Energy Logic:

A Roadmap for Reducing Energy Consumption in the Data Center

Emerson Network Power

Agenda

- Energy efficiency
  - Where we are today
  - What data center managers are looking for
- Energy-saving strategies
  - Energy Logic: data center model
  - Impact of Energy Logic
    - Cascade effect
    - Energy consumption
    - Capacity freed up
    - Payback
  - The 10 strategies
- Recommendations and key take-aways

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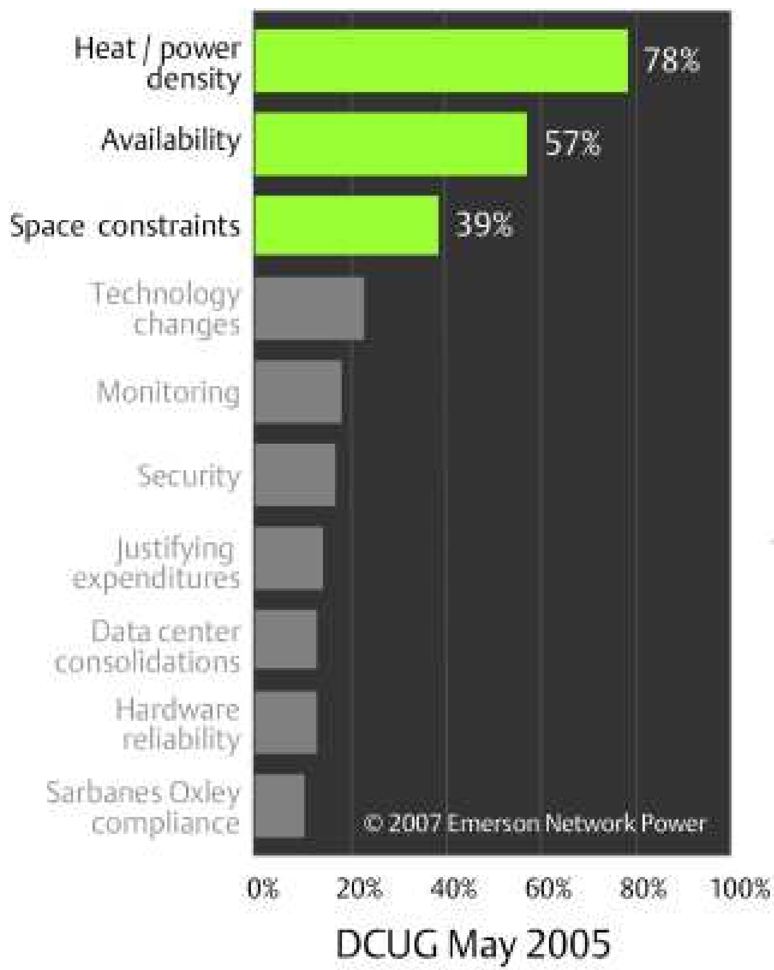
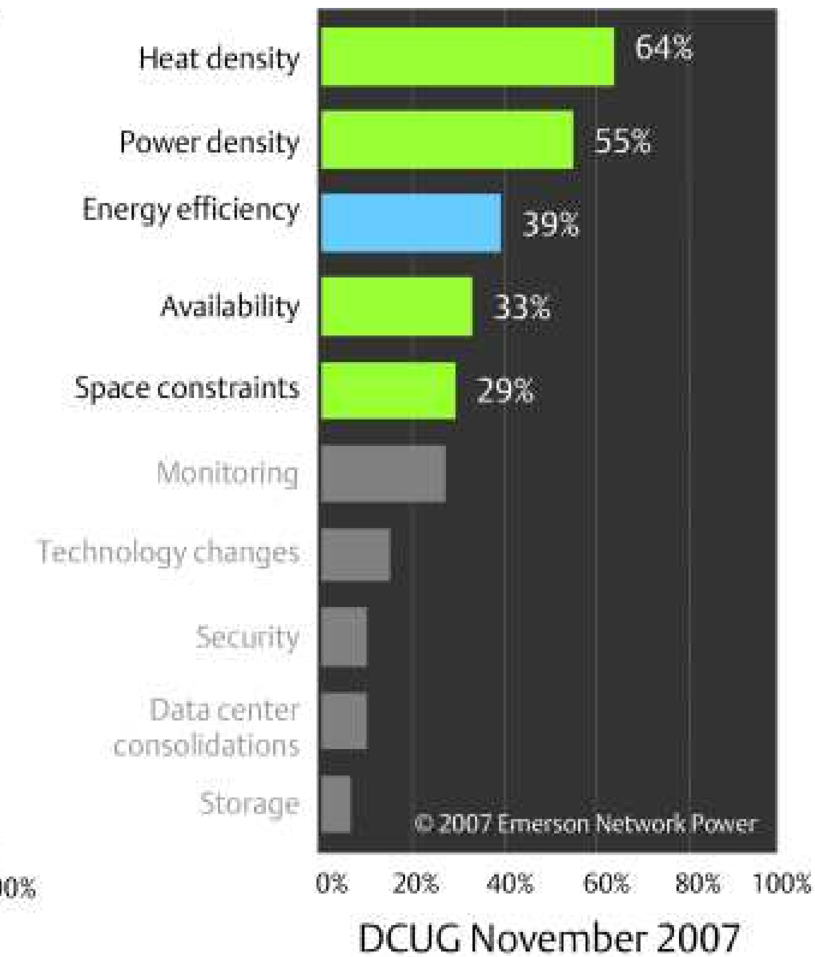
Energy Efficiency Emerging as a Top Concern of Data Center Managers

Along with Power, Cooling & Space Constraints & Availability

What are your top facility / network concerns?





Source: Data Center Users' Group Surveys

IT Perspective on Energy Efficiency

- Top priority is delivering on service level agreements
  - Performance - provide adequate compute capacity
  - Reliability - redundancy at all steps
  - Ability to support
  - Security
- Does IT care about energy efficiency?
  - Yes, but not if it impacts performance and reliability
- What if it frees up power and cooling capacity?
  - Yes! If it does not impact performance and reliability

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What Data Center Managers Are Looking For

- Objective ‘vendor-neutral’ analysis
- Holistic view of the data center
- Quantification of savings from different strategies
- Prioritization of actions
- Actionable advice
- Tailored to different types of data centers
  - 24x7 vs. 8x5; compute-intensive vs. transaction-intensive
- Payback / ROI analysis to help sell to management

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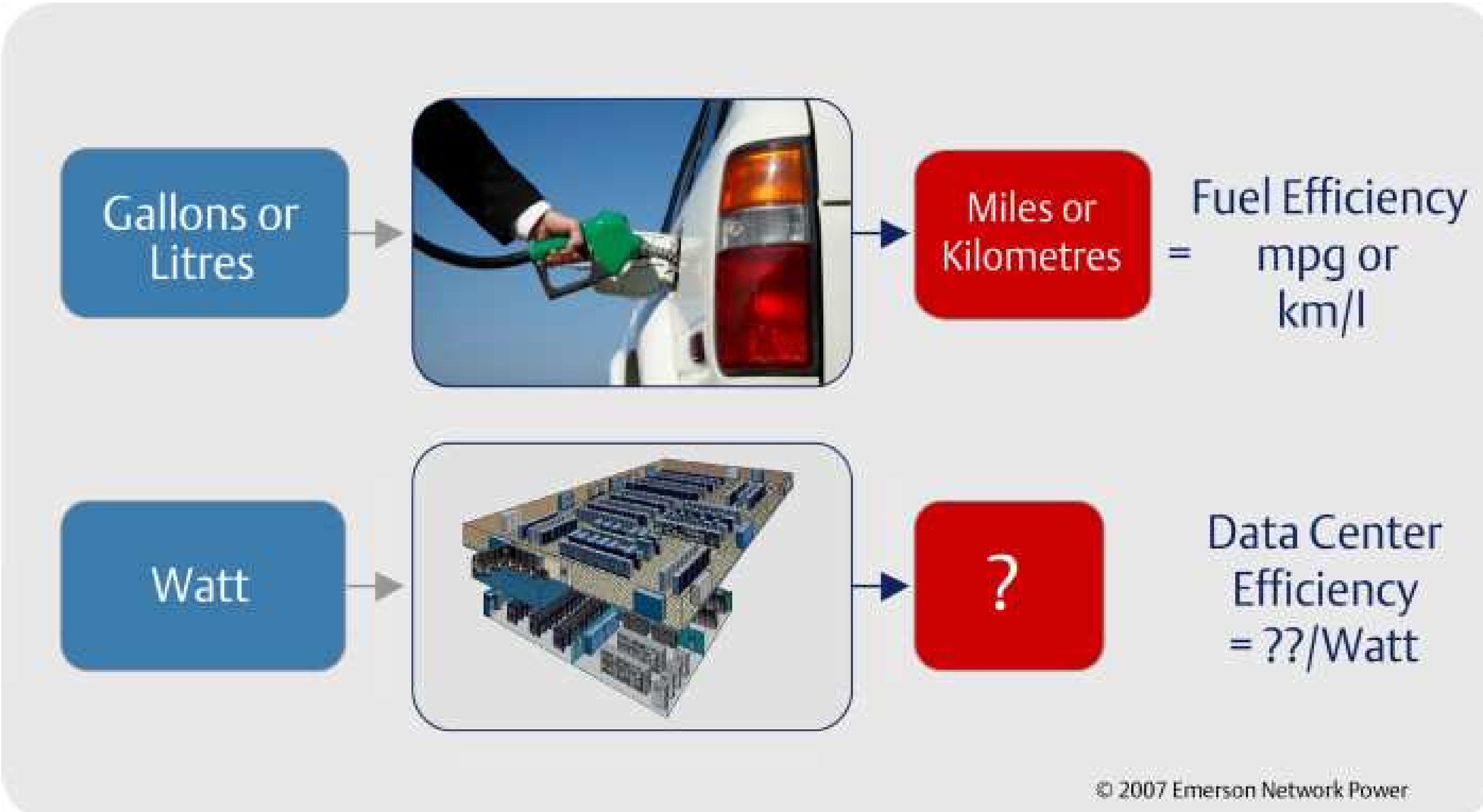
Fact: No Universal Metric For Data Center Output



In the absence of this metric, discussing data center efficiency is not meaningful. We can only talk about reducing data center energy consumption.

