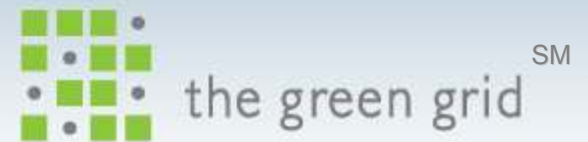


The Green Grid Data Center Metrics

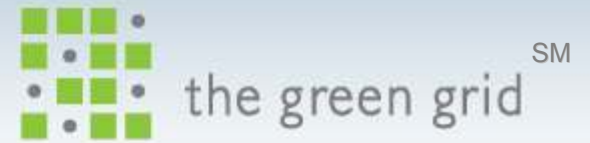
Christian Belady, PE, Microsoft
Metrics and Measurement Work Group

Agenda



- How are we organized?
- Metrics and Measurement Work Group
 - Mission
 - Membership
 - Problem space map
 - Family of productivity metrics
 - Task forces
- Why are metrics important?
- Overview of published Metrics and Measurement Work Group white papers
 - The Green Grid data center power efficiency metrics: PUE and DCiE
 - Existing metrics, guidelines and programs affecting data center and IT energy efficiency
- Metrics and Measurement Work Group sponsored sessions

How are we organized?



**The Green Grid
Board of Directors**



**The Green Grid
Technical Committee**

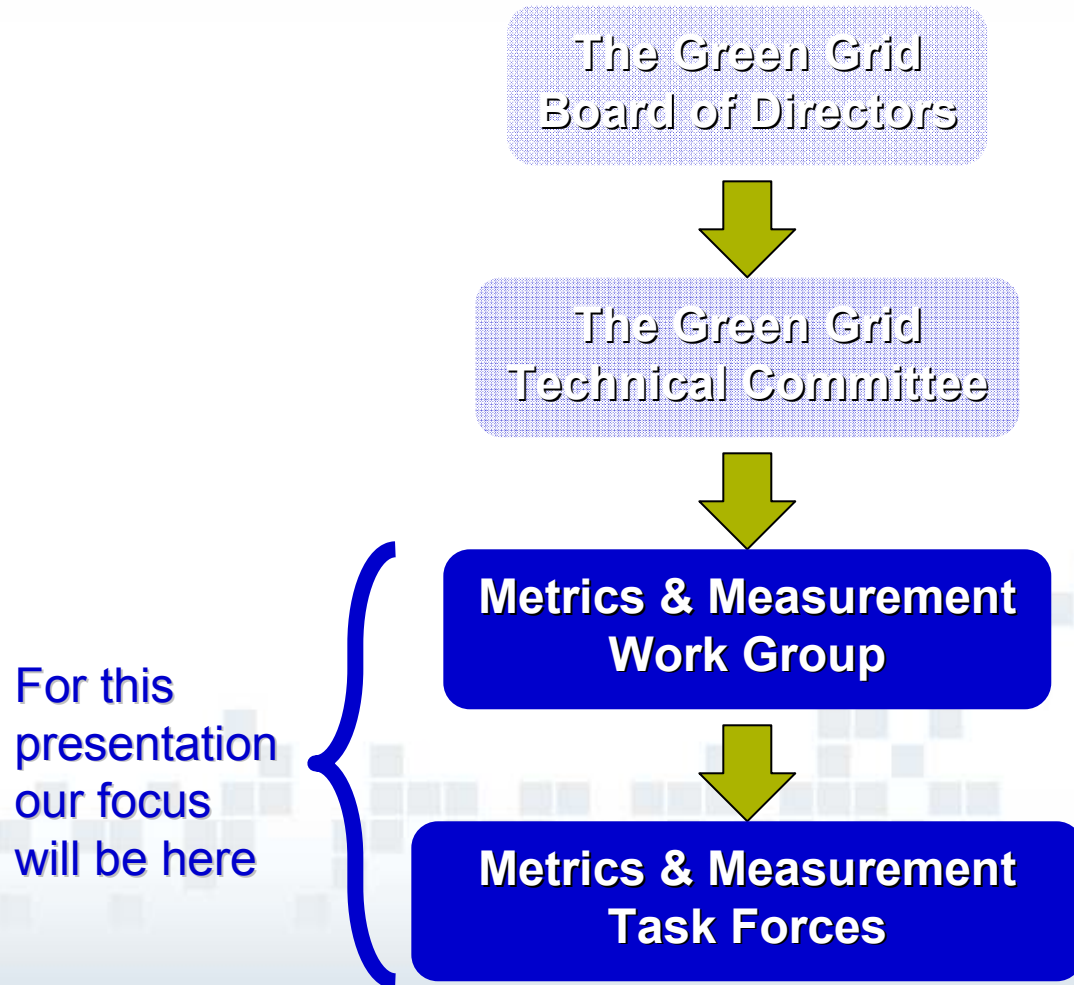
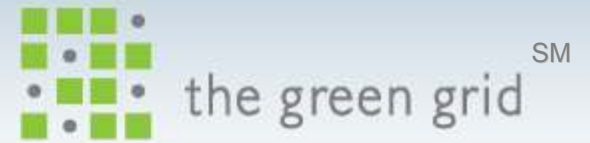


