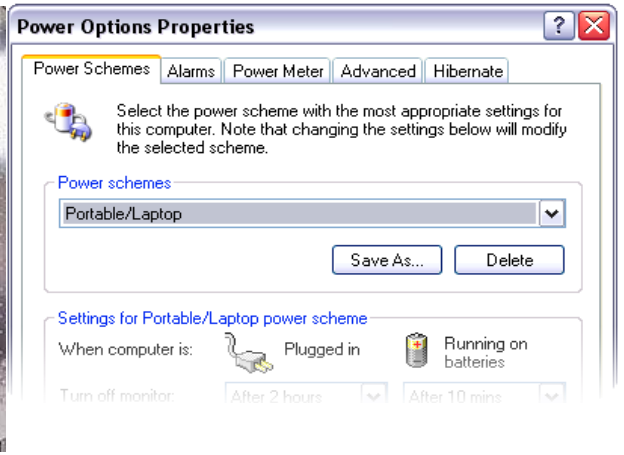
Intel® Corporation Presents:
The Eco-Technology Great Debates

ICT Metrics: From Silicon through the Data Center

Energy Issues Facing the IT Industry

- The global information and communications technology industry accounts for approximately **2% of global CO_2 emissions**.[1]
- Energy costs – typically around 10% of an IT budget—could account for **50% of the average IT budget** in just a few years.[1]
- "By 2010, about half of the Forbes Global 2000 companies will **spend more on energy** than on hardware such as servers."[1]



