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October 11-14, 2010
The Gaylord Texan
Dallas, Texas

The Future of Energy Efficiency of Data Centers and Enterprise IT

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Agenda

- What's Driving Energy-Efficient (EE) IT
- Key Steps to Driving Data Center EE
- EE IT Opportunities going forward
  - Productivity metrics
    - Intel Energy Checker SDK
  - Holistic Data Center Management
    - The Green Grid Data Center Design Guide
    - SNIA collaboration on Storage requirements
- What's in the future for Data Centers
- Recap and Call to Action

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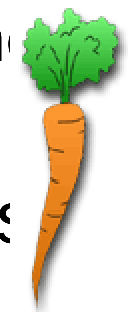
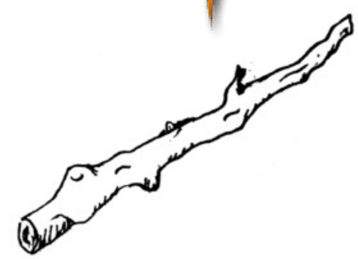
What's Driving Energy-Efficient IT?

- Customer and shareholder pull
  - More focus on energy sources and th environment
- Government and regulatory actions
  - In the US it's carrots
  - in the rest of the world sticks
- Energy costs
  - Until recently, energy efficient IT wasn't a mainstream goal
- Competitive advantage
  - The ability to run IT cheaper and more efficiently





User requirements are evolving to address this need

Global Technology Growth

1 Billion
New Connected Users by 2015

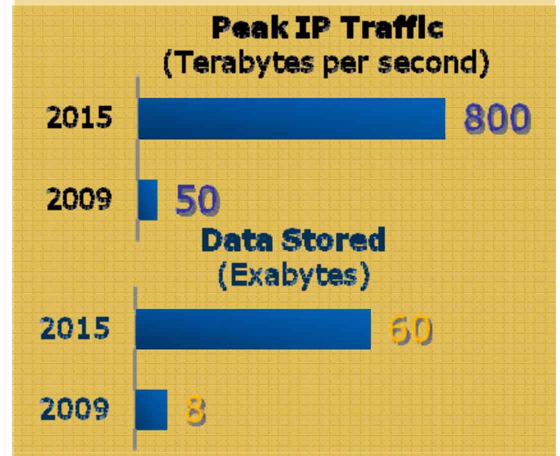
More Users

+10 Billion
Connected Devices

More Computing Devices

and 800 TBytes
IP Traffic

60 EBytes
Data Stored



More Data

Fueling the Growth of Data Centers

Enterprise Example: Statistics

6,300 IT employees
Supporting 78,900 Intel employees in 150 sites

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95 Data Centers
410,000 square feet
55 mW Total Power Load
4,976 Cabinets

~100,000 Servers &
>90,000 PCs (80%+ mobile)

177M e-mail messages
(per month)