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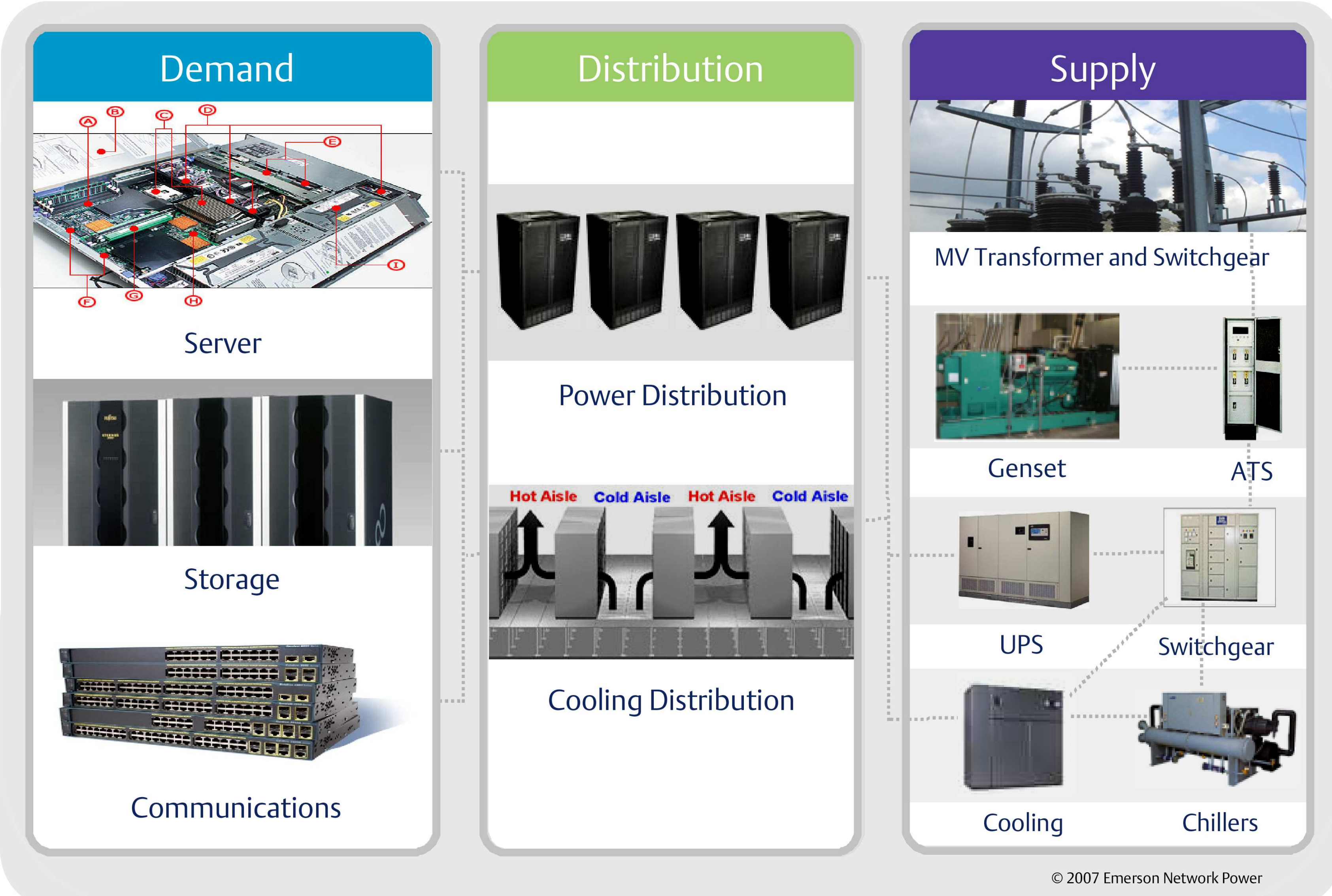
Simple Data Center Layout
(Energy Demand, Distribution and Supply)



Energy Logic: What is it?

- Emerson Network Power approach to reducing data center energy consumption
- Sequential roadmap that starts with IT equipment and moves through to support infrastructure
  - Emphasis is on cascade of savings
- Based on research and modeling
- Provides quantified savings and an estimated ROI
- Frees up power, cooling and space capacity without compromising availability or flexibility

Energy Logic: Three Key Messages

1. **The most effective strategy to save energy:**
   - Start with reducing losses / consumption at the IT equipment level and work your way back through the supporting equipment
     - ***Every watt saved at the equipment level has a cascading effect upstream***
2. As you reduce energy consumption, make sure you do not compromise on availability and flexibility
   - Efficiency Without Compromise™
3. High-density architecture helps reduce energy consumption

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Energy Logic: Model Assumptions

Model Helps Quantify Impact of Actions

- 5,000 sq. ft.
- Server refresh rate: 4 to 5 years
  - Data center has mix of servers ranging from new to 4-years old
  - No virtualization or blades
- No high-density loads
  - Average density ~ 3 kW/rack (120 W/sq. ft.)
- Total compute load about 600 kW
- UPS configuration 2x750 kVA 1+1 redundant
- Hot-aisle / cold-aisle configuration
- Floormount cooling (connected to building chilled water plant)
- MV transformer (5 MVA) at building entrance with associated switchgear

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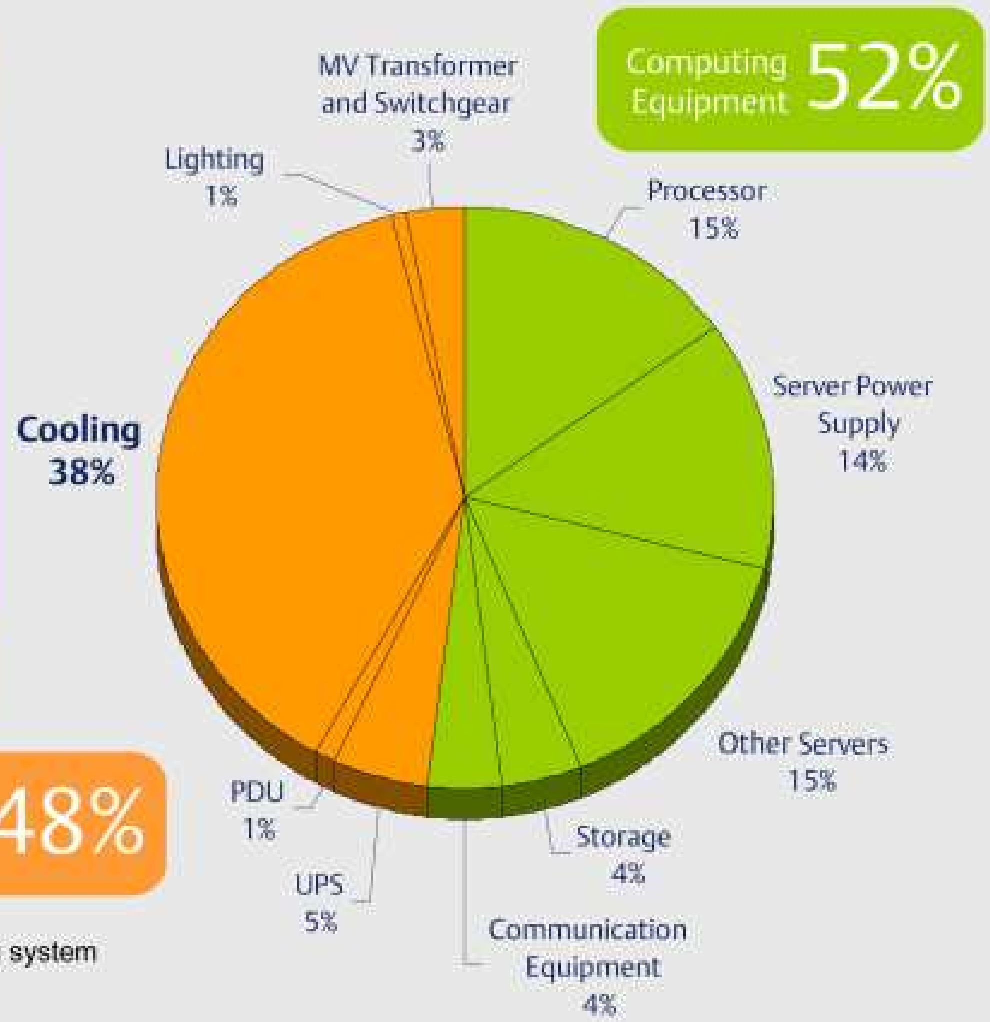
Data Center Energy Consumption Model
5,000 Sq. Ft. Data Center

Equipment Category	Energy Consumption
Computing	588 kW
Lighting	10 kW
UPS & Distribution Losses	72 kW
Cooling Power Draw for Computing & UPS Losses	*429 kW
Building Switchgear / MV Transformer / Other Losses	28 kW
Total Power Draw	1,127 kW

