DATA CENTER DESIGN CONSIDERATIONS AND TRENDS

MUSIC CITY POWER QUALITY GROUP
May 5, 2009
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IEEE Central Tennessee Section

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Topics Covered in this Presentation

- Economic and Environmental drivers
- LEED considerations for data centers
- How UPS advancements can help
- TP1 transformers and PDU's
- How usage voltage can make a difference
- Data center examples
- Discussion & Questions

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Economic and Environmental Drivers

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Climate Change and CO2 Emissions

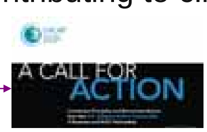
Regardless of political dissuasion pressure is mounting

- Growing scientific, corporate and public opinion in US that CO_2 emissions are contributing to climate change

Public Awareness

Private Sector

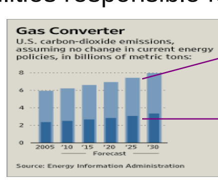
United States Climate Action Partnership
29 Large Corporations and NGOs



Electric Utilities

Edison Electric Institute (EEI)
Association of US Electric Power Utilities

- U.S responsible for ¼ of worldwide CO_2 emissions
- Electric Utilities responsible for 1/3 of US CO_2 emissions



Projected US Carbon-dioxide emissions (EIA)

US Electric Power CO_2 Emissions

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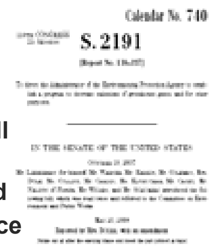
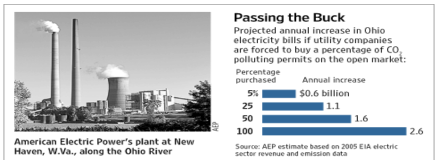
Inevitable regulatory actions and potential cost increases

- **Regulations are rapidly changing**
  - Over 60 proposed bills in Congress to address energy and environmental issues
- **The Lieberman-Warner Bill (S2191) "Cap and Trade" filibustered and then narrowly defeated this last year, will come back in some other form**
- **SEC (GHG-Greenhouse Gases) regulations being studied**
- **States like California already have their own plans in place**



- **The lower the emissions target, the fewer the permits, the higher its prices and prices to consumers**

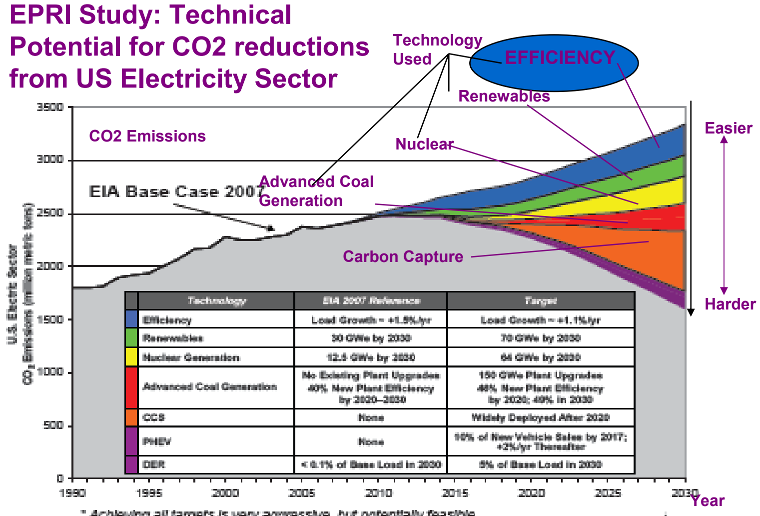
Example: American Electric Power Inc, in Columbus Ohio (# 1 Emitter of CO_2 in the US) Prices may go up as much as 12-50% due to permit costs and technology investment



American Electric Power's plant at New Haven, W.Va., along the Ohio River

Electric energy efficiency is highest impact opportunity to reduce CO2 (Low hanging fruit)

EPRI Study: Technical Potential for CO2 reductions from US Electricity Sector



	Technology	EIA 2007 Reference	Target
	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
	Renewables	30 GWe by 2030	70 GWe by 2030
	Nuclear Generation	12.5 GWe by 2030	64 GWe by 2030
	Advanced Coal Generation	No Existing Plant Upgrades 40% New Plant Efficiency by 2020–2030	150 GWe Plant Upgrades 46% New Plant Efficiency by 2020; 49% in 2030
	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

** Achieving all targets is very aggressive, but potentially feasible.*

- **Efficiency programs can deliver at a lower cost than new power plants**

Duke Energy CEO on behalf of Edison Electric Institute in testimony to Congress (2/12/2007)

- **Energy efficiency standards already in progress in US 40 states**

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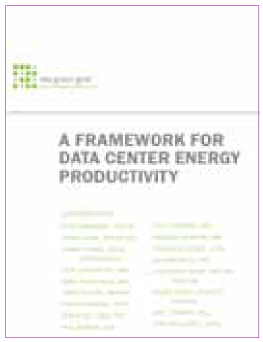
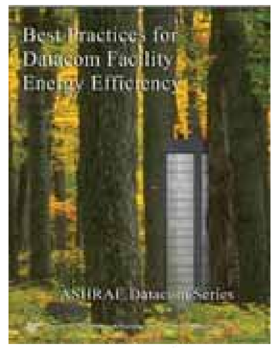
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Data centers among the most energy intensive building infrastructures…

- Consume 20x to 40x the energy of an office building(*)
- Data centers are such major corporate energy consumers and they can't be excluded from carbon footprint caps or reductions
- Many organizations already working on efficiency standards (Green Grid, EPA, DOE, ASHRAE)





* Uptime Institute, Keynote 2008

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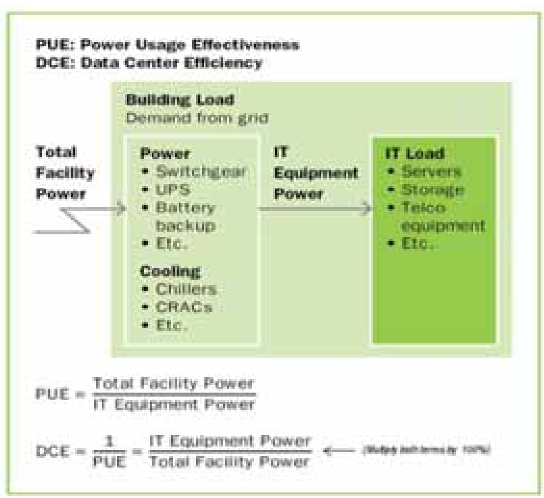
Power Usage Effectiveness (PUE) & Data Center Infrastructure Efficiency (DCIE)*

- The industry recognizes the need for a "MPG" metric of efficiency
- These are stop gap metrics as they do not address the amount of IT work being done
- In the long term we need to use:

Datacenter Productivity =
Useful Work/
Total Facility Power



*From GREEN GRID DATA CENTER POWER EFFICIENCY METRICS:PUE AND DCIE

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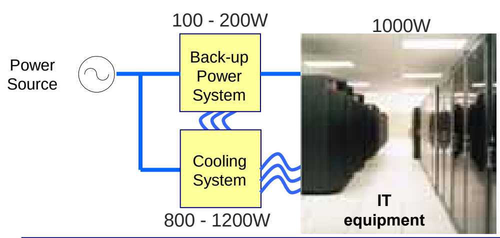
PUE/DCiE Example

- For example, a data center that consumed a total of 1000 kW, where the IT equipment consumed 400kW, would be said to have a PUE of 2.5 and a DCiE of 40%.
- Naturally, PUE and DCiE will vary by data center tier rating, application, geography and weather conditions.
- For instance, a Web hosting center would have a more favorable PUE (a lower number) than the data center supporting a trading floor. A Tier IV data center would have a higher PUE (lower efficiency) than a Tier II design, due to added redundancy.
- The ideal would be a PUE of 1.6, but any well-designed and operated data center could realistically achieve a PUE of 2 while meeting business objectives.

Improving Data Center Efficiency

Power Delivery in a Datacenter



$$\text{IT Efficiency} = \frac{\text{IT Output}}{\text{IT Input Power}}$$

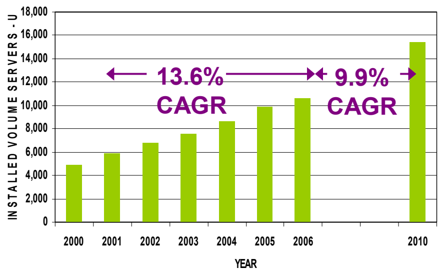
$$\text{Data Center Site Infrastructure Efficiency} = \frac{\text{IT Input Power}}{\text{Total Site Power}}$$

$$\text{Data Center Efficiency} = \text{IT Efficiency} \times \text{Data Center Site Infrastructure Efficiency} = \frac{\text{IT Output}}{\text{Total Site Power}}$$

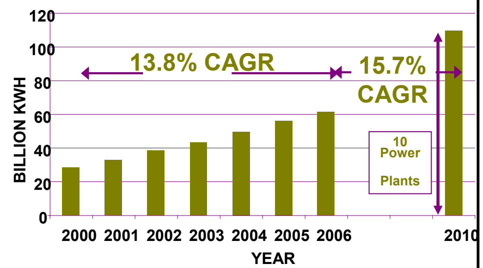
- Improve IT efficiency
  - Maximize IT output while lowering input power
  - Each watt reduced at the IT equipment results in 2 to 3 watts saved at utility
- Improve Site Infrastructure Efficiency
  - Reduce losses & inefficiency in back-up power & cooling systems

…with no sign of slowing or decreasing

Installed number of servers (US)



Data center energy consumption (US)



Sources: EPA 2007 Report to Congress, Vernon Turner/IDC, Koomey 2007

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…leading to higher CO2 emissions from Data Centers

Data Center Greenhouse Emissions

Average data center consumes energy equivalent to 25,000 households

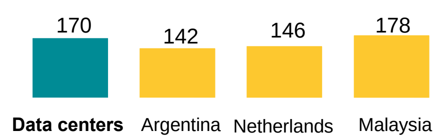
Worldwide energy consumption of DC doubled between 2000 and 2006

90% of companies running large data centers need to build more power in the next 30 months

Carbon dioxide emissions as percentage of world total – industries percentage

Carbon emissions – countries

(Mt CO_2 p.a.)