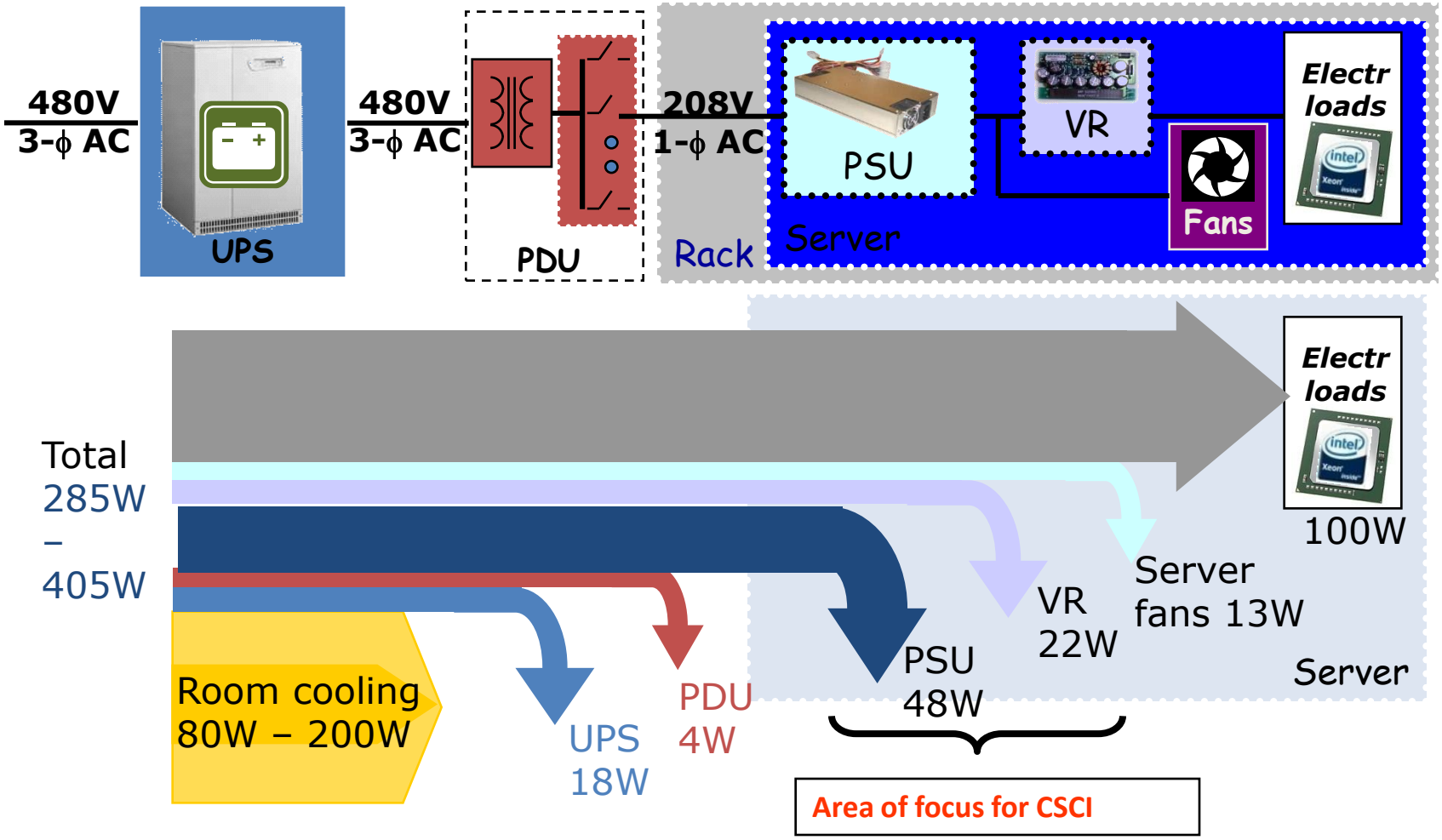
Climate Savers Computing Initiative*

- The Initiative is comprised of consumers, businesses and organizations that have come together to drive energy efficiency by:
  - Increasing the energy efficiency of new PCs and servers
  - Promoting the use of power management

Together, we can reduce computer power consumption 50% by 2010![1]

[1] www.climatesaverscomputing.org

Data Center Power Losses



Multi-Output PSU Efficiency Targets

	CSCI Baseline	CSCI Bronze	CSCI Silver	CSCI Gold
Load Condition				
20%	80%	82%	85%	87%
50%	80%	85% (Pf=0.9)	88% (Pf=0.9)	90% (Pf=0.9)
100%	80% (Pf=0.9)	82%	85%	87%

Single-Output PSU Efficiency Targets

	CSCI Bronze	CSCI Silver	CSCI Gold
Load Condition			
20%	81%	85%	88%
50%	85%	89% (Pf=0.9)	92% (Pf=0.9)
100%	81% (Pf=0.9)	85%	88%

What We are Working to Achieve by 2010

- Goal is to improve computing energy efficiency by **50%**
  - Collectively save **$5.5 billion** in energy costs
- Reduce global CO_2 emissions from computing platforms by **54 million tons** per year
  - Equivalent to removal of **11 million autos**
  - Or eliminating **20 coal plants** from the planet
  - Or planting **25,000 sq. miles** (~65,000 km^2) of trees

Back Up: Energy-Efficient Computers Pay for Themselves

Initial price premium*

Energy savings over first 1-2 years offset costs
Estimated Desktop Savings for 20-30 watt savings at $0.0885/kWh:
~$5.00/yr
~$7.00/yr reduced AC costs
~$11-18/yr power management
Utility rebates can further offset costs

Two Data Center Metrics

Rack Cooling Index (RCI)

Measure of how *effectively the equipment is cooled* within an intake temperature specification.

Return Temperature Index (RTI)

Measure of *level of by-pass air or recirculation air;* both phenomena are harmful to the thermal/energy performance.

Thermal Specifications

(@ Equipment Intake)	Min and Max Recommended (Facility)	Min and Max Allowable (Equipment)
Data Centers		
ASHRAE (2004)	20° – 25°C	15° – 32°C
ASHRAE (2008)	18° – 27°C	15° – 32°C
Telecom Centers		
NEBS (2001, 2006)	18° – 27°C	5° – 40°C

ASHRAE. 2004 & 2008. Special Publication, *Thermal Guidelines for Data Processing Environments,* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

Telcordia. 2001. (Herrlin, M.) Generic Requirements GR-3028-CORE, *Thermal Management in Telecommunications Central Offices*, Issue 1, December 2001, Telcordia Technologies, Inc., Piscataway, NJ.

Telcordia. 2006. (Kluge, R.) Generic Requirements NEBS GR-63-CORE, *NEBS Requirements: Physical Protection*, Issue 3, March 2006, Telcordia Technologies, Inc., Piscataway, NJ.

