Enabling High Efficient Power Supplies for Servers

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Agenda

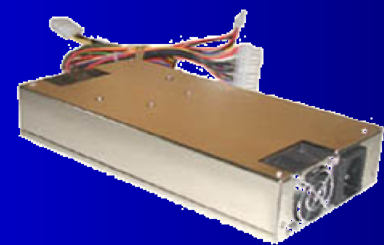
- ⇒Present state of server power delivery
- Why improve server efficiency?
- Initiatives & Programs
- Call to Action

Data Center Power Delivery

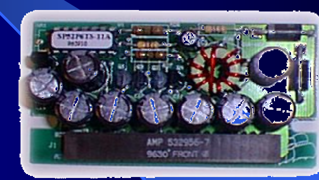
UPS
88 - 92%

Power Dist
98 - 99%

Power Supply
68 - 72%



dc/dc
78 - 85%



HVAC
1,200W / 1 Ton (76%)

US Annual Energy Consumptions of 30TW-h flows through this inefficient delivery path

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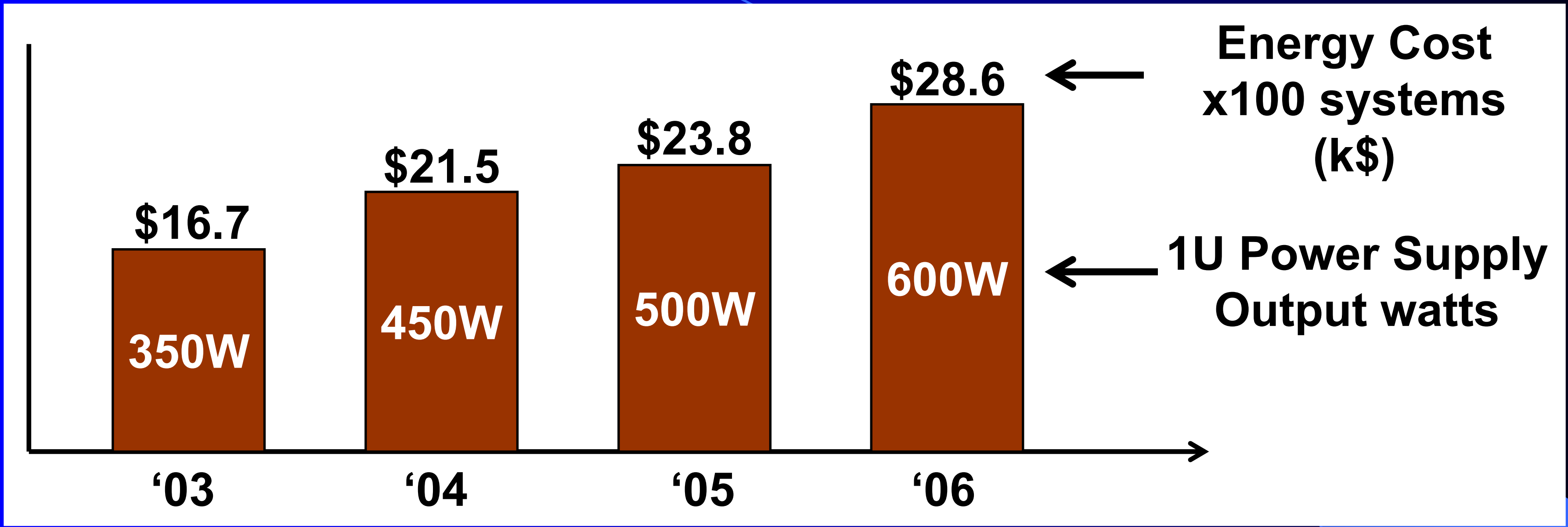
Cost of Power Delivery

Power Path Efficiency		Power (kW)	MW-h	Cost
	Load Cooling	3.1	113	$8,500
Loads	Systems (x100) (not including dc/dc & ac/dc)	9.8		
x 85%	Dc/dc	2.1	109	$8,200
x 70%	Power supply	5.1		
x 90%	UPS	1.9		
x 98%	Distribution	0.4		
x 76%	Delivery Cooling	3.0		
Total = 40%	Total		222	$16,700

Total efficiency ≈ 40%

Cost of power delivery = $8,200 / 100 systems

System Power Roadmap



- Assumptions:
  - Power supply, UPS, & Cooling efficiency flat
  - Average consumption = 34% of Maximum

Energy consumption is increasing

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Energy Savings Estimate: Improving PS Efficiency

- 70% to 85% ≈ 5.8 TW-h AEC improvement
  - *(Range 4.4 TW-h to 9.1 TW-h)*
- Peak Demand Savings ≈ 670 MW
  - *(Range 500MW to 1040 MW)*
- 5.8 TW-h AEC is equivalent to
  - **Power for ≈ 530,000 houses**
  - **Total electricity bill of ≈ $435 million**
  - **≈ 4.4 million tons of CO_2 emission**
  - **Emission from ≈ 890,000 cars**
- ***US Estimates; California ≈ 11% of US savings***

