Telecom & IT Power
Trends and Issues

Tom Gruzs
Liebert Columbus

EMERSON
Network Power
Power Quality Problem:

- When there is a difference between:
  The **Quality of Power Supplied** and
  The **Quality of Power Required by the Load for Reliable Operation**

- **Examples:**
  Electromechanical Clock vs. Digital Alarm Clock
  Motor vs. Motor Drive
Power Quality Solutions

Redundancy
Generator
UPS
Power Conditioning
Surge Protective Devices
Good System Design
Wiring and Grounding

Cost
Powering Telecom Loads
DC Power Basics

Why -48VDC (The Sign)?
- The Battery Positive is Grounded
- Negative Polarity Reduces Corrosion Problems with Underground Cables and Conduits

Why -48VDC (The Value)?
- Low Voltage (<72V or 60V) Did Not Require Licensed Electricians
- Was Not Governed by the NEC
Why not use commercial AC directly?
- DC Was Used to “Carry” Voice Signals
- AC Power Was Not Deemed Reliable Enough for Critical Telecom Applications
- AC Cannot be Easily Stored

Convergence Has Blurred the Difference Between Telecom and IT Loads
DC Power for Critical Loads

- Use Multiple Parallel Rectifiers
  - Ease of Expansion
  - Ease of Redundancy
  - Higher Equipment and Installation Cost
  - Potentially Lower MTBF of Rectifiers
  - Mitigated by the Battery Connection Directly to the Load and Low MTTR

- Requires Inverters to Power AC Loads
- 1 Hour Min. Battery Due to Coup de Fouet Effect
- High Power Applications limited by Voltage Drop
- Power Capacities up to \( \approx 10,000 \) Amps (500 kW)
DC Power for Telecom and IT Loads

AC Power Utility

- Standby Generator
- AC Power Utility

- DC Power Plant
  - Rectifiers
  - Distribution
  - Battery Rack
    - 24 Cells
      - 3 or 8 Hour Battery

DC/DC Converter

- Other DC Loads
- -48VDC Loads

DC/AC Inverter

- AC Loads
- Other AC Loads
  - Lighting, HVAC

ATS
**-48VDC Power Plant Voltage Drop**

Typical Maximum Allowable 2-Way Voltage Drop

-44.5V Min. 1.85 V/Cell

Power Plant w/Distribution

Power Distribution Cabinet

-42.0V Min. 1.75 V/Cell

Battery Rack

Load

0.25V 1.25V 1.0V

2.5V
DC or AC Power for Critical Loads?

**AC UPS**

- Higher Voltage Batteries (120 to 240 Cells)
- Regulated AC Output Voltage
  - Lower End of Discharge Voltage (1.65V/C Typ.)
  - Longer Runs of Higher Power Feasible
- Power Capacities Available up to 3000 kVA
- Redundant Generators Are Typical
- 15 Minute Batteries Typical
- More Complex
  - Mitigated by Commercial AC Power Bypass and Redundancy
AC UPS to Power IT and Telecom Loads

- AC Power Utility
- ATS
- Standby Generator
- AC UPS
- Battery Rack (120 to 240 Cells, 15 Min. Battery)
- AC Distribution
- Rectifier
- 120/208VAC
- -48VDC Loads
- AC Loads
- Other DC Loads
- AC/DC Converter

Other AC Loads
- Lighting, HVAC

Other DC Loads
MTBF SMS Without Bypass = 21,254 Hours
MTBF SMS With Static Bypass = 108,423 Hours

5 x Increase

(Based on MIL-HDBK-217C and Reliability Engineering, ARINC Research Corp, Prentice Hall)
Improving The AC UPS System
Adding Stand-by Generator & ATS
Improving The AC UPS System
N+1 Parallel Redundancy

Note: Individual Module Batteries
-48VDC Power for Telecom Loads & AC UPS for IT Loads

Other AC Loads
- Lighting, HVAC

AC UPS

Battery Rack
- 120 to 240 Cells
- (15 Min. Battery)

AC Loads

DC Power Plant
- Rectifiers
- Distribution
- Battery Rack
- -48 VDC
- (1 Hour Min. Battery)
- -48 VDC Loads
- Other DC Loads

