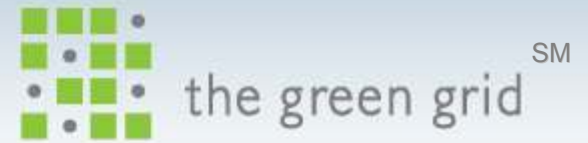


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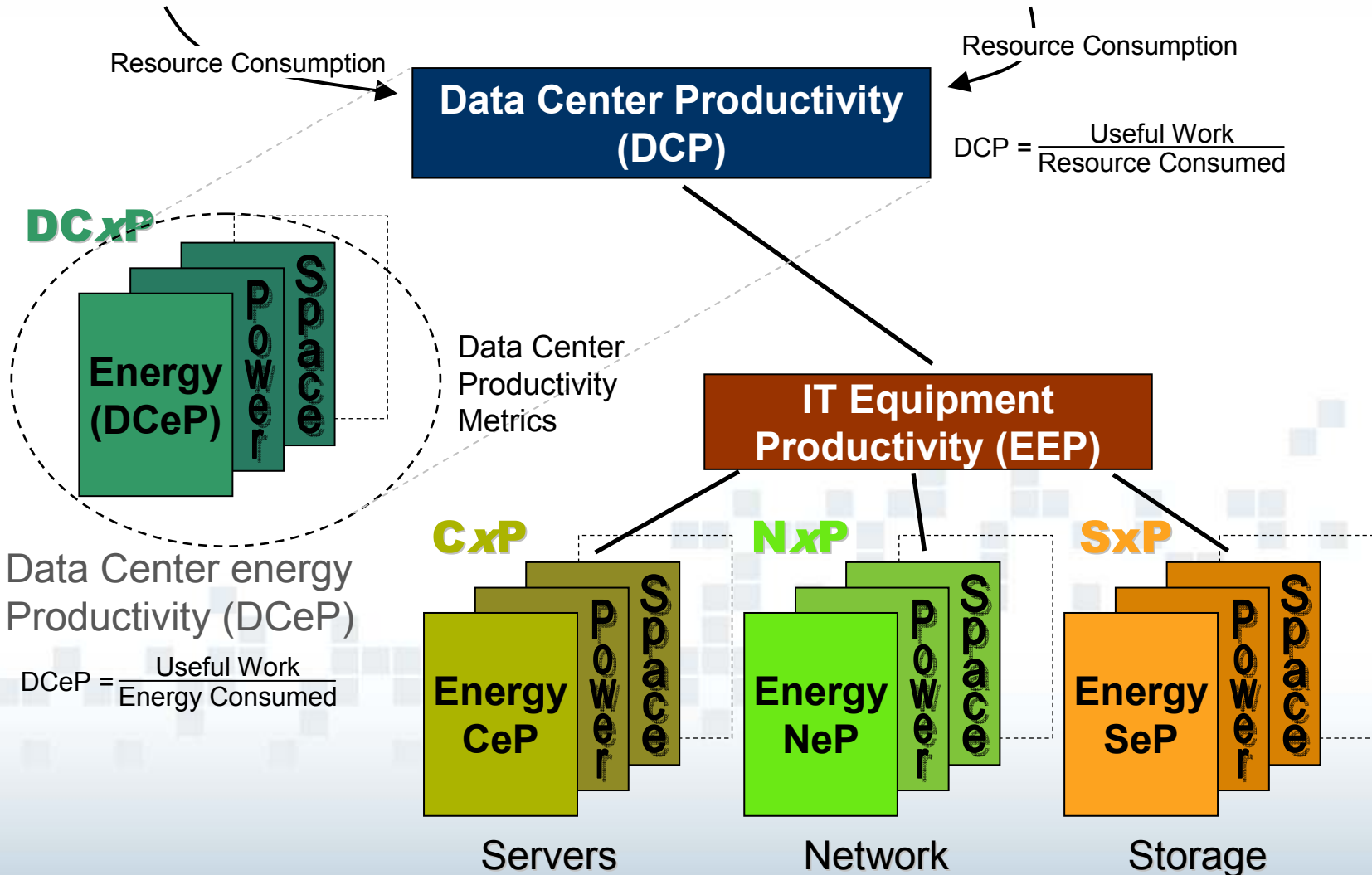
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# Family of Productivity Metrics



