ACTIVITY BASED MODELING for DATA CENTER ENERGY EFFICIENCY PROJECTS

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Why DC's Are Growing: Communications Revolution Plus….

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Why DC's Are Growing: IT is Advancing

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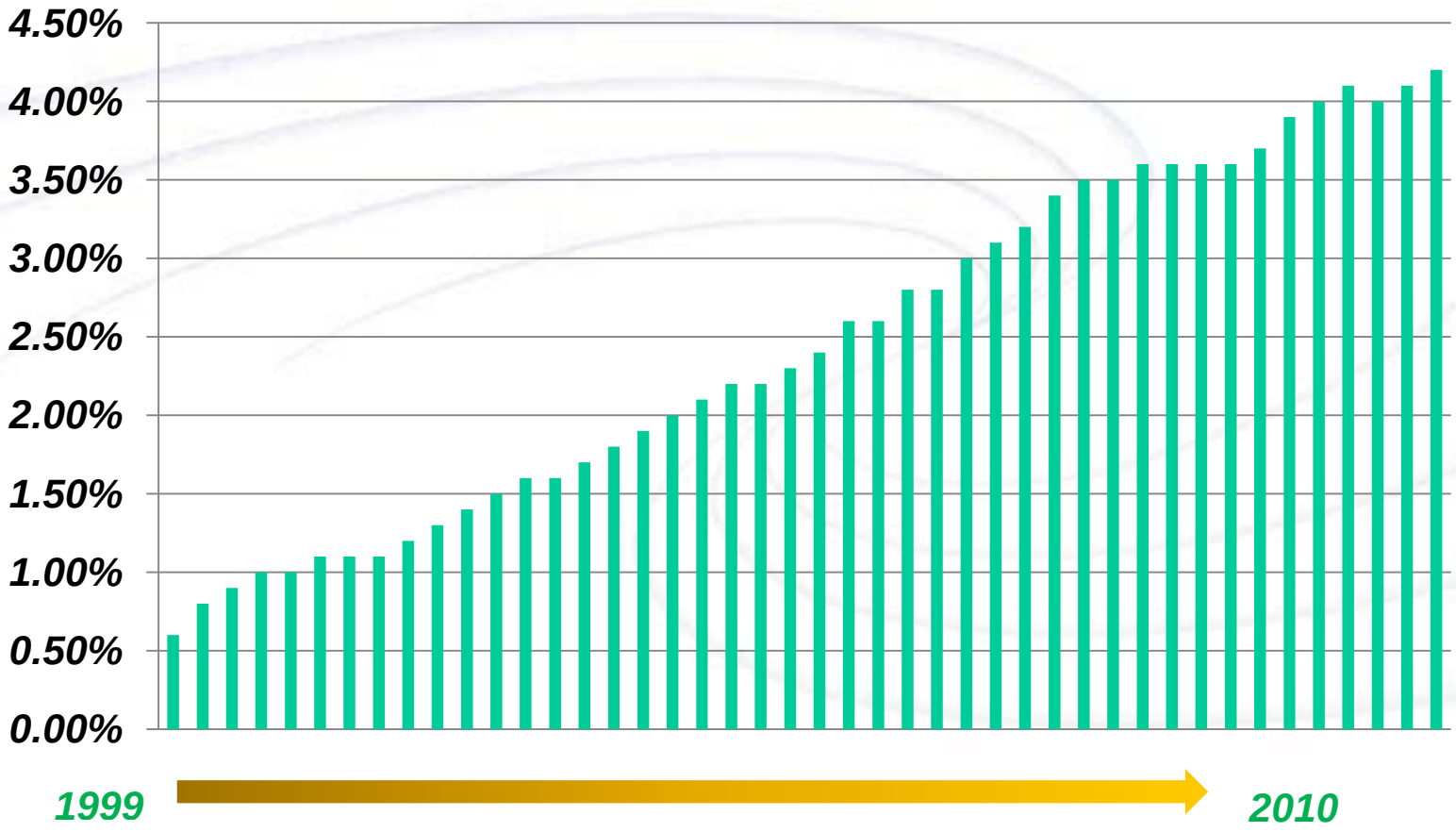
Some DC Growth Stats

- Mobile data revenues to grow from $5.4 billion in 2006 to $37.5 billion by 2010 (eMarketer).
- DC electric power consumption exceeds the entire transportation equipment mfg. sector (DOE 2006).
- Growth in DC energy consumption fastest growing economic sector (DOE 2006).