20k hours of video collaboration
Social Media traffic growing 3X

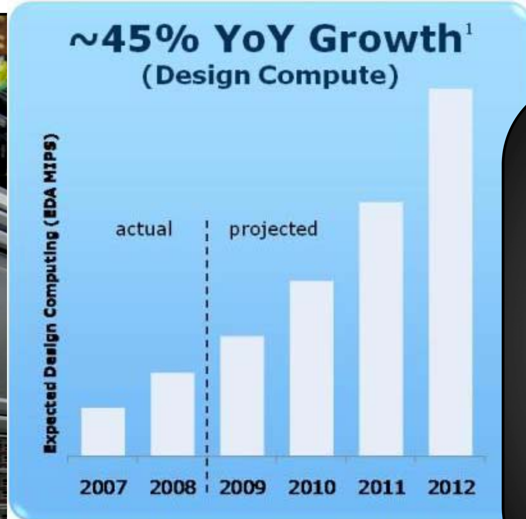
IT/Data Center Overview

D — Design
Design Computing

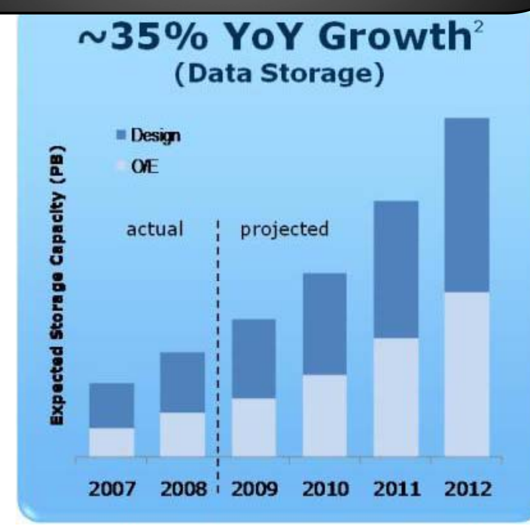
O — Office
General Purpose

M — Manufacturing
FAB/ATM

E — Enterprise



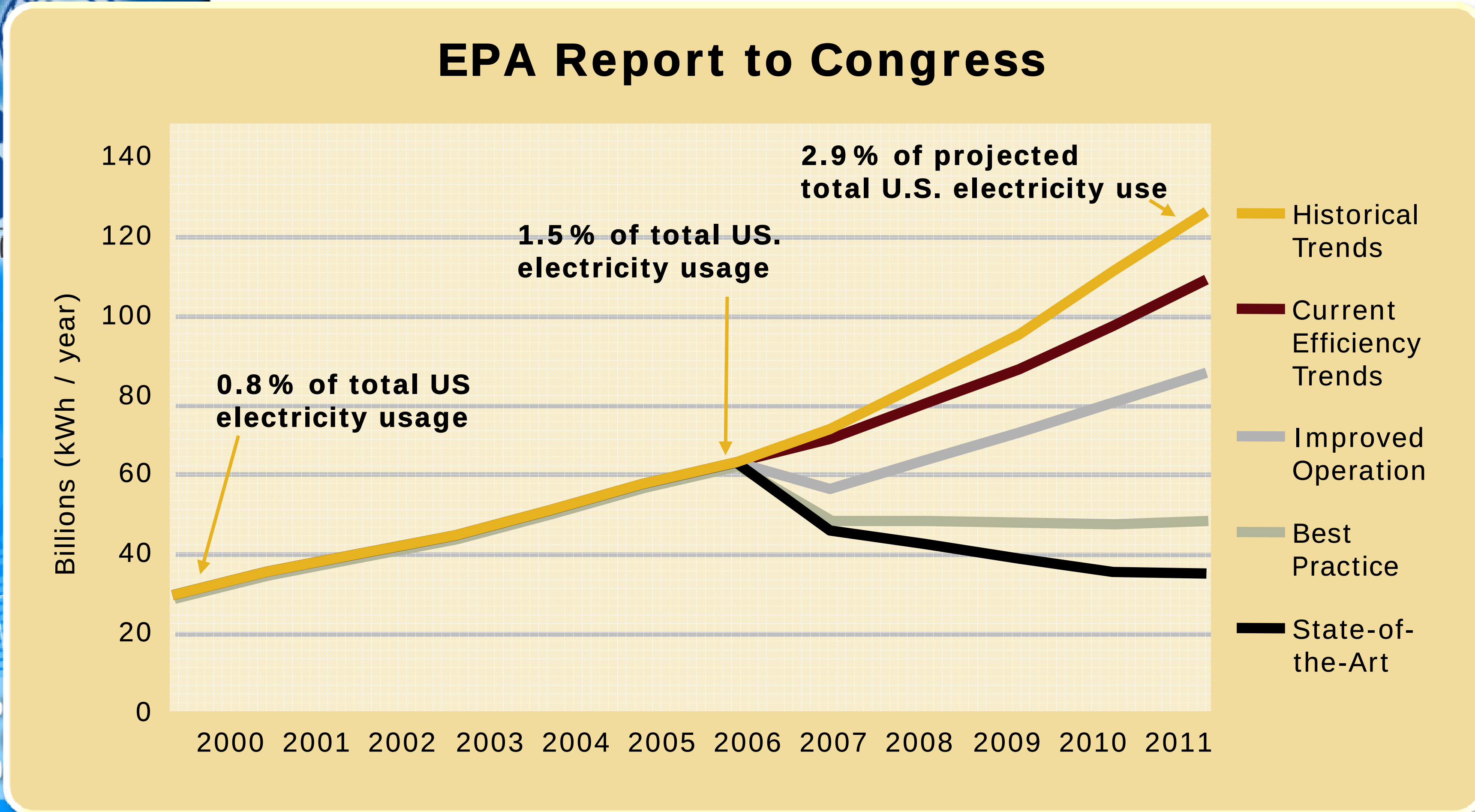
- Proactive refresh
- Virtualize resources
- Optimize network
- Enhance storage solutions
- Improve energy efficiency
- Advanced power & cooling



Dallas, Texas

70% of servers in Intel are in D
30% of servers in Intel are in O, M, and E

Data Center “Crisis”

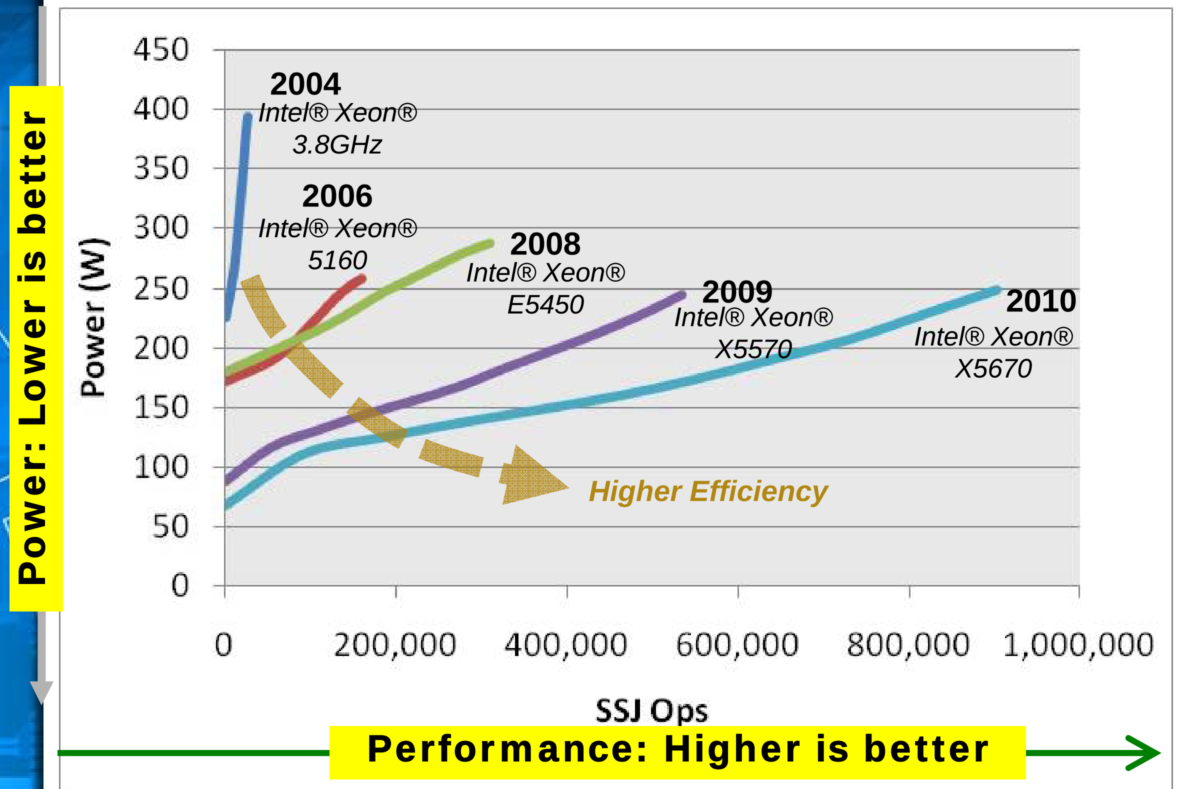


Source: EPA Report to Congress on Server and Data Center Energy Efficiency; August 2, 2007

…or Opportunity?