* Including custom-designed servers (e.g., Google, Yahoo)
Source: Financial Times; Gartner report 2007; Stanford University; AMD; Uptime Institute; McKinsey analysis

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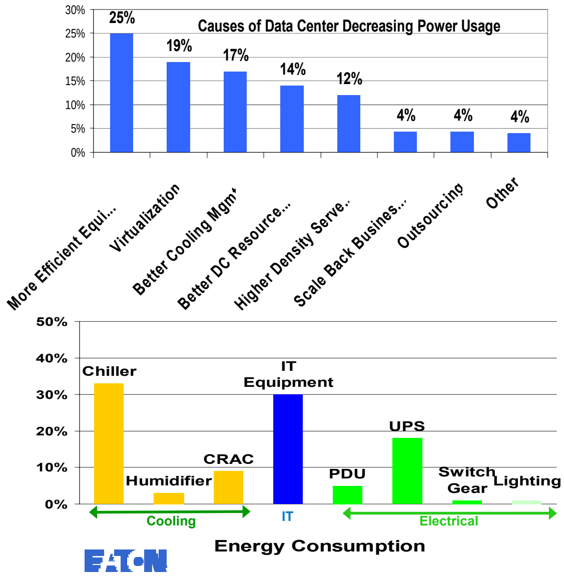
Electrical Equipment where efficiency savings coming today (low hanging fruit)



Survey where power savings coming from today in the data center world

Data Center Energy Consumption

Source: Aperture Research Institute-Uptime 2008, ARI Survey

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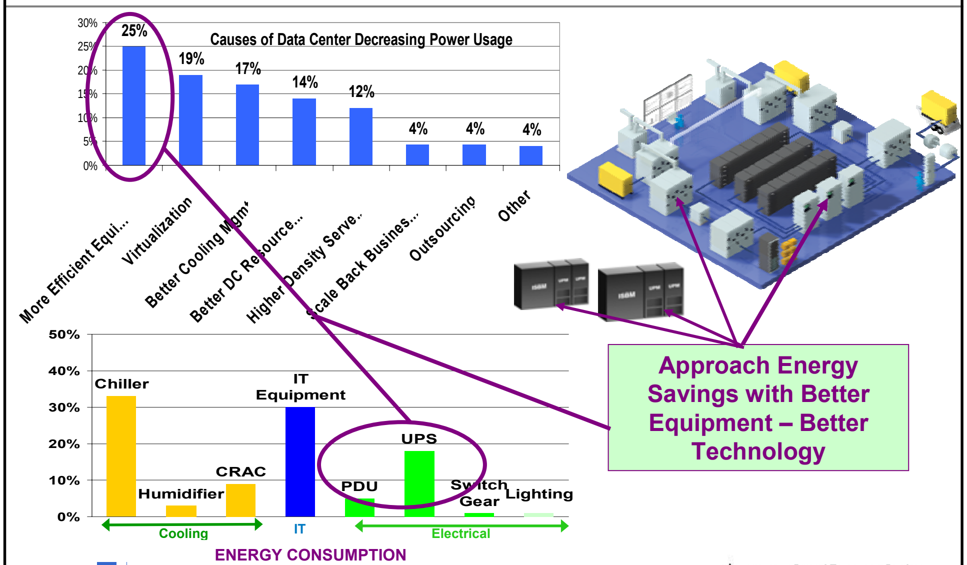
…let's attack efficiency from the point of view of electrical infrastructure



Source: Aperture Research Institute-Uptime 2008, ARI Survey

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LEED Considerations for Data Centers

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Growth in LEED Data Center designs

- As of August 8, 2008 there where nine known LEED certified data centers in the USA
- From the Data Center Knowledge web site:
  - *Platinum - 1*
  - *Gold - 1*
  - *Silver - 2*
  - *Certified – 4*
- *And there are 5 known proposed LEED certified data centers in the works*
- *In 2006 there were only 2 LEED certified data centers in the USA*

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Many more companies are interested…

- Beyond the obvious energy cost savings many companies are considering LEED certification of their data center from a corporate environmental responsibility point of view.
- Hosting operators are beginning to offer their customers “green” options such as renewable energy and other environmental friendly alternatives.
- The Green Grid is lobbying the U.S. Green Building Council to create a LEED certification for the data center.

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From “LEEDTM Rating System Version 2.1”

V2.2 Now available

Optimize Energy Performance

Intent

Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

Requirements

Reduce design energy cost compared to the energy cost budget for energy systems regulated by ASHRAE/IESNA Standard 90.1-1999 (without amendments), as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11 of the Standard.

New Bldgs.	Existing Bldgs.	Points
15%	5%	1
20%	10%	2
25%	15%	3
30%	20%	4
35%	25%	5
40%	30%	6
45%	35%	7
50%	40%	8
55%	45%	9
60%	50%	10

Up to 10 points for energy savings

Innovation in Design

Intent

To provide design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System.

Requirements

Credit 1.1 (1 point) In writing, identify the **intent** of the proposed innovation credit, the proposed **requirement** for compliance, the proposed **submittals** to demonstrate compliance, and the **design approach** (strategies) that might be used to meet the requirements.

Credit 1.2 (1 point) Same as Credit 1.1

Credit 1.3 (1 point) Same as Credit 1.1

Credit 1.4 (1 point) Same as Credit 1.1

Submittals

- ❑ Provide the proposal(s) within the LEED Letter Template (including intent, requirement, submittals and possible strategies) and relevant evidence of performance achieved.

Up to 4 points for innovation

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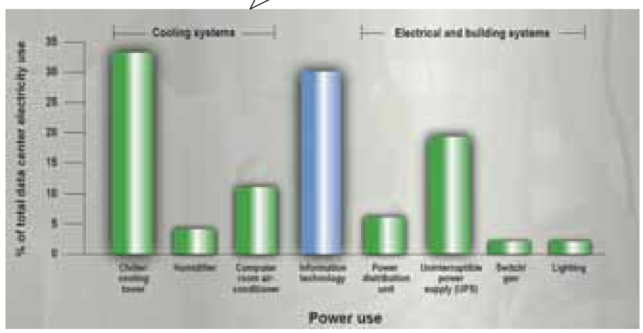
What Others Are Saying

Highlights

Cooling and electrical costs represent up to 44 percent of a data center's total cost of ownership, although some companies are finding that they can't buy extra electricity at any price.

From 2007 Study by IBM

From 2006 Study by APC



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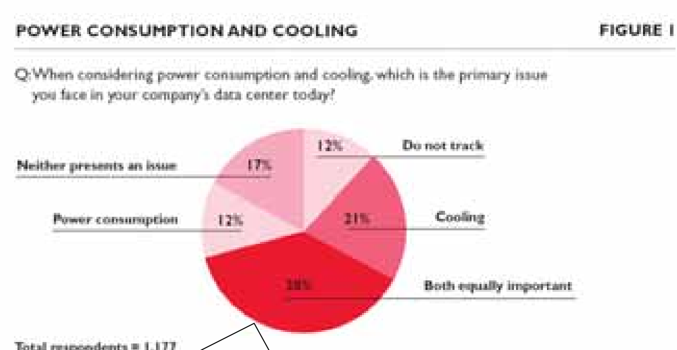
Ziff Davis 2005 Survey



50% of respondents felt that power was their primary issue

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Data Center Energy Challenge

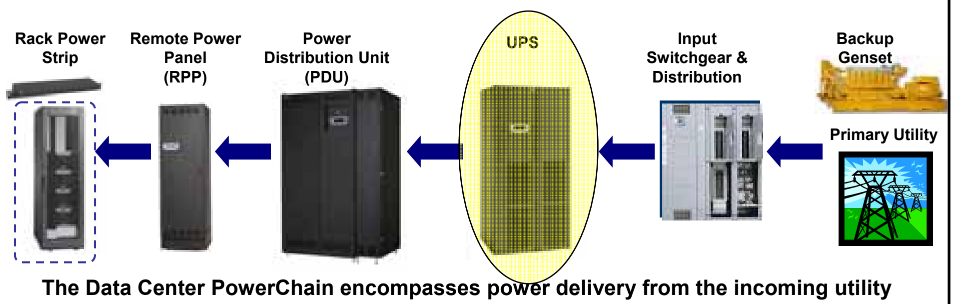
Mission: *Reduce energy costs without sacrificing data center uptime and reliability*

- New “transformerless” UPS designs for larger loads can provide significant energy savings when used in medium to large data centers.
  - These products also have a smaller footprint and less weight
- Energy efficient TP-1 transformers in PDU’s provide considerable ongoing energy savings over the life of a typical data center.

