Data Center Power Distribution

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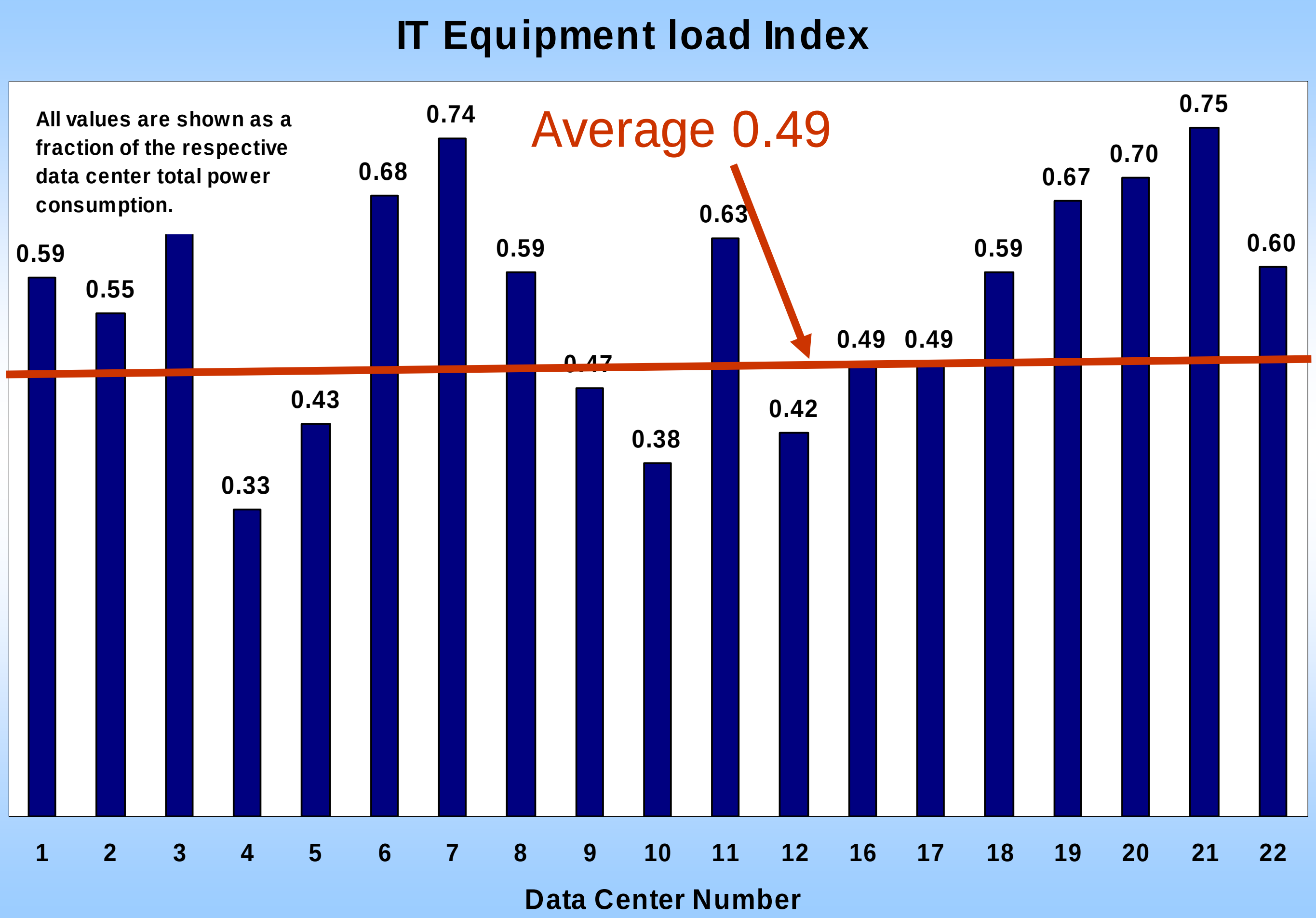