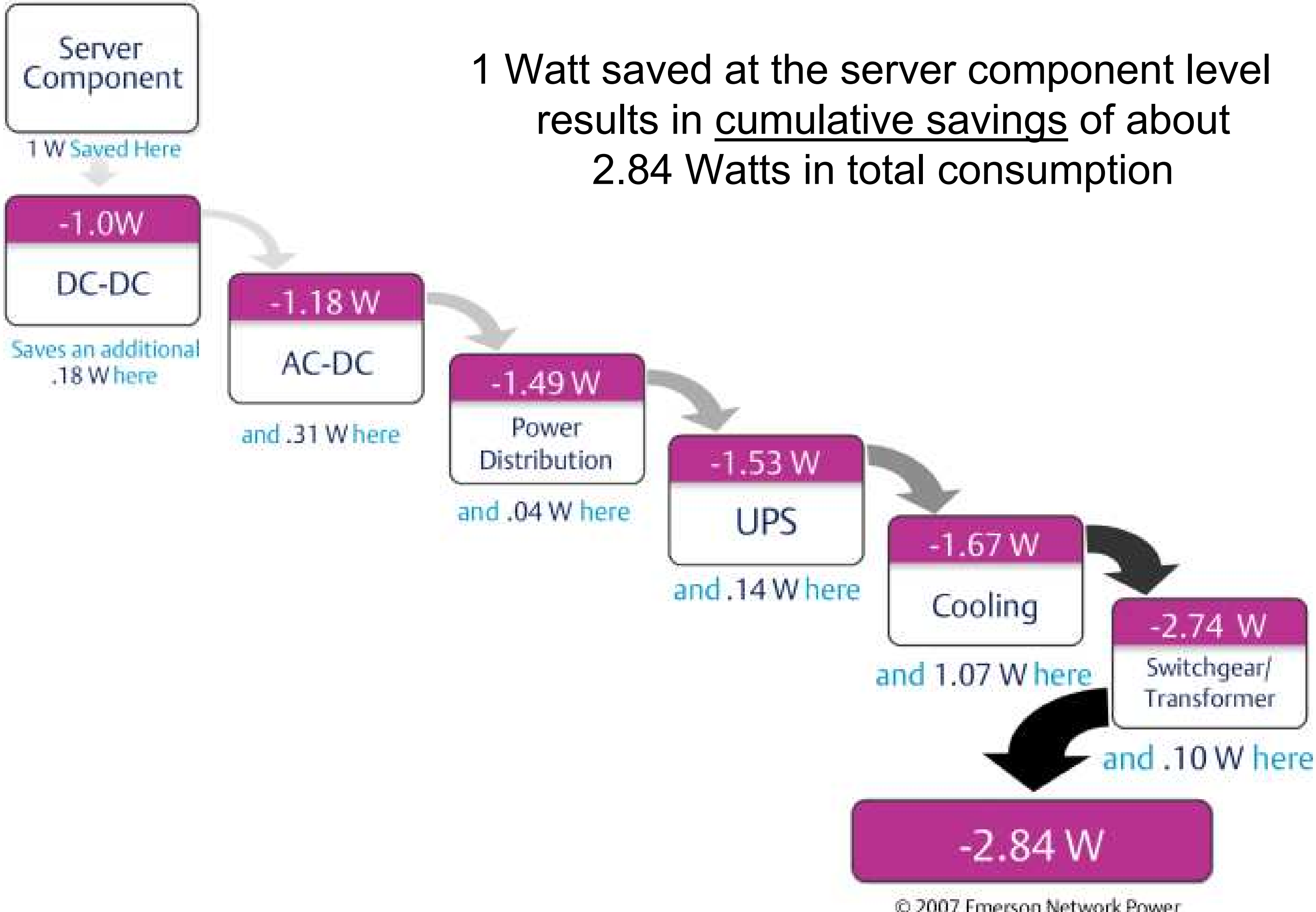


Power and Cooling 48%

* Cooling load assumes chilled water based cooling system

The 'Cascade' Effect

1 Watt saved at the server component level results in <u>cumulative savings</u> of about 2.84 Watts in total consumption

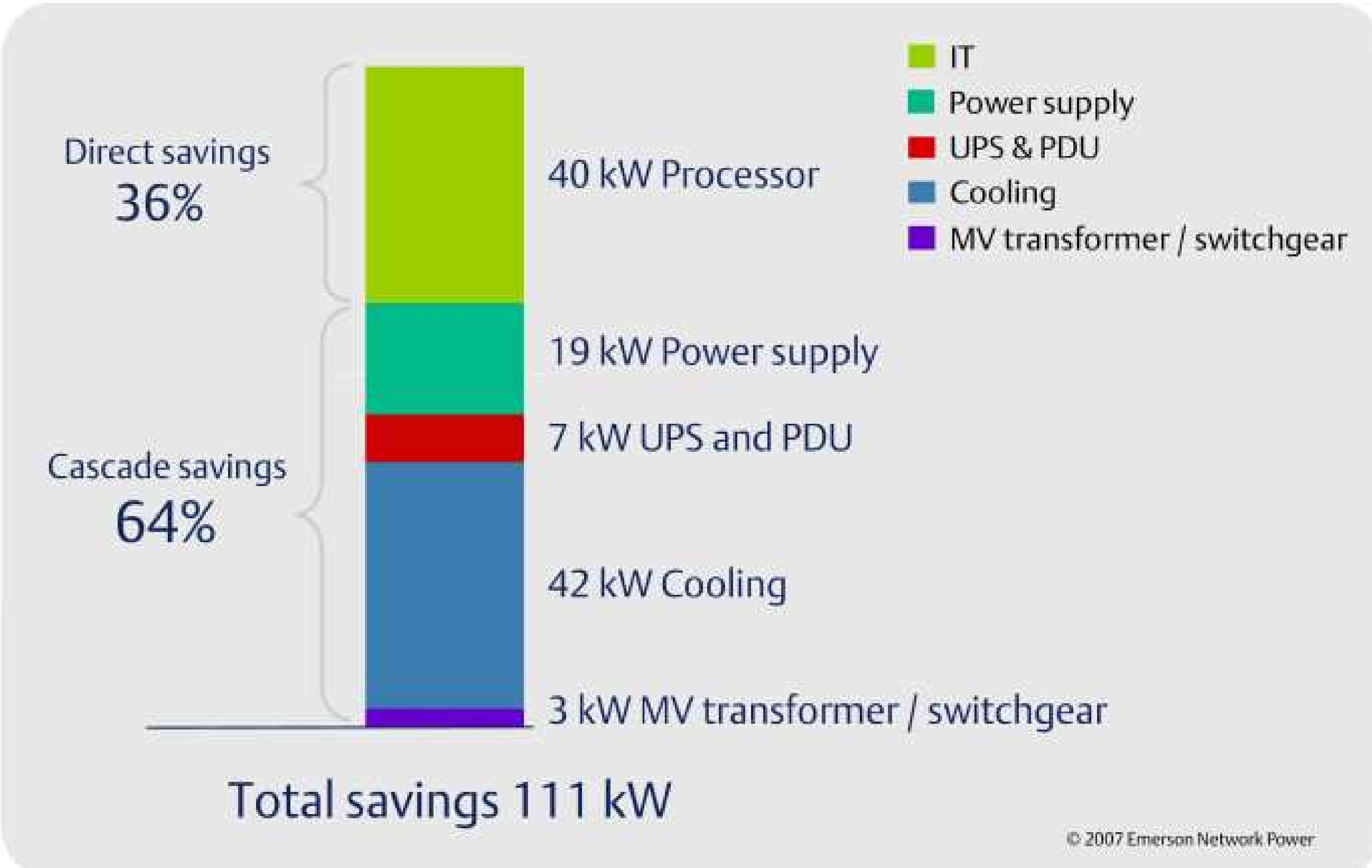


Energy Logic: Cascade Savings Strategies

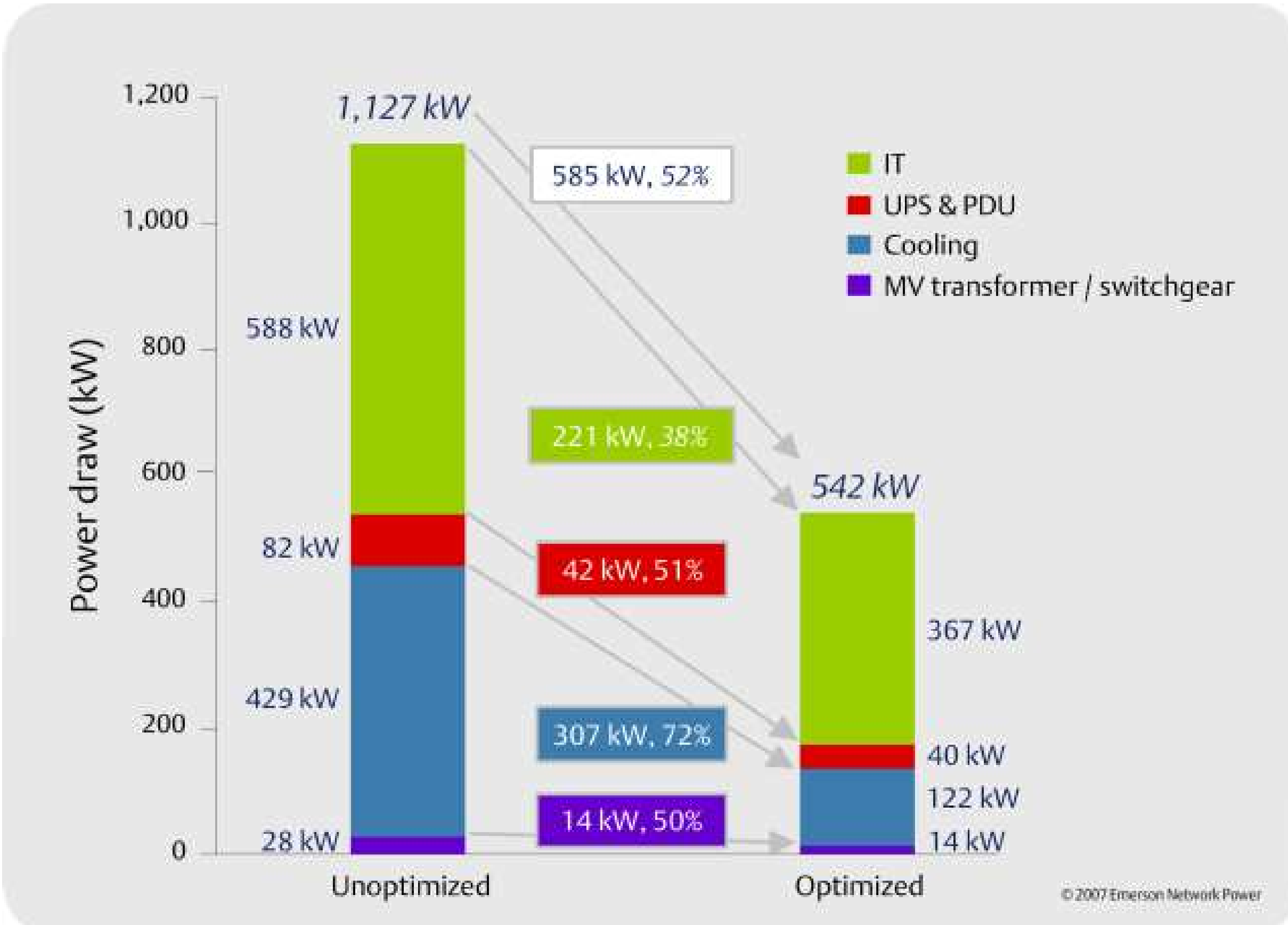
	Strategy	Initial data center	Optimized data center	Saving (kW)	%	
1.	Low-power processor	91 W / processor (average)	70 W / processor	111	10%	30%
2.	High-efficiency power supplies	AC-DC → 79% DC-DC → 85%	AC-DC → 90% DC-DC → 88%	124	11%	
3.	Server power management	Power consumption: 80% of full load when idle	45% of full load when idle	86	8%	
4.	Blade servers	All rackmount	20% blades	7	1%	
5.	Server virtualization	No virtualization	20% servers virtualized	86	8%	11%
6.	Power distribution architecture	208V AC	415V AC provides 240V single-phase	20	2%	
7.	Implement cooling best practices	Hot-aisle / Cold-aisle	Optimized cold aisle and chilled water temp, no mixing of hot and cold air	15	1%	
8.	Variable-capacity cooling	Fixed capacity cooling	Variable capacity refrigeration and airflow	49	4%	11%