Realistic efficiency improvements generate significant energy savings

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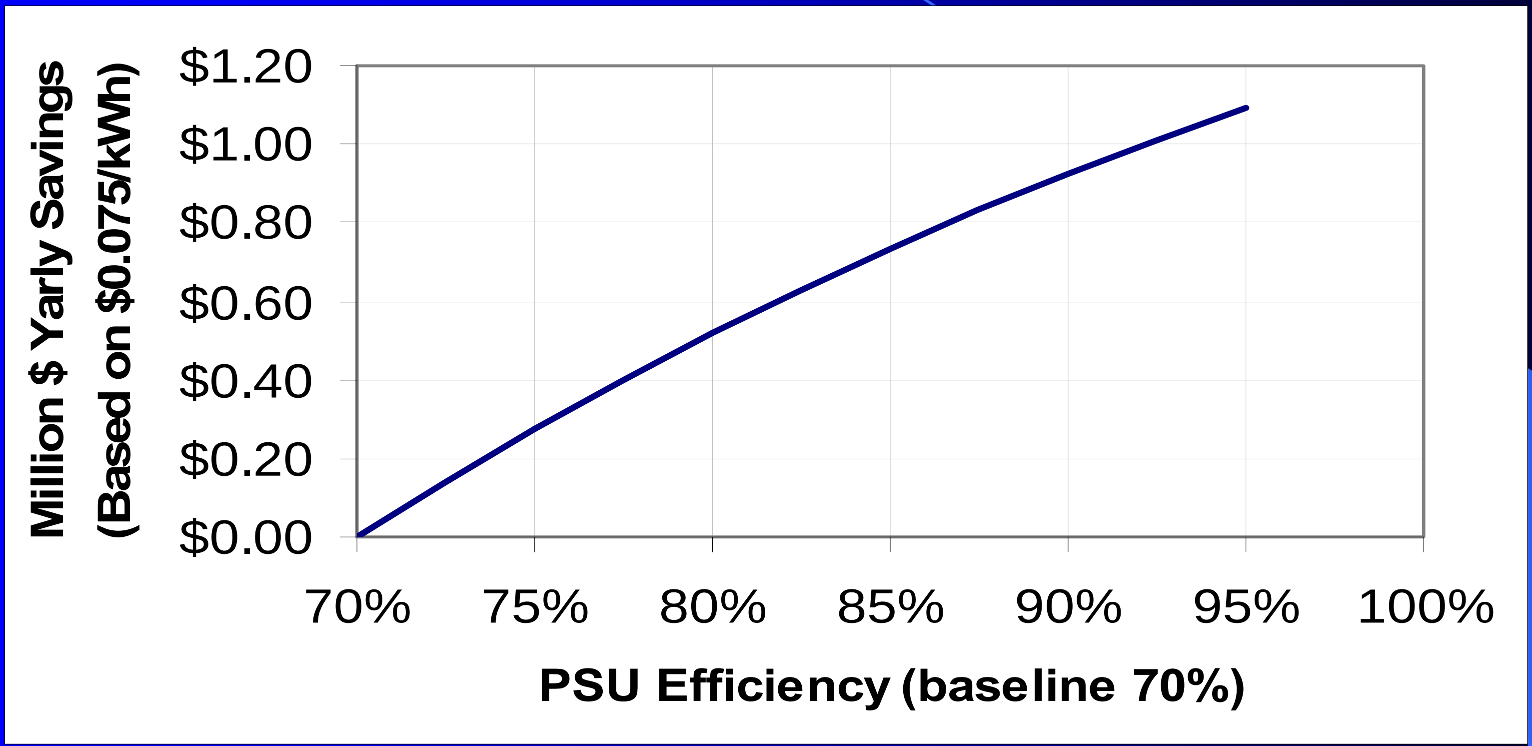
Cost of Power Delivery

Power Path Efficiency		Power (kW)	MW-h	Cost ($k)
	Load cooling	3.1	113	8.5
Loads	Systems (x100) (not including dc/dc & ac/dc)	9.8		
x 85%	Dc/dc	2.1	109 → 62	8.2 → 4.7
x 70% → 85%	Power supply	5.1 → 2.1		
x 90% → 94%	UPS	1.9 → 0.9		
x 98%	Distribution	0.4 → 0.3		
x 76%	Delivery Cooling	3.0 → 1.7		
Total = 40% → 51%	Total		222 → 175	16.7 → 13.2