Facilities Infrastructure

Information Technology Equipment

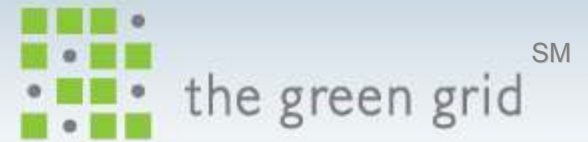


$$DCP = \frac{\text{Useful Work}}{\text{Resource Consumed}}$$

Data Center energy Productivity (DCeP)

$$DCeP = \frac{\text{Useful Work}}{\text{Energy Consumed}}$$

# DCP Task Force Current Status



- The Data Center Productivity Task Force within the Metrics & Measurements Work Group have been working on a methodology to quantify DCeP

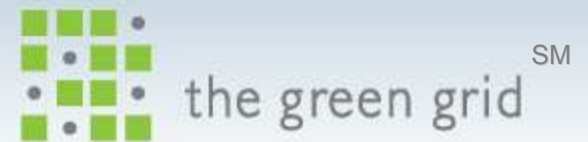
$$\text{DCeP} = \frac{\text{Useful Work}}{\text{Energy Consumed}}$$

- Proposed the following to quantify the numerator:

$$\text{Useful Work} = \sum_{i=1, M} V_i U_i(t) T_i$$

- In its simplest form, quantifying useful work involves counting the number of tasks that complete during a fixed period of time called the “assessment window”
- Capturing more complex characteristics of the workload
  - Add a weight (value)  $V_i$  which accounts for the fact that not all tasks have the same value to the business or end user
  - Add a time-based utility function  $U_i(t)$  that accounts for a customer service level agreement (SLA)
  - Each task to be counted is modified by the product of  $V_i$  and  $U_i(t)$
  - Sum together all terms  $V_i * U_i(t) * T_i$  for the tasks within the assessment window to obtain a measure of work completed

# First DCeP Test Status



- Ran a laboratory experiment using the eCommerce workload of SPECweb<sup>®</sup>\_2005
  - Done for research purposes. Not a conforming run of the SPECweb<sup>®</sup> benchmark
  - Workload defines the “tasks” which are web page requests from simulated clients performing typical eCommerce tasks along with the responses from the webserver
  - Defines the following request types:
    - Index, Search, Browse, Browse\_Productline, ProductDetail, Customizel, Cūstomize2, Customize3, Cart, Login, Shipping, Billing, and Confirm
  - Used the request type and its response to define a task type
  - The standard benchmark software keeps track of the response times and counts completed tasks during the measurement phase of the benchmark. We used this software as-is
  - Power was measured at one second intervals using 3 Extech model 380803 power meters. Data logged to a laptop computer

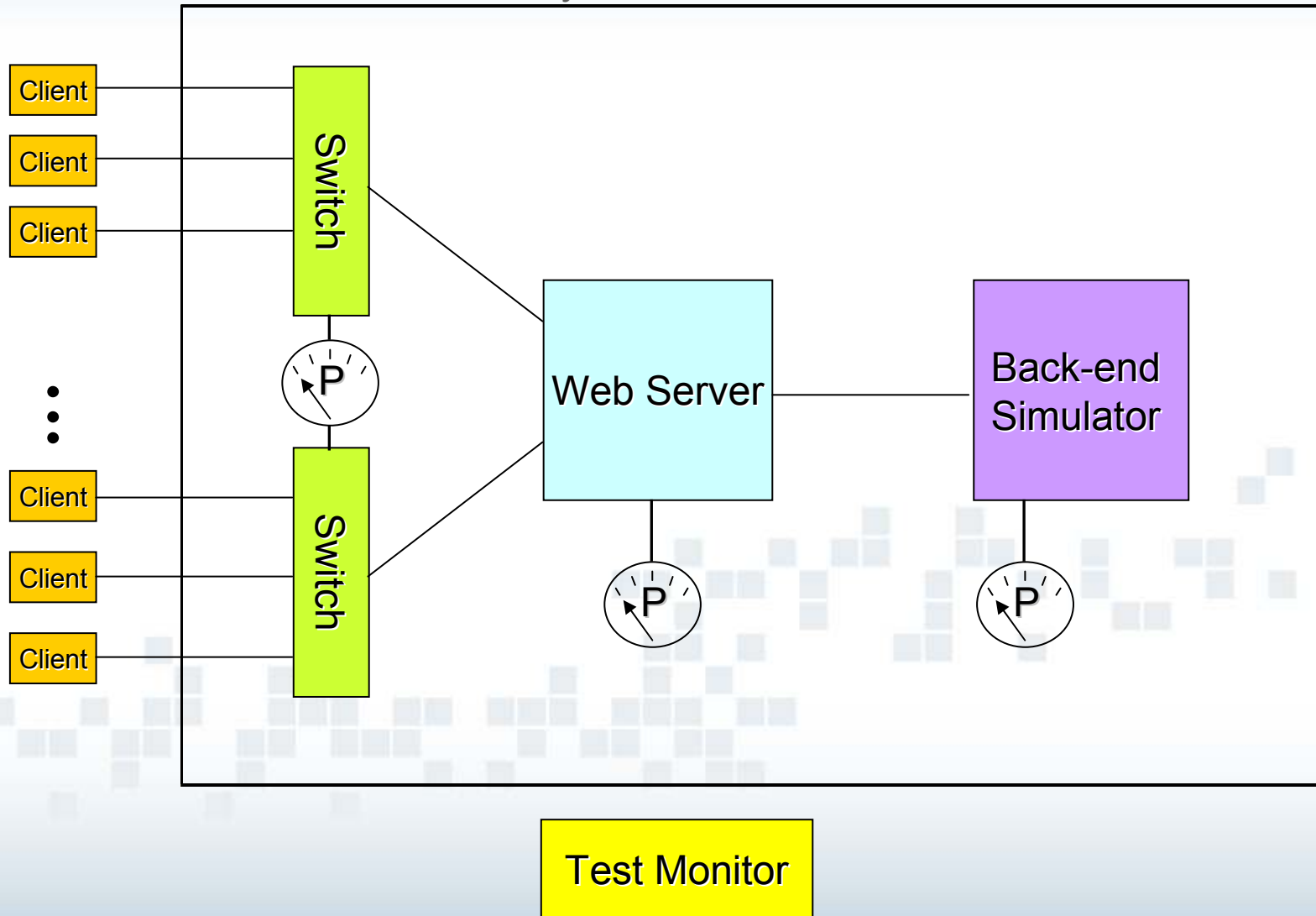
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# Example Computation of DCeP