9.	High-density supplemental cooling	Floormount cooling only	Floormount plus supplemental cooling	72	6%	
10.	Monitoring and optimization	No coordination between cooling units	Cooling units work as a team	15	1%	
	Initial data center load: 1,127 kW		Total savings	585 kW	50%+	

IT Hardware Choices — Operational Best Practices — Power & Cooling Product Efficiencies

Cascade Savings Example - Lower Power Processor



Total Energy Logic Savings With All 10 Strategies Applied



Energy Logic: Energy-Saving Opportunity

Savings potential from each strategy applied individually

Energy-saving strategy	% Savings*
1. Low-power processor	10%
2. High-efficiency power supplies	12%
3. Server power management features	11%
4. Blade servers	1%
5. Server virtualization	14%
6. Power distribution architecture	3%
7. Implement cooling best practices	2%
8. Variable-capacity cooling	7%
9. High-density supplemental cooling	18%
10. Monitoring and optimization	2%

* For every action, downstream cascading benefits are included. Savings are not cumulative!

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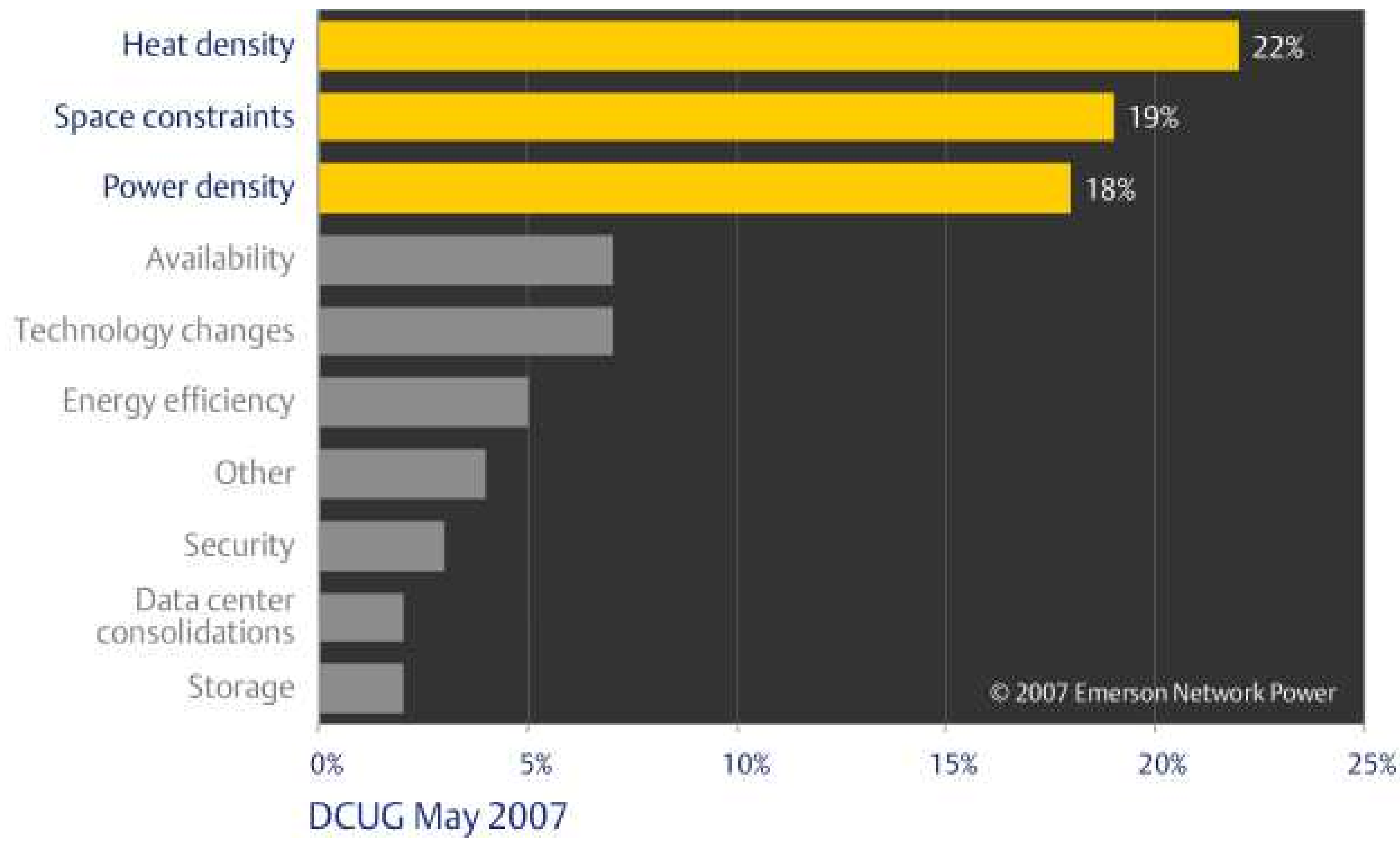
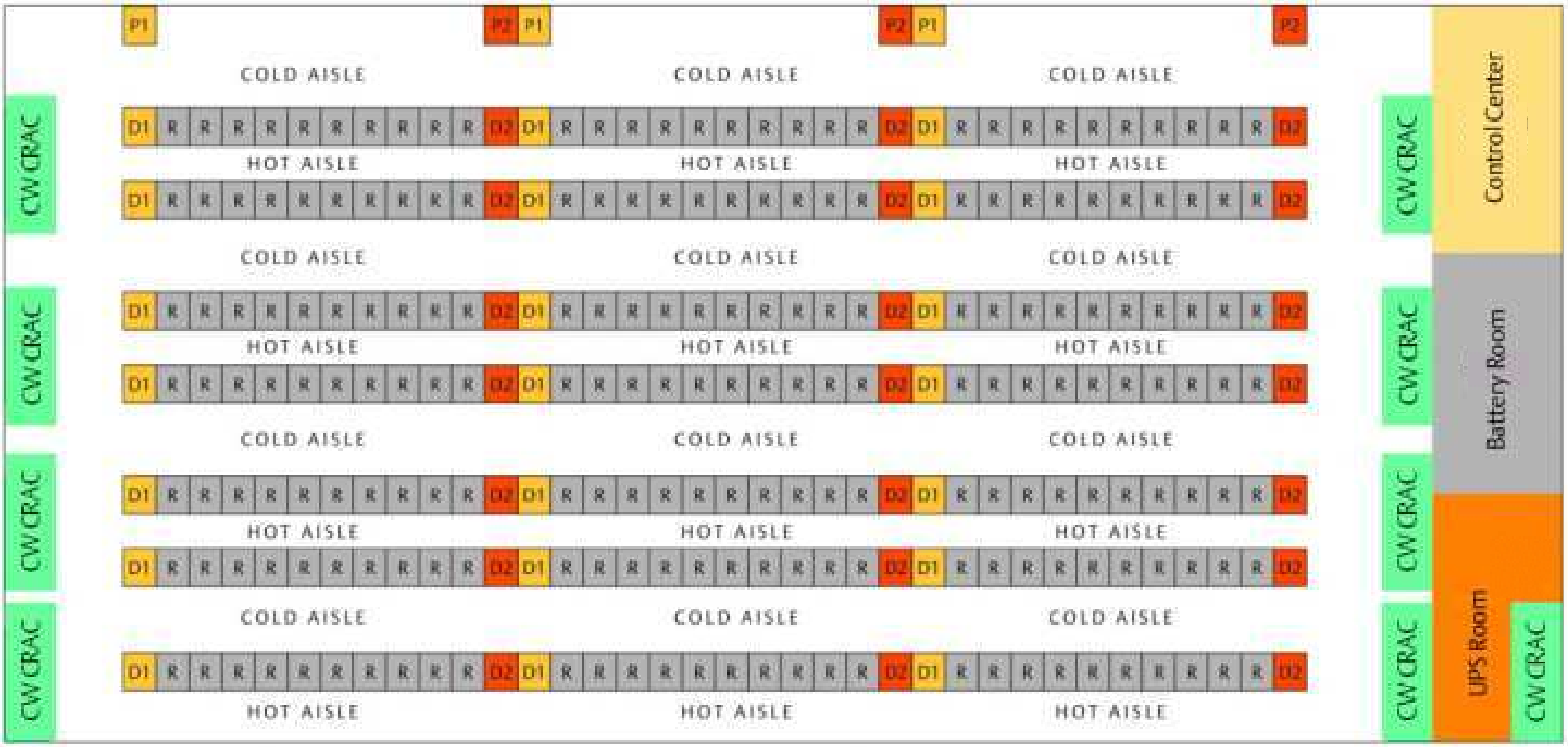
Cooling, Space and Power Constraints Are 'Biggest Issues'