Determining the Compliance

ASHRAE Thermal Guidelines:

- The Thermal Specifications become truly useful when there is an objective way of determining the compliance. The Rack Cooling Index (RCI) was designed to gauge this compliance, and it "compresses" the intake temperatures into RCI_{HI} and RCI_{LO}.

- RCI_{HI} = 100% No over-temperatures
- RCI_{LO} = 100% No under-temperatures
- Both = 100% Absolute compliance

RCI and RTI Ratings

Measure of compliance with Temperature Specifications

Rating (ASHRAE Class 1)	RCI
Ideal	100%
Good	≥96%
Acceptable	91-95%
Poor	≤90%

Herrlin, M. K. 2008. *Airflow and Cooling Performance of Data Centers: Two Performance Metrics*. ASHRAE Transactions, Volume 114, Part 2.

Measure of level of by-pass air or recirculation air in data center

Rating	RTI
Target	100%
Recirculation	>100%
By-Pass	<100%

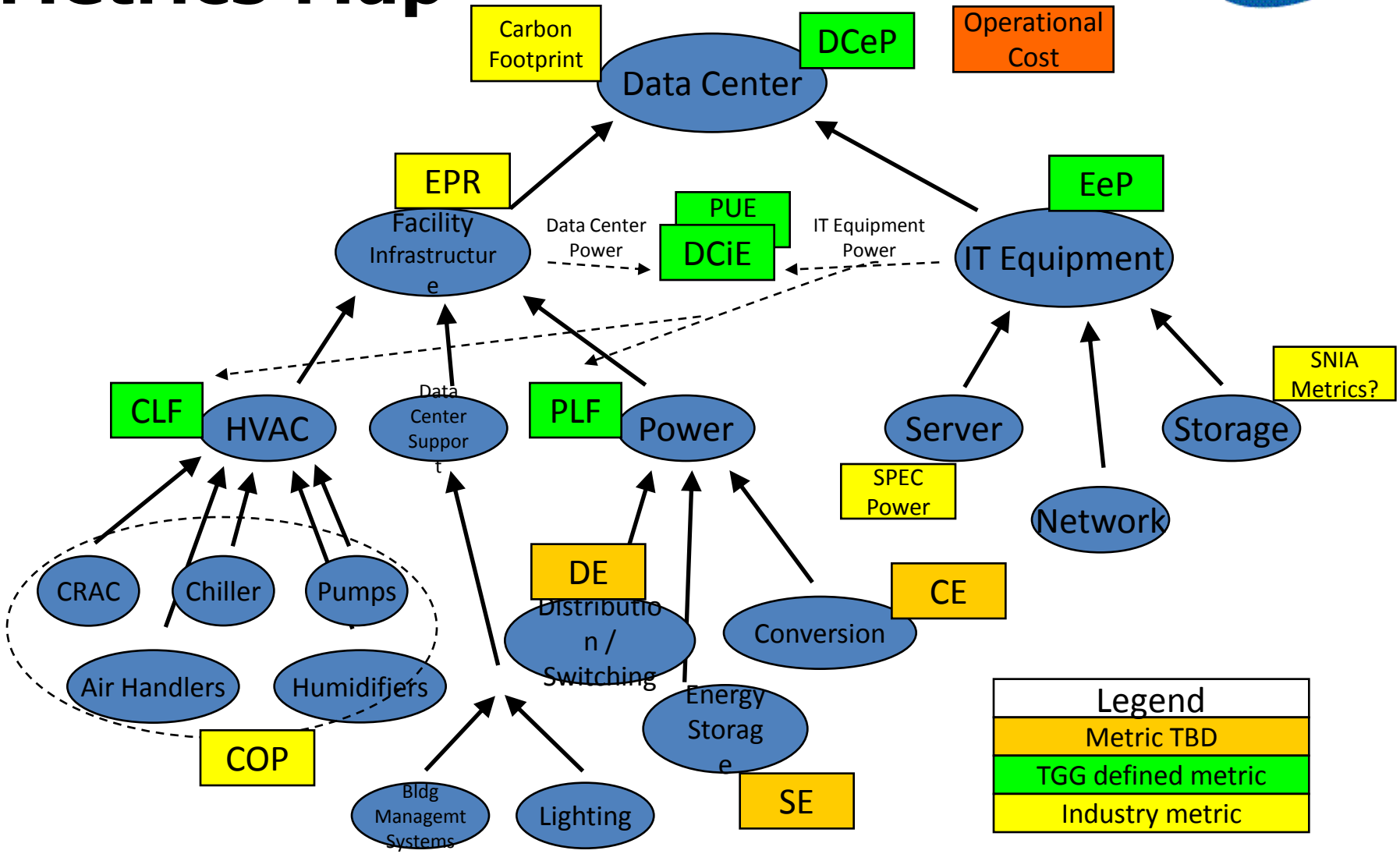
$$RTI = \left[\frac{V_{Equip}}{V_{AHU}}\right] 100\ [\%]$$

