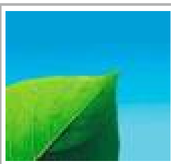
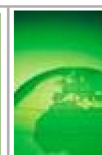
Energy Efficiency for Green Data Centers

System z9 Typical KW





V4

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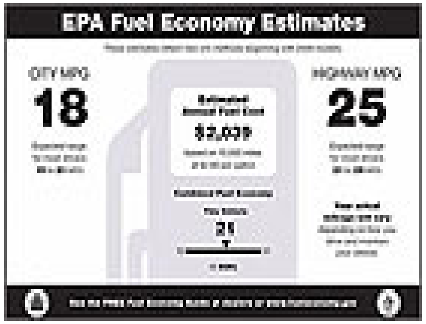
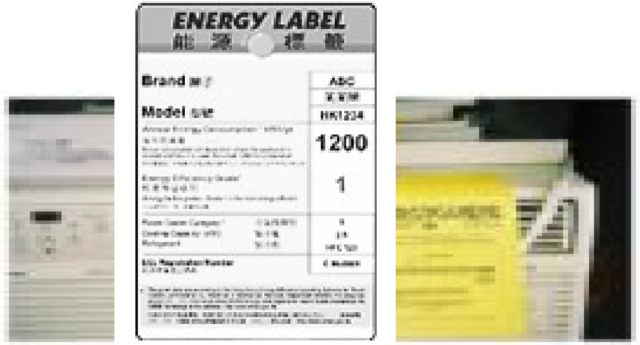
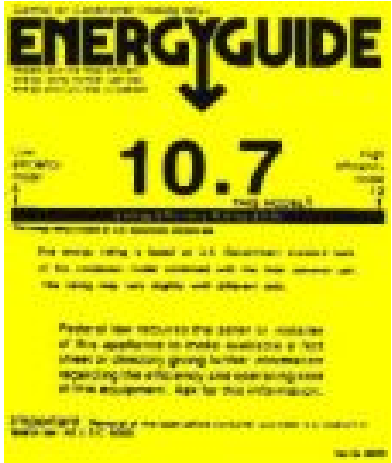
Power and cooling “Measured” / Typical values

- **Examples of Server actually measured System z**
- **Average = typical**
  - **Hourly average (TYPICAL)**
  - **Hourly min and max**

- **Field population of GA3 z9 BC and z9 EC**
  - By model for hundreds and eventually thousands of servers
  - **Typical # is e**xactly what is needed for energy decisions