What is the biggest single issue you currently face?



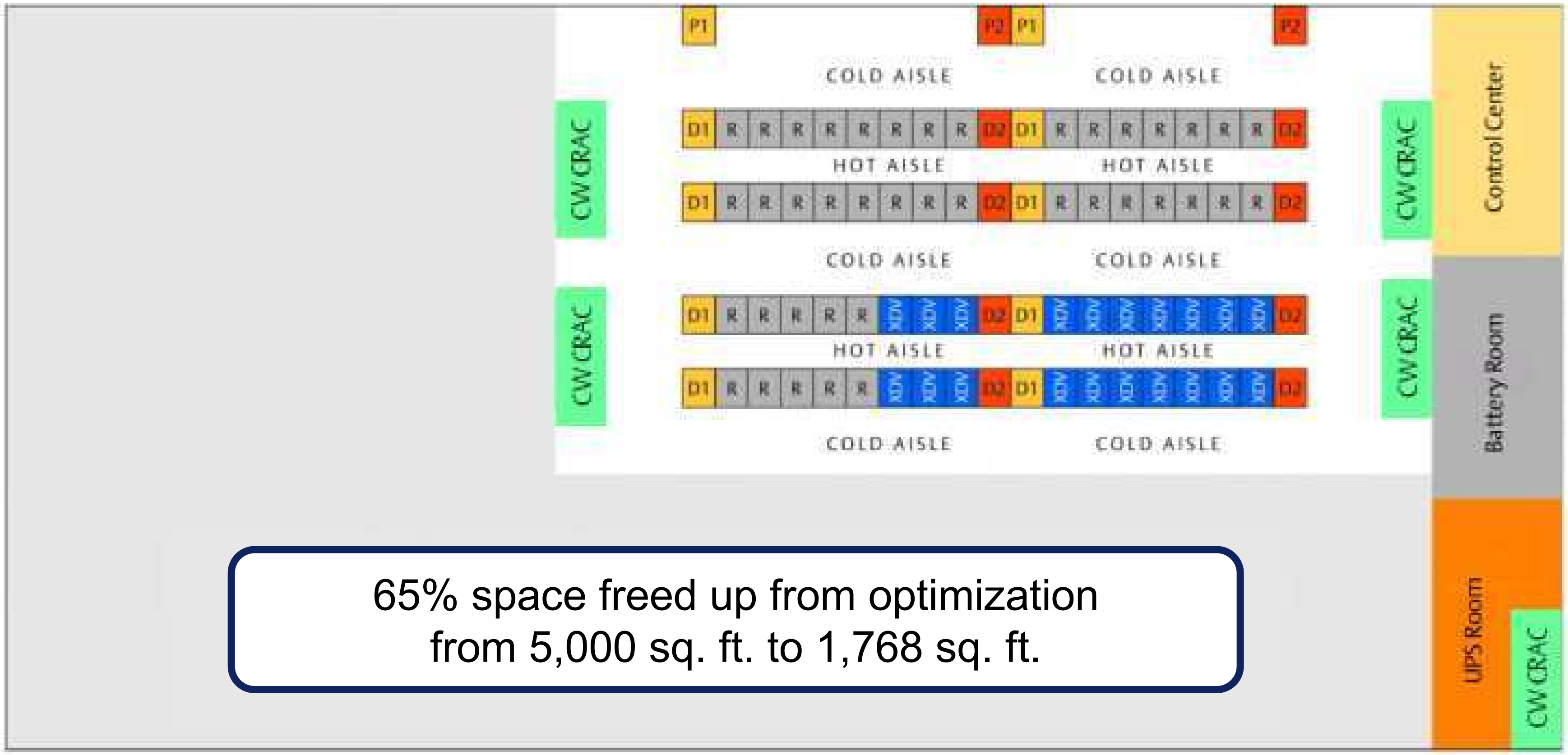
Source: Data Center Users' Group Surveys

Unoptimized Data Center Layout



Base	
Total compute load	588 kW
Power density	2.8 kW/rack
Number of racks	210
Space	4,988 sq. ft.

Optimized Data Center Layout



Optimized	
Total compute load	367 kW
Power density	6.1 kW/rack
Number of racks	60
Space	1,768 sq.ft.

	Standard Density	**High Density**
Power density	3.2 kW/rack	12 kW/rack
Number of racks	40 racks	20 racks

Address Data Center Space, Power & Cooling Constraints

Constraint	Unoptimized	Optimized	Capacity Freed Up for Growth
Space			
Data center space (sq. ft.)	4,988	1,768	3,220 sq. ft. **(65%)**
Power			
UPS	2* 750 kVA	2* 500 kVA	2*250 kVA **(33%)**
Cooling			
Cooling plant (tons)	350	200	150 **(43%)**
Building entrance switch and genset			
Building entrance switchgear and genset (kW)	1,169	620	549 **(47%)**

Power, cooling and building entrance switchgear should be sized for peak load!

Energy Logic: Energy-Saving Strategies Payback Period

	Strategy	Estimated Payback
1	Low-power processor	12 to 18 months
2	High-efficiency power supplies	5 to 7 months
3	Server power management features	Immediate
4	Blade servers	TCO reduction by 38%*
5	Server virtualization	TCO reduction by 63%**
6	Power distribution architecture	2 to 3 months
7	Implement cooling best practices	4 to 6 months
8	Variable-capacity cooling	4 to 10 months
9	High-density supplemental cooling	10 to 12 months
10	Monitoring and optimization	3 to 6 months

* Source: IDC ** Source: VMWare

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Prioritize Actions Based on Compute Load & Type of Operation

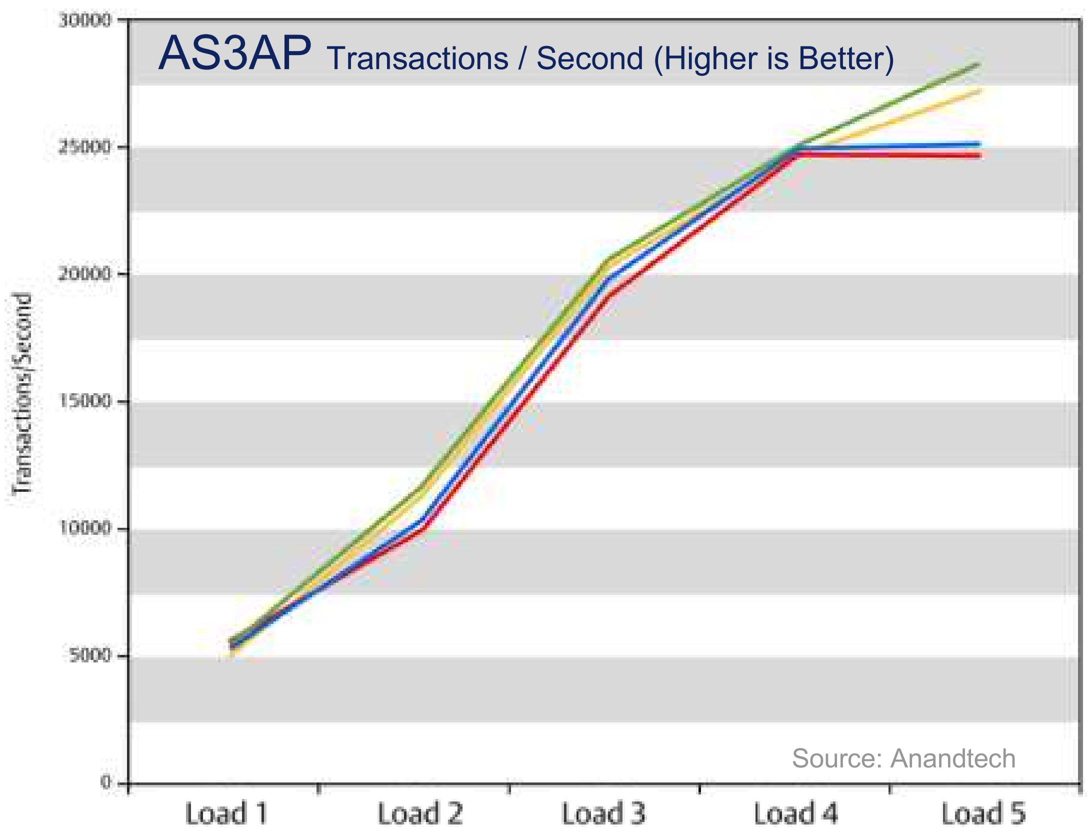
Core operation time

	Transaction intensive Example: web server	Compute intensive Example: data applications
24 x 7	1. Low-power processor 2. High-efficiency power supplies 3. Blade servers	1. Server virtualization 2. Lowest power processor 3. High-efficiency power supplies 4. Consider mainframe architecture
8 x 5	All of above plus power management features	All of above plus power management features
	Cooling best practices Variable capacity cooling High-density supplemental cooling 415V AC distribution Monitoring and optimization	