Example: LBNL Data Center

Metric	Value	Interpretation
RCI_{HI}	100%	No temperature above the recommended range (ideal)
RCI_{LO}	47%	Sever under-temperatures (<90% means “poor”)
RTI	53%	Sever over-ventilation by 89% (1/0.53)

These metrics are currently being incorporated into the DOE/LBNL Data Center Energy Assessment Protocol.

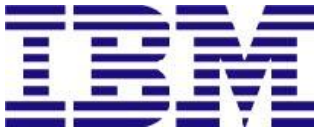
Metrics Map


Carbon Footprint
Data Center
DCeP
Operational Cost
EPR
Facility Infrastructure
Data Center Power
PUE
DCiE
IT Equipment Power
IT Equipment
EeP
CLF
HVAC
Data Center Support
PLF
Power
Server
Storage
SNIA Metrics?
SPEC Power
Network
CRAC
Chiller
Pumps
Air Handlers
Humidifiers
COP
DE
Distribution / Switching
Conversion
CE
Energy Storage
SE
Bldg Managemt Systems
Lighting
Legend
Metric TBD
TGG defined metric
Industry metric

The Green Grid

- A global consortium dedicated to advancing energy efficiency for data centers and business computing ecosystems by:
  - Defining meaningful, user-centric models and metrics
  - Developing standards, measurement methods, best practices and technologies to improve performance against the defined metrics
  - Promoting the adoption of energy efficient standards, processes, measurements and technologies
- www.thegreengrid.org

Who's In The Green Grid?
Board of Director Member Companies



Why Do Data Centers Exist?

- You know you have to have them!
  - Run your internal financial controls / business model
  - Maintain customer and product data bases
  - Provide Customer Relationship Management as well as Business to Business interface
  - Make all aspects of your business run more efficiently
  - Meet requirements of the law

- But . . .
  - Running a data center is expensive
  - Increases in capacity and density have turned the data center into an energy intensive "information factory"
  - The future? More growth! And no end in sight!

The Green Grid Initiatives:

Creating a framework for best practices

- Create shared definitions, benchmarks and metrics to enable real-time measurement monitoring and control of data center energy efficiency and productivity
- Create baseline 'state-of-the-industry' documentation including benchmark architectures and a repository of data center efficiency knowledge
- Create a comprehensive technology roadmap for future data center design to maximize efficient and productive operations
- Assess new and alternate data center technologies
- Monitor progress on all fronts and provide periodic updates