Annual cost reduced by $3,500 / 100 systems

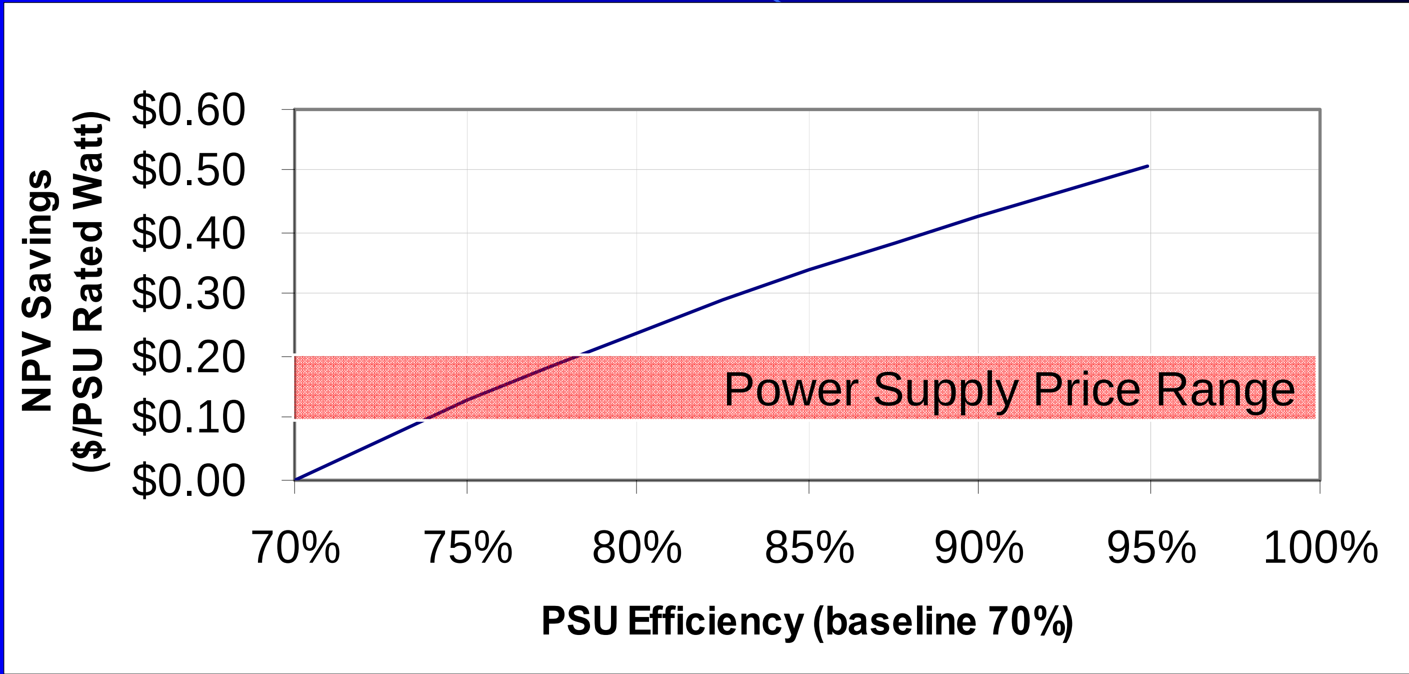
Case Study: PSU efficiency effects on data center cost



Based on NY Data Center # 2 Case Study (LBNL); Total IT Load: 4335 kW; http://datacenters.lbl.gov/NYDataCenter.html

85% efficiency ≈ $750,000 annual savings !