**Metrics & Measurement
Work Group**



**Metrics & Measurement
Task Forces**

How are we organized?



Metrics and Measurement Work Group



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- Mission

- Provides the means and methods for measuring key data center and data center subsystem performance characteristics
- Provides protocols for energy-efficient data centers

- Members

- 43 Active members
- 43 Observers
- 2 Chairs

- Voting Companies

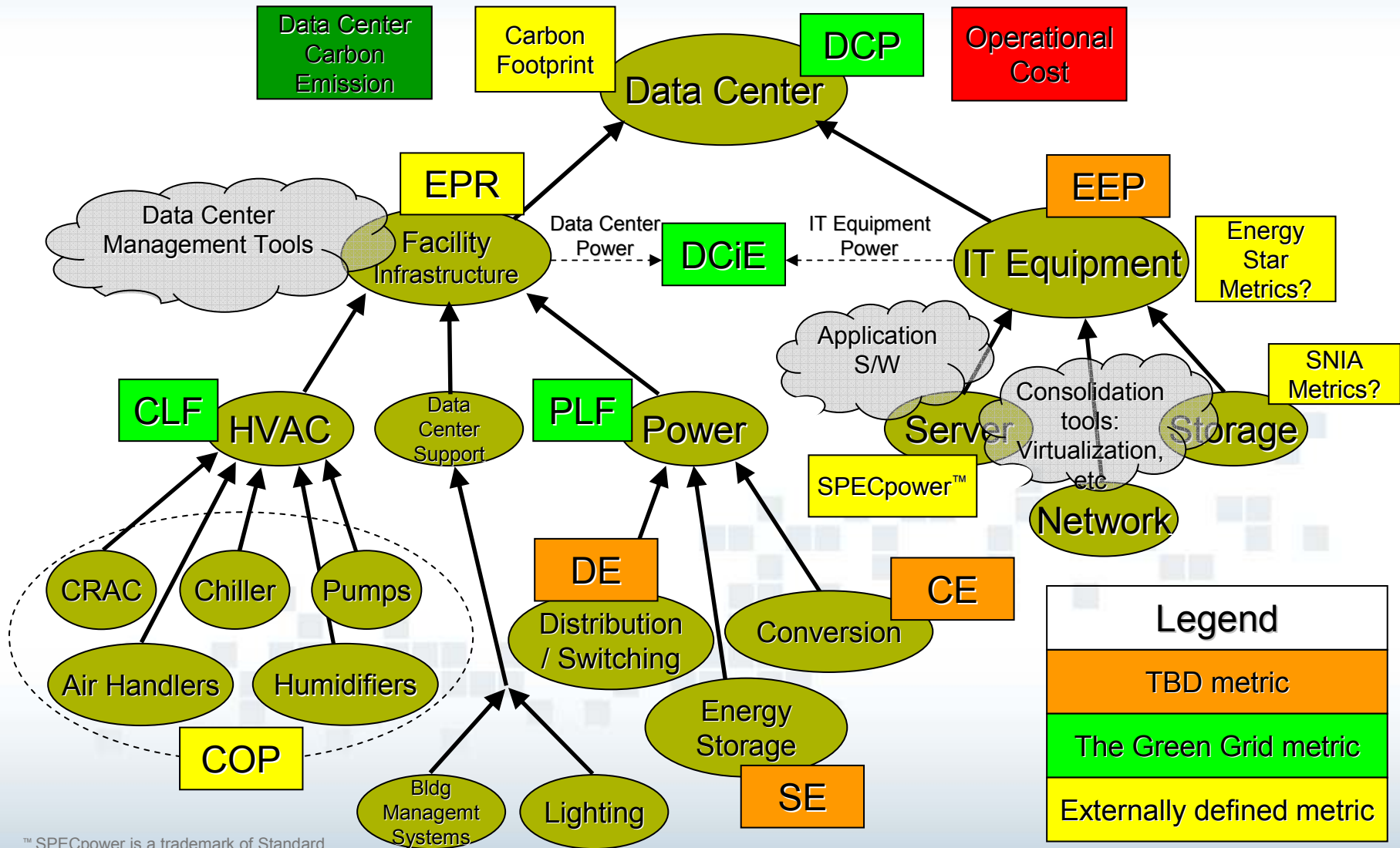
- 21 Companies
 - Each Contributor member company has 1 vote