Strategy 1: Low-Power Processor

1

	Sockets	Clock Speed	Standard Power	Low Power	Savings
AMD	1	1.8 - 2.6 MHz	103 W	65 W	38 W
	2	1.8 - 2.6 MHz	95 W	68 W	27 W
Intel	2	1.6 - 2.0 MHz	80 W	50 W	30 W



Chip makers and independent analysts claim no or negligible impact on compute performance

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Strategy 2: High-Efficiency Power Supplies

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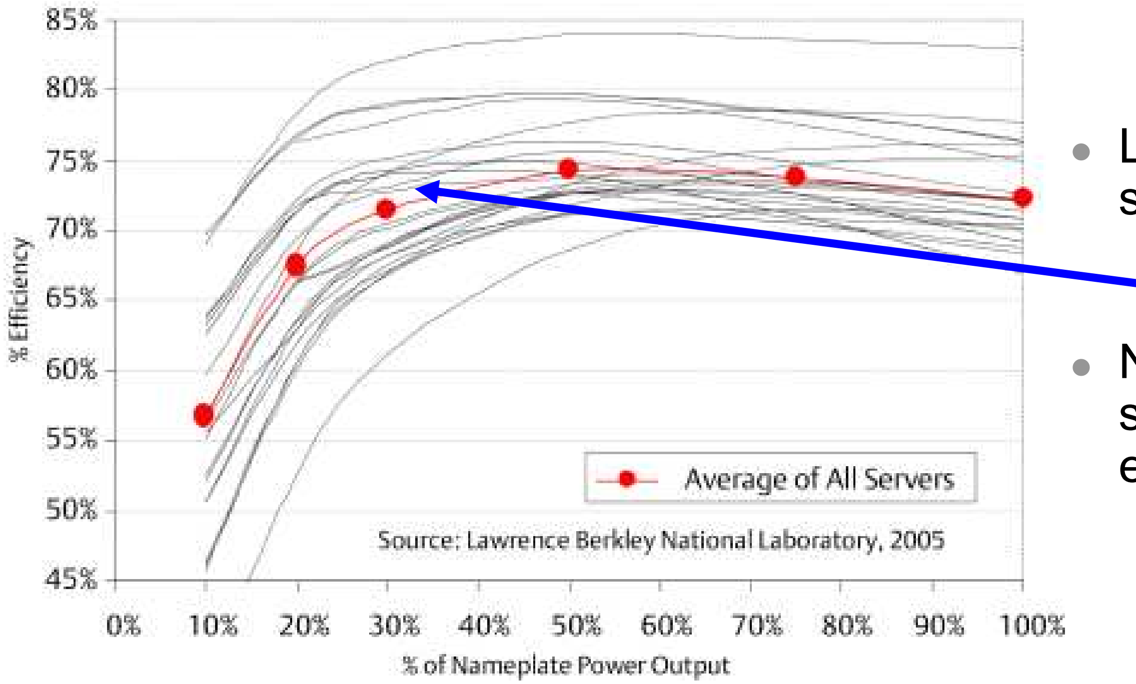


- LBNL reported power supply efficiency
  - 72% - 75% at 30% load
- New power supplies have substantially higher efficiencies
  - 89% - 91% @ 30% load

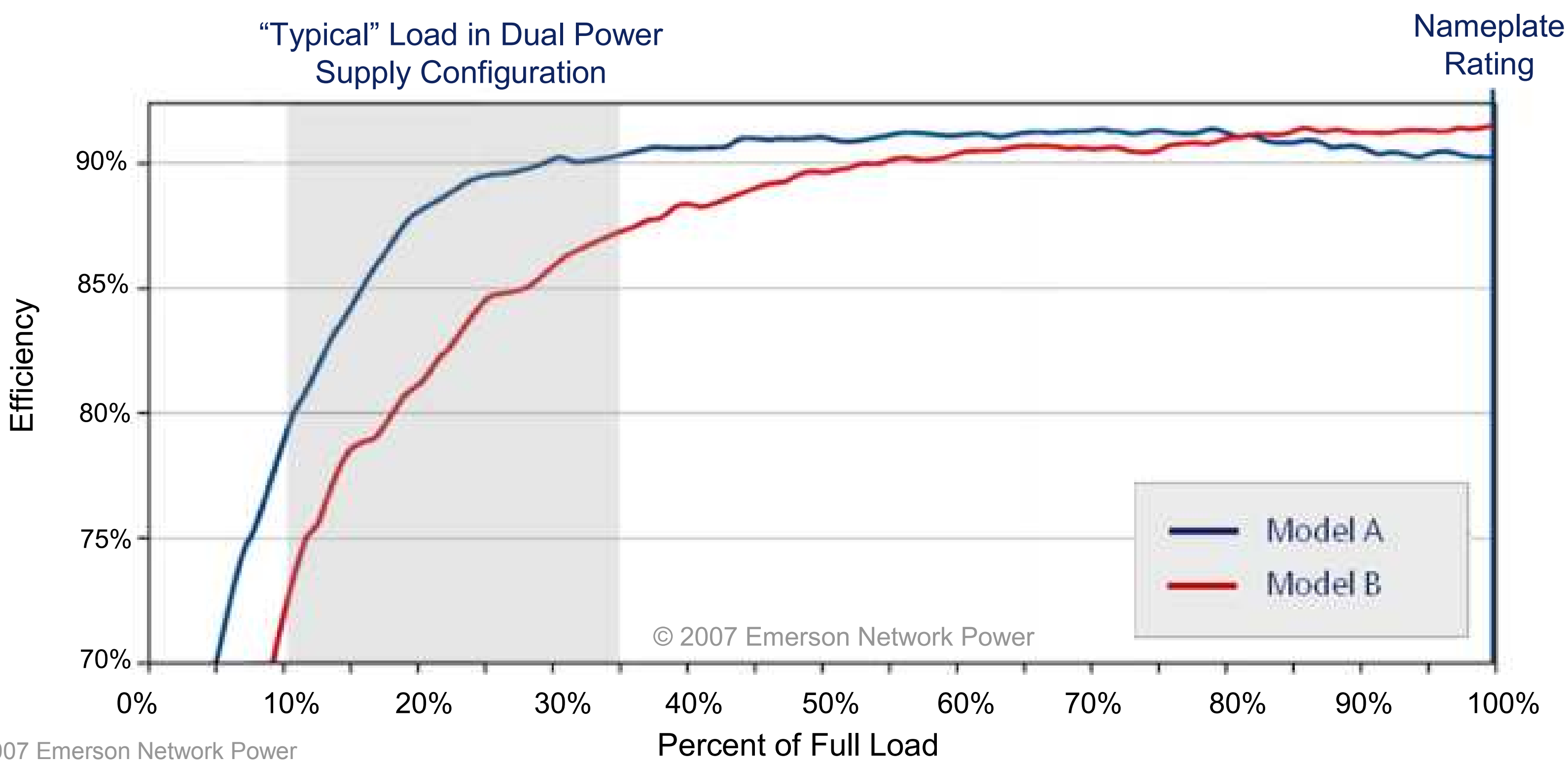
Right-size your power supply

- Typically server power supplies are oversized to accommodate maximum server configuration
  - Even though most servers are shipped at much lower configurations
  - Higher losses associated with oversized power supplies

Strategy 2: High-Efficiency Power Supplies (cont.)

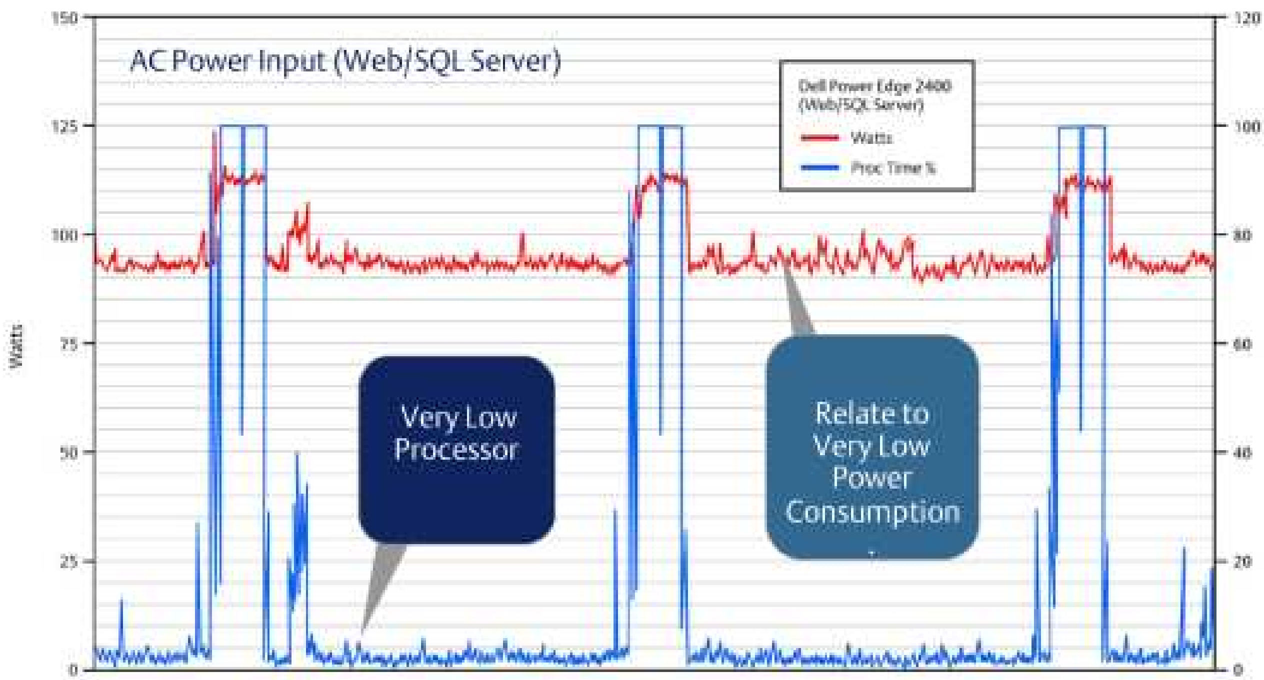
3

- Which power supply will you choose?
  - Power supply A: 91% efficient at nameplate rating, or power supply B: 93% efficient at nameplate rating?
- Power supplies are never at nameplate rating
  - Dual power supplies are never loaded at >50% under normal conditions
- Spec the power supply which is more efficient at 10% - 35% load