IT Industry Helping IT Users

Best Practices Whitepapers

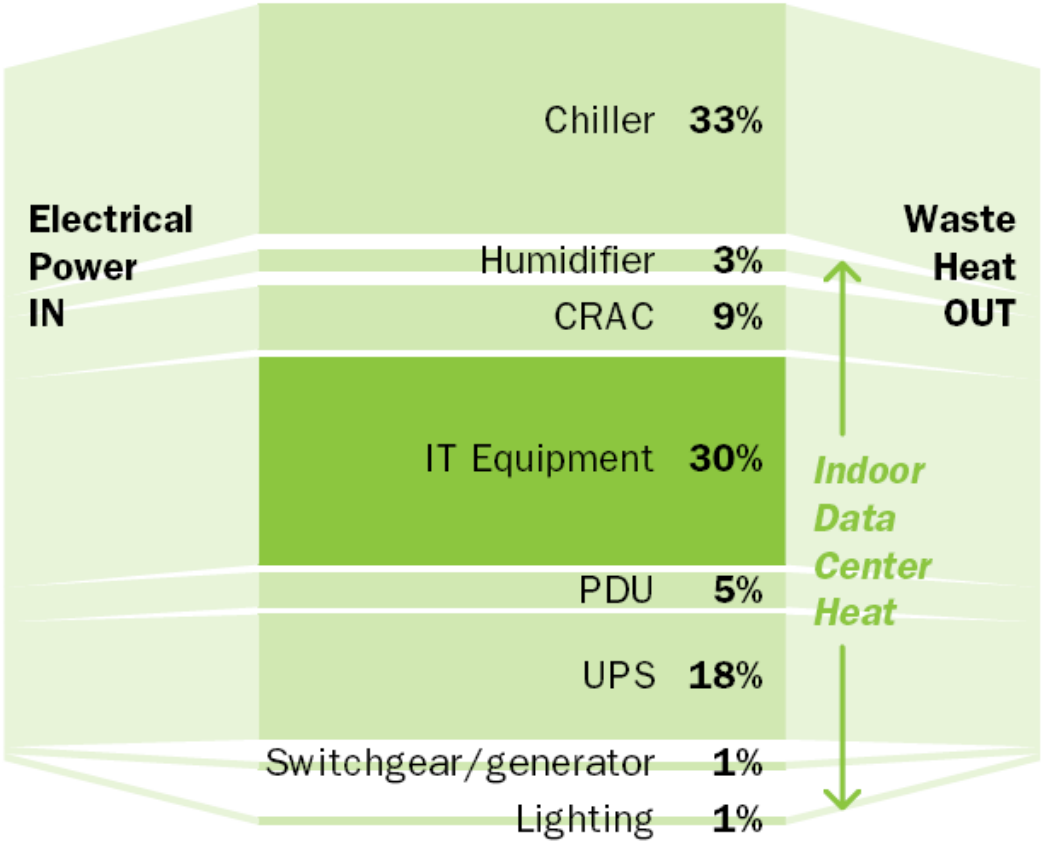
- Five Ways to Reduce Data Center Server Power Consumption
- Seven Cooling Strategies
- The Green Grid Data Center Power Efficiency Metrics: PUE and DCiE
- Qualitative Analysis of Power Distribution Configurations for Data Centers
- Guidelines for Energy Efficient Data Centers

See http://www.thegreengrid.org/gg_content/

Why Are Metrics Important?

- Awareness – "If you can't measure it, you can't improve it"
- Benchmarking
  - Improving operations – continuous improvement
  - Comparing across the industry – company to company
  - Improvement over time – generation to generation
  - Technology – validate claims
- Resulting in
  - Better efficiency
  - Better total cost of ownership

Where Does the Power Go?