Sustained Efficiency Improvement

2 Socket Volume-Server Power vs. Performance



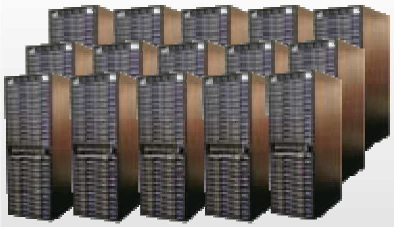
Source: SPECpower_ssj2008* 2 socket results from SPEC.org as of August 2010

Efficiency at 30% Utilization increasing with 67% CAGR

Performance and power consumption results are based on certain tests measured on specific computer systems. Any difference in system hardware, software or configuration will affect actual performance. Configurations: Two-socket Systems, Test Results for SPECpower_ssj2008, Testing by Hewlett-Packard. **For more information go to http://www.intel.com/performance**

Server Refresh example in 2010

2005



15 Racks of Single Core Servers

2010

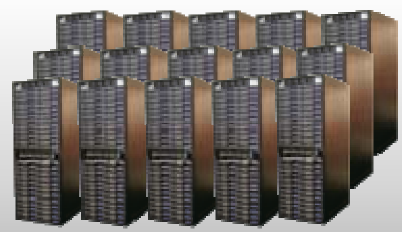
Efficiency Refresh 15:1

1 rack of new quad core Servers

More than 90% Annual Energy Cost Reduction (estimated)

– OR –

Performance Refresh 1:1



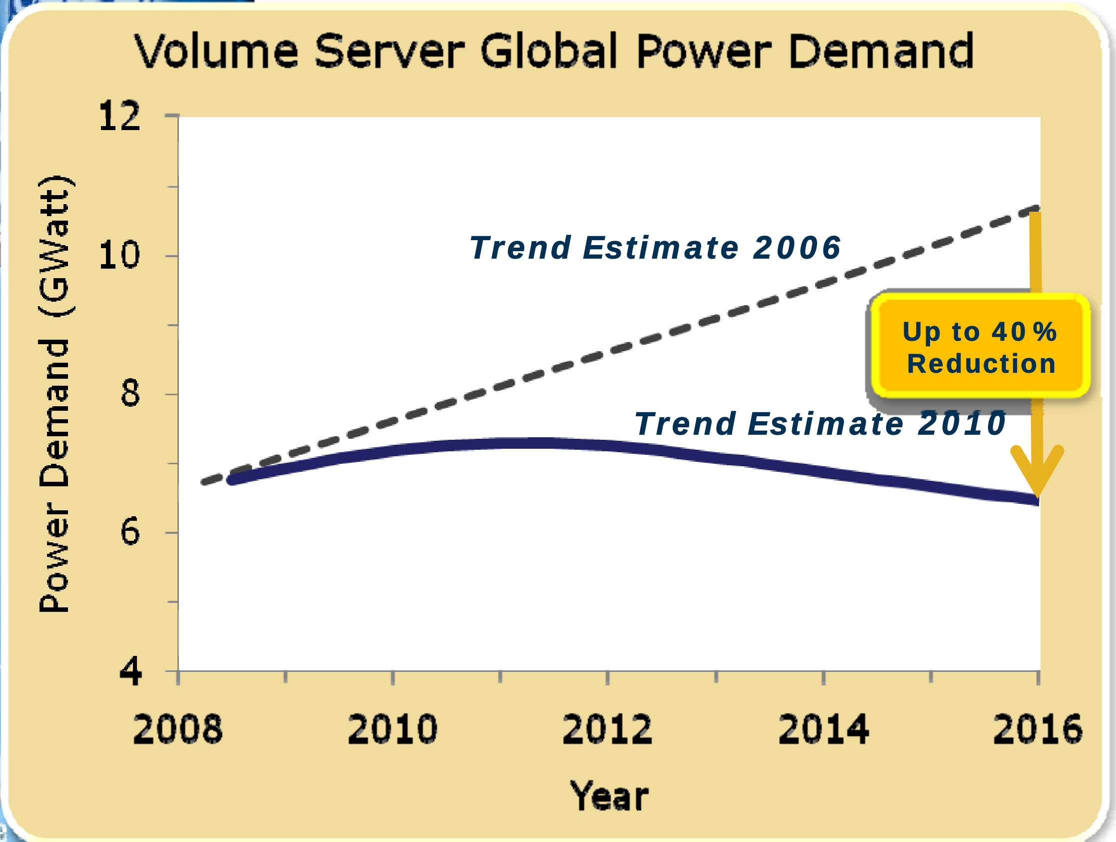
15 racks of quad core Servers

Up to 15x Performance

8% Annual Energy Costs Reduction (estimated)

Source: Intel estimates as of Jan 2010. Performance comparison using SPECjbb2005 bops (business operations per second). Results have been estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.

Server Efficiency Focus – Global Impact



Assumes Four Year Server Refresh Cycle.

By 2016…

- Number of Servers Increases 1.5X
- Compute Capacity Grows 9X
- Total Server Energy Consumption **Stays Constant**

The Tide is Turning on Data Center Energy Consumption

Estimated results: Results have been estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance or power consumption. All products, computer systems, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice

Key User Steps to DC Efficiency

- Organize for success
  - All key stakeholders reporting to a single C-level executive
    - IT manager, facilities manager, energy buyer
- Define metrics of success and reporting mechanisms
  - PUE is a good start to understand facility overhead in place
  - Productivity and QoS for SLAs
  - Do the baseline measurement to identify where the power is going
- Take advantage of the benefits of:
  - Server Refresh, Free Air Cooling, Efficient Power Distribution solutions, Operational Best Practices….