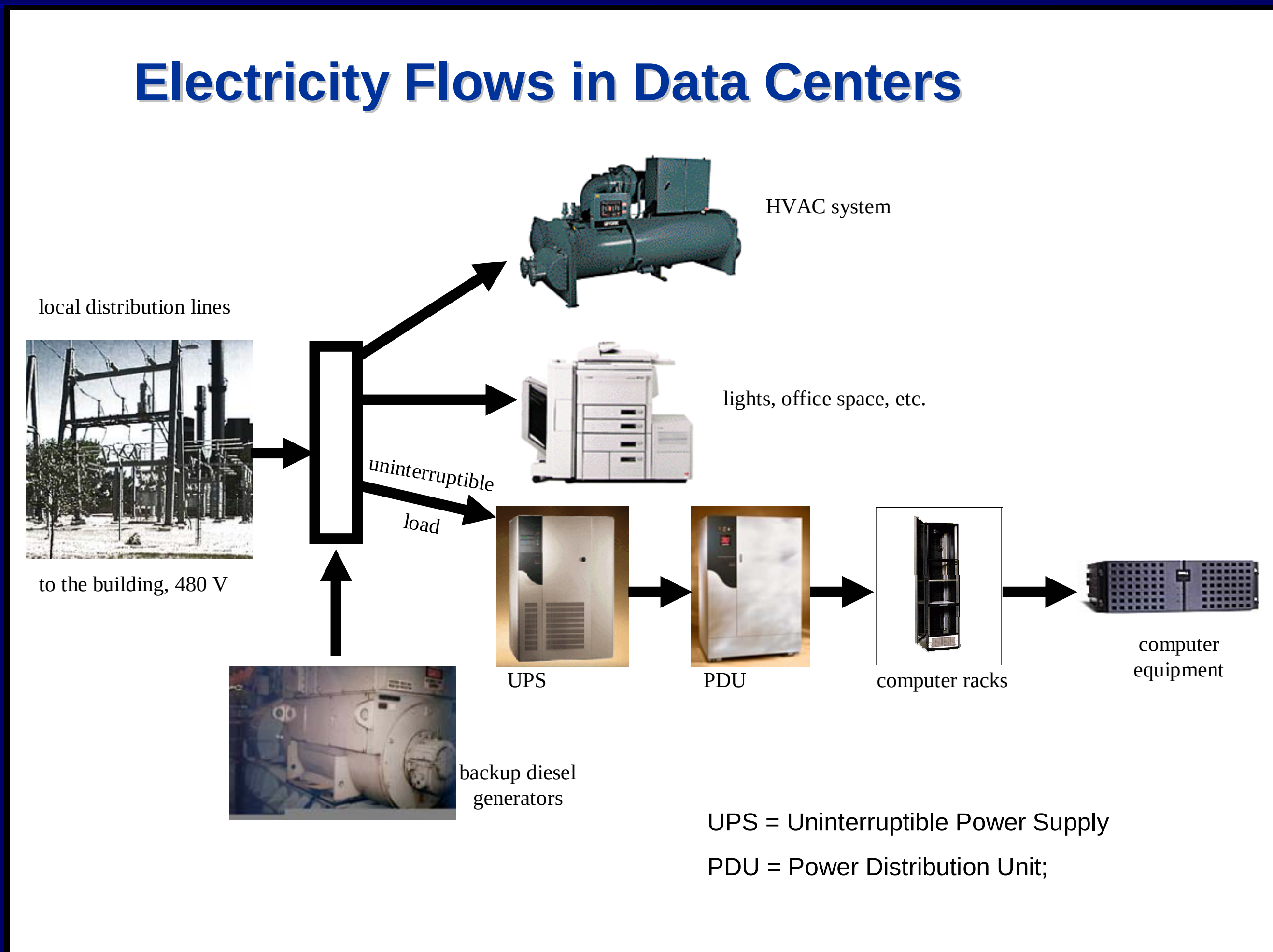
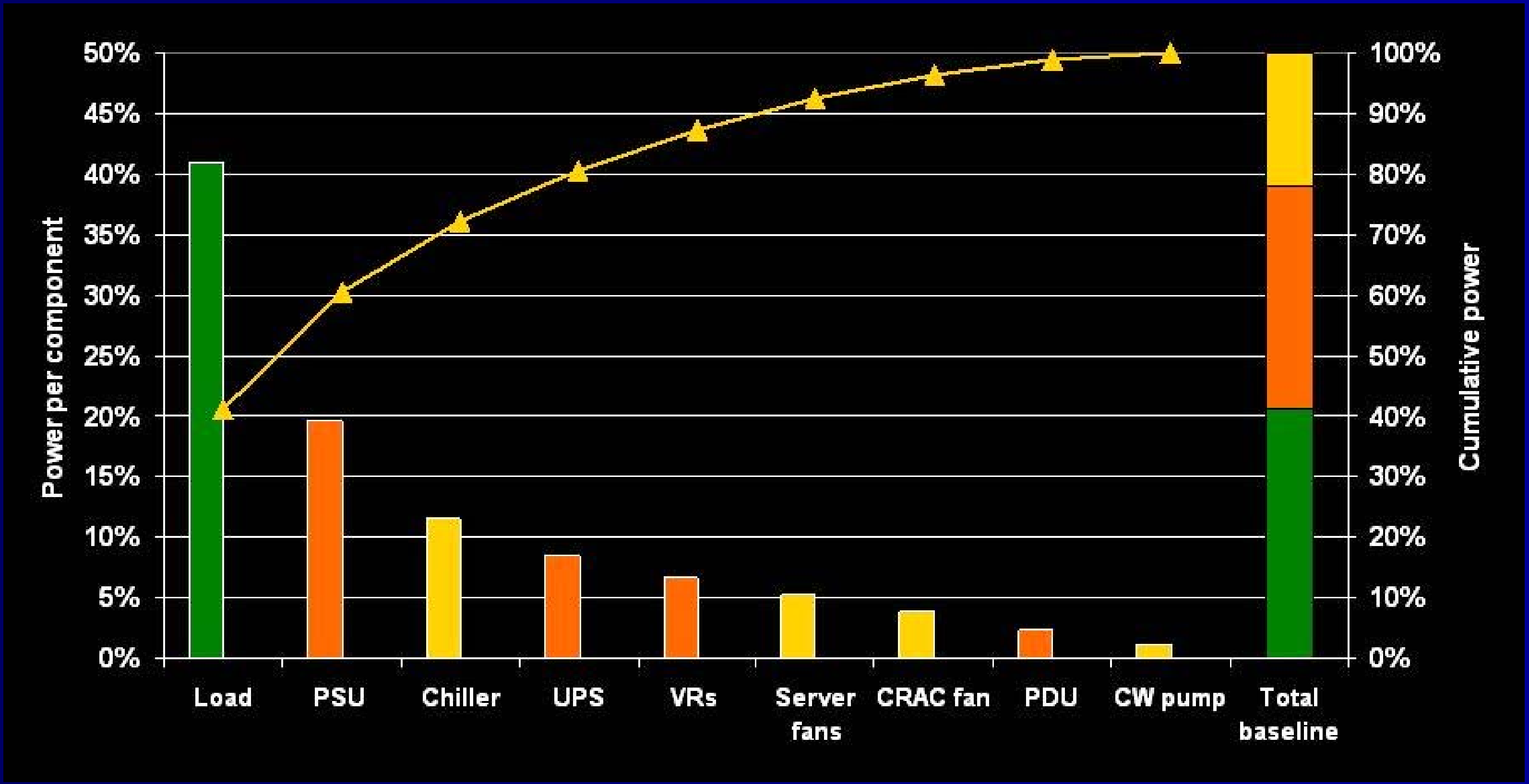
Percentage of power delivered to IT equipment