On-line Retail Sales Growth, etc.



Industrial Sized DC's

10 Largest DC's in the World*

NAME	WHERE	Sq. Ft.	NOTES
SuperNAP	Las Vegas, NV	400,000	250mW
Microsoft 9A/9B	Quincy, WA	470,000	
DuPont Fabros	Elk Grove, IL	485,000	
Microsoft	Phoenix, AZ	538,000	
Microsoft	Dublin, Ireland	550,000	
Microsoft	Chicago, IL	700,000	224,000 Servers
Next Generation	Wales, UK	750,000	
NAP of the Americas	Miami, FL	750,000	
QTS Metro Center	Atlanta, GA	990,000	80mW
350 East Cermak	Chicago, IL	1,100,000	100mW

*SOURCE: datacenterknowledge.com

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A Growing Challenge

Utilities Must Work With DC Management to Maximize Energy Efficiency.

BUT……How Can You Approach the Problem Unless You Can Measure It?

The DOE Says PUE

(Lower is Better)

$$PUE = \frac{\text{IT + MES Load}}{\text{IT Equipment Load}}$$

It's Not Good Arithmetic

(The Boulder Incident)

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Data Center = Industrial Facility

INPUTS:
Ingredients
Equipment
Energy

OUPUTS:
Beer in Bottles, Cans, Kegs

INPUTS:
Raw Data
Equipment
Energy

OUPUTS:
Data
Voice
Video

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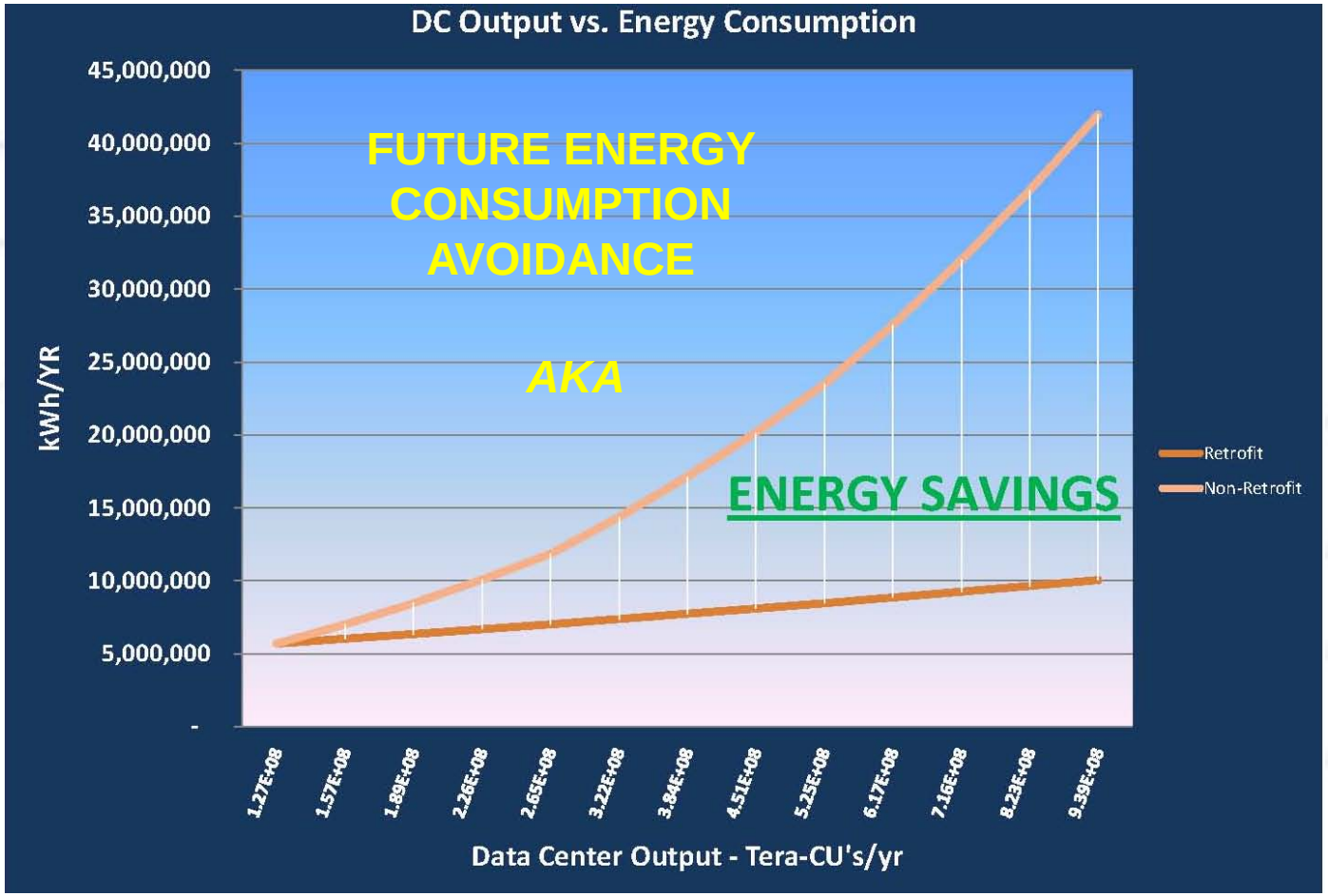
IPVMV Chapter 4 and DC's