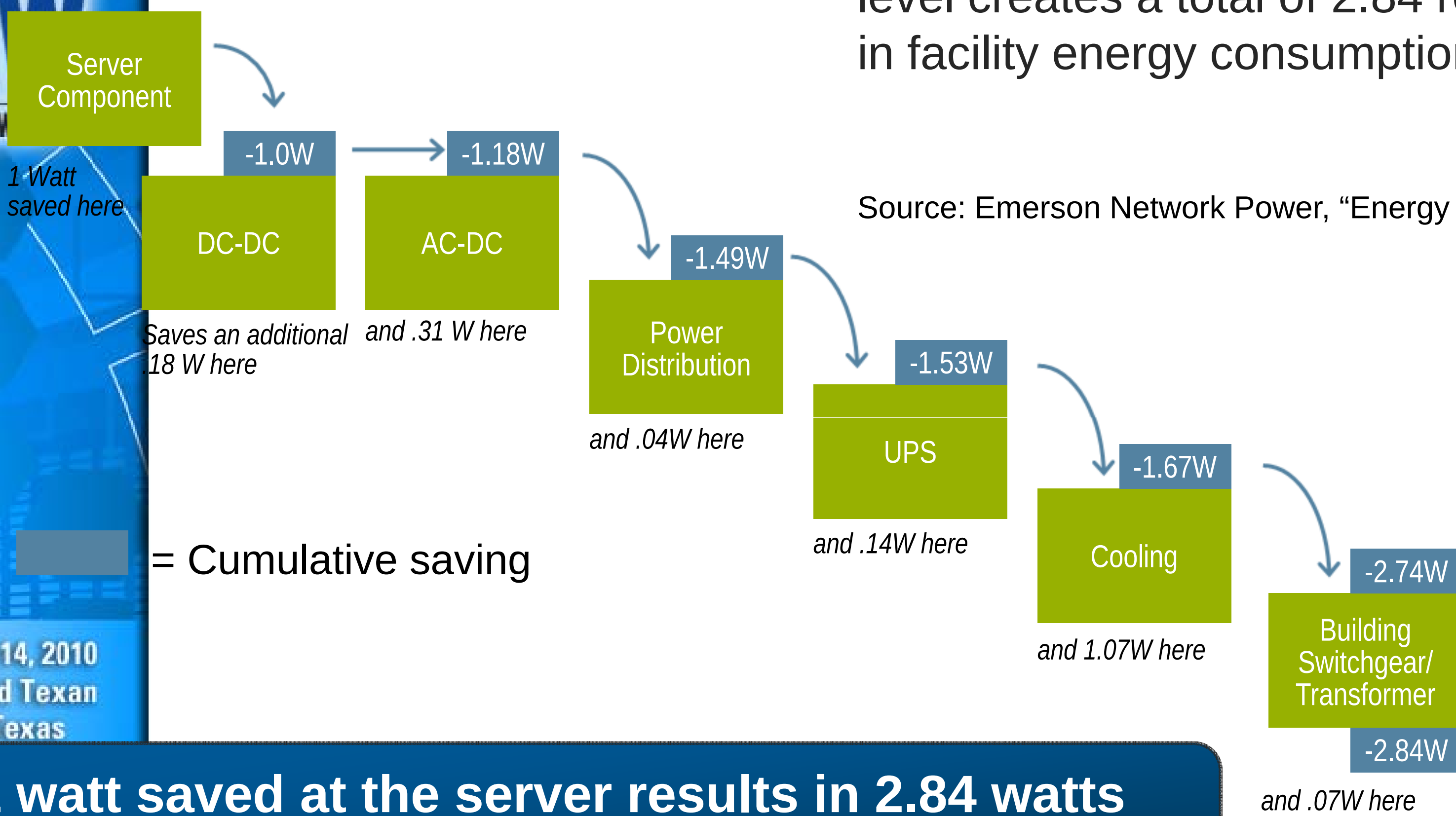
PUE=Facility Power/IT Power

Strategy: Addresses Impact of IT on Facilities

The Cascade Effect

With the Cascade Effect, a 1 Watt savings at the server component level creates a total of 2.84 reduction in facility energy consumption

Source: Emerson Network Power, "Energy Logic"