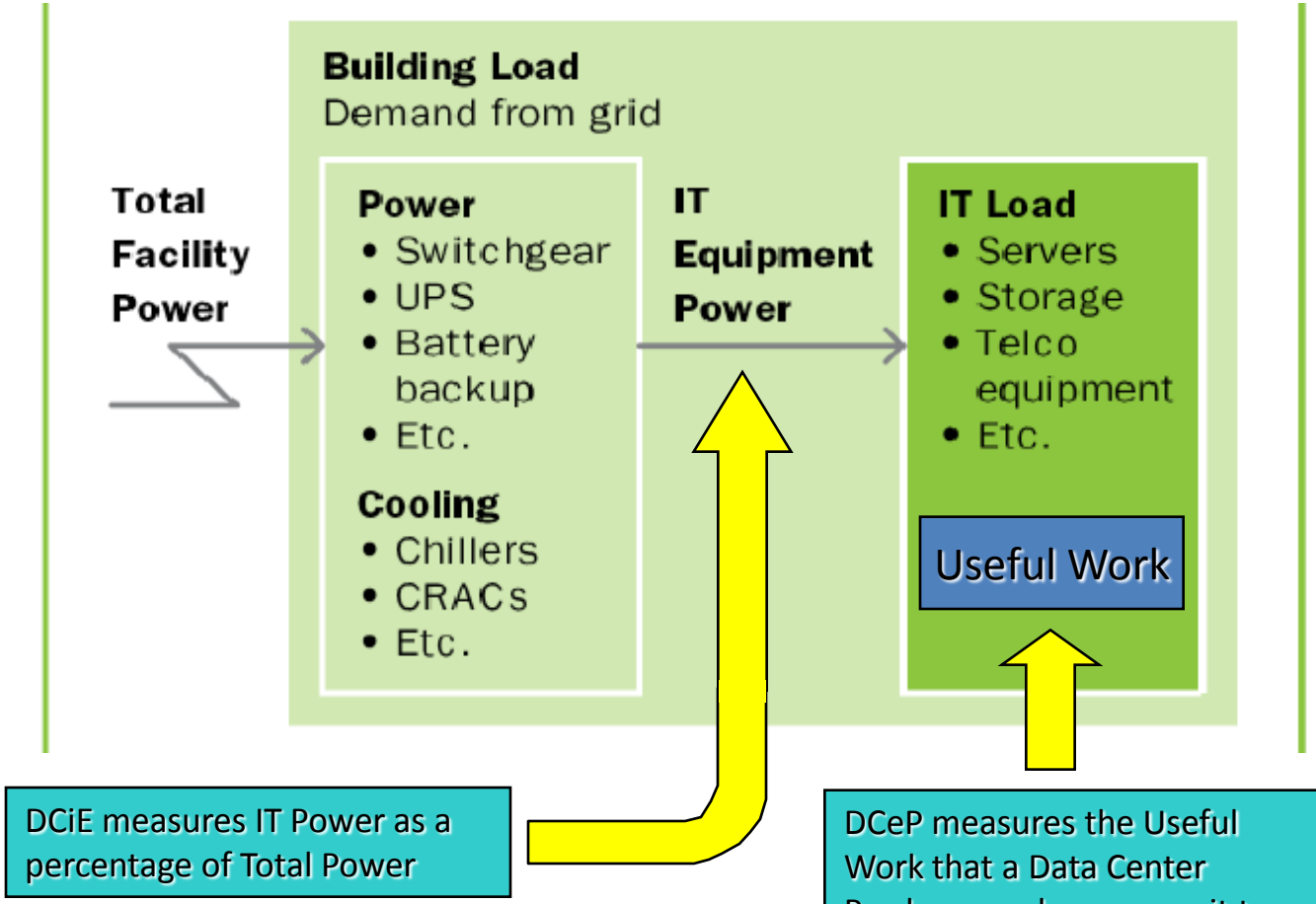


Individual data centers can vary substantially.

Data Center Metrics

- Data Center infrastructure Efficiency (DCiE)
  - Provides a figure of merit on how well your infrastructure equipment delivers power to your IT equipment and how well it removes the heat generated.
- Data Center energy Productivity (DCeP)
  - Measures the amount of useful work your IT equipment produces relative to the total amount of energy required to produce that work (including power delivery and heat removal).

Data Center Metrics



Data Center energy Productivity

What is Data Center Productivity (DCeP)?

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

$$\text{DCeP} = \frac{\text{Useful Work a Data Center Produces}}{\text{Energy Required to Produce this Work}}$$

- Useful work is defined as completed tasks that have value to the end user or business supported by the data center

Your Energy Action Checklist

- Conduct accurate assessments of energy use
- Validate assumptions and monitor consumption to assess opportunities and risks
- Systematically address individual data center efficiency issues
- Minimize impact to data center operations and business objectives
- Create an "Energy Strategy" which publicly states goals and milestones for the data center and for the enterprise

BACKUP

Who's In The Green Grid?

Contributor Members

- ADP
- Avocent
- Brocade Communications Systems
- BT plc
- Chatsworth Products, Inc.
- Cisco
- COPAN Systems
- Delta Products Corporation
- Digital Realty Trust
- Eaton
- EMC
- Emerson Network Power
- Enterprise-Rent-A-Car
- Fujitsu Limited
- Fujitsu Siemens Computers GmbH
- InterXion
- IXIA
- NEC Corporation
- Novell
- PG&E
- Pillar Data Systems
- QLogic
- Rackspace
- Saft Power Systems Inc.
- SatCon Stationary Power Systems
- STRATO Rechenzentrum AG
- SunGard Data Systems
- Symantec Corporation
- Teradata
- Texas Instruments
- The Uptime Institute
- Tokyo Electric Power Company
- Trane
- Verari Systems, Inc.
- Verdiem
- Vette Corp
- Western Digital
- ZT Group Int'l Inc

Who's In The Green Grid?