DC/DC Converter

AC Power Utility
- ATS
- Standby Generator

-48VDC Power for Telecom Loads & AC UPS for IT Loads

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**Distributed DC Power Plants**

- Multiple Smaller Rectifiers Located Close to the Loads
  - Centralized AC UPS Eliminates Distributed Batteries
  - AC Power Provides Higher Power for Longer Distribution Distances
  - Potentially Higher Equipment Cost w/ Lower Installation Costs for Lower Total Cost
  - Potentially Lower Equipment MTBF (More Rectifiers)
  - No DC Battery Mitigated by the Redundant AC UPS, DC Rectifiers and Dual-Input Loads

- Co-Dependence of AC and DC Loads
Ref. “AC, DC or Hybrid Power Solutions for Today’s Telecommunications Facilities”, INTELEC 2000
DC or AC Power for Critical Loads?

- Both Can Be Made to Work
- Answer Depends on:
  - Load Requirements
    - AC or DC Inputs
    - Percentage of AC and DC
  - Customer Preferences
  - Economics
- Higher Power Applications Favor AC
- AC or DC Power for Higher Efficiency?
AC or DC Power for Higher Efficiency

**AC Power**

- **AC UPS**
  - Commercial AC Power
  - Eff. = 0.92

- **AC Load**
  - Eff. = 0.85

**Overall Efficiency** = 0.78

**DC Power**

- **Rectifier**
  - Commercial AC Power
  - Eff. = 0.89

- **DC Load**
  - Eff. = 0.88

**Overall Efficiency** = 0.78
Voice Over IP (VoIP) and Power Over Ethernet (PoE)
**Converged Networks – The Power Challenge**

- **Entire Network is Critical**
  - Even short interruption can be damaging
  - Single point of failure for both Data and Voice
  - Voice prioritization (911 access, QoS)

- **Traditional Telecom Service Providers Designed System for High Availability Power to the Telephone**
  - Now power to operate network resides in the facility

- **Power Demand**
  - PoE introduces -48VDC power into Enterprise Network
  - PoE consumption can be up 7 times the power for data only
    - Switch requires multiple, higher ampacity, 208V, or 3-phase power
  - Additional power requirements will drive need for cooling
  - VoIP may require longer battery run times
  - Space requirements
Changing Responsibility in Enterprise Network

- Traditional Approach:
  - Two Separate Networks’ Responsibilities
    - Voice - Telecom Service Provider
    - Data – Data Processing / IT Manager
    - Infrastructure – Facility Manager

- Converged Network:
  - Single network responsibility
    - IT Manager
      - May not have Facility Manager
      - (especially in smaller businesses)

**Power to Operate Network is the User’s Responsibility**
3 Ways to Power VoIP Phones

- **Wall power**
  - Needs DC converter for connecting IP phone to AC wall outlet

- **Power over the Ethernet (PoE):**
  - External power (Mid Span)
    - Needs external power patch panel
    - Patch panel delivers -48VDC over pairs 3 and 4
  - Inline power
    - Powered linecards for switches and routers
    - Uses pairs 1 and 2 (same as Ethernet) for delivering -48VDC
PoE Switch Power Requirement Example

- Typical Office with 196 lines
  - PoE Switch
  - All ports PoE Enabled

- Power Requirement for the Ethernet Switch
  - Switch 800W
  - PoE 196 x 17.3W ~ 3390W (17.3W=15.4W/conversion efficiency)
  - TOTAL 4190W Over 5X Increase in Power

PoE Significantly Increases the Switch’s Power Requirement
AC or DC Powered Switch

- AC Input Power Supplies must process Switch and PoE Power
- Some Switches Require an Extra Power Shelf to Generate -48VDC Power for Switch and PoE
- DC Input Allows Powering the -48V PoE Directly
AC or DC Powered Ethernet Switch?