Benchmarking energy end use

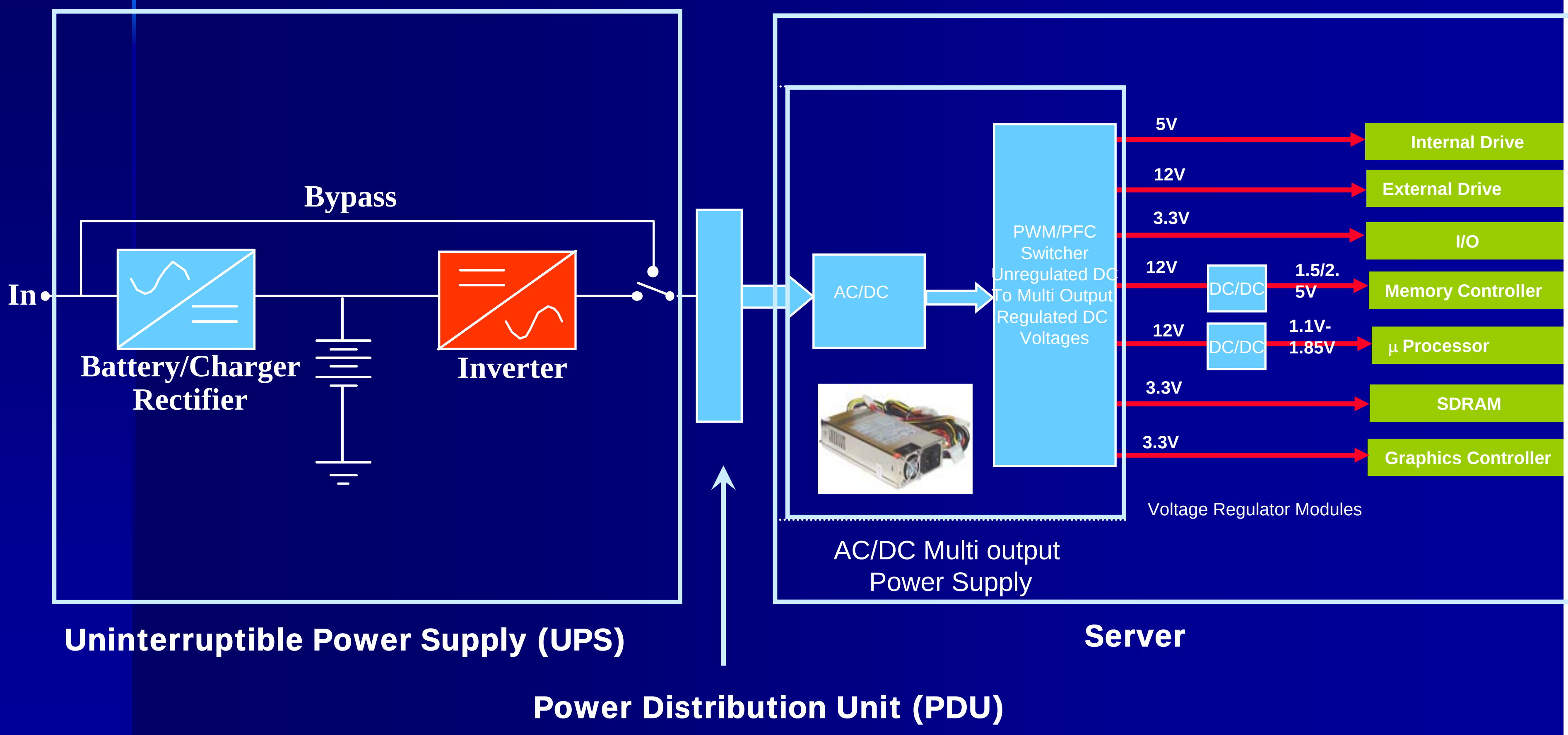


Overall power use in Data Centers



Courtesy of Michael Patterson, Intel Corporation

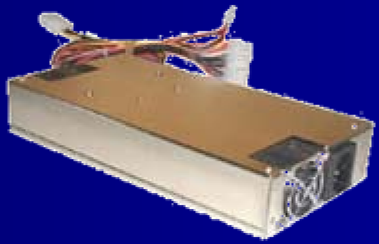
Data Center power conversions



Data Center Power Delivery System

UPS	Power Dist	Power Supply	DC/DC
85 - 92%	98 - 99%	68 - 72%	78 - 85%



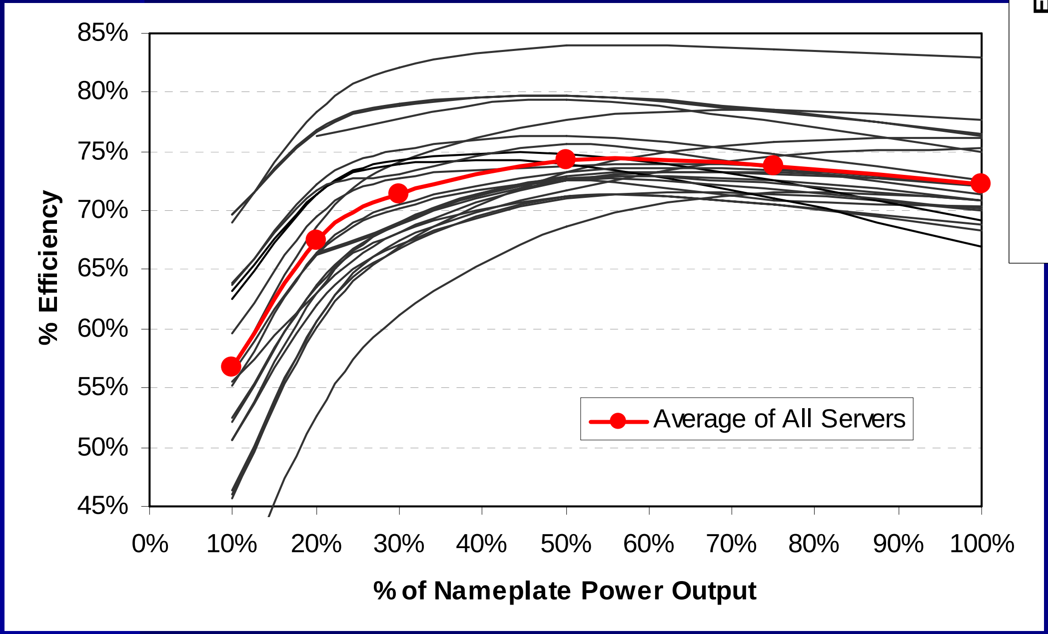