The Green Grid's Approach to Measuring DCP

Metrics and Measurement Work Group Metrics Taxonomy

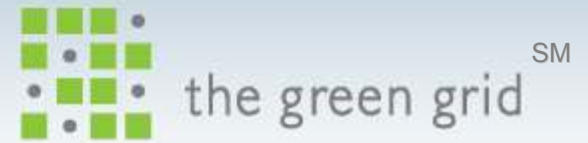


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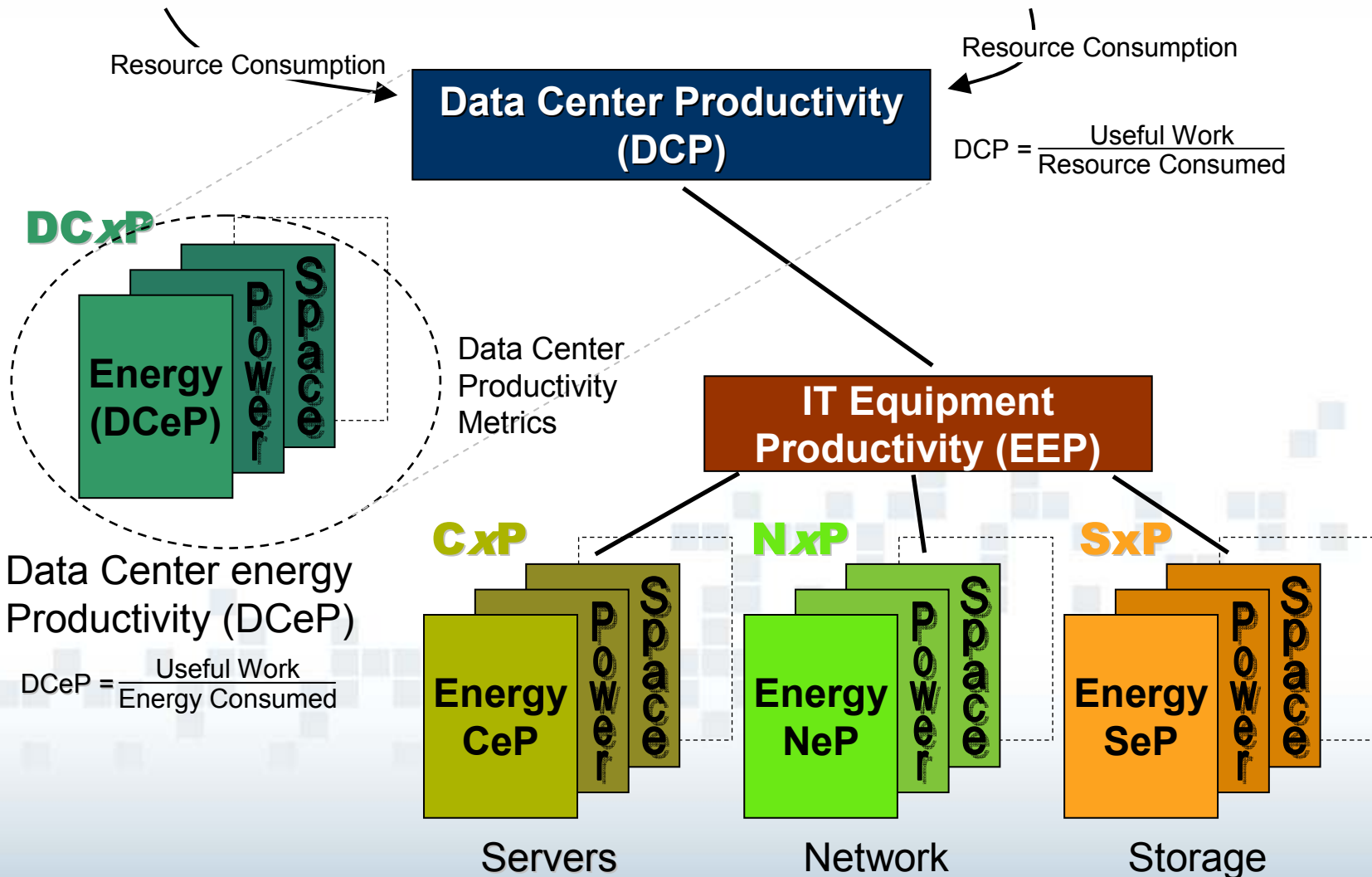
™ SPECpower is a trademark of Standard Performance Evaluation Corporation (SPEC)