Leveraging technology and experience to deliver customer value

How UPS Advancements Can Help

The Data Center PowerChain

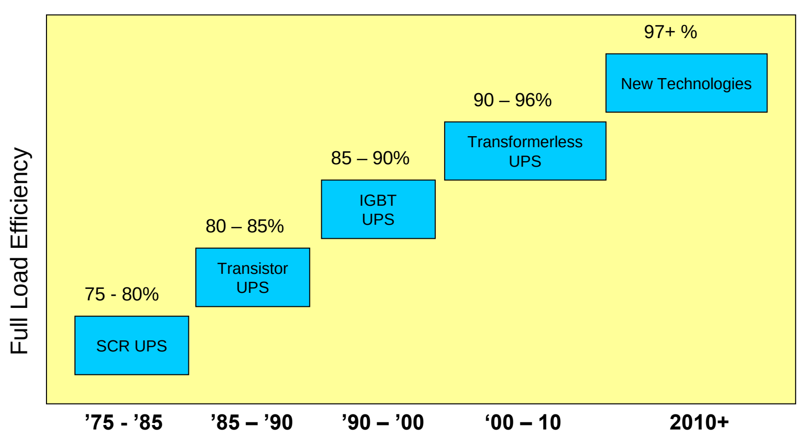


The Data Center PowerChain encompasses power delivery from the incoming utility feed to the IT equipment in an enclosure

- Key Components contributing to power loss in back-up power system
  - UPS (Uninterruptible Power Supply) efficiency: 80 to 95% and greater
  - PDU (w. transformer) efficiency: 94 to 98%

UPS Energy Efficiency Evolution

UPS Energy Efficiency Improvements



Transformer Based UPS Systems

- May use SCR's, GTO's or IGBT's for output switching
- May use stepwave or PWM inverter scheme
- All need internal transformer for:
  - Isolation
  - Filtering
- Transformer accounts for 50% or more of the total UPS losses

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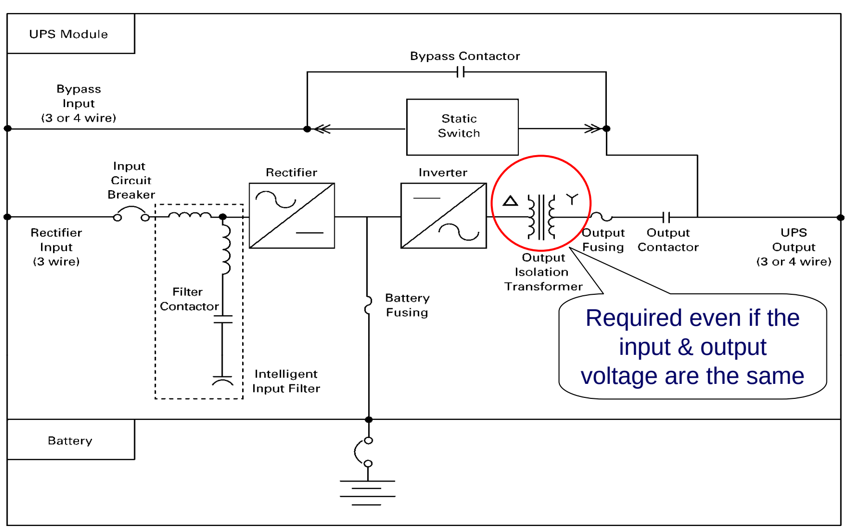
Transformer Based UPS Systems



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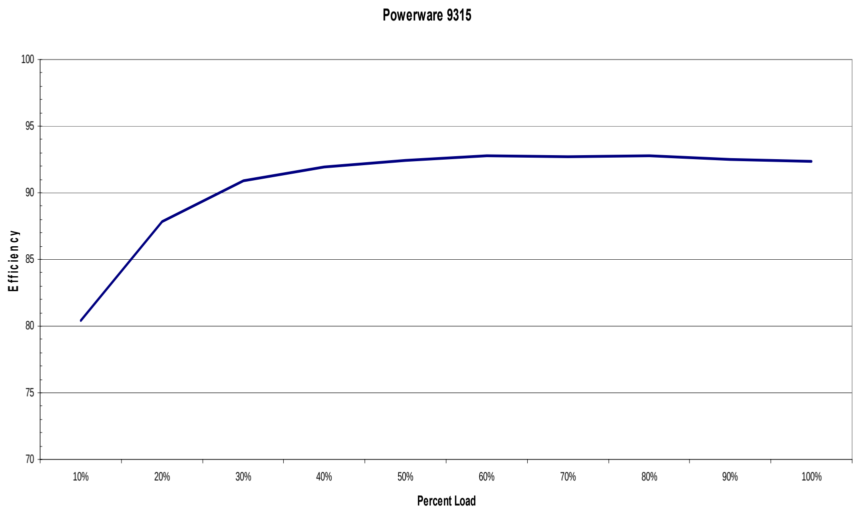
Efficiency Curve of Transformer UPS



Transformerless UPS Designs

These have been available in lower kVA ratings for over 10 years

Transformerless UPS Designs

- Use high speed switched IGBT's for both rectifier and inverter.
- PWM power converter design for low input distortion and smooth sine-wave output.
- Lighter weight
- Smaller footprint
- Elimination of transformer reduces losses by as much as 75%

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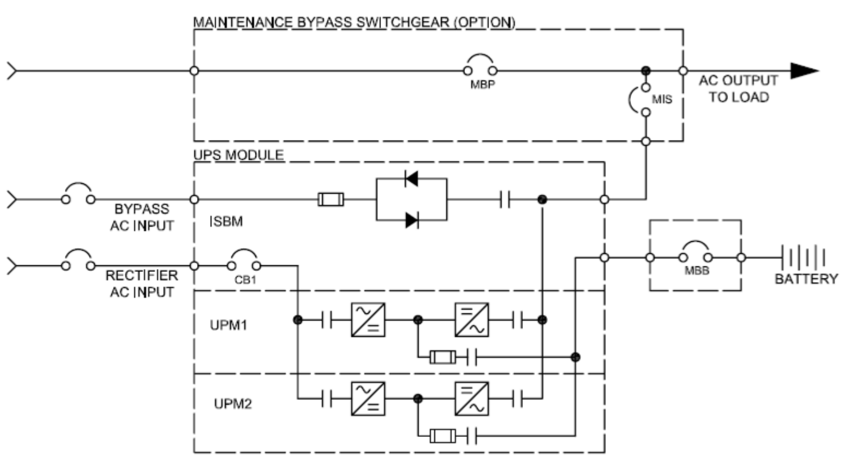
Transformerless UPS Designs



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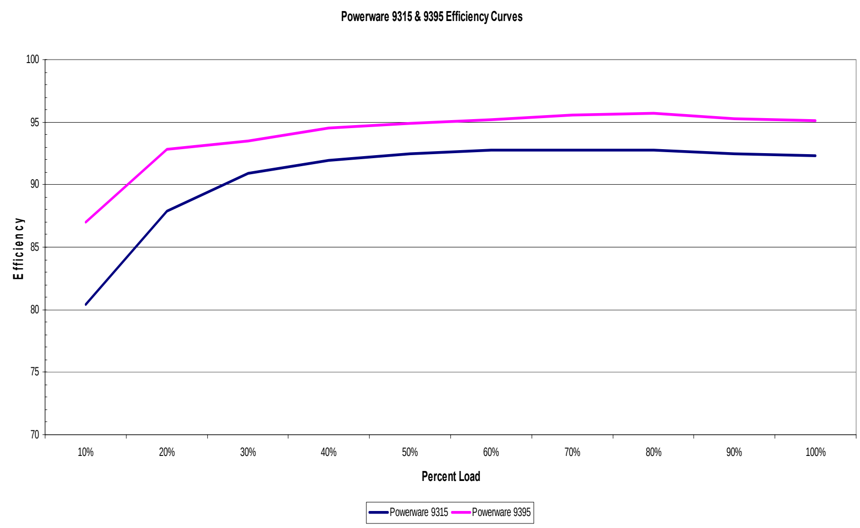
Comparison of Efficiency Curves



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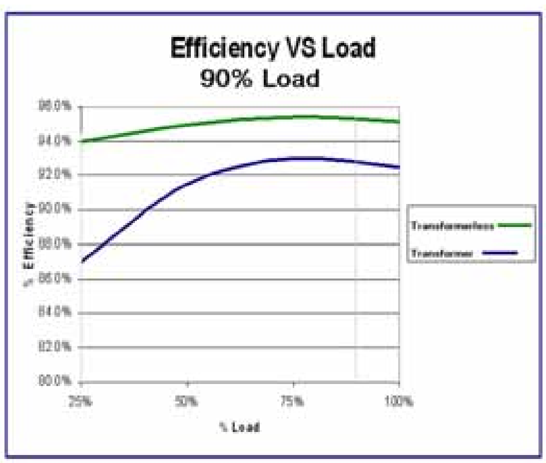
Comparison of Efficiencies