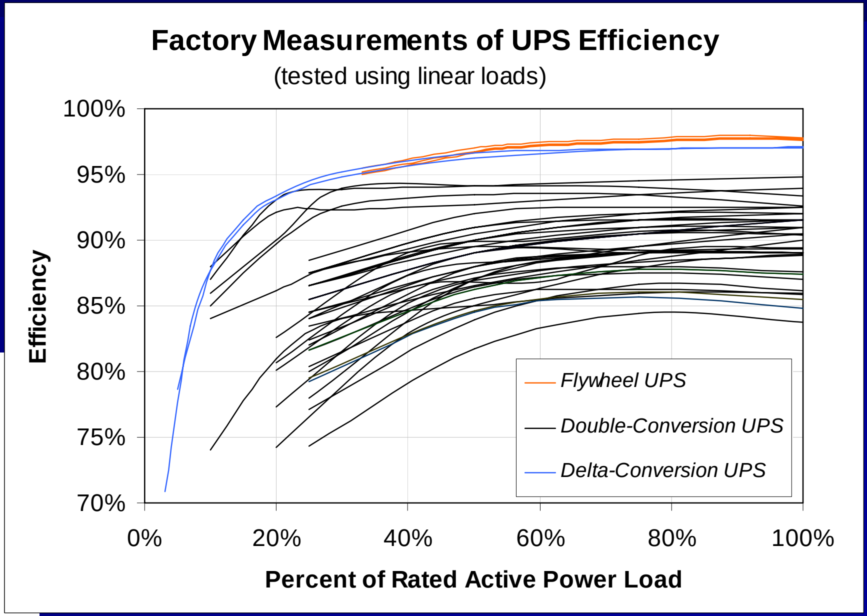

The heat generated from the losses at each step of power conversion requires additional cooling power

Power for cooling can equal or exceed the direct losses

Prior research illustrated large losses in power conversion

Power Supplies in IT equipment

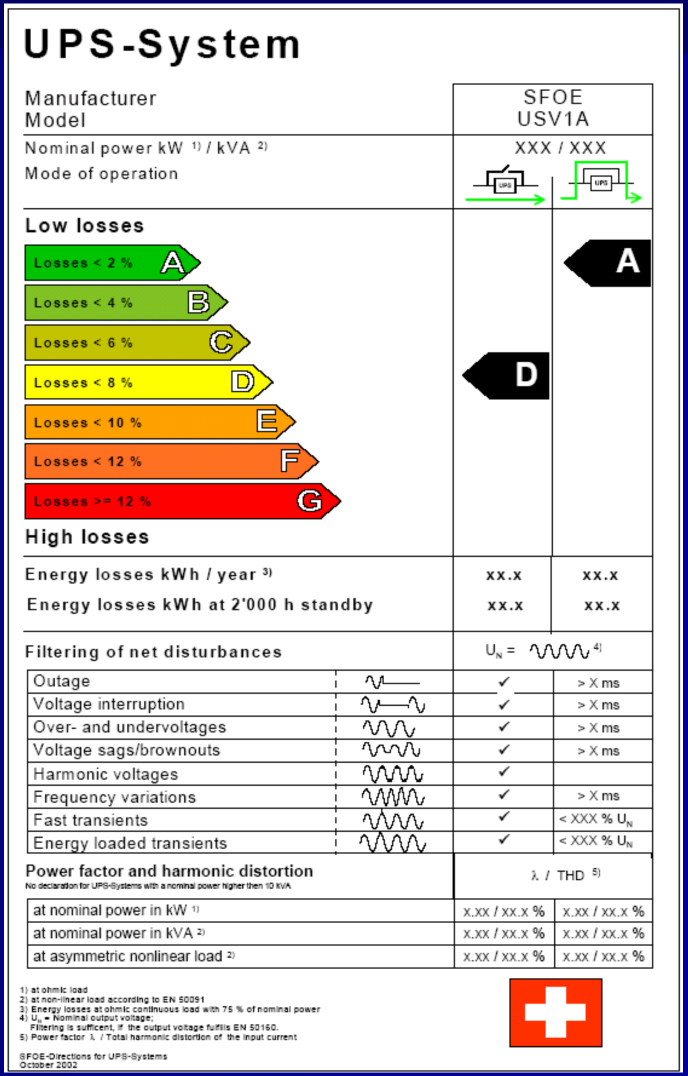




Uninterruptible Power Supplies (UPS)