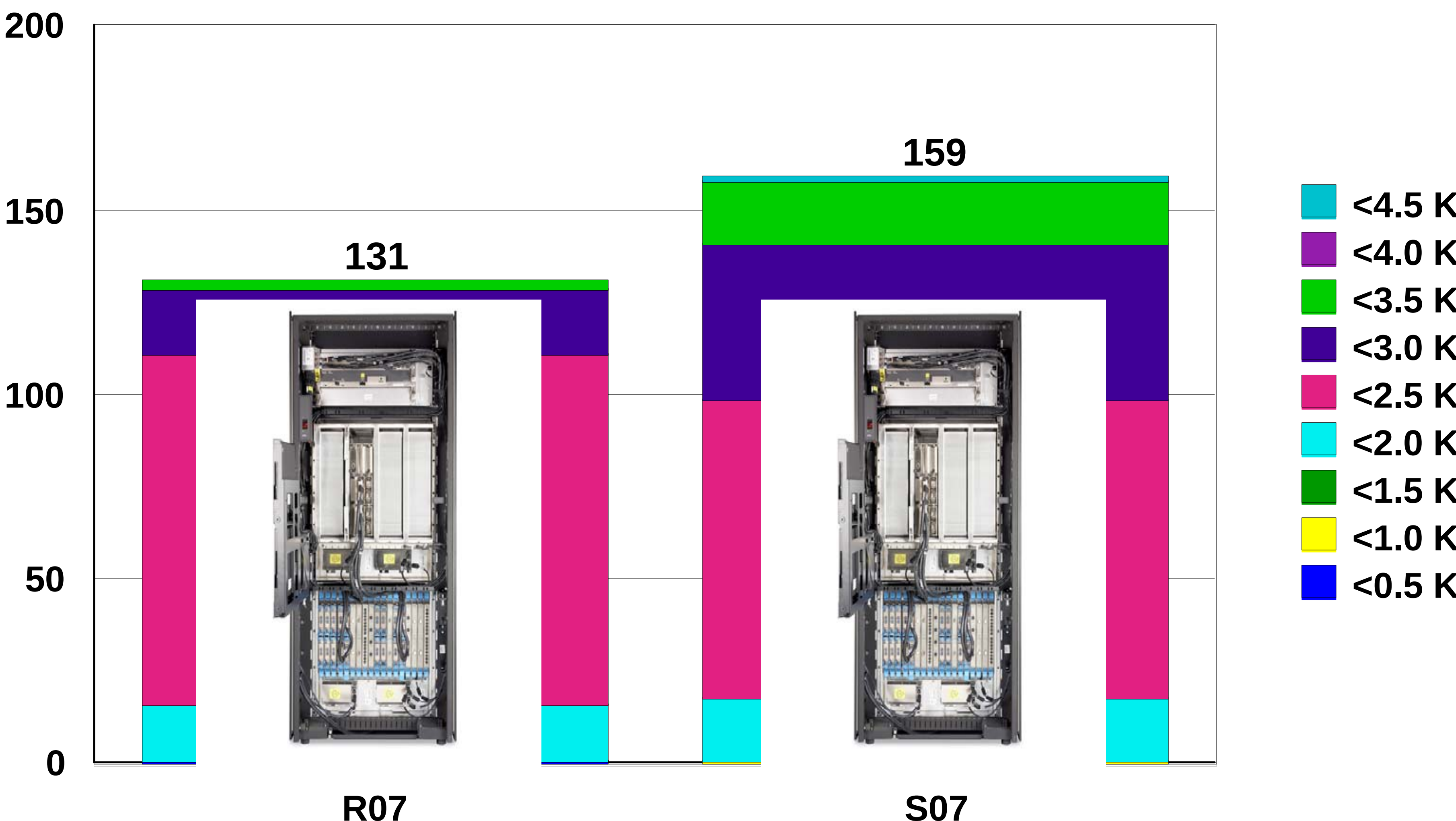






z9 BC Maximum average hourly power consumption for th month of 8/2007 - excludes '0' samples

290 Systems at GA3 code levels



Typical Energy Consumption System z9 BC (KW)