Load Rating (VA) =	495000.0
Load Power Factor =	1.00
Unit Watts =	495000.0
Energy cost per KW Hr (usage charge + taxes($/kWhr) =	$0.06
Demand charge per kWhr =	$0.00
Total Cost per kWhr =	**$0.06**
Transformer Based product efficiency from chart =	92.7%
Transformerless UPS efficiency from chart =	95.3%
Loss in watts with Transformer Based product =	36135.0
Loss in watts with Transformerless UPS =	23265.0
Extra energy used to operate Transformer Based product =	12870.0
Loss in Btu/hr with Transformer Based product =	123297.7
Loss in Btu/hr with Transformerless UPS =	79383.5
Extra Btu/hr used to operate Transformer Based product	43914.3
Daily energy savings using Transformerless UPS =	$18.53
Yearly energy savings using Transformerless UPS =	$6,764.47
* Cooling efficiency ratio =	70%
Daily cooling savings using Transformerless UPS =	$12.97
Yearly cooling savings using Transformerless UPS =	$4,735.13
Total yearly combined savings per Transformerless =	**$11,499.60**
Qty of Modules	1
Total yearly combined savings using Transformerless =	**$11,499.60**



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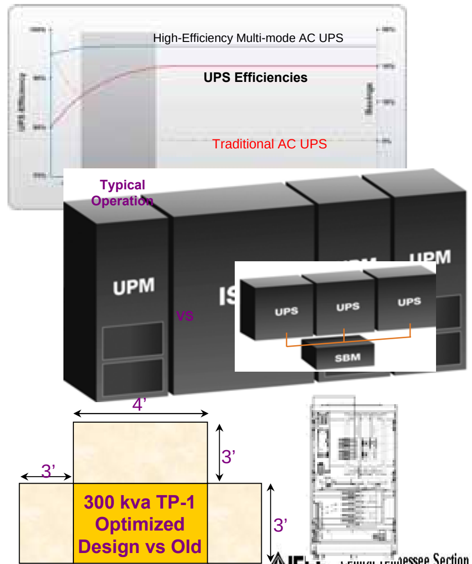
Smaller and more efficient technologies yield operational, space & transportation savings

- **High Efficiency UPS that does not sacrifice reliability**
- **UPS Transformerless Design and higher operating frequencies to reduce footprint and weight**
- **PDU withTP-1 High Efficiency Transformer plus optimized mechanical design**



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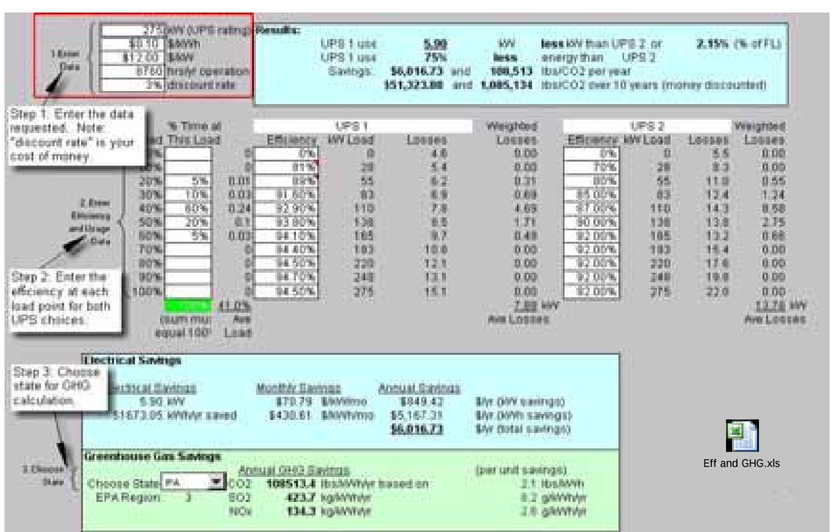
System Efficiency and Greenhouse Gas Analysis



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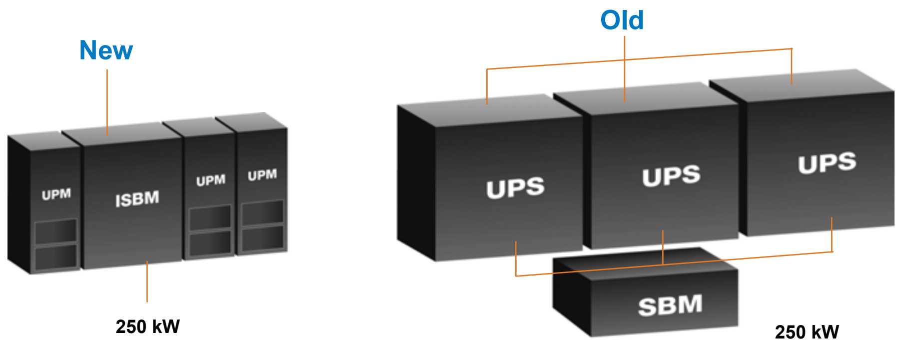
Medium Data Center 500 KVA redundant

Operational Cost Savings new technology versus traditional UPS



Annual Energy Savings: 821 MW-hr
Annual Carbon Savings: 710 tons
Annual Cost Savings: $99 K(*)

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* Includes Cooling Cost Savings

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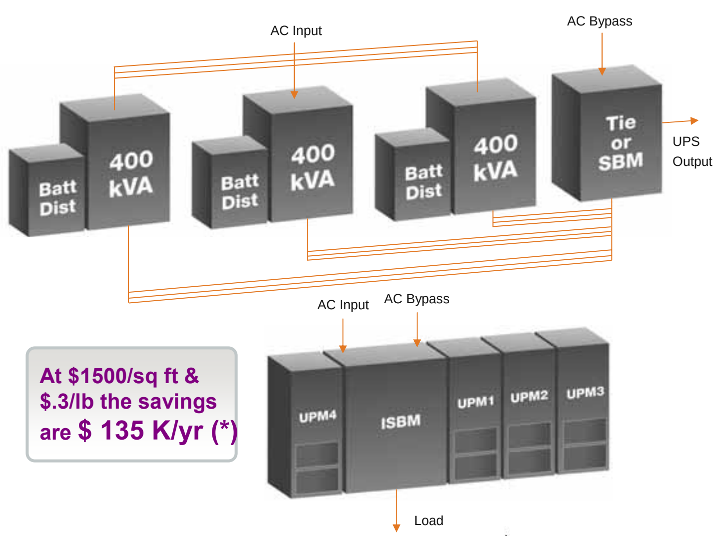
Large Data Center 825 KVA redundant

Weight and Space Differences yielding concrete savings

Old

125 sq. ft.
19,125 lb system weight*
Extensive site wiring

*Excluding batteries



New

39 sq. ft.
6,365 lb system weight*
Minimal site wiring

*Excluding batteries

At $1500/sq ft & $.3/lb the savings are $ 135 K/yr (*)

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* Includes Cooling Cost Savings

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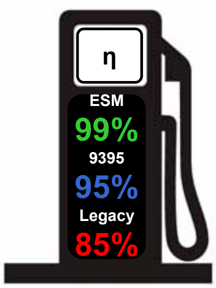
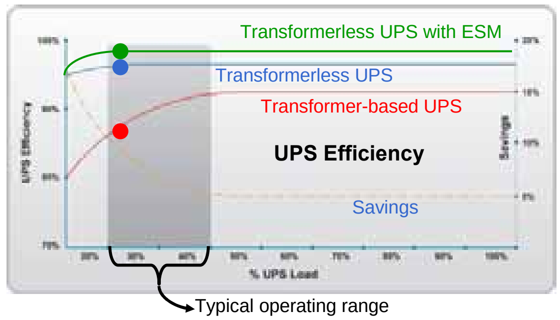
Energy Saver Mode compared to legacy UPS systems





- Energy Saver Mode 99% or higher efficiency for 20% to 100% load range
- 6% to 15% efficiency improvement across full load range vs traditional UPS
- Continuous power tracking and proprietary DSP algorithms combined with transformerless topology ensures critical loads are always protected

You select the desired efficiency

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Other Transformerless UPS Advantages

- Green, environmentally-friendly design:
  - Reduction of hazardous material
  - Lowest energy required of production
  - Less fuel used to ship
  - No large transformers
  - High efficiency design
    - Less wasted electricity
    - Less wasted cooling
  - High Power Density = less building infrastructure waste

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Transportation savings

15 tons of CO_2 emissions are saved for every 100 MVA worth of data center UPS compared to legacy equipment (avg 500 miles)

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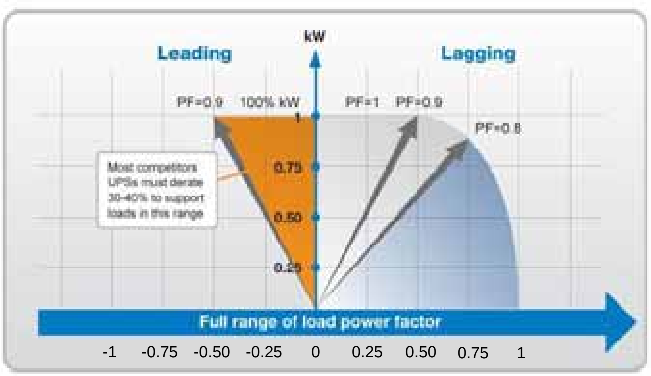
Performance to meet the load requirements



Today's power factor corrected data center loads are becoming more "leading."