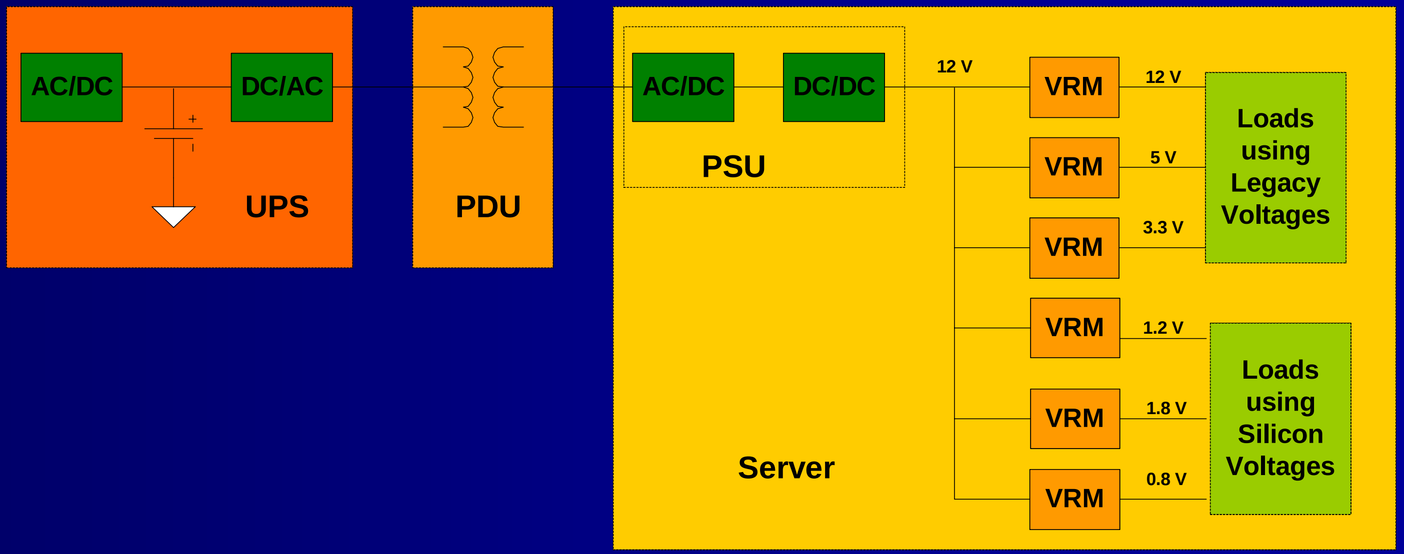
UPS labeling

- Based upon proposed European Standard
- Possible use in Energy Star program
- Possible use in Utility incentive programs
- Possible use in Federal Procurement specs