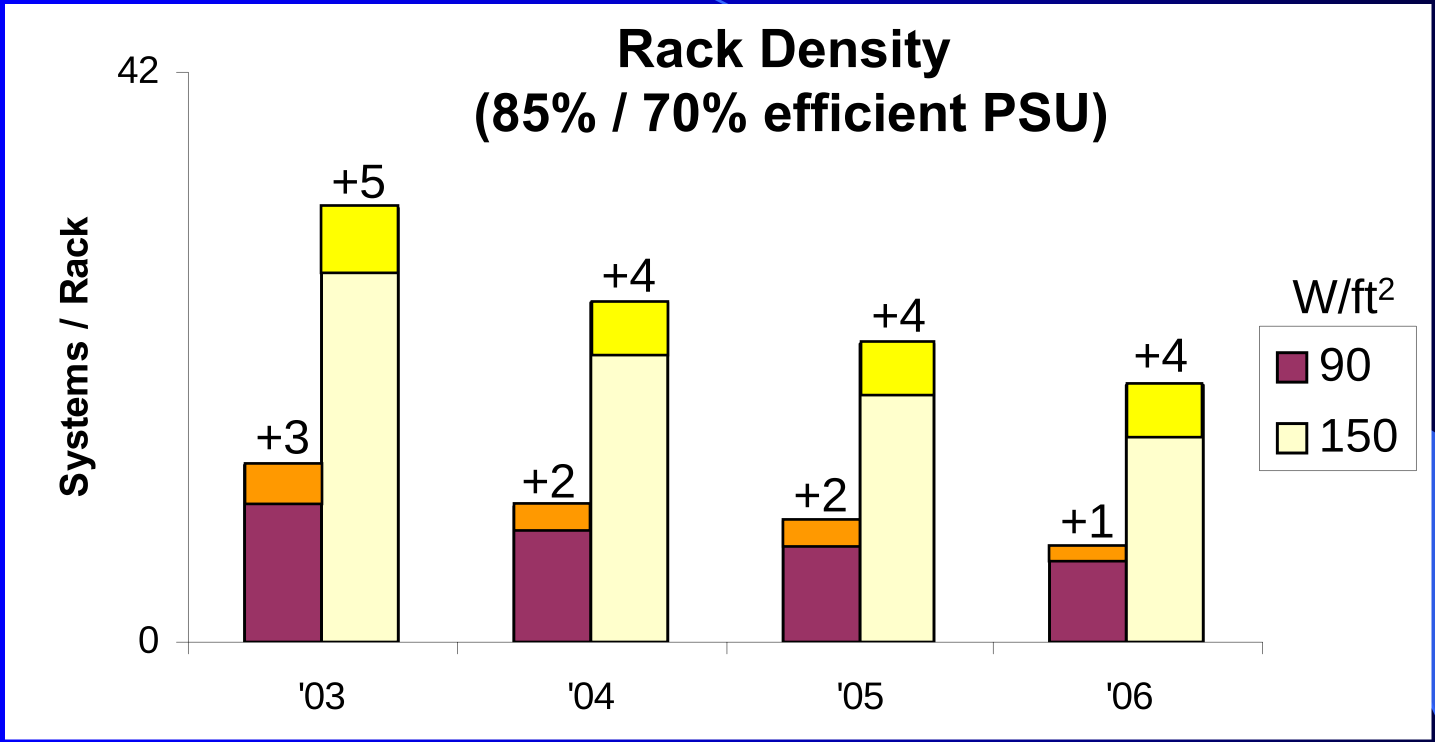
The Business Case for Increasing Server PSU Efficiency



See http://hightech.lbl.gov/ for calculation and assumptions ; based on a 350W PSU powering a 1U server with 120W load, 4 year life cycle

85% Efficiency ≈ $40 per power supply savings annually

System Density Improvements



- Typical density = 90-150W/ft2 (2.7-6.7KW / rack)

85% efficient power supply = +1 to +5 more systems / rack

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⇒Initiatives & Programs

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Intel power management initiatives

- Demand Based Switching (DBS)
  - Lower power consumption when processor utilization is low
- PS Monitoring Interface (PSMI)
  - Measure power delivery efficiency
  - Measure real power consumption
- Power Configuration Tool (Pconfig)
  - Estimated system thermal load
- CEC and SSI involvement

PS Research Background

- Lawrence Berkley National Laboratory working on a 10-year research initiative/ “roadmap” for Energy Efficient Data Centers.
- Project sponsored by PIER (Public Interest Energy Research) program of the California Energy Commission.
- http://datacenters.lbl.gov/

Research Roadmap

- Collecting and analyzing data center market information (benchmarking data center energy use, developing best practices, etc.)
- Improving facility efficiency (HVAC, electrical, monitoring and controls, etc.)
- Improving interface between facility/building systems and IT equipment
- Improving efficiency of IT equipment

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Ecos/EPRI-PEAC's part:

1. Server power supply efficiency
2. UPS efficiency
3. (Server benchmarks)

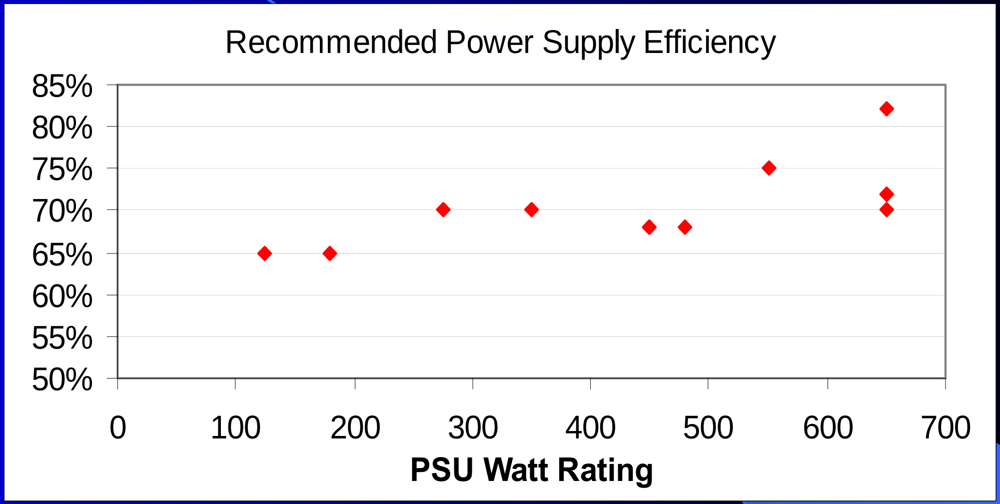
Server PS Project : Goals

- Short term:
  - Secure industry support for strategy to improve server PS efficiency
  - Develop a standard test method and conduct efficiency tests
  - Make data on PS efficiency by server model (and estimates of economic benefits) widely available

Today's Efficiency Level for Server Multi output AC/DC

PSU Type	Power (W)	Efficiency
EPS 1U	125	65%
EPS 1U	550	75%
EPS 2U	480	68%
EPS 2U	650	72%
ERP 2U	350	70%
ERP 2U	650	82%
EPS 12V	450	68%
EPS12V	650	72%
ERP12V	450	68%
ERP12V	650	70%
TPS	180	65%
TPS	275	70%

Source: Server System Infrastructure (SSI) PSU Specification



EPS: Entry Power Supply
ERP: Entry Redundant Power
TPS: Thin Power Supply

Market is at these efficiency levels

EPS 1U Version 2.1 Loading Guidelines

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125W (Loading in Amps)							
Loading	**+12V1**	**+12V2**	**+12V3**	**+5V**	**+3.3V**	**+5Vsb**	**-12V**
Full	3.0	N/A	N/A	12.0	6.0	1.0	0.0
Typical	1.5	N/A	N/A	6.0	3.0	1.0	0.0
Light	0.6	N/A	N/A	2.4	1.2	1.0	0.0
250W (Loading in Amps)							
Loading	**+12V1**	**+12V2**	**+12V3**	**+5V**	**+3.3V**	**+5Vsb**	**-12V**
Full	7.8	6.5	N/A	7.8	10.4	1.0	0.0
Typical	3.9	3.3	N/A	3.9	5.2	1.0	0.0
Light	1.6	1.3	N/A	1.6	2.1	1.0	0.0
350W (Loading in Amps)							
Loading	**+12V1**	**+12V2**	**+12V3**	**+5V**	**+3.3V**	**+5Vsb**	**-12V**
Full	11.9	10.6	N/A	7.9	10.6	1.0	0.0
Typical	6.0	5.3	N/A	4.0	5.3	1.0	0.0
Light	2.4	2.1	N/A	1.6	2.1	1.0	0.0

SSI adding efficiency testing to align with EPRI-PEAC testing method

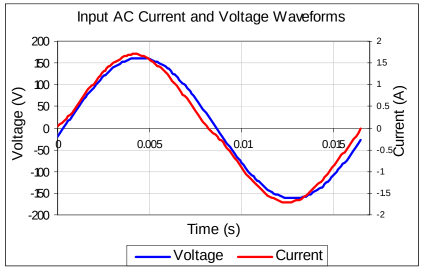
Server Power Supply Efficiency Test Report

TYPICAL EFFICIENCY (50% Load): 77%
AVERAGE EFFICIENCY : 75%

Serial Number	2
Manufacturer	Delta Electronics
Model	DPS-20PB -118 B Rev 04
Serial	BZT0237025302
Year	2002
Type	TPS1U
Test Date	6/14/2004

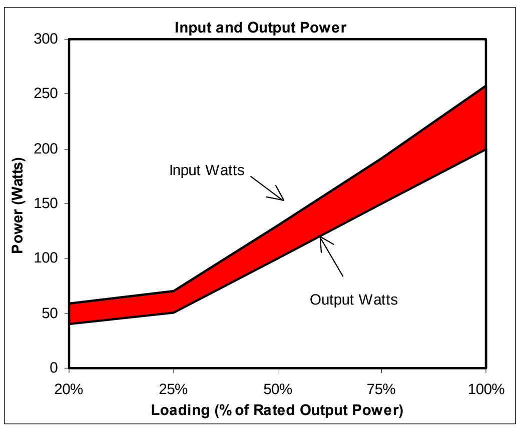
Rated Specifications	Value	Units
Input Voltage	100~127/ 200~240	Volts
Input Current	3.2/1.6	Amps
Input Frequency	50-60	Hz
Combined Max. Output Power on 5V and 3.3V	152.9	Watts
Rated Output Power	**202.9**	**Watts**

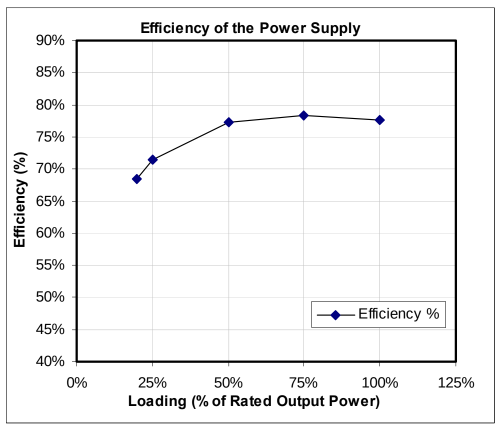
Note: All measurements were taken with input voltage at 115 V nominal and 60 Hz.