General Members

- 1E
- 365 Main
- 42U
- Active Power
- ADC
- Advanced Green Technologies
- Afco Systems
- Alfa Tech Cambridge
- Allstate
- Alpikom SpA
- Angstrom Microsystems
- Astaro Corporation
- Avnet Technology Solutions
- Azul Systems
- Betfair Limited
- BigFix, Inc
- Blackwave Inc
- BLADE Network Technologies
- Bloomberg LP
- Broadcom Corporation
- BULL SAS
- Capaciti
- Cassatt Corporation
- Cherokee International
- Ciena Corporation
- Coldwatt Inc.
- CommScope, Inc.
- Compellent Technologies
- Corning Cable Systems
- CRAY INC
- Crossbeam Systems Inc
- Data Domain, Inc.
- Degree Controls, Inc
- Devon IT
- Dimension Data
- Dot Hill Systems Corp
- EBSCO Publishing
- EDS
- EqualLogic, Inc
- Equinix, Inc
- e-shelter facility services
- Evoswitch Netherlands B.V.
- ExaGrid Systems
- Exelon Corporation
- Facebook
- FedEx
- Force10 Networks
- Forsythe Solutions Group, Inc
- Fujitsu FIP Corporation
- GE Consumer & Industrial
- GlassHouse Technologies (UK)
- GMO Hosting & Security, Inc
- Green Data Systems
- Greene Engineers
- Hangzhou H3C Technologies Co., Limited
- Hifn, Inc.
- Hitachi, Ltd.
- Host Europe GmbH
- INDILINX Co., Ltd.
- Infinity SDC Limited
- Internet Initiative Japan Inc.
- Intransa, Inc.
- ITOCHU Techno-Solutions Corporation
- Juniper Networks
- Keysource Ltd
- Lee Technologies
- Lockheed Martin Corp
- Logicalis UK Limited
- LSI
- Mandragore
- Mazzetti & Associates
- Mellanox Technologies
- Micron Technology, Inc.
- Mitsubishi UFJ Securities International plc
- National Semiconductor
- NaviSite Inc.
- Netezza
- Network Appliance
- NetXen Inc
- News Corporation
- Nexsan Technologies
- Nomura Research Institute, Ltd.
- nscglobal Ltd.
- NTT America, Inc
- NTT COMWARE Corporation
- NTT DATA CORPORATION
- NTT Facilities, Inc
- ONStor Inc
- Ortronics
- OSI soft, Inc.
- Overland Storage
- Panduit Corp
- Platform Computing
- PowerFile
- Qimonda
- Quantum Corporation
- Quantum Energy Services & Technologies, Inc.
- RACKWISE
- RampRate Sourcing Advisors
- Raritan, Inc.
- RipCode, Inc.
- Rittal Corporation
- Rothstein Kass
- S & C Electric Company
- Samsung Electronics Company, Ltd
- Savvis
- Seagate Technology
- Sepaton
- Server Technology Inc
- ServerVault Corp
- SGI
- Siemens Corporate Research
- Silicon Mechanics
- SingleHop, Inc
- SmartBunker
- SOFTBANK IDC Corp
- SoftLayer
- Source IT Energy
- Spectra Logic
- Storwize Inc
- Synapsense
- Syska Hennessy
- TA Migration Solutions LTD
- Tandberg Data
- TEAM Technologies, LLC
- Telvent
- Terremark Worldwide, Inc.
- Total Site Solutions
- Tretecnic Pty Ltd
- Triangle Computer Services
- Underwriters Laboratories, Inc
- Unisys Corporation
- University of California, San Diego
- UTC Power
- Vossel Solution
- Wipro Technologies
- Wright Line LLC
- Xiotech
- Xyratex