- "Energy, water or demand savings cannot be directly measured, since savings represent the absence of energy/water use or demand. Instead, savings are determined by comparing measures or demand before and after implementation of a program, making adjustments for changes in conditions."
- SOURCE: Concepts and Options for Determining Energy and Water Savings, Volume 1, Chapter 4 IPMVP FRAMEWORK AND OPTIONS (published April 2007).

DC's Compared to Typical Industrial Facilities

- It's Not About Load Reduction At Current Production Levels
- It's About Implementation of Efficient Infrastructures That Will Minimize Growth in Energy Consumption

Avoiding Future Energy Consumption



Basic DCEE Model

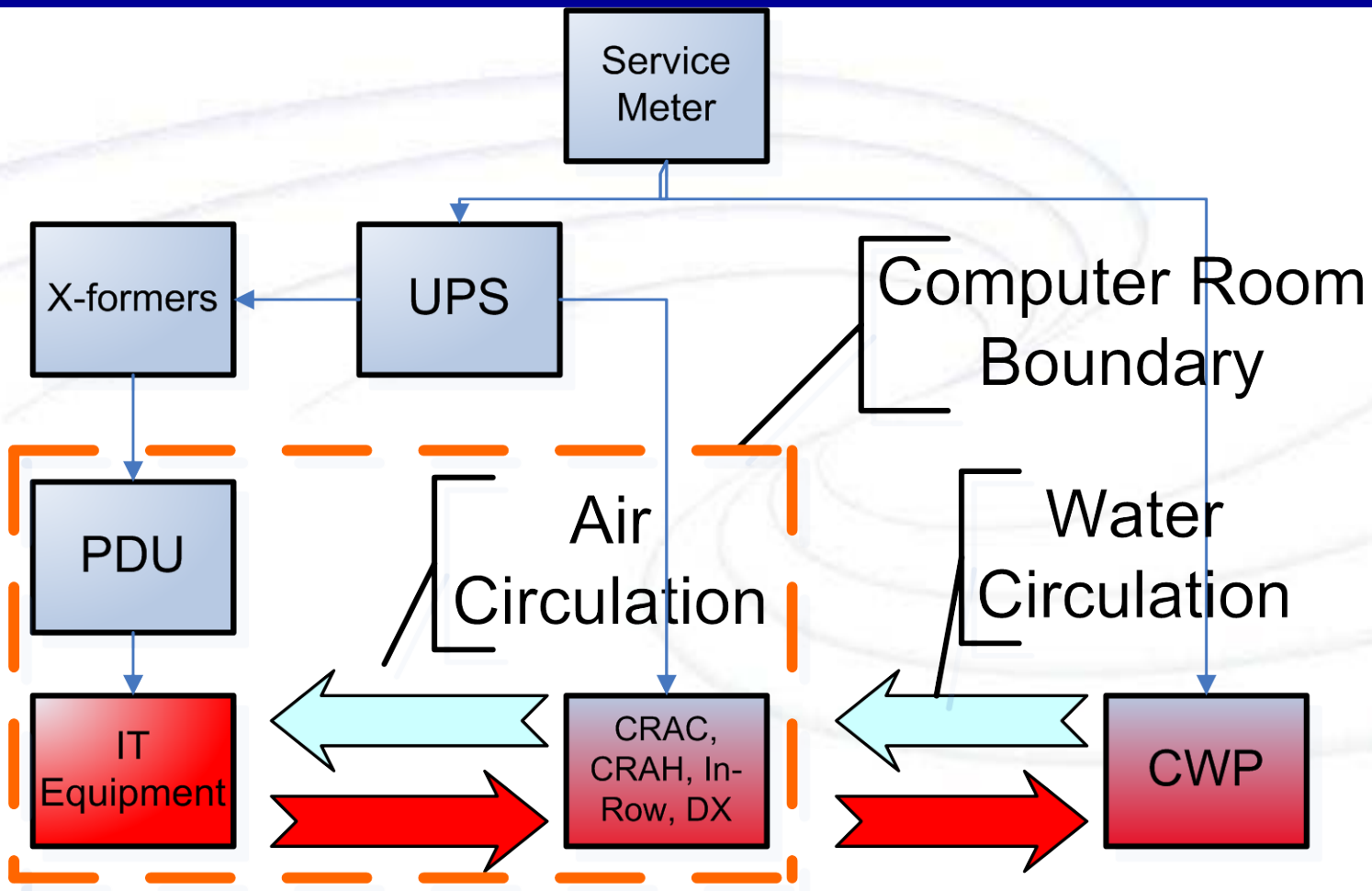
$$\text{kWh Saved} = \left[\text{kWh}_{P1} \times \frac{\text{Output}_{P2}}{\text{Output}_{P1}} \times \text{I-Std Factor} \right] - \text{kWh}_{P2}$$