With the modern transformerless designs, there is no need to derate the UPS for leading pf loads. Many legacy UPS's must be derated!

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Next Generation Modular UPS

9395 1100 kVA capacity

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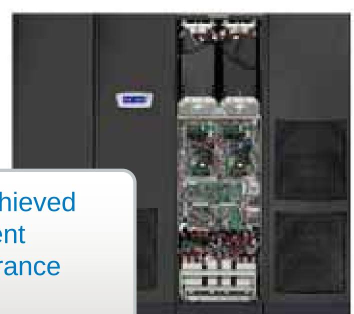
Concurrent Maintenance

- With new modular transfomerless N+1 redundant UPS designs, you can completely isolate and service a redundant module, while the other module carries the load… no need to go to bypass for service



"…high-availability cannot be achieved without considering the concurrent maintainability and the fault-tolerance of the underlying infrastructure"

The Uptime Institute

Concurrent maintenance = higher availability

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TP1 Transformers and PDU’s

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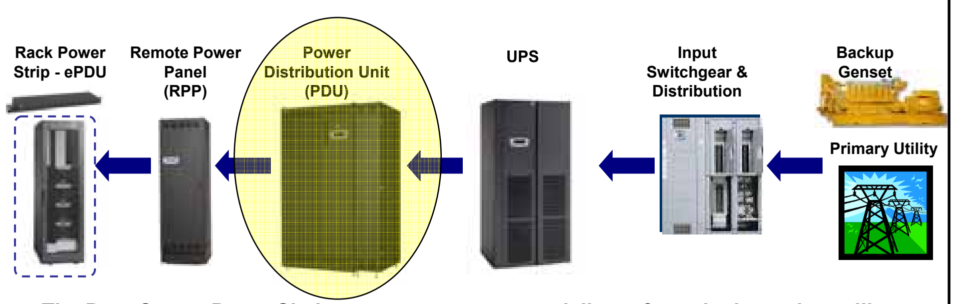
The Data Center PowerChain



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- Key Components contributing to power loss in back-up power system
  - UPS (Uninterruptible Power Supply) efficiency: 80 to 95%
  - PDU (w. transformer) efficiency: 94 to 98%

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PDU Energy Savings

- PDU energy savings all relate to the efficiency of the transformer used in the design
- The normal dry-type transformer used in PDU's has been of "standard" high efficiency type
- All distribution transformers are now required to be the more energy efficient TP-1 type since January 2007
- Higher initial cost of TP-1 is quickly offset by energy savings

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Energy Policy Act of 2002

- The final rule issued on the Energy Policy Act of 2002.
- *"DOE sees no reason to modify the term ''Uninterruptible Power Supply transformer'' in its regulations, or to completely revise its definition of this term. Nonetheless, DOE recognizes that, in characterizing an uninterruptible power supply transformer as one that ''supplies power to'' an uninterruptible power system, 10 CFR 431.192, DOE's definition may be confusing and slightly inconsistent with its description in the SNOPR of this type of transformer.* ***Therefore, to make the definition consistent with its expressed intent in the SNOPR, to which there was no objection, in today's rule DOE is clarifying its definition of ''Uninterruptible Power Supply transformer'' by replacing the phrase ''supplies power to'' with ''is used within.''*** *This modification does not expand or reduce the intended group of Uninterruptible Power Supply transformers that DOE wishes to exempt from its standard. Rather, this change provides greater clarity of the scope of this exemption."*
- It is clear then that the exemption applies to transformers used in the UPS, not down stream in a PDU.

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Standard & TP-1 Efficiencies

Three-phase kVA	Standard efficiency level (%)	TP-1-2002 efficiency level (%)
30	96.5	97.5
45	96.6	97.7
75	96.7	98.0
112.5	96.9	98.2
150	97.1	98.3
225	97.3	98.5
300	97.4	98.6

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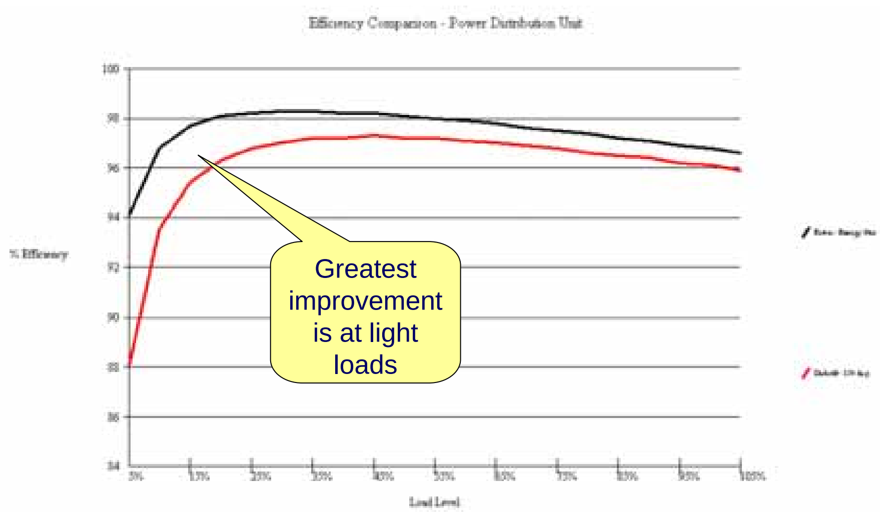
Efficiency Comparison



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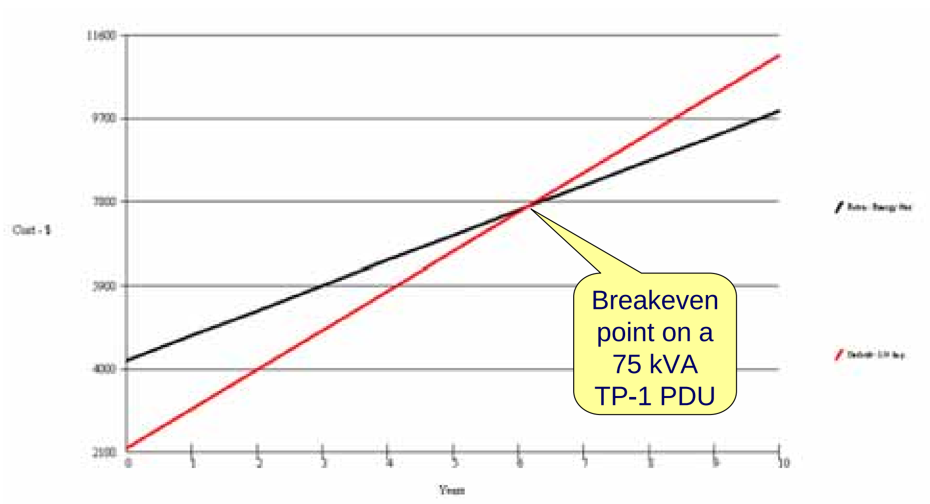
PDU with TP-1 Payback



TP-1 Savings can be Significant

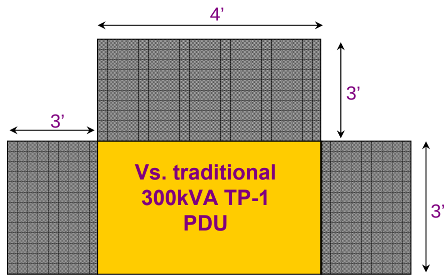
	Regular Transformer	Energy Efficient Transformer	Difference
Additional Costs for TP1			$4,250
Efficiency	97.30%	98.60%	1.30%
Annual cost of losses *	$2,202	$1,142	$1,060
Simple payback (yrs.)			4.01
Lifetime cost of losses *	$30,310	$15,720	
Present value of savings			$14,590
Overall Savings for 100 PDUs	**$1,459,000**		

- Above is an actual example from a large data center that will be using 100 – 300 kVA PDU’s
- Additional up-front cost of TP-1 based PDU was recouped in 4 years
- And they avoided the risk of not passing inspection!