Strategy 3: Server Power Management

3



Source: EPRI field instrument, page 22 of LBL High Performance Buildings: Data Centers Pub Dec 2005

Servers consume 75%-80% of peak load power even when the processor is idle.

- Server processors have power management features built in
  - Can reduce power draw when processor is idle
- Typically power management features are turned off
- Turning on power management feature reduces processor idle power to ~45% of peak or less
- Test your OS / applications for latency

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Strategy 4: Blade Servers

4

Comparison of hardware for rackmount servers & blade servers

Constraint	14 one-U servers	Blade System (14 blades)
Disk drives	14	1
CD-ROMs	14	1
Fans	112	2
Power supplies	28	4
Line cords	28	4
KVM cables	14	1
Ethernet cables	28	8
Fibre channel cables	28	4
Systems management cables	13	1

Source: IBM white paper 'BladeCenter packaging, power and cooling'

- Blade servers consume about 10% less power compared to equivalent rackmount servers
  - Common components in chassis – fans, communication cards, etc.
- **Blades enable high-density architecture!**

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Strategy 5: Server Virtualization

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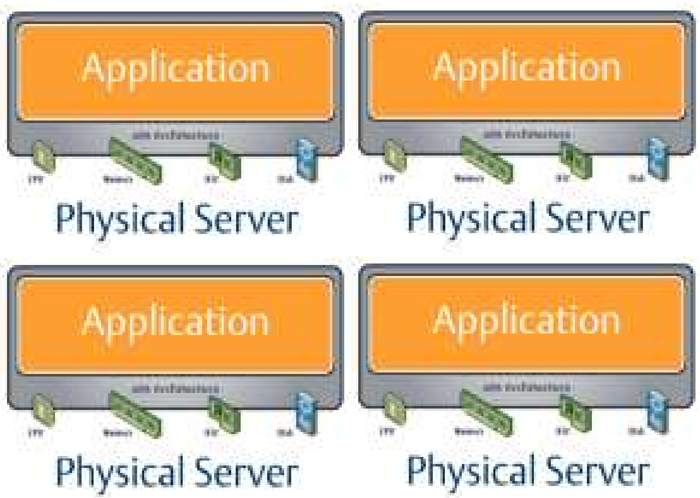
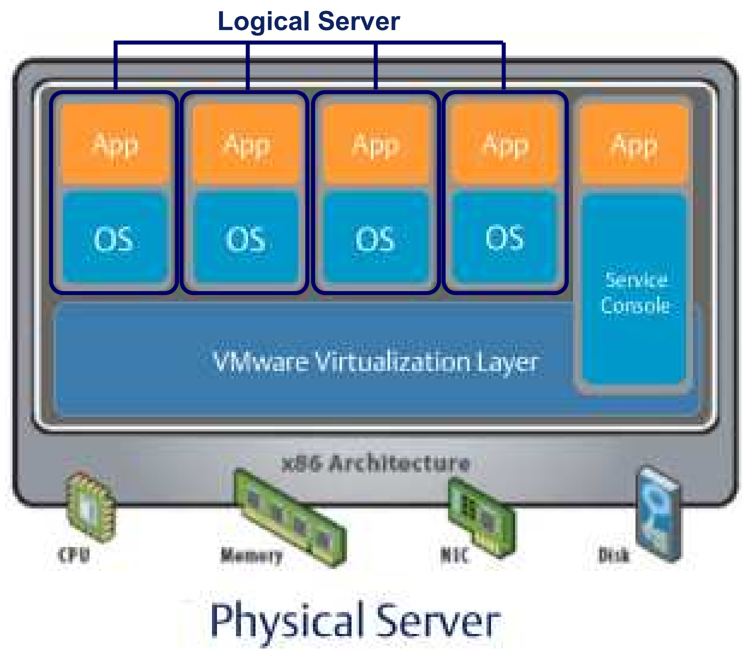
Before Virtualization



Typical Virtualization Architecture



- Virtualization increases server utilization by decoupling hardware and software
- Multiple 'logical servers' on a single physical server
- Energy savings with **fewer number of servers**
  - Consolidation ratios of 8:1 are typical

Source: VMware

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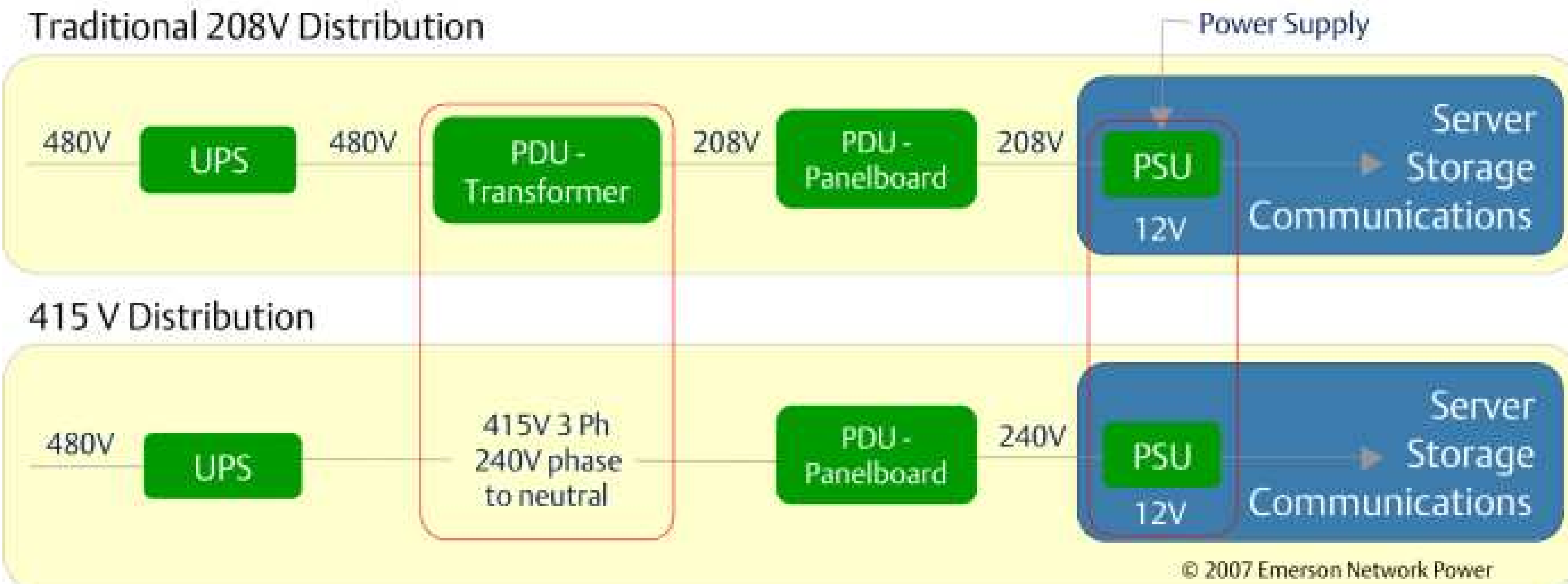
Strategy 6: Power Distribution Architecture

6



- Servers are capable of taking 240V input
  - Power supplies are 0.6% more efficient at 240V than at 208V
- Change power distribution to 415V 3-phase which is 240V line-neutral
- Energy efficiency gain
  - Elimination of PDU transformer losses
  - Improved server power supply efficiency at higher voltage

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Strategy 7: Implement Cooling Best Practices

7

- Reduce energy waste
  - Improve vapor barrier – unnecessary humidification / dehumidification
  - Reduce solar heat gain; air leakages in the room, under-floor and ceiling
- Optimize airflow
  - Reduce airflow restrictions under the floor
  - Arrange racks in hot-aisle / cold-aisle configuration
  - Reduce air recirculation using blanking plates where appropriate
  - Place cooling unit at the end of the hot aisle
  - Use ducts to return hot air to the cooling unit
- Use optimal set points
  - Proper cold aisle temperature – adjust room set point (68°F to 70°F)
  - Raise the chilled water temperature above 45°F
- ASHRAE guideline books available
- Thermal assessments can help jump start the process

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Strategy 8: Variable-Capacity Cooling