Where:

P1 is the baseline measurement period

P2 is the post DCEEM measurement period

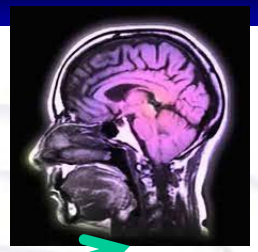
Quantifying DC Energy Consumption



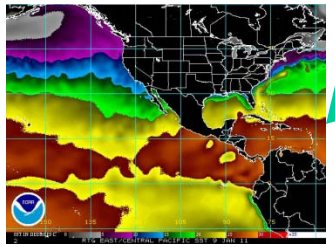
Useful Tools for Measureing DC Energy

- CA Tech - ECOMeter®
- Power Assure – Power Assure®
- APC – DCIM™
- Emerson Network Power – Aperature™
- Modius - Modius™

Quantifying DC Output



$$\varepsilon_0 \int E \cdot dA = \sum q$$
$$\int B \cdot ds = \mu_0 \int J \cdot dA + \mu_0 \varepsilon_0 \frac{d}{dt} \int E \cdot dA$$
$$\int E \cdot ds = -\frac{d}{dt} \int B \cdot dA$$
$$\int B \cdot dA = 0$$



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THE (TERA) COMPUTE UNIT (TCU)

- A Measureable Quantity of Work Produced in Response to End-User Demand
- Examples:
  - Online Mapping: Giga-Bytes of map content served
  - Banking: ATM Transactions Processed
  - S/W Dev: Giga-Bytes of Code Builds
  - Online Storage: Peta-Bytes of data stored
- Types of Metrics:
  - Bytes, CPU “Ticks”, IP Packets, FLOPS, MIPS
- Hard to Find Good Measurement Tools, but E-health® by CA Tech is a good bet.