PDU Footprint & efficiency savings

Footprint:

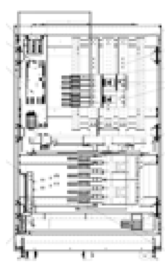
- Complete front accessibility
  - Can save up to 30 sq. ft
  - Real estate savings up to
    $30K per year per PDU



Efficiency:

TP-1 transformer is 2% more efficient than conventional, this translates to savings of

$4.7K per year per PDU



Traditional

300 kVA PDU

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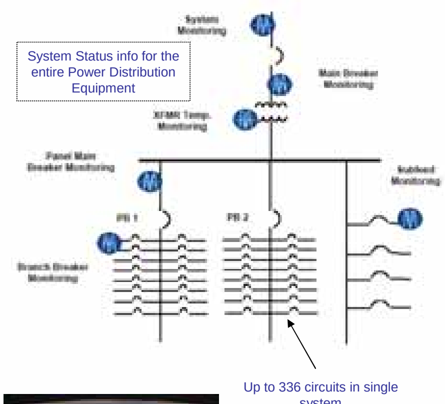
Metering Systems
Verify Energy Savings

- **Display**
  - Standard 8 x 40 LCD
  - Can display Main, Sub-feed and Branch circuits up to 336 pole positions in one local display
- **Real Time Clock**
  - Tracks event history, with integrated, real-time clock for diagnostics and forensic analysis
- **Energy Management Planning**
  - Stores 23 months of data for diagnostics, comprehensive load profiling and energy planning
  - Minimum and Maximum values of Current (I), Power (KW) & Power Factor (PF) from Main to Branch circuits



23 months of power profiling for management & planning

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Monitoring real time power distribution data

- Increasing need to monitor the branch current level on a 7x24 basis
- Helps in determining during a MAC if a piece of equipment can be added to a circuit without overloading that branch circuit
- The current draw by IT equipment can vary 50-100% on a 7x24x365 basis
  - Application usage
  - Business seasonality
  - Dual corded loads
- Lights-out datacenter driving need for remote monitoring ability
- Power loading trends support capacity planning

PDU / RPP: Metering of 100s of branch circuits feeding 10's of enclosures with one IP address

Sub-distribution module: Metering of 10s of power strips in a few enclosures with one IP address

Enclosure power strip: Metering of a few branch circuits in a power strip with one IP address

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How Voltage Can Make a Difference

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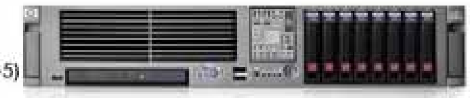
Input Voltage Choice

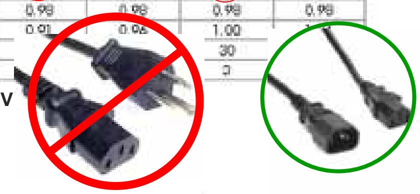
Overview

HP ProLiant DL380 Generation 5 (G5)



Power Supply Specification - AC	Part number	380622-001				
	Spare Kit	403781-001				
Operational Input Voltage Range (Vrms)	90 to 264					
Frequency Range (Nominal) (Hz)	47 to 63 (50/60)					
Nominal Input Voltage (Vrms)	**100**	**120**	**208**	**220**	**230**	**240**
Max Rated Output Wattage Rating	800	850	1000	1000	1000	1000
Nominal Input Current (A rms)	10.0	8.8	5.85	5.5	5.2	4.97
Max Rated Input Wattage Rating (Watts)	980	1035	1193	1186	1172	1169
Max. Rated VA (Volt-Amp)	1000	1056	1217	1210	1196	1193
Efficiency (%)	81.5	82	84	84	85	85.5
Power Factor	0.98	0.98	0.98	0.98	0.98	0.98
Leakage Current (mA)	0.44	0.52	0.91	0.96	1.00	[illegible]
Max. Inrush Current (A peak)	30	30	[illegible]	[illegible]	30	[illegible]
Max. Inrush Current duration (mS)	3	3	[illegible]	[illegible]	3	[illegible]

- **Virtually all IT equipment is rated to work from 100V to 240V AC input**
- 11% less losses by using 208V instead of 120V
- 17% less losses by using 230V instead of 120V



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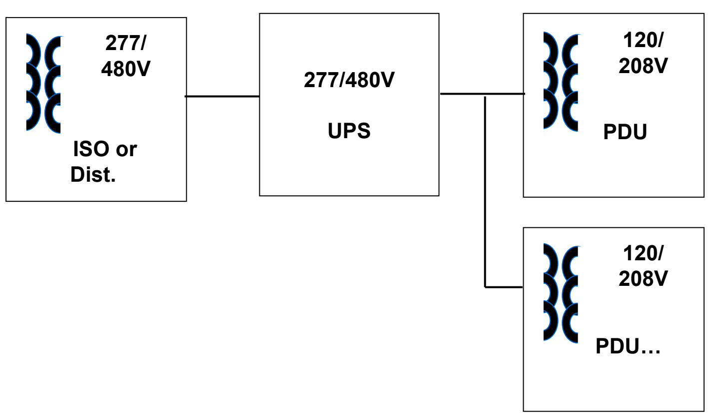
North American 120/208V System



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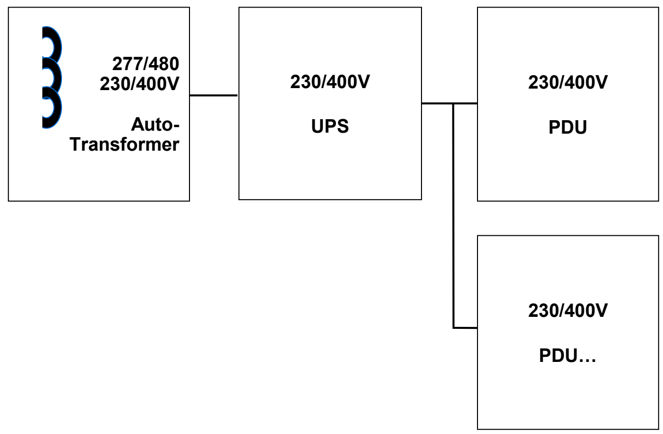
Global 230/400V System



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230/400VAC v. 120/208VAC Power Distribution

Technology

- 230/400 VAC is a global platform for power distribution
- Eliminates need for PDU transformer to step-down 480V to 208V

Energy Savings Benefit

- Improved efficiency of 4 to 6% (half from eliminating transformer and half from IT equipment power supply)

Other Benefits

- PDU without transformers (RPP) is less expensive and takes up less space
- Auto transformer is lower cost and smaller than isolation transformer

Drawback

- The 480 to 400 auto transformer is not an off the shelf device today

Example

- 1000 servers @500W/server with 5% Savings
- Annual Energy Savings @$0.1/kWhr = $43K

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Additional Resources

U.S. Department of Energy

http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html

Energy Star Transformer Program

http://www.energystar.gov/index.cfm?c=ci_transformers.pr_ci_transformers

NEMA Transformer Data

http://www.nema.org/prod/pwr/trans/

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Data Center Examples

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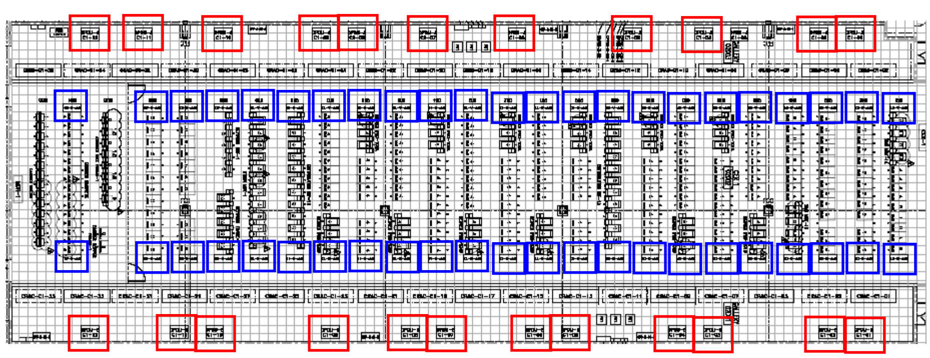
Sample Project Design

- Customer: Major Financial Institution
- Location: Northern New Jersey
- Size: 38,000 Square Feet
- Type: Raised Floor - 4 Data Fields
- Power: 24,600kVA total capacity
  9,840kVA expected load
  40% capacity

Customer Layout – Phase 1



= QTY 82, 300kVA PDU with TP-1 Energy Efficient transformer (40% loaded)

= QTY 162 RPP (dual feed, main-tie-main input with Energy Management System)

Power Distribution Configuration

PDU

- 300kVA, K13, Low Inrush, Low Temperature Rise
- Dual Input, 4 x 400A Sub-feed distribution w/ expansion capability for one additional 400A sub-feed

RPP

- 4 x 400A; 42 circuit high density panels
- Dimensions 24” x 48” x 72” to match IT cabinets
- Main-tie-main configuration with electromechanical interlocking
- EMS Level 3 (BCM) Monitoring with web interface

Energy Efficient Transformers

Utilize NEMA TP-1 transformer design spec:

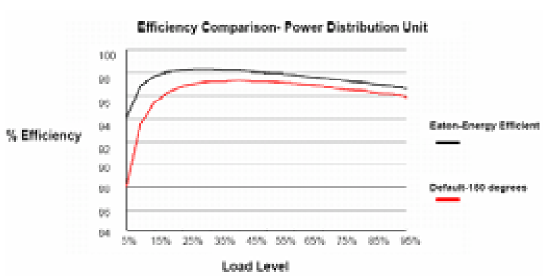
•Grain oriented steel laminates. Miter cut to form the core stack

•2 % gain in efficiency throughout the load curve

Energy Policy Act of 2005

•Encourages use of TP-1 transformers in data center

•Requires TP-1 transformers on the general use grid



TP-1 Transformers will be labeled as such.