Family of Productivity Metrics

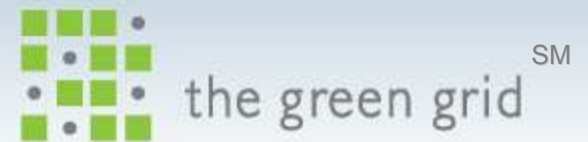


Facilities Infrastructure

Information Technology Equipment

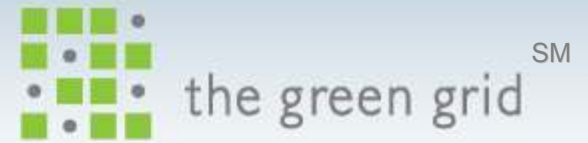


Task Forces



1. Problem Space Roadmap Task Force (Andy Rawson)
 - Provide a pictorial view of industry metrics
2. Re-publish Metrics Task Force (Christian Belady)
 - Refresh and refinement of Metrics white paper
3. Existing Metrics Task Force (Gary Verdun)
 - Existing Metrics / Protocols white paper
4. DC Productivity Analysis Task Force (Andy Rawson)
 - DC Productivity map and white paper
5. DCiE Detailed Analysis Task Force (Dan Azevedo)
 - DCiE breakdown to component level white paper
6. Rating System Task Force (Roger Tipley)
 - Provide a rating system and consistent methodology
7. Global Metrics Alignment Task Force (TBD)
 - Drive adoption of Global metrics by working with EU

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

Overview of White Papers



The Green Grid Data Center Power Efficiency Metrics: PUE and DCiE

- The Green Grid provides an update to the first white paper called “The Green Grid Data Center Power Efficiency Metrics” which
 - First introduced PUE (Power Usage Effectiveness) as an industry metric for data center infrastructure efficiency
 - Also, introduced DCE (Data Center Efficiency) which was the reciprocal of PUE but was not explicitly recommended as an industry metric
- The updated paper was a result of industry feedback
 - Clarification on the definition of PUE and DCE
 - DCE was morphed to Data Center Infrastructure Efficiency (DCiE)
 - Industry’s desire to also have a true industry efficiency metric (i.e. 0-100%)
 - Environmental Protection Agency and Lawrence Berkeley National Laboratory prefer this
 - Industry’s desire to explicitly state that the metric is designated for infrastructure