- 48VDC PoE
AC vs. DC Small UPS Efficiency Consideration

**Normal Operation**

**AC UPS System Efficiency**

\[0.96 \times 0.92 \times 0.8 = 0.70\ (70\%)

**DC UPS System Efficiency**

\[0.91\ (91\%)

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**Diagram**

- **Utility AC**
  - **AC UPS**
    - AC to DC
      - 96% efficiency
    - DC to AC
      - 92% efficiency
    - Battery
  - **DC UPS**
    - DC to AC
      - 75-80% efficiency
    - DC to DC
      - 5VDC
      - 12VDC
      - 48VDC

- **Battery**: 48VDC

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AC vs. DC Small UPS Efficiency Consideration

On Battery Operation

AC UPS System Efficiency
0.92 \times 0.8 = 0.74 (74\%)

AC

DC

96\% eff

92\% eff

75-80\% eff

120VAC

Battery

Battery

48VDC

Directly to PoE

5VDC

12VDC

48VDC

DC UPS System Efficiency – 100\%

AC

DC

91\% eff

48VDC

Battery

Battery

5VDC

12VDC

48VDC

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Facility Planning Considerations for VoIP

- Criticality to the Business (Voice, Data)
- Increased Power Requirement
- Equipment Location (Available Space, Open Room, Closet)
- Generator on Site?
- Back up Time Required in Case of Power Failure
- Required Reliability / Availability (Redundancy Required)
- AC, DC or Hybrid Power Solution?
- Protection for All Levels of the Network
- Cooling Needs
- Monitoring
- Ease of Expansion
- Ease of Maintenance
High Availability
Power Systems

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What is “High Availability”? 

- Term widely used in the information technology industry
  - Increasing need for non-stop computing
  - Demand for “uninterruptible” power (7xForever)
- Not a standardized “product” or “offering”
  - Manufacturers are free to use the term at their discretion
  - High Availability is more than just a product or system configuration
- **Decision maker** must determine the level of availability desired vs. cost to achieve
# Industry Tier Definitions

**Uptime Institute**

<table>
<thead>
<tr>
<th>Tier Requirement</th>
<th>Tier 1</th>
<th>Tier II</th>
<th>Tier III</th>
<th>Tier IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>System + System</td>
</tr>
<tr>
<td>System Component Redundancy</td>
<td>N</td>
<td>N+1</td>
<td>N+1</td>
<td>Minimum of N+1</td>
</tr>
<tr>
<td>Distribution Paths</td>
<td>1</td>
<td>1</td>
<td>1 normal and 1 alternate</td>
<td>2 simultaneously active</td>
</tr>
<tr>
<td>Compartmentalization</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Concurrently Maintainable</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fault Tolerance (single event)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Tier designations attempt to categorize how high availability data centers are designed
- Uptime Institute does not allow partial Tier Designations
## Uptime Institute
### Typical Tier Attributes