Energy Efficient Transformers

Considerations:

- **Cost of capital**
- **Utility rate for data center**
- **Initial transformer cost**
- **Transformer load level**
- **Service life of transformer**

	Regular Transformer	Energy Efficient Transformer	Difference
Additional Costs for TP1			$4,250
Efficiency	97.30%	98.60%	1.30%
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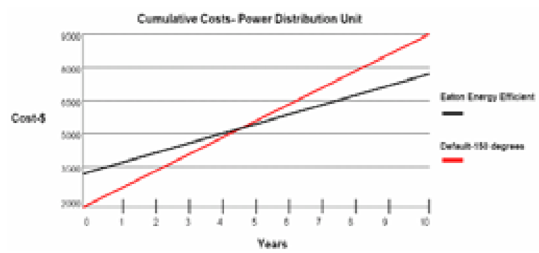
Simple payback (yrs.)			4.01
Lifetime cost of losses *	$30,310	$15,720	
Present value of savings			$14,590
Overall Savings for 100 PDUs		**$1,459,000**	

Perform a Total Cost of Ownership assessment to determine your Individual payback period.

Use D.O.E & NEMA tools to help.



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Power Cabinet Flexibility

Main-tie-main configuration

- A & B source redundancy
- Electromechanical interlocking for safe transition

Extra depth - 48”

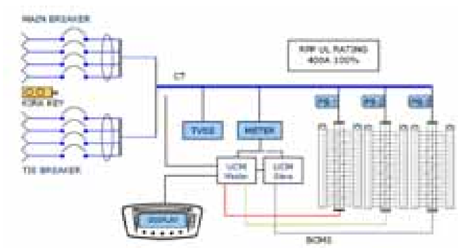
- Line up & match with rack
- Provide extra room for Main breakers
- Extra wiring space

High power density

- 3 or 4 x 400A panels

EMS Level 3 Monitoring

- Ensure power management to the branch level



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Power Capacity Planning

1. Is your rack power density continuously going up?

2. How often do you add/change breakers?
   - How do you do achieve load balancing at the branch breaker level in such an environment?

3. Can you identify trends in power consumption due to applications, seasonality or period?
   - How do you ensure your breakers don't experience overload?

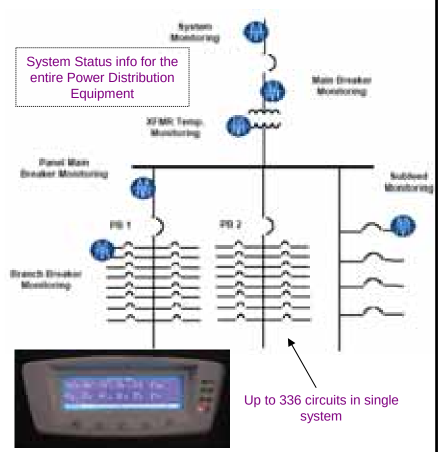
Energy Management Systems

Comprehensive Metering Points
- Monitors all single points of failure
- System-level Monitoring: 24/7 branch circuit, sub-feed and main breaker level monitoring
- Monitor hundreds of pole positions in a single system

Real-time Information
- Issues warnings and alarms if conditions exceed user-defined thresholds
- Tracks event history with real-time clock for time stamping
- Makes all data available on a local display
- Multiple connectivity options including IP

Capacity Planning
- Stores 23 months of data for diagnostics, comprehensive load profiling and energy planning
- Minimum and Maximum values of Current (I), Power (KW) & Power Factor (PF)
- Ability to maximize available power and drive usage in each branch circuit to its limit
- Load balance per phase

Broad Applications
- One system to support all power distribution equipment
- Interface with existing software & BMS applications



23 months of power profiling for management & planning

Summary

When designing your data center power distribution:

1. Assess Total Cost of Ownership:
   - Energy efficient transformers
   - Lower heat output
   - Leverage space saving designs

2. Request tools and configurations that improve your system availability:
   - Redundant designs with bypass features
   - Rugged, maintainable designs
   - Comprehensive metering and connectivity features

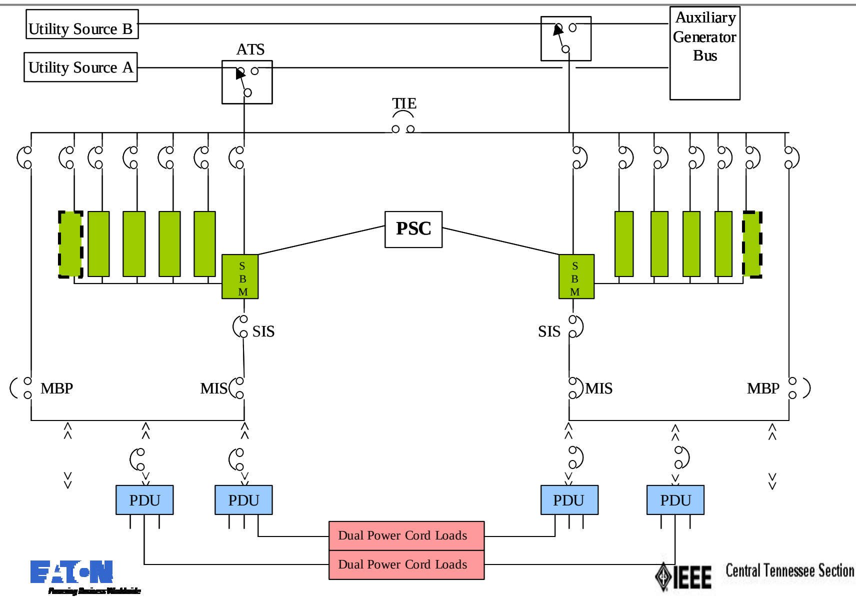
2. UPS System with A/B topology and Redundant Distribution

- UPS System(s)

  UPS(s) will support 82 PDU's, 300 kVA each
  - Practical maximum system current of 4000 amps
    - Results in multiple 3MVA Parallel Redundant A/B bus UPS systems to support the customers' site
  - N+1 UPS Redundancy is required on both the "A" and "B" bus
  - Multi-cord loads deployed throughout the Datacenter
  - Capabilities for concurrent maintenance are required
  - "Main-Tie-Tie-Main" connection at the RPP level