Input AC Current Waveform (I_{THD} = 5.7% at 50% Load)

I_{RMS} A	PF	I_{THD} (%)	Load (%)	Fraction of Load	Input Watts	DC Terminal Voltage (V)/ DC Load Current (A) 12.0/6.0	5.0/22.0	3.3/13.0	-12.0/0.25	5.0 SB/1.0	Output Watts	Efficiency %
0.56	0.92	7.9%	20%	Light	59	12.0/0.95	4.98/3.47	3.30/2.06	-	4.99/1.00	41	68%
0.66	0.94	7.5%	25%		71	12.0/1.22	4.98/4.46	3.30/2.64	-	4.99/1.00	51	72%
1.15	0.98	5.7%	50%	Typical	130	11.9/2.57	4.98/9.41	3.24/5.58	-	4.97/1.00	100	77%
1.69	0.99	4.9%	75%		192	12.0/3.93	4.93/14.39	3.20/8.52	-	4.97/1.00	150	78%
2.25	0.99	3.3%	100%	Full	258	12.0/5.27	4.88/19.34	3.28/11.42	-	4.97/1.00	200	78%





These tests were conducted as a part of California Energy Commision initiative to improve the efficiency of the server power supplies used in the Data Centers through the Public Interest Energy Research (PIER) program.
Tested by EPRI PEAC Corporation,Knoxville, TN.

EPRI PEAC The Power of Reliability

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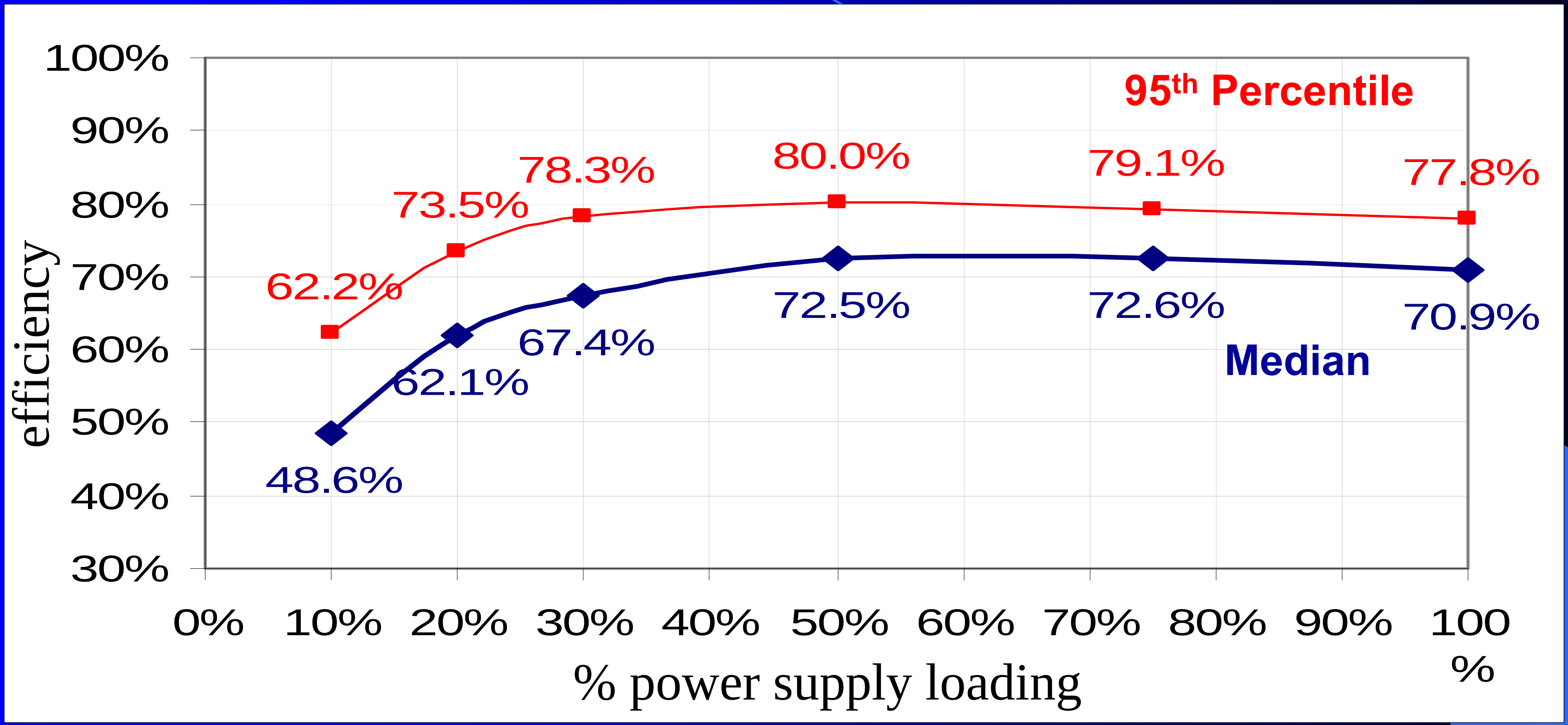
A consistent test protocol, loading guideline & test report format will allow more visibility on power supply efficiency