<table>
<thead>
<tr>
<th></th>
<th>Tier I</th>
<th>Tier II</th>
<th>Tier III</th>
<th>Tier IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building Type</strong></td>
<td>Tenant</td>
<td>Tenant</td>
<td>Stand-alone</td>
<td>Stand-alone</td>
</tr>
<tr>
<td><strong>Staffing shifts</strong></td>
<td>None</td>
<td>1 Shift</td>
<td>1+Shifts</td>
<td>&quot;24 by Forever&quot;</td>
</tr>
<tr>
<td><strong>Staff/shift</strong></td>
<td>1/shift</td>
<td>1-2/Shift</td>
<td>2+Shift</td>
<td></td>
</tr>
<tr>
<td><strong>Useable for Critical Load</strong></td>
<td>100% N</td>
<td>100% N</td>
<td>90% N</td>
<td>90% N</td>
</tr>
<tr>
<td><strong>Initial Build-out kW per Cabinet (typical)</strong></td>
<td>&lt;1 kW</td>
<td>1-2 kW</td>
<td>1-2 kW</td>
<td>1-3 kW</td>
</tr>
<tr>
<td><strong>Ultimate kW per Cabinet (typical)</strong></td>
<td>&lt;1 kW</td>
<td>1-2 kW</td>
<td>&gt;3 kW¹²³</td>
<td>&gt;4 kW¹²</td>
</tr>
<tr>
<td><strong>Support Space to Raised-Floor Ratio</strong></td>
<td>20%</td>
<td>30%</td>
<td>80-90+ %</td>
<td>100+ %</td>
</tr>
<tr>
<td><strong>Raised-Floor Height (typical)</strong></td>
<td>12”</td>
<td>18”</td>
<td>30-36”</td>
<td>30-42”</td>
</tr>
<tr>
<td><strong>Floor Loading Lbs/ft² (typical)</strong></td>
<td>85</td>
<td>100</td>
<td>150</td>
<td>150+</td>
</tr>
<tr>
<td><strong>Utility Voltage (typical)</strong></td>
<td>208, 480</td>
<td>208, 480</td>
<td>12-15 kV</td>
<td>12-15 kV</td>
</tr>
<tr>
<td><strong>Single Points-of-Failure</strong></td>
<td>Many + Human Error</td>
<td>Many + Human Error</td>
<td>Some + Human Error</td>
<td>Fire, EPO + Some Human Error</td>
</tr>
<tr>
<td><strong>Representative Planned Maintenance Shut Downs</strong></td>
<td>2 Annual Events at 12 Hours Each</td>
<td>3 Events Over 2 Years at 12 Hours Each</td>
<td>None Required</td>
<td>None Required</td>
</tr>
<tr>
<td><strong>Representative Site Failures</strong></td>
<td>6 Failures Over 5 Years</td>
<td>1 Failure Every Year</td>
<td>1 Failure Every 2.5 Years</td>
<td>1 Failure Every 5 Years</td>
</tr>
<tr>
<td><strong>Annual Site-Caused, End-User Downtime (based on field data)</strong></td>
<td>28.8 hours</td>
<td>22.0 hours</td>
<td>1.6 hours</td>
<td>0.8 hours</td>
</tr>
<tr>
<td><strong>Resulting End-User Availability Based on Site-Caused Downtime</strong></td>
<td>99.67%</td>
<td>99.75%</td>
<td>99.98%</td>
<td>99.99%</td>
</tr>
<tr>
<td><strong>Typical Months to Plan and Construct</strong></td>
<td>3</td>
<td>3-6</td>
<td>15-20</td>
<td>15-30</td>
</tr>
<tr>
<td><strong>Fist Depbyed</strong></td>
<td>1965</td>
<td>1970</td>
<td>1985</td>
<td>1995</td>
</tr>
</tbody>
</table>
Large Data Center

Site Availability Failures

- Infrastructure System Failures
  - 82% Electrical

- Electrical System Failures
  - **79% From UPS to Load**
    - 49% Caused By Humans
  - 11% UPS and Batteries
  - 10% Other
Power System Configurations

Tier 1

- Service Feed
- Surge Suppression
- Transfer Switch
- Engine Generator
- Precision Cooling
- UPS Module
- Power Distribution
- Single Critical Bus to Loads
- Load
- Load
**Power System Configurations**

*Tier 2 – Redundant Components*

- Engine Generator
- Engine Generator
- Service Feed
- Surge Suppression
- Transfer Switch
- Precision Cooling (UPS Module)
- Precision Cooling (UPS System Control)
- UPS Bypass
- UPS System Control
- UPS Module
- Power Distribution
- Load

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*Single Critical Bus to Loads*
Power System Configurations

Tier 3 – Dual Distribution (Concurrent Maintenance)

Service Feed A
Surge Suppression
Transfer Switch
N+1 Engine Generators
UPS System Cabinet
UPS Module
UPS Module
Power Distribution
Load
Load

Service Feed B
Surge Suppression
Transfer Switch
Power Distribution
Precision Cooling

Bus A
Bus B
Power System Configurations

**Tier 4 – Dual Bus** *(Two Active Paths)*

- **Bus A**
  - Service Feed A
  - Surge Suppression
  - Transfer Switch
  - Engine Generator
  - Precision Cooling
  - UPS System Cabinet
  - UPS Module
  - Power Distribution
  - Load

- **Bus B**
  - Service Feed B
  - Surge Suppression
  - Transfer Switch
  - Engine Generator
  - Precision Cooling
  - UPS System Cabinet
  - UPS Module
  - Power Distribution
  - Load
Power System Configurations