1 watt saved at the server results in 2.84 watts saved at the Data Center meter

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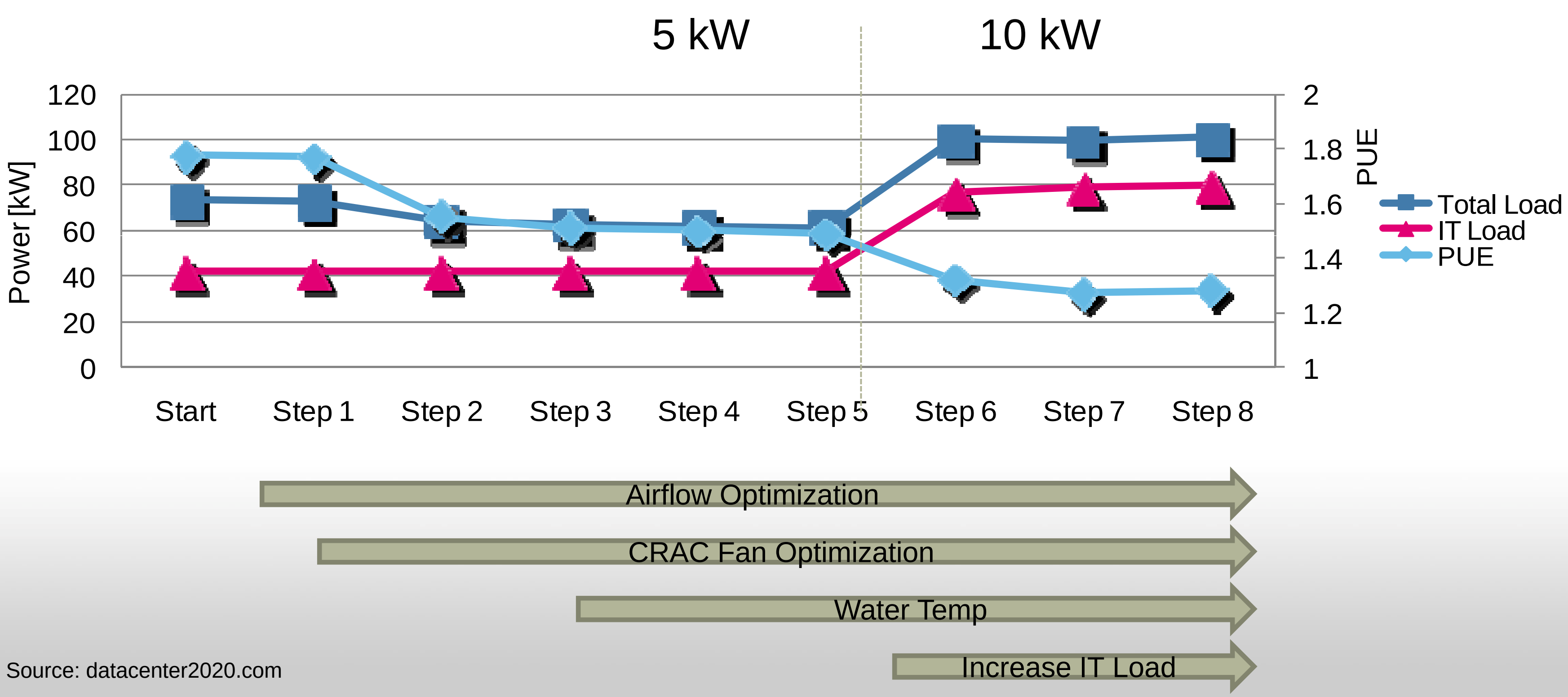
Infrastructure Optimization: Raising Data Center Capacity



Source: datacenter2020.com

Implementing Best Practices Improved PUE from 1.8 to 1.3

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What Are the Future Implications?

- Regulatory actions and requirements
  - ENERGY STAR* (in US) and carbon use regulations (WW)
- Customer requirements
  - At both Data Center and IT equipment for:
    - Instrumentation
    - Management
    - Reporting



Why Productivity Metrics?

- Enables data center operators to measure and increase their IT productivity
  – Drives more business efficiency in a standards based way.
- Addresses WW regulatory objectives
  – drive data center energy efficiency and carbon management programs
- Supports objective of holistic data center management (DCDG)
  – allows users to prove to themselves the value of investing in EE IT

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How do we get there?

- Architectural Definitions
  - Standard unit(s) of work/productivity for application types
  - Standard mechanism of data logging and collection beyond single application/server
    - The Green Grid (TGG) has advocated using Intel’s Energy Checker SDK
  - Future: Normalized unit of measurement for data center “mpg’.
    - TGG’s “Productivity Proxy Experiment” is first of a series of POC experiments

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BEC1

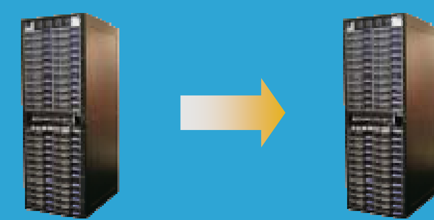
Intelligent Power/Thermal management

1. Power Monitoring:

- **Real-time power consumption**
- **Avoid data center hotspots**
- **Thermal / Power aware scheduling**
- **Data center planning**

2. Increase Rack Density:

- **Up to 40% increase in server count per rack[1]**
- **Maximize capex ROI for available rack power**



3. Power Optimization:

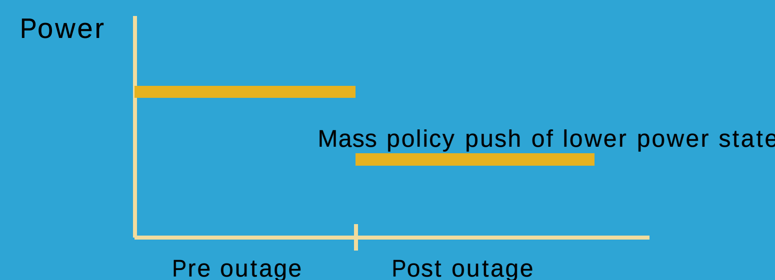
- **Save up to 10-40 Watts[2] – results will vary**
- **Best results w/ IO or memory intensive workloads**

Workload	Pre cap power	Pre cap perf	Post Cap power	Post cap perf
Cpu intsv				
Io intsv				
Memory				
Mix / real				

Workload Characterization

4. Business Continuity:

- **Prolong operation during DC outage**



Well known Intel Intelligent Power Node Manager use cases…

1. Based on Baidu & China Telecom test results. Results will vary based on workload and system configuration.
2. Based on 2009 BMW test results. Results will vary based on workload and system configuration.

Slide 17

BEC1 Added IDF page number, switched to standard call out box and Verdana, wrapped Node Manager twice, formatted footnote, aligned bullets, made text bigger, IDF team suggests a build/animation of info.