Server PS Efficiency Test Data: Current Market



Measurement based on loading guideline documented in server PS test protocol at http://hightech.lbl.gov/psupplies.html .
Sample Size N = 13; Data Source: EPRI PEAC

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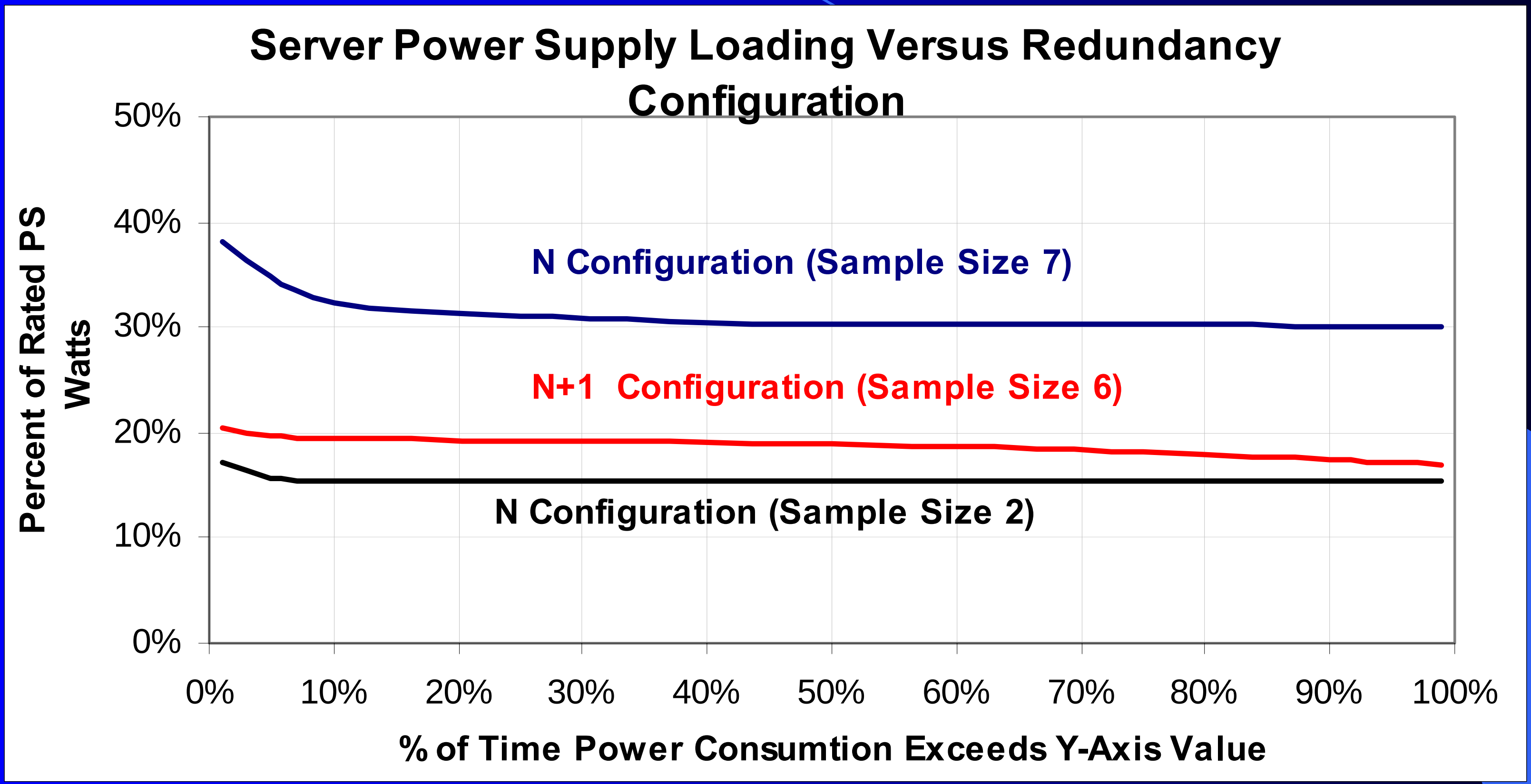
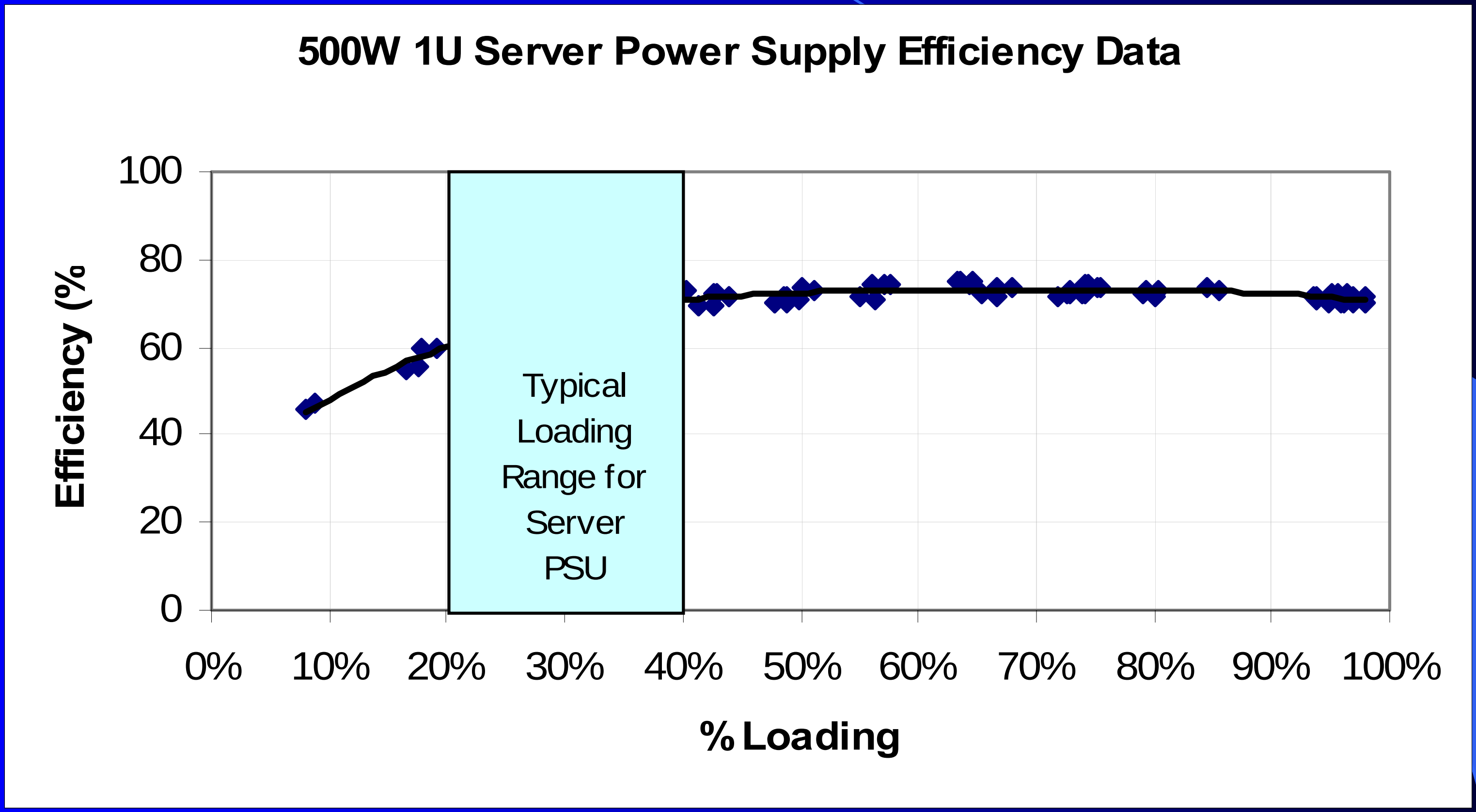
Loading Versus Redundancy



Light load efficiency especially important for redundant systems

Importance of a Flat Power Supply Efficiency Curve



More design focus on light load efficiency needed

Server PS Project : Goals

- Long term:
  - Move the market towards widespread adoption of energy efficient PS in data centers
  - Create an energy efficiency labeling program such as ENERGY-STAR® for server power supplies

Call to Action

- Market higher efficiency – it saves users $
- Incentives for improving power supply efficiency are coming
- Suppliers: offer higher efficiency as a competitive advantage
- Provide feedback on ERPI-PEAC efficiency testing & loading