Dual Bus – Tier 4

Design Goals

7 x 24 x 365 Non-Stop Operation

- Uninterrupted System Maintenance
- Redundancy in DISTRIBUTION
- Redundancy in UPS
  - Eliminate Single Points Of Failure
  - Maximum Fault Tolerance
  - Fully Utilize Dual Input Equipment
  - Provide Dual Source Availability To Single Input Equipment
PowerTie
Facilitating System Maintenance

Left:
- Source 1
  - MMU
  - SCC 1

Right:
- Source 2
  - MMU
  - SCC 2

MMU = Multi-Module Unit
SCC = System Control Cabinet

System - To - System Transfers Without Bypass

- Both Critical Loads Can Be Carried by One System
- System Maintainable Without Critical Load on Bypass
- Momentary or Continuous Tie Options
SUSTAINING High Availability Power Systems

- **Service**
  - Preventative Maintenance
    - Identify POTENTIAL problems
    - Replace limited life components before failure
    - Implement safety and performance upgrades to products
  - Remedial Maintenance
    - Fast Response Time
    - Repair Parts Availability

- Proper Service Increases Product Reliability And Reduces MTTR
- **INCREASED AVAILABILITY**
ITE Room
Power Distribution
ITE Room Power Distribution

- Optimize space utilization and scale power based on growth
- Facilitate equipment placement to maximize cool air to hot racks
- Facilitate equipment change
  - Many Small Breakers
  - Fewer Large Breakers
Two-Stage Distribution Adds Pole Capacity and Reduces Under Floor Cabling

Traditional Single-Stage Distribution

- Power Distribution Unit
  - Voltage Transformation, Monitoring and Branch Circuit Breakers
- 126 Poles
- IT Loads

Two-Stage Distribution

- Power Transformation Unit
  - Voltage Transformation Monitoring
  - Output Breakers
- Larger Capacities
- Remote Distribution Cabinets
  - 168 Poles Each

IT Loads
Single Stage Distribution Methods

- Blocked Air Flow
- More Circuits, Bigger Circuits
- Longer Cables
- More Difficult to Manage Change
Single-Stage Power Distribution

Under-floor Congestion

Heavy Cable Congestion Underfloor
High Density Two-Stage Power Distribution
Two Stage Power Distribution Benefits

- PDU to Multiple distribution cabinets
  - Reduces cross-aisle obstructions
  - Reduces restrictions to cooling air flow
  - More conducive to Dual-Bus distribution
  - Easier to locate, replace, add circuits
  - More distribution per square foot
  - More breakers per transformer
  - Shorter branch circuit lengths
**ITE Room Power Distribution**

### High Number of Small Loads (>1 Pole per kVA)

- **UPS System:** 480V
- **PDU:** 208/120V
- **Remote Distribution Cabinet:** 4 x 42 Poles
- **Racks:** 4 to 8 Poles per Rack, 15 to 30 Amps Each

### Fewer Larger Loads (<1 Pole per kVA)

- **UPS System:** 480V
- **PDU:** 208/120V or 480/277V
- **Racks:** 4 to 12 Poles per Rack, 30 to 100 Amps Each
**High Density Distribution**

**High density loads – Two-Stage Distribution**

- UPS System
- PDU
- Power Distribution Cabinet
- Racks

- 480V
- 208/120V
- 208/120V
- 44 x 6kW Racks
- 24 x 10kW Racks
- 10 x 23kW Racks

**Extreme Density Loads – Higher Voltage Distribution**

- UPS System
- PDU
- Racks

- 480V
- 400/230V or 480/277V
- 40 x 13kW Racks
- 22 x 23kW Racks
- 10 x 53kW Racks
IT Perspective of Energy Efficiency

- 42% of DCUG survey respondents are currently analyzing their Data Center Efficiency
- Top Priority is Delivering on Service Level Agreements
  - Performance – Adequate Computing Capacity
  - Reliability – Meet Availability Goals
  - Security
- Does IT Care About Energy Efficiency?
  - Only if it Does Not Impact Performance or Reliability
  - Interested in Freeing Up Power and Cooling Capacity

Source: DCUG Survey Fall 2007

- Data Centers Consume >1.5% of all Electricity in the US
- EPA Energy Star Initiative – Data Collection Stage
How Do You Measure Data Center Efficiency?