Backus, EmilyX C, 8/16/2010

BEC2

… Are Actually Points in a Much Larger Continuum

Larger Payoff & Complexity

Usage Model	Benefits	Use Cases
• Perform **real time server power monitoring**	Reduce stranded power by scheduling available data center power to actual server power consumption	• **Real time monitoring of power consumption** • Manage data center hot spots • Power & thermal scheduling • Power use trending & forecasting
• **Power guard rail**: impose power guard to prevent server power consumption from straying beyond preset limit	Deterministic power limit and guaranteed server power consumption ceiling	• **Maximize server count per rack** and therefore CapEx ROI per available rack power when rack is under power budget with negligible per server performance impact
• **Static power capping**: operate servers under a permanent power capped regime	Operation under impaired power availability conditions	• Maximize per rack performance yield when rack under power budget • **Application power optimization** • Application performance compensation • **Business continuity**: continued operation in the presence of power outages
• **Dynamic power capping**: adjust server performance profile to workload demand	Optimize infrastructure for QoS to match SLA exactly	• Match capping set points to workload • Support for multiple service classes
• **Energy Management**	Cut electricity costs	• Dynamic reconfiguration to achieve extreme power proportional computing
• **Integrated DC Power Management**	Realize power optimization across server, communications, storage	• Use server sensor data to optimize cooling equipment set points

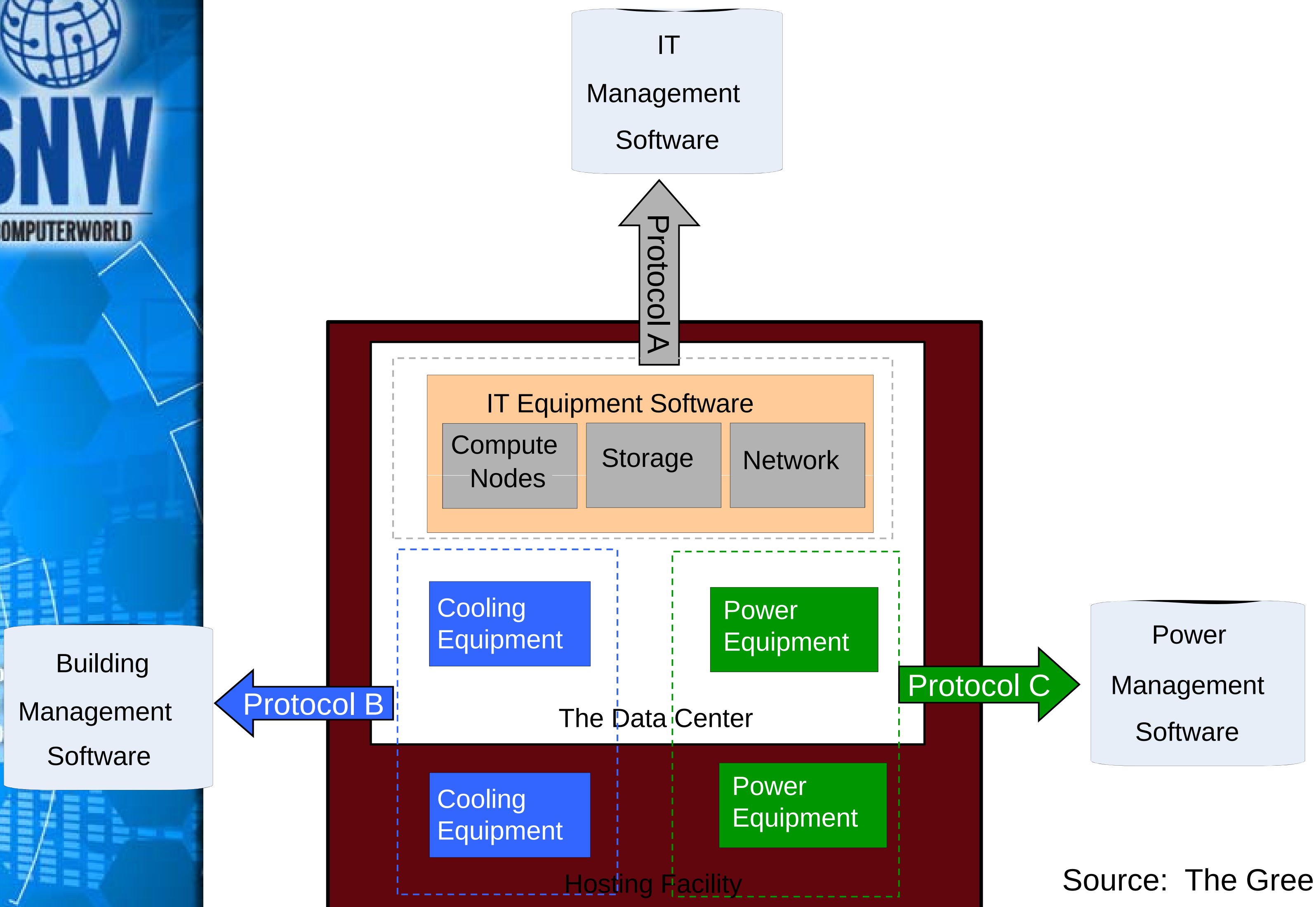
The continuum suggests data center efficiency evolution model

Slide 18

BEC2 Added IDF page number, moved chart down, center all text in chart, switched to standard call out box, changed text to Verdana, IDF team suggests some sort of animation.
Backus, EmilyX C, 8/16/2010