System z9 BC KW	Model R07	Model S07
Max	3.5	3.5
Typical 90%	3.0	3.5
Typical 50%	2.5	2.5

Based on field data August and Sept. 2007

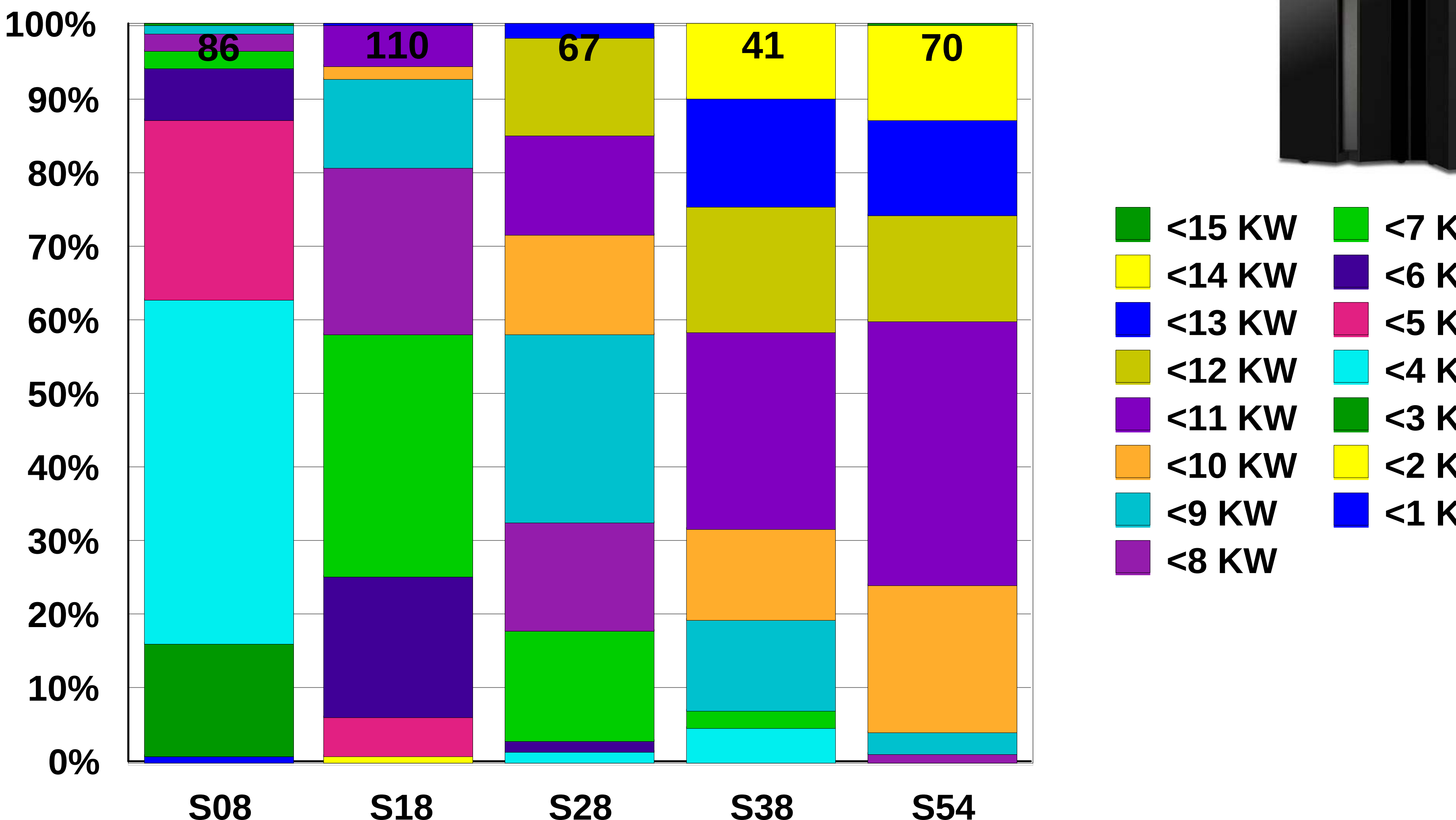
+90% of measured systems within average of hourly averages