EPA Measurement: Facility Input Power / IT Power
Energy Efficiency

- Perceived the greatest opportunities:

  - Cooling equipment: 49%
  - Servers (including embedded power supplies): 46%
  - Power equipment (i.e. UPS, PDU): 39%
  - Storage: 21%
  - Overall power architecture (DC vs. AC data center): 19%
  - Communications (i.e. switches, routers, etc.): 10%
  - Other: 6%

Source: DCUG Survey Fall 2007
Data Center Power Draws

- Air Movement: 12%
- Electricity Transformer/UPS: 10%
- Lighting, etc.: 3%
- Cooling: 25%
- IT Equipment: 50%

# Typical Data Center Power Consumption

## Equipment Category

<table>
<thead>
<tr>
<th>Equipment Category</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing</td>
<td>588 kW</td>
</tr>
<tr>
<td>Lighting</td>
<td>10 kW</td>
</tr>
<tr>
<td>UPS &amp; Distribution Losses</td>
<td>72 kW</td>
</tr>
<tr>
<td>Cooling Power Draw for Computing &amp; UPS Losses</td>
<td>429 kW</td>
</tr>
<tr>
<td>Building Switchgear / MV Transformer / Other Losses</td>
<td>28 kW</td>
</tr>
<tr>
<td><strong>Total Power Draw</strong></td>
<td><strong>1,127 kW</strong></td>
</tr>
</tbody>
</table>

## Power and Cooling

* Cooling load assumes chilled water-based cooling system

- **Computing Equipment**: 52%
- **Server Power Supply**: 14%
- **Other Services**: 15%
- **Storage**: 4%
- **Communication Equipment**: 4%
- **UPS**: 5%
- **PDU**: 1%
- **Lighting**: 1%
- **Cooling and Switchgear**: 3%

(Based on 5000 Sq Ft Data Center)
The Cascade Energy Savings Effect

1 Watt saved at the server component level results in cumulative savings of about 2.84 Watts in total consumption.
# Potential Energy Saving Strategies

## Cascade Effect

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Initial Data Center</th>
<th>Optimized Data Center</th>
<th>Saving (kW)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Low power processor</td>
<td>91W / Processor (Average)</td>
<td>70 W / Processor</td>
<td>111</td>
<td>10%</td>
</tr>
<tr>
<td>2. Higher efficiency power supplies</td>
<td>AC-DC (\rightarrow) 79%</td>
<td>AC-DC (\rightarrow) 90%</td>
<td>124</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>DC-DC (\rightarrow) 85%</td>
<td>DC-DC (\rightarrow) 88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Server power management</td>
<td>Power Consumption: 80% of full load when idle</td>
<td>45% of full load when idle</td>
<td>86</td>
<td>8%</td>
</tr>
<tr>
<td>4. Blade servers</td>
<td>All Rack-mount</td>
<td>20% Blades</td>
<td>7</td>
<td>1%</td>
</tr>
<tr>
<td>5. Server Virtualization</td>
<td>No virtualization</td>
<td>20% Servers Virtualized</td>
<td>86</td>
<td>8%</td>
</tr>
<tr>
<td>6. Power distribution Architecture</td>
<td>208V AC</td>
<td>415V AC provides 240V single phase</td>
<td>20</td>
<td>2%</td>
</tr>
<tr>
<td>7. Implement cooling best practices</td>
<td>Hot aisle – Cold aisle</td>
<td>Optimized Cold Aisle &amp; Chilled Water Temp, No Mixing of Hot &amp; Cold Air</td>
<td>15</td>
<td>1%</td>
</tr>
<tr>
<td>8. Variable Capacity Cooling</td>
<td>Fixed Capacity Cooling</td>
<td>Variable Capacity Refrigeration &amp; Airflow</td>
<td>49</td>
<td>4%</td>
</tr>
<tr>
<td>9. High Density Supplemental Cooling</td>
<td>Floormount Cooling only</td>
<td>Floormount plus supplemental cooling</td>
<td>72</td>
<td>6%</td>
</tr>
<tr>
<td>10. Monitoring and Optimization</td>
<td>No coordination between cooling units</td>
<td>Cooling units work as a team</td>
<td>15</td>
<td>1%</td>
</tr>
</tbody>
</table>