Modeling Benefits –

Move From Current "Islands of Management"…



Source: The Green Grid

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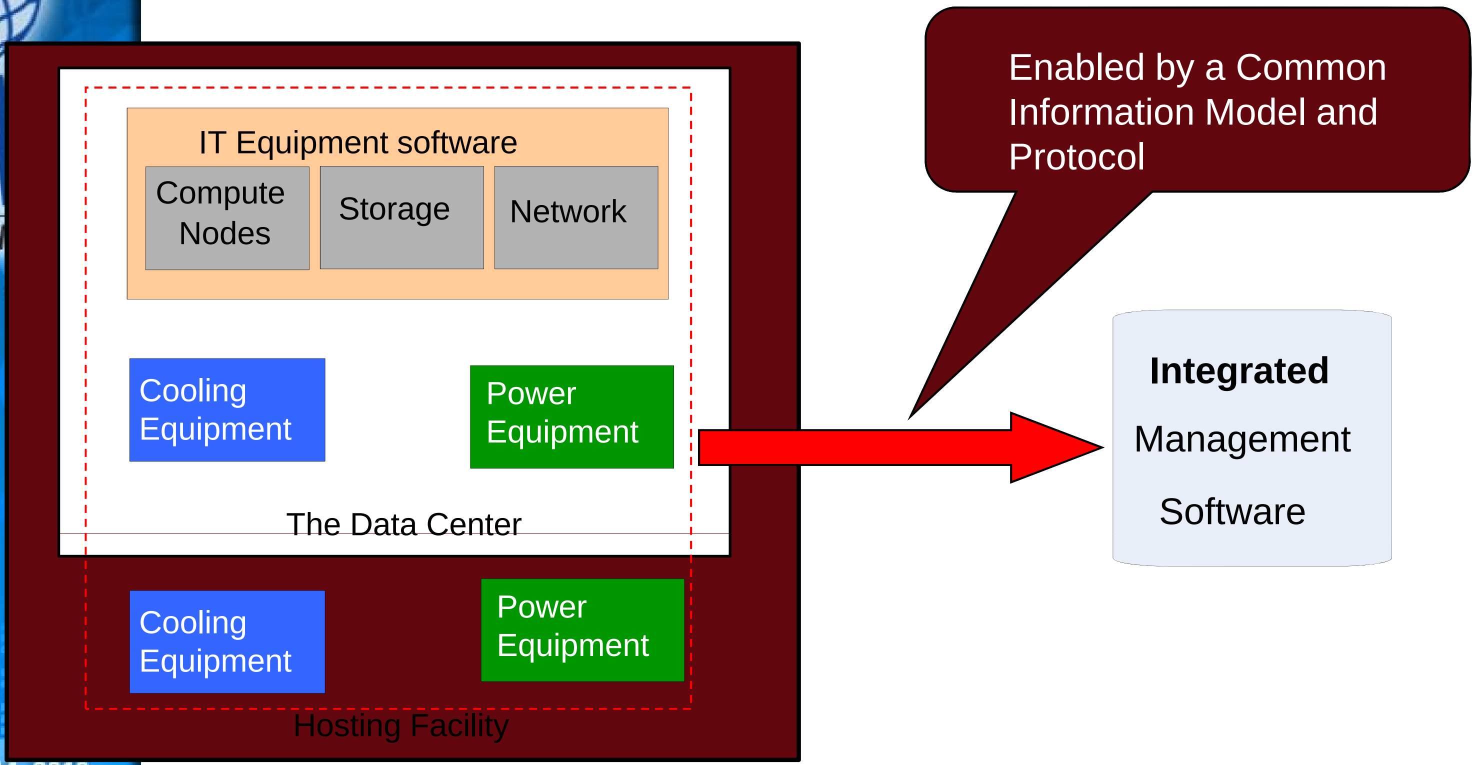
Modeling Benefits –

… To Integrated Data Center Management



- Improves Management Capabilities
- Lowers Integration Time, Effort and Cost
- Less investment, promotes more competition

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Source: The Green Grid

What’s coming in the future for Efficient Data Centers?

IT/Data Center Energy Efficiency becomes a portion of the total sustainability agenda

- New metrics defined
  - Reuse factor – acknowledging and crediting organization for things like waste heat re-use
  - Carbon Usage metrics
  - Water Usage metrics
- More regulatory actions
  - Energy star will raise the bar on IT equipment
    - Servers, Storage, UPS
    - Will add new categories such as networking equipment
  - California looking at updating building codes to include economizers as is ASHRAEA 90.1
  - EPEAT for Data Center equipment
- Carbon legislation at the state level
- Standardized Utility Incentives for improvements in data center energy efficiency and/or productivity

What Can You Do as a Developer?

- Customer Product requirements will call for EE capabilities
  - Power management, low power states and features, higher ambient operating temp.,
- Instrumentation is key to policy based management of the data center
  - Standardized reporting via IPMI instrumentation
  - Node level power and thermal control
- Work is under way in The Green Grid to tie all the equipment islands together
  - Data Center Design Guide defines specific modeling and protocol requirements
  - SNIA collaboration is noticeably absent
- Productivity metrics will require Intel® Energy Checker (or equivalent) capabilities

Additional Sources of Information

Web Links

- Whatif.intel.com – Energy Checker SDK
- intel.com/it
- The Green Grid: www.**thegreengrid**.org
- Climate Savers Computing Initiative: www.**climatesaverscomputing**.org
- Digital Europe: www.**digitaleurope**.org
- IT Industry Council: www.**itic**.org

ENERGY STAR* Collateral and References

- ENERGY STAR (Server/Workstation) compliance collateral (under NDA):
  - # 413482 – ENERGY STAR* Companion CD-ROM Rev. 3.0, ENERGY STAR Compliance Tool
  - # 411729 – Workstation and Server Platform ENERGY STAR* Readiness Checks
  - # 411732 – ENERGY STAR* Readiness Checklist Rev. 2.0
- Power Supply Efficiency, 80 PLUS: www.80plus.org
- ENERGY STAR v5.0 System Implementation Whitepaper: http://download.intel.com/design/processor/applnots/321556.pdf
- ENERGY STAR for computer servers: http://www.energystar.gov/ia/partners/product_specs/program_reqs/servers_prog_req.pdf

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Backup

CIM Reporting charts

UPS example

Metered values

Attribute	Definition	Units	Notes
Input	RMS Voltage	Volts	Per Phase
	RMS Current	Amperes	Per Phase
	Real Power	Kilowatts	Per Phase
	Energy = Real Power * Time Interval	Kilowatts-hr	Per Phase
	Frequency	Hz	
Output	RMS Voltage	Volts	Per Phase
	RMS Current	Amperes	Per Phase
	Real Power	Kilowatts	Per Phase
	Real Power * Time Interval	Kilowatts-hr	Per Phase
	Frequency	Hz	Per Phase
System	Temperature	Degrees C	
	Pressure	PSI	
	Liquid Level OK	Logic High	