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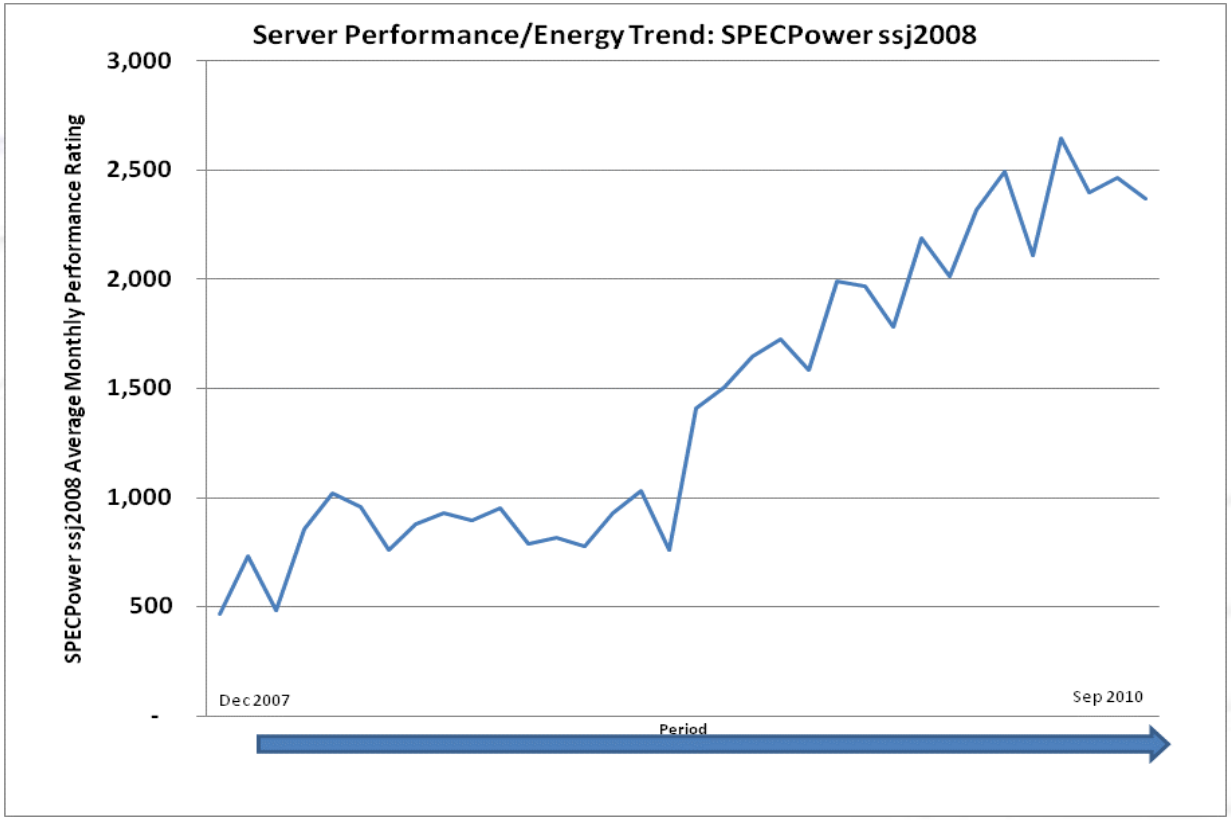