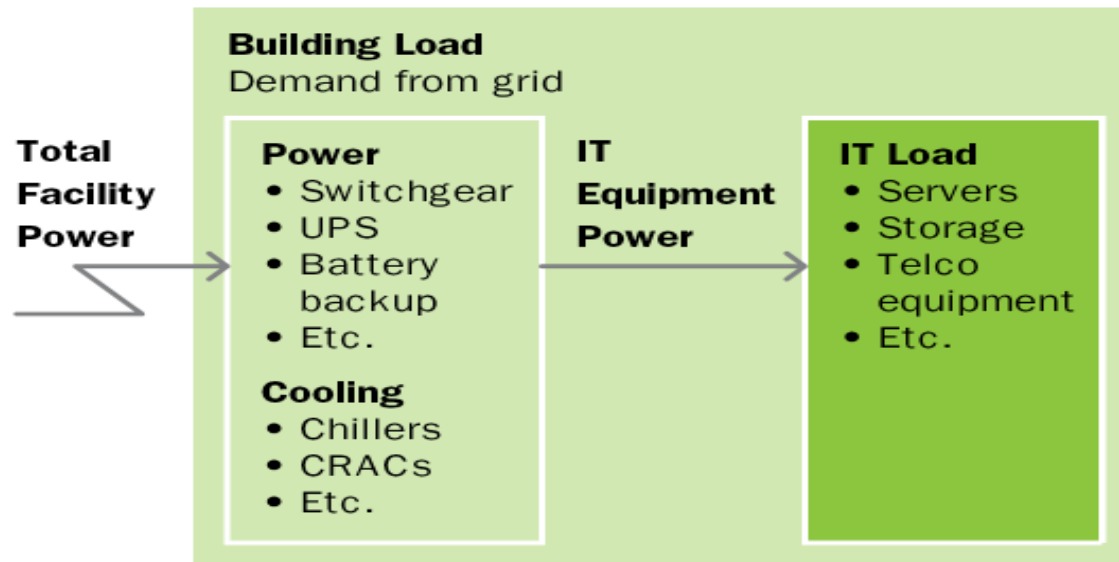
The Green Grid Data Center Power Efficiency Metrics: PUE and DCiE



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DCiE: Data Center Infrastructure Efficiency

DCE: Data Center Efficiency



$$\text{PUE} = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

$$\text{DCiE} := \frac{1}{\text{PUE}} = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}} \leftarrow \text{(Multiply both terms by 100\%)}$$

The Green Grid Data Center Power Efficiency Metrics: PUE and DCiE



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- Paper also lays the foundation for future work in the area of metrics
 - Metrics such as Data Center Productivity that may have the form as follows:

$$\text{Data Center Productivity} = \frac{\text{Useful Work}}{\text{Total Facility Power}}$$

- Dissection of PUE and DCiE

$$\text{PUE} = 1/\text{DCiE} = \text{Cooling Load Factor (CLF)} + \text{Power Load Factor (PLF)} + 1.$$

Uninterruptible power supplies (UPS)

Chillers

Direct expansion (DX) units

Cooling tower

Distribution losses external to the racks

Batteries

Servers

Switch gear

Computer room air conditioners

Pumps

Generators

Power distribution units (PDUs)

Lighting

Storage

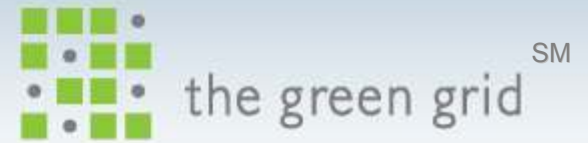
Overview of White Papers



Existing Metrics, Guidelines and Programs Affecting Data Center and IT Energy Efficiency

