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

Intel Technology Symposium
2004
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
## Cost of Power Delivery

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

**Total efficiency ≈ 40%**

**Cost of power delivery = $8,200 / 100 systems**
Assumptions:
- Power supply, UPS, & Cooling efficiency flat
- Average consumption = 34% of Maximum

Energy consumption is increasing
Agenda

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Energy Savings Estimate: Improving PS Efficiency

- 70% to 85% $\approx$ 5.8 TW-h AEC improvement
  - (Range 4.4 TW-h to 9.1 TW-h)
- Peak Demand Savings $\approx$ 670 MW
  - (Range 500MW to 1040 MW)
- 5.8 TW-h AEC is equivalent to
  - Power for $\approx$ 530,000 houses
  - Total electricity bill of $\approx$ $435 million
  - $\approx$ 4.4 million tons of CO2 emission
  - Emission from $\approx$ 890,000 cars
- US Estimates; California $\approx$ 11% of US savings

Realistic efficiency improvements generate significant energy savings
## Cost of Power Delivery

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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dc/dc</td>
<td>2.1</td>
<td>109</td>
<td>8.2</td>
</tr>
<tr>
<td>Power supply</td>
<td>5.1 → 2.1</td>
<td>62</td>
<td>4.7</td>
</tr>
<tr>
<td>UPS</td>
<td>1.9 → 0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>0.4 → 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery Cooling</td>
<td>3.0 → 1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>222 → 175</strong></td>
<td><strong>16.7 → 13.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

Total = 40% → 51%

Annual cost reduced by $3,500 / 100 systems

Intel Technology Symposium 2004
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/](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 \(\approx\) $40 per power supply savings annually
System Density Improvements

Rack Density
(85% / 70% efficient PSU)

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

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

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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

<table>
<thead>
<tr>
<th>PSU Type</th>
<th>Power (W)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS 1U</td>
<td>125</td>
<td>65%</td>
</tr>
<tr>
<td>EPS 1U</td>
<td>550</td>
<td>75%</td>
</tr>
<tr>
<td>EPS 2U</td>
<td>480</td>
<td>68%</td>
</tr>
<tr>
<td>EPS 2U</td>
<td>650</td>
<td>72%</td>
</tr>
<tr>
<td>ERP 2U</td>
<td>350</td>
<td>70%</td>
</tr>
<tr>
<td>ERP 2U</td>
<td>650</td>
<td>82%</td>
</tr>
<tr>
<td>EPS 12V</td>
<td>450</td>
<td>68%</td>
</tr>
<tr>
<td>EPS12V</td>
<td>650</td>
<td>72%</td>
</tr>
<tr>
<td>ERP12V</td>
<td>450</td>
<td>68%</td>
</tr>
<tr>
<td>ERP12V</td>
<td>650</td>
<td>70%</td>
</tr>
<tr>
<td>TPS</td>
<td>180</td>
<td>65%</td>
</tr>
<tr>
<td>TPS</td>
<td>275</td>
<td>70%</td>
</tr>
</tbody>
</table>

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

Source: Server System Infrastructure (SSI) PSU Specification

Market is at these efficiency levels

Recommended Power Supply Efficiency

![Graph showing recommended power supply efficiency levels](source)

PSU Watt Rating

85%
80%
75%
70%
65%
60%
55%
50%
# EPS 1U Version 2.1
## Loading Guidelines

### 125W (Loading in Amps)

<table>
<thead>
<tr>
<th>Loading</th>
<th>+12V1</th>
<th>+12V2</th>
<th>+12V3</th>
<th>+5V</th>
<th>+3.3V</th>
<th>+5Vsb</th>
<th>-12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>3.0</td>
<td>N/A</td>
<td>N/A</td>
<td>12.0</td>
<td>6.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Typical</td>
<td>1.5</td>
<td>N/A</td>
<td>N/A</td>
<td>6.0</td>
<td>3.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Light</td>
<td>0.6</td>
<td>N/A</td>
<td>N/A</td>
<td>2.4</td>
<td>1.2</td>
<td>1.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### 250W (Loading in Amps)

<table>
<thead>
<tr>
<th>Loading</th>
<th>+12V1</th>
<th>+12V2</th>
<th>+12V3</th>
<th>+5V</th>
<th>+3.3V</th>
<th>+5Vsb</th>
<th>-12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>7.8</td>
<td>6.5</td>
<td>N/A</td>
<td>7.8</td>
<td>10.4</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Typical</td>
<td>3.9</td>
<td>3.3</td>
<td>N/A</td>
<td>3.9</td>
<td>5.2</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Light</td>
<td>1.6</td>
<td>1.3</td>
<td>N/A</td>
<td>1.6</td>
<td>2.1</td>
<td>1.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### 350W (Loading in Amps)

<table>
<thead>
<tr>
<th>Loading</th>
<th>+12V1</th>
<th>+12V2</th>
<th>+12V3</th>
<th>+5V</th>
<th>+3.3V</th>
<th>+5Vsb</th>
<th>-12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>11.9</td>
<td>10.6</td>
<td>N/A</td>
<td>7.9</td>
<td>10.6</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Typical</td>
<td>6.0</td>
<td>5.3</td>
<td>N/A</td>
<td>4.0</td>
<td>5.3</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Light</td>
<td>2.4</td>
<td>2.1</td>
<td>N/A</td>
<td>1.6</td>
<td>2.1</td>
<td>1.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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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
Year 2002
Type TP31U
Test Date 6/14/2004

Input and Output Power

These tests were conducted as a part of California Energy Commission 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.
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.
Loading Versus Redundancy

Server Power Supply Loading Versus Redundancy Configuration

- N Configuration (Sample Size 7)
- N+1 Configuration (Sample Size 6)
- N Configuration (Sample Size 2)

Light load efficiency especially important for redundant systems
Importance of a Flat Power Supply Efficiency Curve

500W 1U Server Power Supply Efficiency Data

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