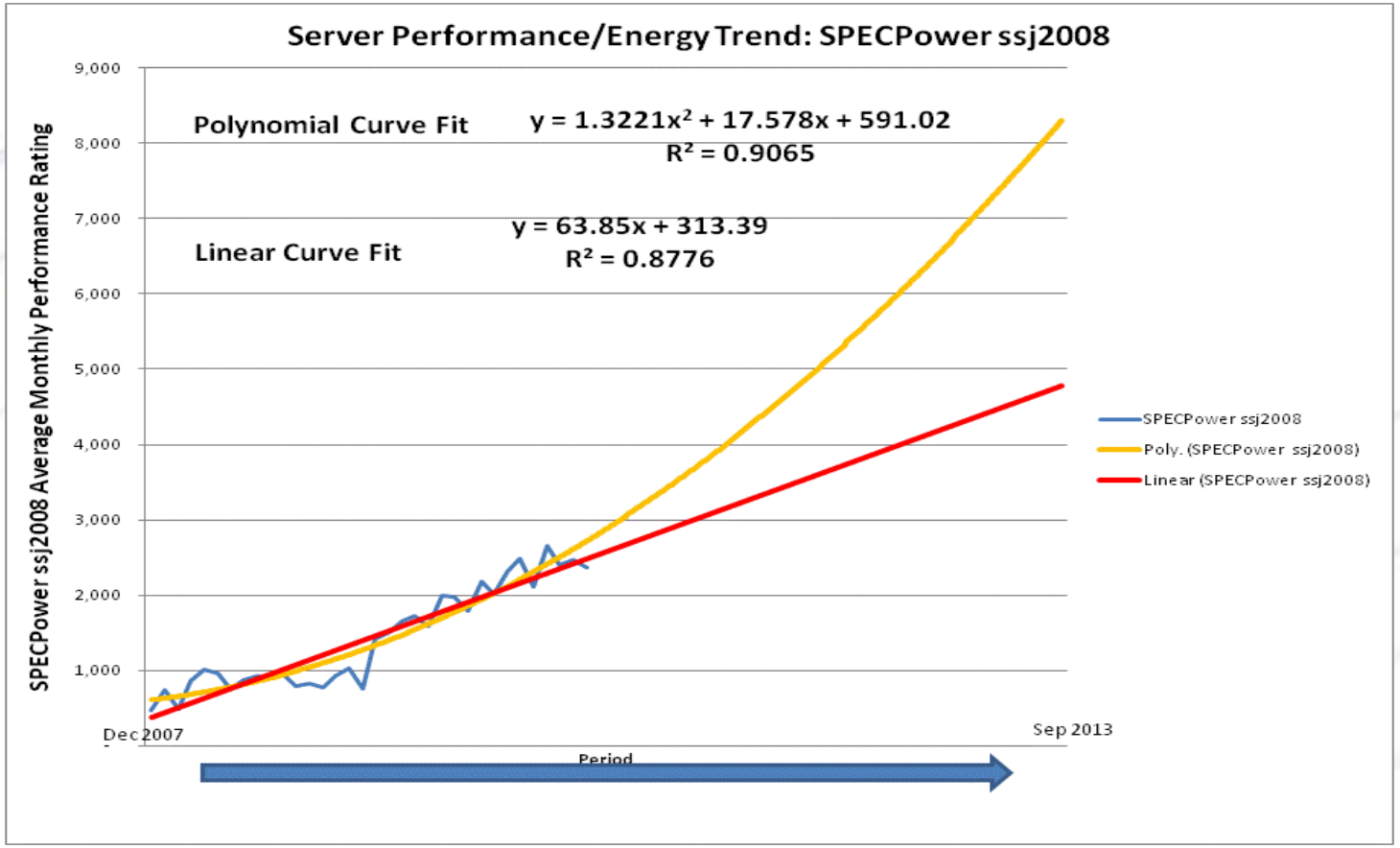
Quantifying I-Std Adjustment: Server Operational Performance