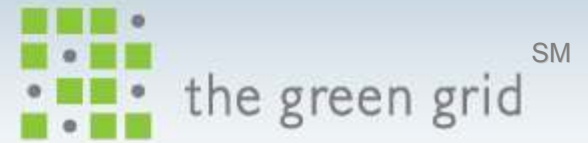
- The Green Grid provides a survey of various organizations that are currently investigating issues surrounding data center power and energy efficiency
- Provides the following for each organization considered
 - Overview of the stated purpose and scope of the organization
 - A list of any metrics or programs managed by the organization that relate to data center energy efficiency
 - Area of data center addressed
 - Lifecycle stage of data center addressed
 - The Green Grid's commentary on the organization or metric, where appropriate

Existing Metrics, Guidelines and Programs Affecting Data Center and IT Energy Efficiency



- Organizations / Metrics Covered
 - 80 Plus program
 - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
 - Alliance for Telecommunications Industry Solutions (ATIS)
 - Climate Savers Computing Initiative
 - Ecma
 - EPA Energy Star
 - PG&E High Tech Energy Efficiency Incentive
 - Server Energy Measurement Protocol
 - Standard Performance Evaluation Corporation (SPEC) - Power and Performance Committee
 - Storage Network Industry Association (SNIA)
 - Space, Watts and Performance (SWaP)
 - U.S. Green Building Council (USGBC)
 - The Uptime Institute
 - The Green Grid

How it Fits into The Green Grid Roadmap



- Survey existing metrics
 - The Green Grid will leverage existing metrics whenever possible and focus its efforts on areas in need of revised or new metrics
- Evaluate areas in most need of new or improved metrics
- Develop appropriate metrics directed at those areas identified as having the greatest need
- This work forms the backdrop for future papers to be published by The Green Grid

Metrics and Measurements Work Group Sponsored Sessions



Christian Belady, Microsoft

Roger Tiple, HP (Moderator)

Paul Scheihing, U.S. Department of Energy
 Bill Tschudi, U.S. Department of Energy
 Michael Zatz, U.S. Environmental Protection Agency
 Jan Viegand, European Commission,
 Paul Roggensack, California Energy Commission
 Ray Pfeifer, Silicon Valley Leadership Group

Dan Azevedo, Symantec
 Andy Rawson, AMD

Christian Belady, Microsoft (Moderator)

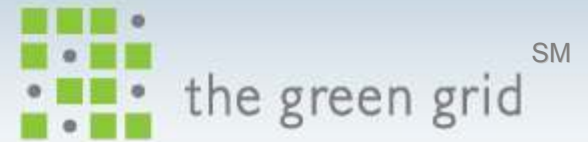
Jim Smith, Digital Realty Trust
 Ken Uhlman, Eaton
 Wade Vinson, Hewlett-Packard
 Kelly Roark, Microsoft
 Tommy Darby, Texas Instruments

Agenda (subject to change)		
Tuesday, February 5, 2008		
	Track 1	Track 2
9:00am	Keynote and Open Session	
10:30am	Global Perspective in Energy Efficiency	
12:00pm	Break	Break
12:30pm	Working Lunch: The Green Grid Data Center Metrics	
1:30pm	Rating Systems for Data Centers Panel	
3:00pm	Break	Break
3:30pm	Industry's Collaboration with Government on Energy Efficiency – Information Technology Industry Council	Utility Incentive/Rebate Initiatives Panel
4:45pm	Baseline Efficiency Measurement Market Study (Members-Only Session)	ASHRAE's Building Ratings and Codes
6:00pm	Reception	
Wednesday, February 6, 2008 (members-only)		
	Track 1	Track 2
8:00am	Leveraging IT and Facilities Organizational Behavior	The Green Grid's Initial Technology Roadmap
9:00am	Measuring Data Center Productivity	Peer Review of Lawrence Berkeley National Laboratory Study on Direct Current in the Data Center
10:15am	Break	
10:45am	Five Ways to Save Server Power	Seven Ways to Improve Cooling
12:15pm	Lunch	
1:30pm	Measuring DCiE Today Panel	
3:00pm	Break	
3:30pm	The Green Grid Annual Members' Meeting / Member Feedback	

Thank you for attending
The Green Grid Technical Forum

For more information please go to
www.thegreengrid.org

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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get connected to efficient IT