Initial Data Center Load: 1127 kW  
Total Saving: 585 kW  
50% +
Low Power Processors

<table>
<thead>
<tr>
<th>Sockets</th>
<th>Clock Speed</th>
<th>Standard Power</th>
<th>Low Power</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMD</td>
<td>1 1.8 - 2.6 MHz</td>
<td>103 W</td>
<td>65 W</td>
<td>38 W</td>
</tr>
<tr>
<td></td>
<td>2 1.8 - 2.6 MHz</td>
<td>95 W</td>
<td>68 W</td>
<td>27 W</td>
</tr>
<tr>
<td>Intel</td>
<td>2 1.6 - 2.0 MHz</td>
<td>80 W</td>
<td>50 W</td>
<td>30 W</td>
</tr>
</tbody>
</table>

Chip makers and independent analysts claim no or negligible impact on compute performance.
Higher Efficiency Power Supplies

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

Before Virtualization

![Diagram showing four physical servers with applications running on them.]

Typical Virtualization Architecture

![Diagram showing a single physical server with a VMware virtualization layer, multiple logical servers, and consolidation of applications.]

- 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

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Cooling Best Practices

- 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
**Optimized Racks**
**Improve Cable Management and Air Flow**

- Blanking Panels
- Increased Door Perforations
- Multiple Cable Management Options to fit site needs
- Arrangement of Cabling to Keep from Blocking Air Flow
Variable Cooling Capacity

- 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

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

DX Units
- Compressor uploading / airflow
- Variable compressors
  - Multi-step / Digital
  - Higher EER point
Conventional Hot-Aisle/Cold-Aisle Cooling

Applications Generally Limited to Less than 6kW per Rack
High Density Supplemental Cooling

- 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
High Density Supplemental Cooling

The Liebert XD Units Enhance The Hot Aisle/Cold Aisle Approach

The XDO and XDV fill the cold aisle with air at the temperature required for proper operation of the electronic equipment.

- High Density Applications in Excess of 30kW per Rack
- 30% Reduction in Power to Provide the Required Cooling
  - Reduces Fan Power by up to 65%

Side views of Computational Fluid Dynamics (CFD) by Fluent.
Monitoring and Optimization

Teamwork: None

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

Teamwork: In operation

Control Disables heaters in "Cold Zone"

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Proactive Alarm Management: Collaborating with Other Systems

Complete Integration of All Critical Facilities Equipment

- Critical Air Systems
- Critical UPS Systems
- Critical Power Distribution
- Critical Battery Systems
- Switchgear and ATS
- Generators
- Critical Facilities Monitoring System
- Fire Suppression
- Pumping Systems
- Fuel Tanks
- Security
- Leak Detection
- Third-Party Equipment
Proactive Monitoring to Reduce Downtime

Break-Fix, Non-Performance-Based Monitoring

- Up
- Down
- Up
- Down

React! | Repair
React! | Repair

Proactive, Performance-Based Monitoring

- Up
- Down
- Up
- Up

Proactive Action
Planned Repair
Proactive Action
Downtime Eliminated

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New Monitoring Technologies Are Available

Smart Power Strips
Monitor In-rack Power and Environmental Conditions

Branch Circuit Monitoring
to monitor each PDU output circuit
Predictive Analysis
Performance Monitoring

Battery Monitoring

Patented Battery DC Resistance Measurement
Battery Monitoring Gives You Confidence in Your Battery System

- Identify Problems Prior To Failure Point – Locate Weak Cell Among Good
- Reduce Mean Time To Repair
- Improve Purchasing Decisions Based On Data
Proactive Monitoring Increases Availability

Example is from a Cellular Telephone Company. The customer invested in very detailed monitoring so that they could:
1. Reduce the number of trips to cell sites by going to the site with the proper equipment and parts
2. Get to the site before the system went down by deploying on warnings and changes

Both were achieved.

Hours of Uptime Per Year

Break-Fix Monitoring

Proactive Monitoring

77% Reduction in Downtime

1 year = 8,765 hours
Thank You