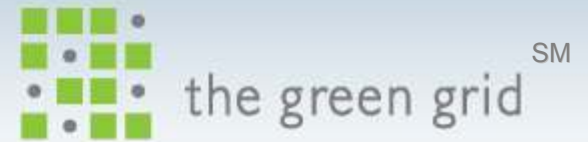


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System under test



# Experiment Results



- First determined the maximum number of simulated users that the system under test would support running the eCommerce workload
- Backed off the number of users to 66% of the maximum
- First “warmed up the system” to fill memory and storage caches, then started both task completion and power measurement data logging
- A total of 675075 requests were satisfied during the assessment window time period
- 0.4582 kWhrs of energy was consumed by the SUT equipment
- Assumed that for our “data center” 0.7W of power are used in conditioning the power and cooling the equipment for every watt delivered to the equipment

$$DCeP_{exp} = 675075 / (0.4582 * 1.7) = 866,658 \text{ Normalized Tasks/ kWhr}$$

# Next Steps / Long Term Vision

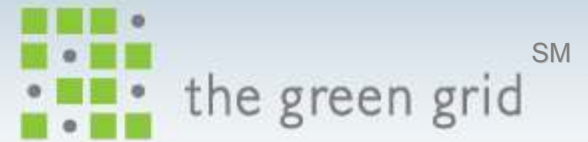


- Further the automation of DCeP
- Further clarify the definition of DCeP “tasks” to enable the metric to be more widely adopted
- Follow the framework as outlined previously to continually evolve the DCP metric family
- M&M WG are currently requesting from the Technical Committee to create a new Task Force to work with our Liaison groups in achieving global alignment with DCiE, DCeP, and any new metrics identified
  - A shorter term DCP “proxy” deliverable has shown a great deal of interest within the Green Grid and (hopefully) partnering with group(s) like the European Union Code of Conduct
- Spark additional interest within The Green Grid membership to help support the existing and proposed new Task Force
- Ultimate goal is to reintegrate the various productivity metrics to support a final DCP metric and Data Center Rating System

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The Green Grid Technical Forum

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# Backup Slide – Metrics Taxonomy Acronyms



- CE – Conversion Efficiency
- CLF – Cooling Load Factor
- COP – Coefficient of Performance
- CRAC – Computer Room Air Conditioner
- DE – Distribution Efficiency
- DCiE – Data Center Infrastructure Efficiency
- DCP – Data Center Productivity
- EEP – Equipment Energy Productivity
- EPR – Electricity Production Rate (for Combined Heat and Power systems)
- HVAC – Heating, Ventilation, and Air Conditioning
- PLF – Power Load Factor
- SE – (energy) Storage Efficiency
- SNIA – Storage Networking Industry Association
- SPEC - Standard Performance Evaluation Corporation



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