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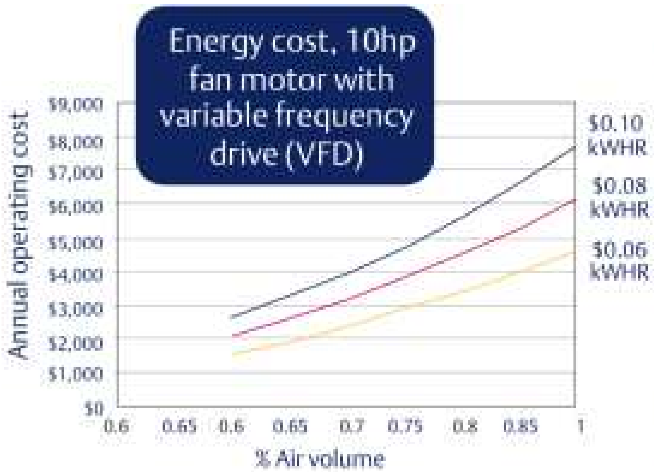
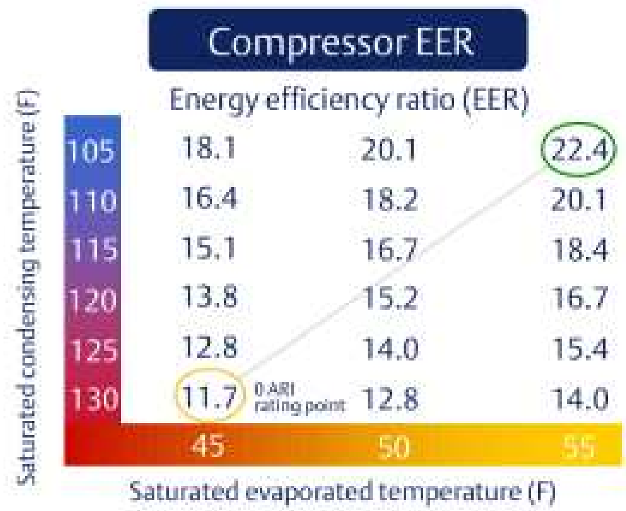
- IT loads have a large variation in cooling and airflow requirements
  - Virtualization, power management, new equipment
- Need to match cooling capacity with the IT load
  - Eliminates over cooling and improves cooling efficiency with reduced cycling





<u>Chilled Water Units</u>

- Valve (CW) / airflow
- Variable airflow
  - Reducing fan speed by 20% reduces power consumption by 50%
  - VFD retrofit kits are available

<u>DX Units</u>

- Compressor uploading / airflow
- Variable compressors
  - Multi-step / Digital
  - Higher EER point

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Strategy 9: High-Density Supplemental Cooling

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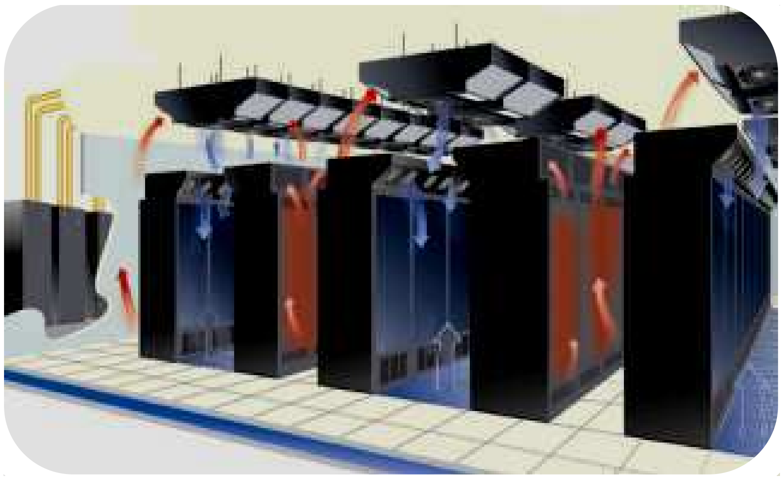

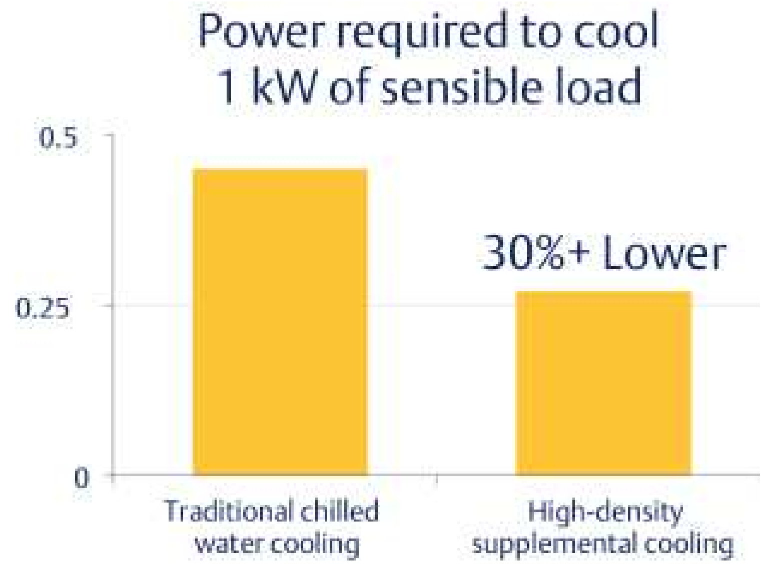

- Higher efficiency gains from “cooling closer to the source”
  - Fan power reduces by up to 65%
  - Higher performance cooling coils
    - Higher entering air temperature
  - 100% sensible cooling
- Zero footprint cooling solution
- Cooling capacity available over 30 kW/rack

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Strategy 10: Monitoring and Optimization

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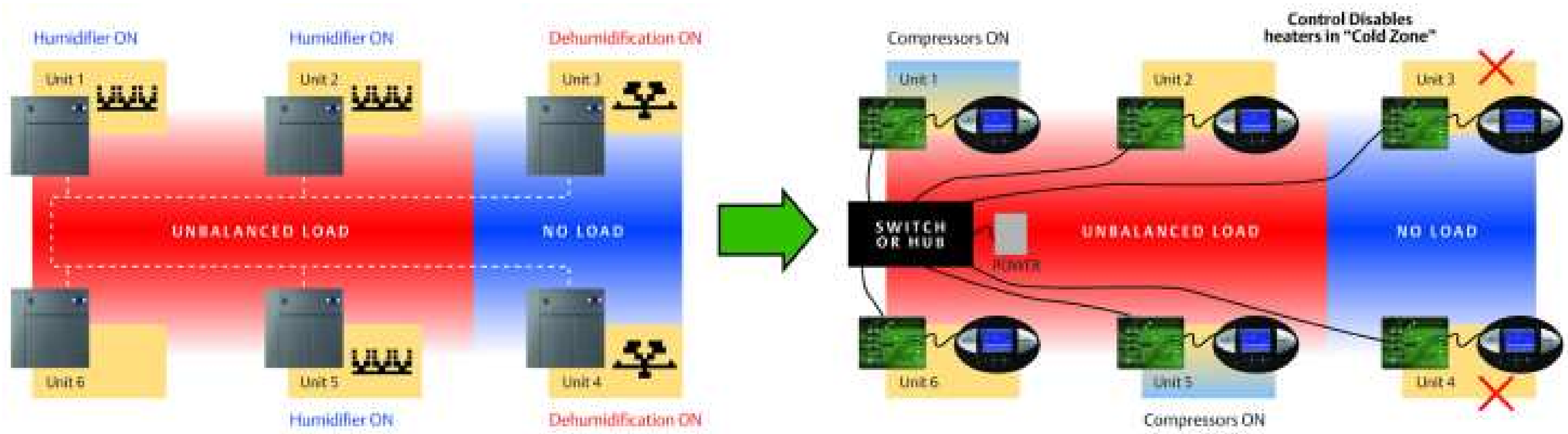
Teamwork: None | **Teamwork: In operation**



- Use monitoring and optimization tools to improve efficiency
- Cooling - share data to team multiple units
  - Manage compressor load, humidification, dehumidification, and cycling
- Power - UPS and PDU optimization, management, and control

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Other Opportunities

- Identify and disconnect ‘ghost servers’
  - Servers not performing useful tasks but still consuming power
- Storage
  - Consolidate data storage from direct attached storage to network attached storage
  - Faster disks consume more power
    - Reorganize data so less frequently used data is on slower drives
- Use economizers where appropriate
  - Economizers allow outside air to be used to support data center cooling during colder months
- Monitor and reduce ‘parasitic’ losses
  - Parasitic losses of 30 kW to 50 kW by generators for 1 MW load
  - Exterior lighting, security and fire suppression systems
  - Perimeter access control, employee services

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So What Should Data Center Managers Do?

- Existing facilities
  - Set in place equipment purchase policies (involve procurement dept)
    - When replacing or buying new servers and IT equipment, specify
      - Lowest power processors
      - ***Most*** efficient power supplies, ***at part loads*** (20% - 35% load)
      - Enable server power management features
    - *Savings will not accrue immediately, but over time*
  - Start IT projects
    - Move toward blade servers wherever possible (enables high density)
    - Evaluate and implement server virtualization
  - Implement best practices
    - Alternate power distribution architecture
    - Cooling best practices
  - Infrastructure upgrade
    - Variable-capacity cooling
    - High-density supplemental cooling
    - Monitoring and optimization
- Greenfield sites
  - Design with all strategies implemented on day one or as early as possible!

Energy Logic: ~~Three~~ Four Key Messages

1. **The most effective strategy to save energy:**
   - Start with reducing losses / consumption at the IT equipment level and work your way back through the supporting equipment
     - ***Every watt saved at the equipment level has a cascading effect upstream***
2. As you reduce energy consumption, make sure you do not compromise on availability and flexibility
   - Efficiency Without Compromise™
3. High-density architecture helps reduce energy consumption
4. Even if efficiency is not your key concern, implementing these strategies will free up capacity of your key constraints – power, cooling & space

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Questions?

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