Typical AC distribution today

480 Volt AC



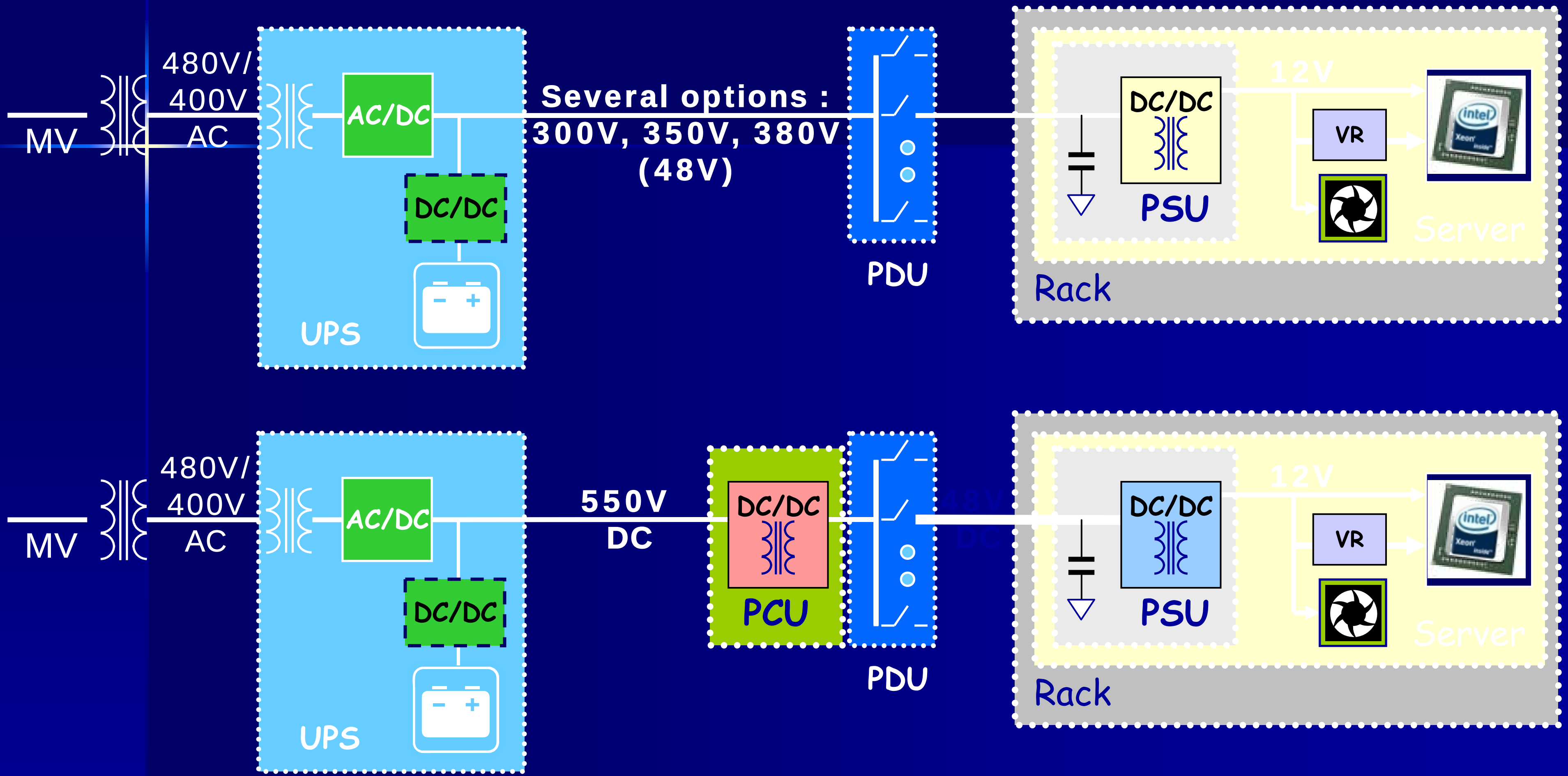
Distribution considerations

- Distributing higher voltage AC or DC to the load is more efficient
- Less copper at higher voltage – copper cost is very high
- Safety is key consideration
- Electricians are needed at higher voltages
- Disconnecting DC creates an arc
- UL rated equipment exists
- Equipment in use is rated to 600V. now.

Thomas Edison:

"My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous. I can therefore see no justification for the introduction of a system which has no element of permanency and every element of danger to life and property."