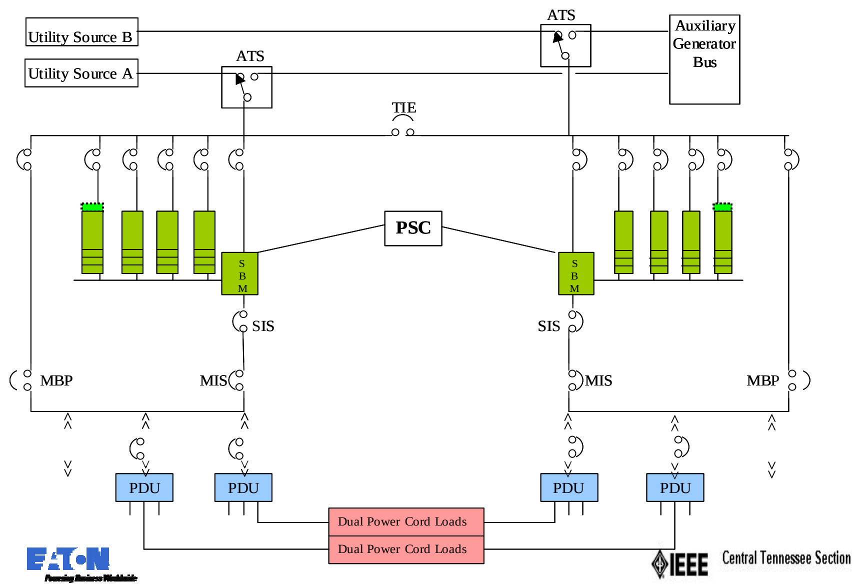
3 MVA A/B Bus Conventional

5x 750 kVA Modules per "side" including N+1



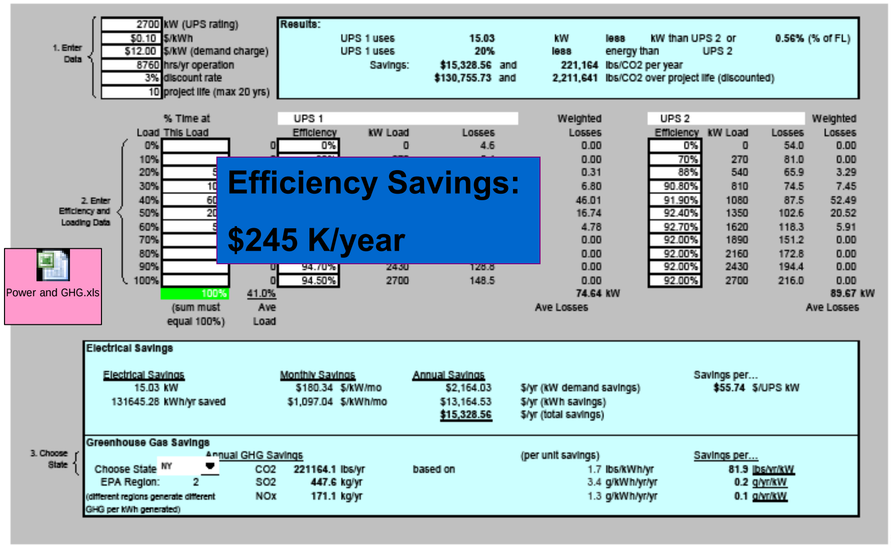
3 MVA A/B Bus Modular

4x 825 kVA Modules per "side" w/N+1 UPM



Power and Carbon Savings

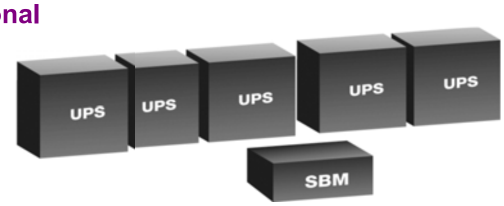
for the previously described case



Large Parallel UPS 3 MVA

Footprint Cost Savings for Modular versus Traditional UPS

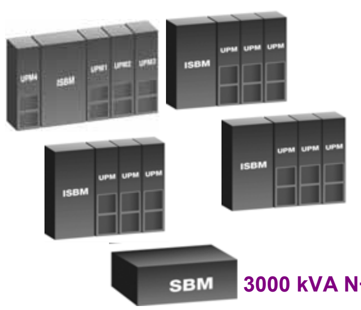
Conventional N+1



3000 kVA N+1

456 Sq. ft.

Transformerless N+1



3000 kVA N+1

366 Sq. ft.

- **Difference in footprint is 90 Sq. ft.**
- **NY Datacenter floor space = $1000 per Sq. ft., per year!**
- **Savings: $90K per year, $900K over 10 year system life**

Flexible, Scalable, Upgradeable

On-site upgrade 550 kVA Redundant

On-site upgrade 825 kVA Redundant

- Add another 275 kVA in the field for redundancy, or for capacity
  - Simply choose an ISBM sized for future growth
  - Leave space on the left side
- Enables flexibility for future changes in load demands, and new requirements for higher reliability

Advantages of Modular/Scalable Design

- Additional UPM(s) can be easily deployed to provide N+X redundancy
- Footprint and service access space is minimized
- Green and Sustainable processes and materials are used throughout the system, from Supply Chain through Startup
- System efficiency is improved 1-2% over conventional UPS…(Modular system is loaded ~50% per UPM, where conventional system is loaded ~40% per UPM module)

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Summary

When designing your data center UPS back up:

1. Assess Total Cost of Ownership:
   - Energy efficient transformer-less design
   - Lower heat output
   - Leverage space saving designs
   - Other maintenance and installation benefits (EZ Capacity Test, labor savings)
2. Request tools and configurations that improve your system availability:
   - Comprehensive metering, connectivity and software features

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Sample Project Summary

When designing your data center power distribution:

1. Cumulative Footprint Savings Ownership:
   - PDU: $2.6 M / year transformers
   - UPS: $720 K / year
   - Total: $3.3 M / year
   - Total over life: 33 M! space saving designs
2. Cumulative Efficiency Savings
   - PDU: $385 K / year bypass features
   - UPS: $245 K / year
   - Total: $630 K / year
   - Total over life: $6.3 M !
   - **TOTAL SAVINGS= $39.3 MM over life**
   - **TOTAL CARBON SAVINGS= 23K tons CO2**, **maintainable** design and connectivity features

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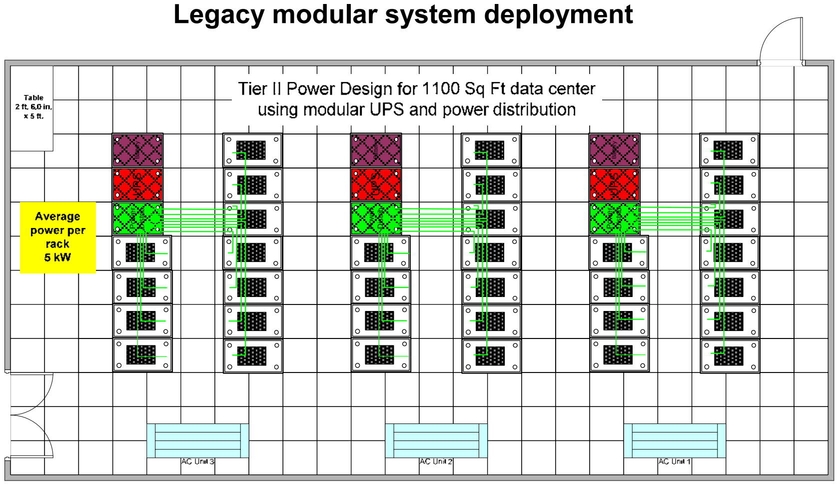
Application: Small Data Center

- Requirement
  - Customer looking for ~1000 Square foot Data Center
  - Standard CRAC units will be utilized
  - Design at 5kW per rack
  - Design to be Tier II
  - Current power available, full output of 225kW transformer @ 208V

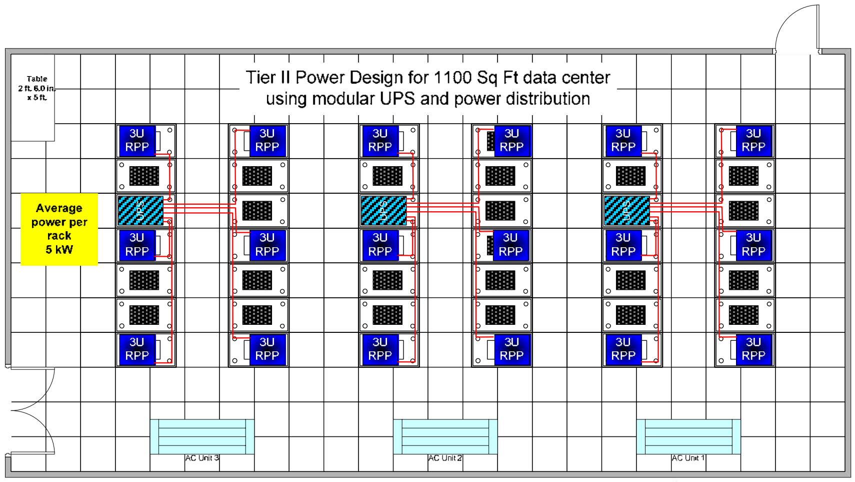
Data center legacy modular system

Legacy modular system deployment



New Rack Mounted UPS Solution

Unique rack mounted UPS with modular distribution system



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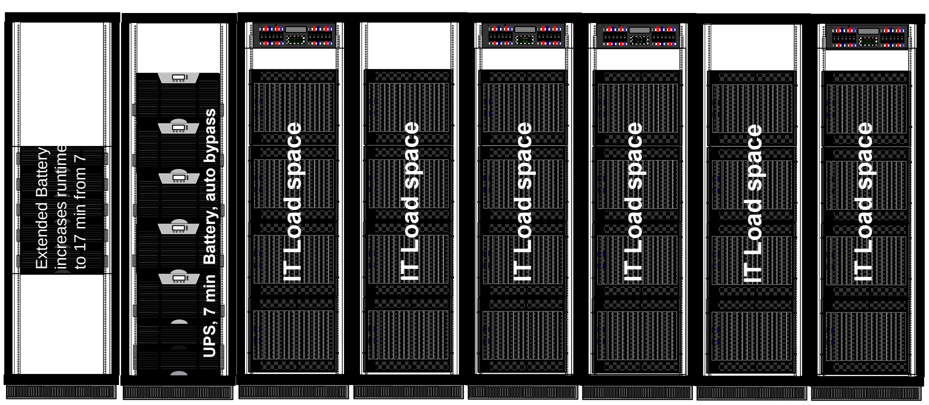
Example configuration

(6) IT cabinets @ 8kW per cabinet, 48kW total, Redundant (N+1) UPS with 10 min battery



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Comparing “unique” to “legacy”

Comparison of system designs, Tier II Data Center at 5kW per rack

Room Size	24'x48'		
Square Ft	1152		
Total equipment racks	42		
	Unique	Legacy	Improvement using new technology
UPS & Battery only racks	3	6	50%
Power distribution racks	0 + (18 x 3U)	3 x 42U	
Total U for distribution	54U	126U	57%
Total usable “U” space	1584	1386	198U (4.7 racks) 15%
Total sq Ft used for power	21	36	41%
Total usable kW @ 5kW per rack	180 kW	165kW	9%
Watts per Sq Ft	156	143	9%
Tons of cooling for UPS systems	1.4	4.0	65%
Number of 3 phase cables from power distribution to racks	18	33	45%
Estimated Cable Used	180 ft	330 ft	45%
Energy usage per year (165kW @ $.10 kWhr)	$ 148,876	$ 156,826	5%
Total energy savings in 5 years	$39,748		
Total cooling energy savings 5 years (70% ratio)	$27,824		
Total savings during 5 years of operation	**$67,572**		

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Discussion & Questions

Thank You!

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