+50% of measured systems within average of hourly averages

Not even one of the Systems at or near label power, 5.3 KW

z9 EC Average average hourly power consumption for the month of 8/2007 - excludes '0' samples

374 Systems at GA3 code levels



Typical Energy Consumption System z9 EC (KW)

System z9 EC model KW	S08	S18	S28	S38 / S54
Max	9	12	12	14
Typical 90%	6	9	12	13
Typical 50%	4	7	10	11

Based on field data August and Sept. 2007

No system at max label rating of 18.3 KW

+90% of measured systems within average of hourly averages

+50% of measured systems within average of hourly averages

Typical Energy Consumption System z9 EC S54 (KW)

System z9 EC	S54
Max	15
Typical 90%	13
Typical 50%	11

Based on Field Data August and Sept. 2007

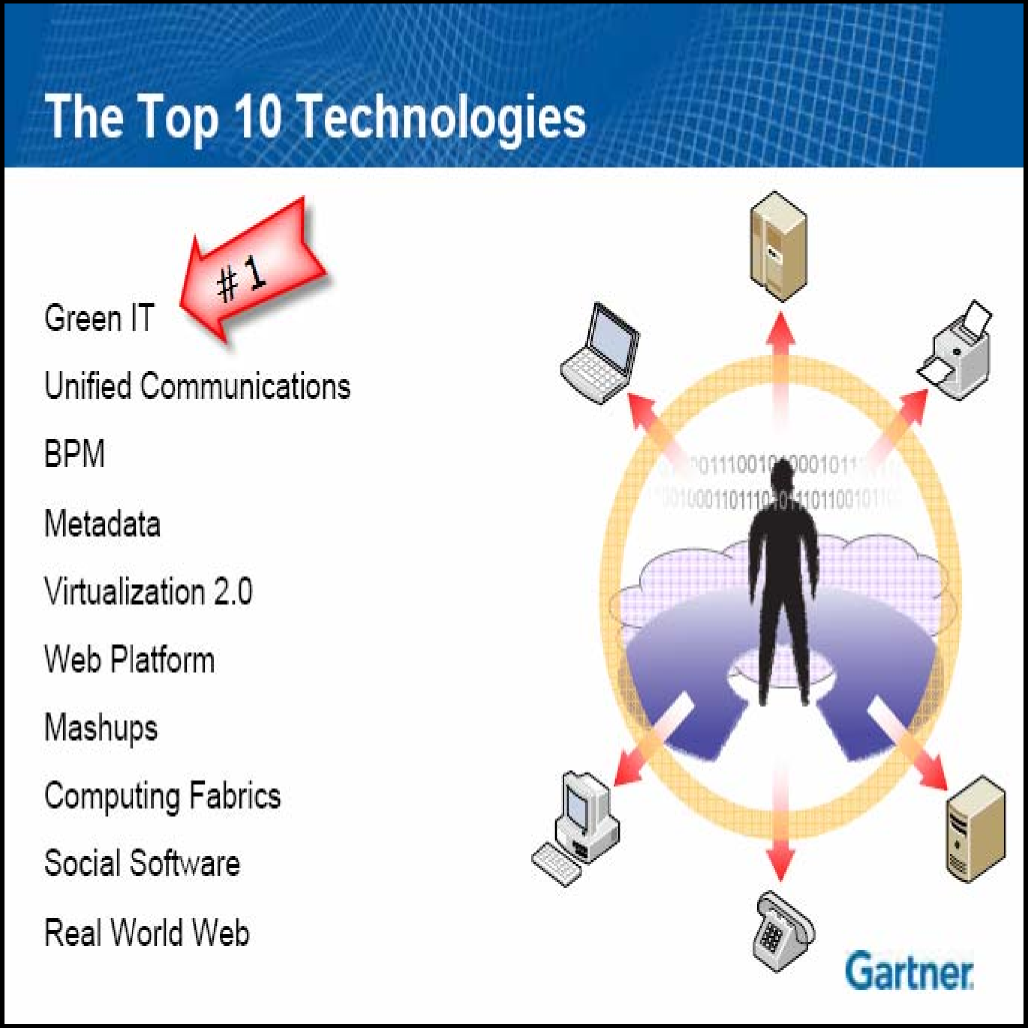
No system at label power 18.3 KW

EPA Report to Congress on data center energy efficiency is consistent with the IBM five steps to a green data center

Scenario	IT Equipment	Site Infrastructure (Power and Cooling)
Improved operation ▪ 20% Energy Savings	▪ Continue current trends for server consolidation ▪ Eliminate unused servers ▪ Adopt "energy-efficient" servers to modest level ▪ Enable power management on 100% of applicable servers ▪ Assume modest decline in energy use of enterprise storage equipment	30% improvement in infrastructure energy efficiency from improved airflow management
Best practice ▪ 45% Energy Savings	All measures above plus: ▪ Consolidate servers to moderate extent ▪ Aggressively adopt "energy-efficient" servers ▪ Assume moderate storage consolidation	Up to 70% improvement in infrastructure energy efficiency from all measures in "Improved operation" scenario, plus: ▪ Improved transformers and uninterruptible power supplies ▪ Improved efficiency chillers, fans, and pumps ▪ Free cooling
State-of-the- art ▪ 55% Energy Savings	All measures above plus: ▪ Aggressively consolidate servers ▪ Aggressively consolidate storage ▪ Enable power management at data center level of applications, servers, and equipment for networking and storage	Up to 80% improvement in infrastructure energy efficiency, due to all measures in "Best practice" scenario, plus: ▪ Direct liquid cooling ▪ Combined heat and power

Source: EPA Response to Congress for Public Law 109-431, 08/07/07. See page 53 for more details.

Gartner's list of Top Ten Technologies for 2008



Why Green IT is #1

- **2006 many technical barriers and limitations were overcome.**
- **2007 moved from a niche to widespread adoption.**
- **2008 business are planning new and revised approach to green.**

Thank You

Barriers to Energy Efficiency and How you can set Goals

1. **Defining Efficiency (same or better service with less energy)**
2. **First Cost (Up front costs vs. investing for payback over time)**
3. **Split Incentives (who pays electric bill / who invests capital)**
4. **Risk Aversion (security and interrupted operations / measurements and incentives)**
5. **Learning Curve (running equipment vs. equipment running energy efficient)**
6. **Quickly Changing Technology (IT vs. HVAC mismatch)**
7. **Lack of Energy Monitoring (collecting data on components for improving efficiencies, actively managing or charge back)**

Source EPA Report p.84 - 89

Customer Example of Year end 2008 Goals

1. **Energy Consumption – Reduce 10%**
2. **Server room reduction – 40%**
3. **IT resources ROHS compliant – achieve 30%**
4. **Dispose of resources (through Green process) – 25%**
5. **Educate/Certify Staff – 5%**
6. **Improve Energy Efficiency – 20%**

Potential Energy Efficiency Opportunities Table 3-6

- **Computing software** Design software to avoid excess code and inefficienciestreat CPU cycles as a finite resource) Provide developer tools to help improve efficiency of software Enable shifting of computational load among systems for maximizing energy efficiency Upgrade applications no longer supported on latest technology and/or operating systems, allowing removal of legacy servers Implement virtualization to allow consolidation of server and storage hardware