Various DC architectures



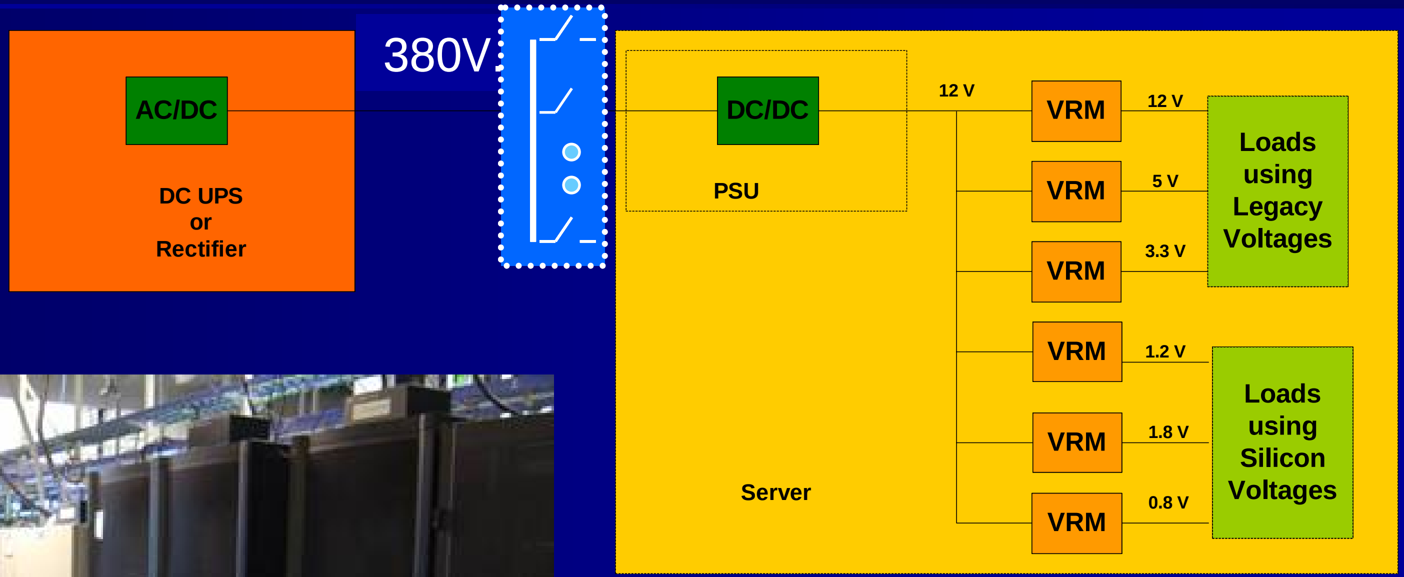
Courtesy of Annabelle Pratt, Intel

380 V. DC Demonstration

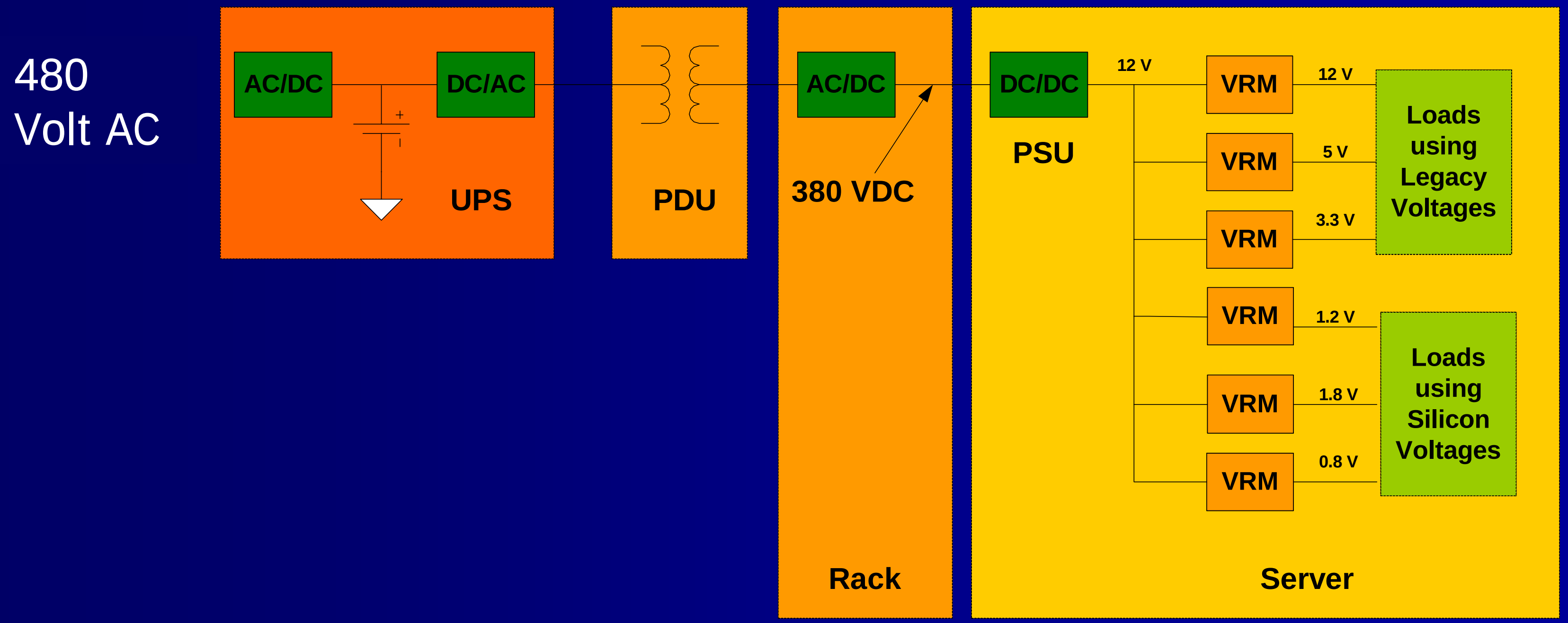
- Side-by-side comparison of traditional AC system with new DC system
  - Facility level distribution
  - Rack level distribution
- Power measurements at conversion points
- Servers modified to accept 380 V. DC
- Artificial loads to more fully simulate data center