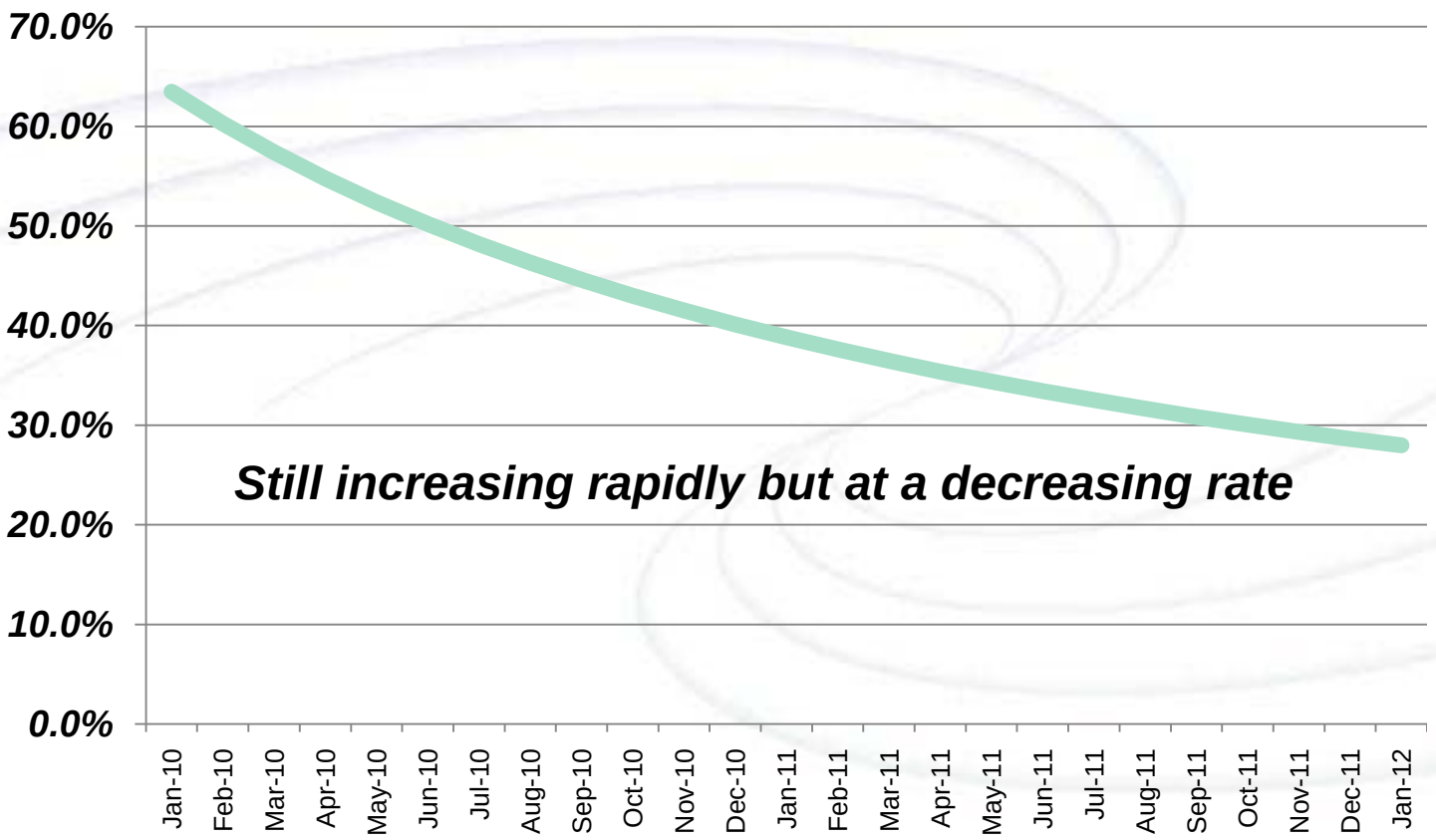
Source: www.SPEC.org

Quantifying Industry Standard: Server Performance Trends



Source: www.SPEC.org

% Increase in Server Productivity



Top Five IT-EE Measures

1. IaaS/SaaS/Cloud
2. Latency/Bottleneck Reduction
3. Storage Area Network - Retrofit
4. Server/Application Bench Testing
5. Virtualization/Consolidation

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Top Five MES-EE Measures

1. Containerization
2. In-Row Cooling
3. Economizers
4. Aisle Isolation
5. CRAC, CRAH Controls

DCEE PROJECT EXAMPLE ASSUMPTIONS

	Pre-EEM (Baseline)	Post-EEM (M&V Per 1)	%
Annualized Energy Consumption (gWh)	102	70	-31%
Annualized DC Output (TCU)	6.82E+17	1.15E+18	+68%
SPECPower ssj2008 Index	2,740	3,505	+28%
# Servers in Service	16,718	9,514	-43%
Server Capacity in Service (TCU)	7.23E+18	8.03E+18	11%
CPU Utilization	8.8%	13.6%	55%

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Savings Calculation

$$\text{gWh Saved} = \left(\text{gWh}_{P1} \times \frac{\text{Output}_{P2}}{\text{Output}_{P1}} \times \text{I-Std Factor} \right) - \text{gWh}_{P2}$$

$$\text{gWh Saved} = \left(102 \times \frac{1.15\text{E+}18}{6.82\text{E+}17} \times \frac{2{,}740}{3{,}505} \right) - 70$$

$$\text{gWh Saved} = \left(102 \times 1.68 \times .78 \right) - 70$$

$$\text{gWh Saved} = 134 - 70 = 64$$

Conclusions

- Understand How DC's in Your Territory Scale Their Infrastructure
- Go "Holistic" But - Focus on IT Infrastructure First, Then MES
- Bridge the IT/Facilities Management Divide
- Use Longer M&V Periods to "Prove Out" Infrastructure Efficiencies in a Growth Environment
- Use Sound Measurement Technologies