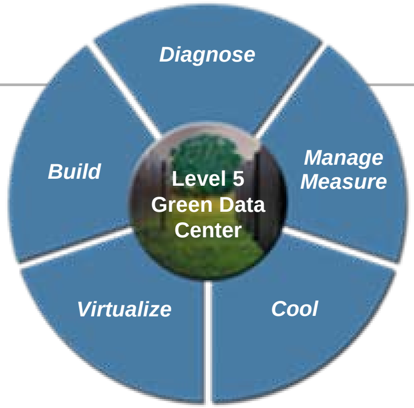
- **IT hardware (computing, storage and network)** *Operational Improvements* Turn off (ideally remove) dead, obsolete, or excess equipment Turn off or power-manage equipment that won't be used for extended periods of time (e.g., development systems not in active use, systems for future expected increases in activity, etc.) Enable power-management features on existing equipment (e.g., frequencyvoltage scaling) Maximize utilization of storage capacity through shared data storage, data compression, and data de-duplication Accept high-efficiency power supplies over full operating range including DC-DC conversions) or directly accept moderate DC voltage Digitally control power supplies to better match output to load Use high-efficiency variable speed fans (within IT equipment) Reduce energy use at lower utilizations (whether the resource is processing capacity, memory, communications, or etc.). Applies to individual systems and to clusters. Improve microprocessors to lower leakage current, increase system integration, etc. Use storage virtualization and massive array of idle disks (MAID) technologies to allow storage power Use centralized servers (large systems to improve sharing of computer resources Improve hardware support for virtualization Use built-in power monitoring

- **Electrical Systems** Use high-efficiency power distribution (i.e., higher-voltage AC or moderate-voltage DC (50-600 VDC)) Use premium-efficiency motors in fans and pumps Use high-efficiency UPS units over full range of load Use rotary-based UPS units Right size power distribution and conversion to optimize efficiency Use on-site generation with grid as back-up

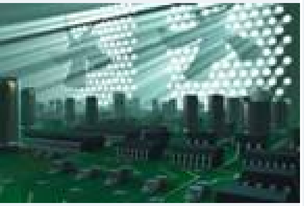
Potential Energy Efficiency Opportunities Table 3-6 continued

- **Heat Removal** Improve airflow management (i.e., use hot/cold aisle configuration or penetration sealing) Adjust environmental conditions (temperature and humidity set points) to allow wider range while still meeting manufacturer specifications Optimize data center airflow configuration using visualization tools (computational fluid dynamics modeling or infrared tomographyUse high-efficiency variable-speed air-handler fans and chilled water pumps Use variable-speed chillers Use variable-speed, primary-only chilled water pumping Use high-efficiency chiller and chilled water supply motors Use high-efficiency CRAC units Use air-side economizers (outdoor air) when outdoor conditions permit (preferably in mild climate locations) 54 (operation)) (server count Use water-side economizers (cooling tower) when outdoor conditions permit (preferably in mild climate locations) Commission infrastructure systems to ensure set points are at proper values, sensors are in calibration, airflow is within design tolerances, etc. Rebalance air-handler system after significant IT reconfiguration Size systems and configure redundancy to maximize efficiency e.g., use redundant air-handler capacity in normal Increase chilled water supply and return temperature difference to reduce chilled water flow Optimize chilled water plant (cooling tower) Reuse waste heat for space heating Use direct liquid cooling (water or other dielectric liquid with currently available technologyi.e., in-rack or in-row cooling) and emerging technology (i.e., in-chassis or chip-level)
- **Controls and Management** Use system management hardware/software that enables powering down (to sleep and/or off) parts of server clusters during times of low utilization Dispatch non-time-sensitive computational operations to reduce peak computing load and allow reduction of total Provide for standard reporting of power use, platform temperature, and processor utilizations to assist operators in understanding and managing energy use in their data centers Use shared computing models, such as grid computing Optimize cooling controls to dynamically match the cooling supply to the IT heat load Dynamically optimize the assignment of work across the data center to ensure maximum efficiency Monitor power in real time
- **Distributed Generation** Use combined heat and power Use renewable energy (e.g., photovoltaic panels) Use fuel cells
- *Each opportunity is not necessarily applicable to all data centers

Benefits of a Green Data Center



Green should
Optimize IT and use our planets resources wisely

	From	To
Financial 	Rising global energy prices	Ability to accurate view baseline energy cost
	Squeeze on IT budgets	Cost savings from more efficient energy use
	Constraints on IT growth	Relax budgetary pressures to allow growth
Operational 	High density server systems	More computing performance per kilowatt
	Exploding power & cooling cost	Shift energy to cool / energy to operate ratio
	Systems availability risks	Extend the life of IT equipment
Environmental 	Corporate social responsibility	Meaningful energy conservation
	Lack public image	Improved public image
	Improve employee moral	Positive contribution to the Green movement creates a good place to work