Facility-level 380 V. DC distribution

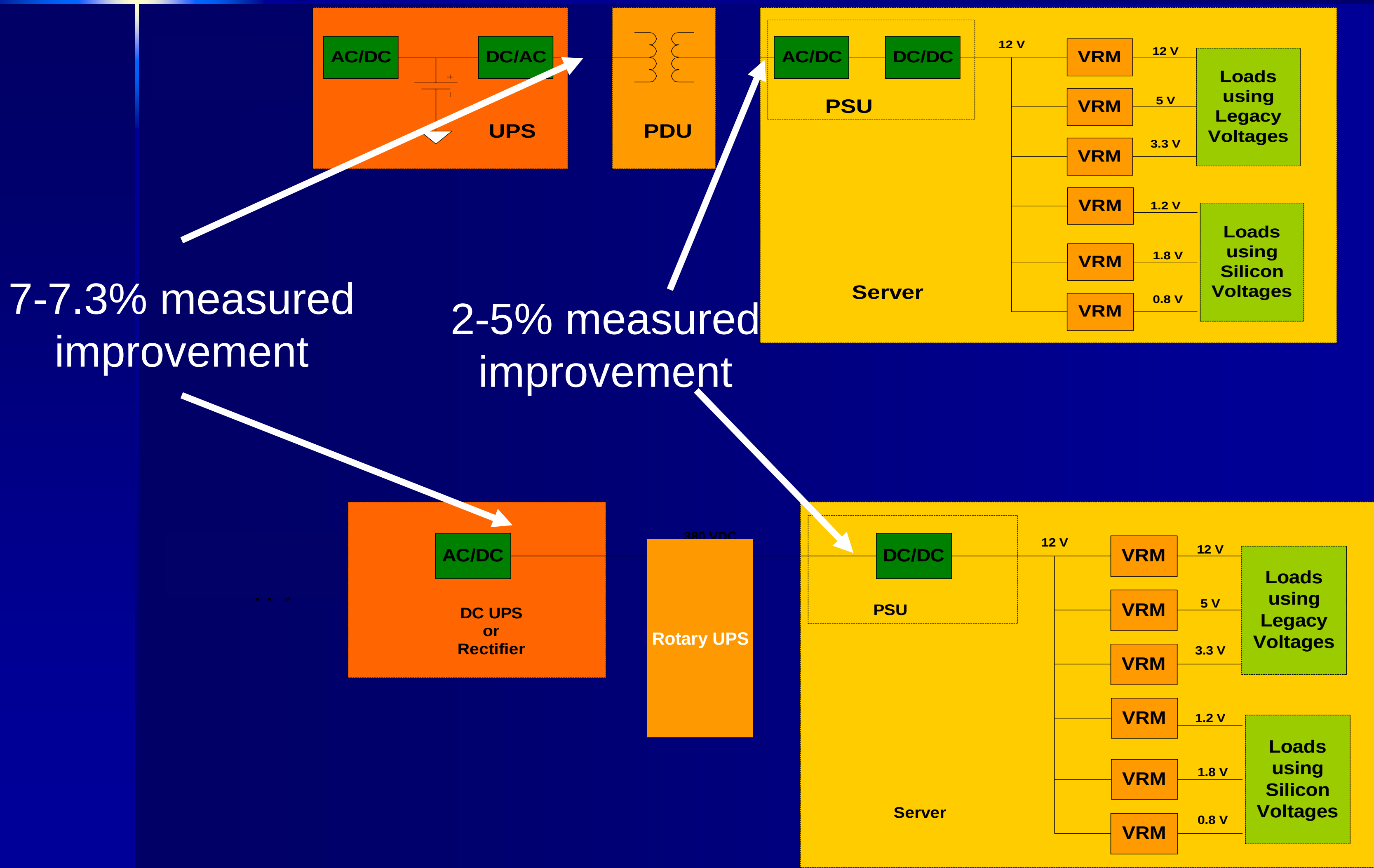
480
Volt AC



Rack-level DC distribution



Measured Best in Class AC system loss compared to DC



Picture of demonstration set-up – see video for more detail

Demonstration Highlights

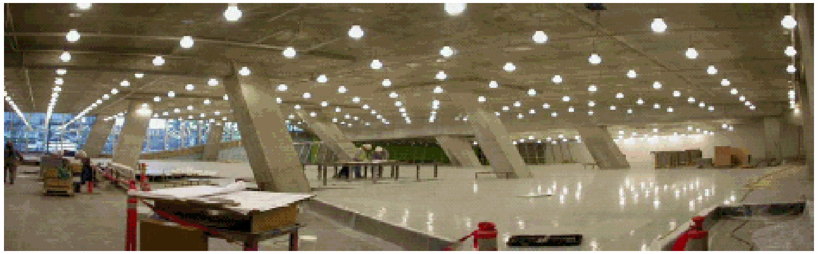
- All equipment was commercially available and UL rated.
- Connectors at the IT equipment need to be standardized
- Typical energy savings can be 20% or more
- Reliability is expected to be improved – fewer points of failure
- In the long term, first cost could be lower

Most of the Center Can Operate on DC

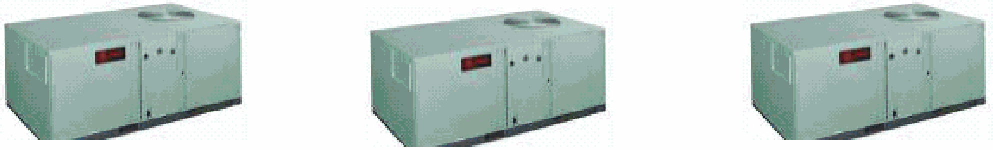
- DC lighting was included

Most of the Center Can Operate on DC

- Lighting



- HVAC



On-Site Power Production (DG)

Implications could be even better for a typical data center

- Redundant UPS and server power supplies operate at reduced efficiency
- Cooling loads would be reduced.
- Both UPS systems used in the AC base case were "best in class" systems and performed better than benchmarked systems – efficiency gains compared to typical systems could be higher.
- Further optimization of conversion devices/voltages is possible

Data Center Power Delivery

For a typical center energy savings could exceed 20%

	UPS	XFMR	PS	Total Efficiency	
Typical Efficiency	85.00%	98.00%	73.00%	60.81%	
DC Option	92.00%	100.00%	92.00%	84.64%	
	Compute Load (W)		Input Load (W)		Difference
Typical Efficiency	10,000		16444.93		
Optimized DC Option	10,000		11814.74		28.16%

Connectors exist

Connectors with the right form factor are being developed

DC Power – path forward:

- DC power pilot installation(s)
- Standardize distribution voltage
- Standardize DC connector and power strip design
- Server manufacturers develop power supply specifications (including disturbances)
- Power supply manufacturers develop prototypes
- UL and communications certification
- Address other types of IT equipment (storage, switches, etc.)

Industry Partners in the Demonstration

Equipment and Services Contributors:

- Alindeska Electrical Contractors
- APC
- Baldwin Technologies
- Cisco Systems
- Cupertino Electric
- Dranetz-BMI
- Emerson Network Power
- Industrial Network Manufacturing (IEM)
- Intel
- Nextek Power Systems
- Pentadyne
- Rosendin Electric
- SatCon Power Systems
- Square D/Schneider Electric
- Sun Microsystems
- UNIVERSAL Electric Corp.

Other firms collaborated

Stakeholders:

380voltsdc.com
CCG Facility Integration
Cingular Wireless
Dupont Fabros
EDG2, Inc.
EYP Mission Critical
Gannett
Hewlett Packard
Morrison Hershfield Corporation
NTT Facilities
RTKL
SBC Global
TDI Power
Verizon Wireless

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Discussion / Questions??