Status values (current)

Attribute	Definition	Units	Notes
DC Input	Recharging	%	
	Discharging	%	
	Low	Logic High	
	Fully Discharged	Logic High	
ID	Name/Model	Text String	
	Manufacturer	Text String	

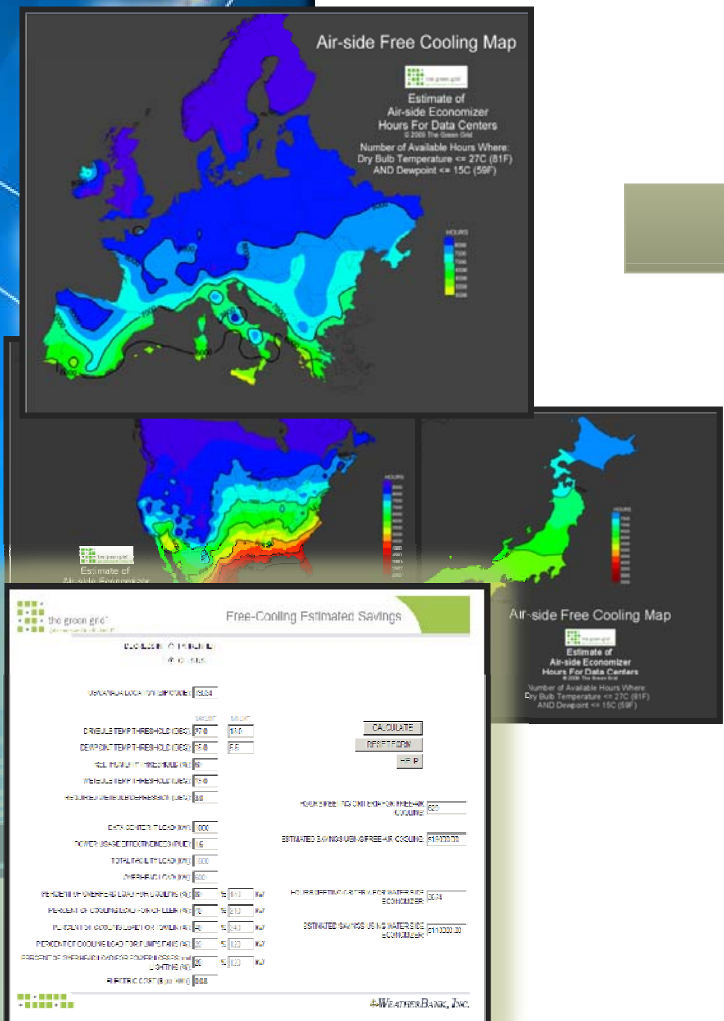
New status values (future)

Attribute	Definition	Units	Notes
Location	Physcial location	Datacenter	Security Sensitivity
		Floor #	Security Sensitivity
		Room #	Security Sensitivity
Startup	Boot time	minutes	Staging time
Serial Number	Manufacturer ID	alphanumeric	

Metered values (future)

Attribute	Definition	Units	Notes
Ambient	Temperature	Degrees C	Room
	Humidity	%	Room
True Power Factor	Total Distortion Power Factor		Per Phase

Free Cooling



Data Center Savings

Paris

1MW Data Center
.132/kW hour

€330,000/year savings with free cooling <u>or</u> €180,000 /year savings with a water-side economizer

Source: The Green Grid

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Efficiency Required from Gate to Grid

CPU/Chipset

- Low power Processors
- Perf/power trade-offs
- Power Management

Motherboard

- Bios Configuration
- VR Efficiency
- LV Memory
- HDD's / SSD's

System

- Thermal Design
- Component Layout
- Power Supply Opt
- Thermal Management
- High T_{amb}

Rack

- Resource sharing/aggregation
- Thermal Mgmt (Rack Cooling Index)
- Power Distribution

Data Center

- Resource Management
- PUE optimization
- Economizers
- Power Conditioning
- UPS

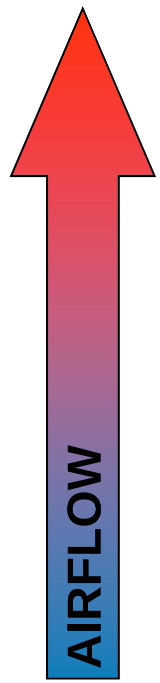
Power Optimized Data Center

Efficiency Losses "Cascade"

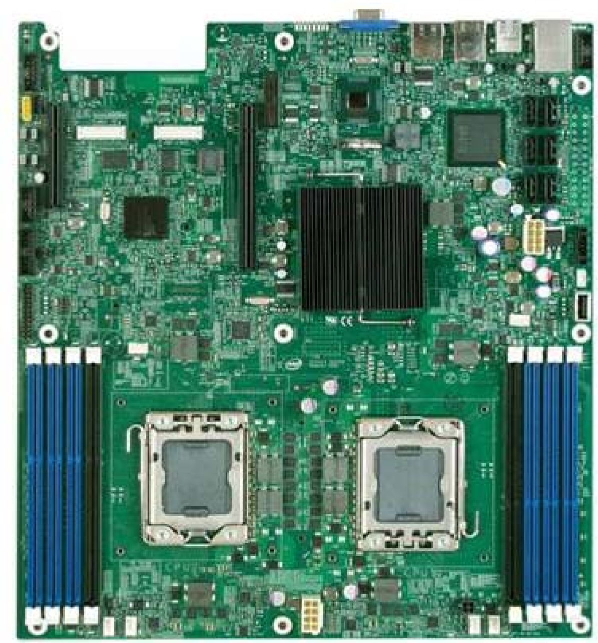
Optimizing Baseboard Layout

Shadowed Layout

Source: Intel



Non-Shadowed Layout



Non-Shadowed Layout Enables Lower Fan Power and Wider Temperature Range

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