

## High Voltage Distribution Bus and its Impact on Overall Efficiency and Cost

Randy Malik

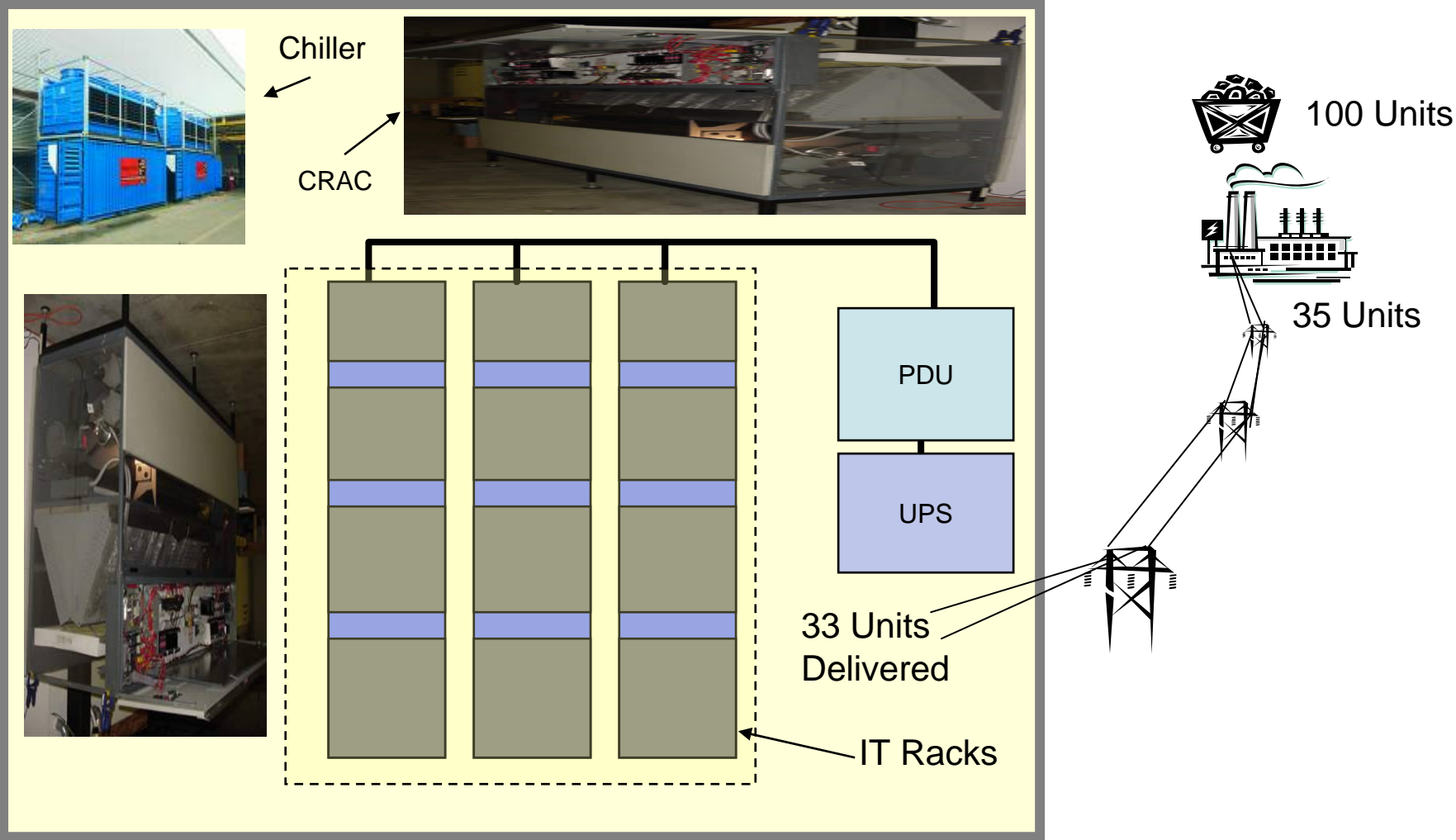
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# Typical Data Center Energy End Use



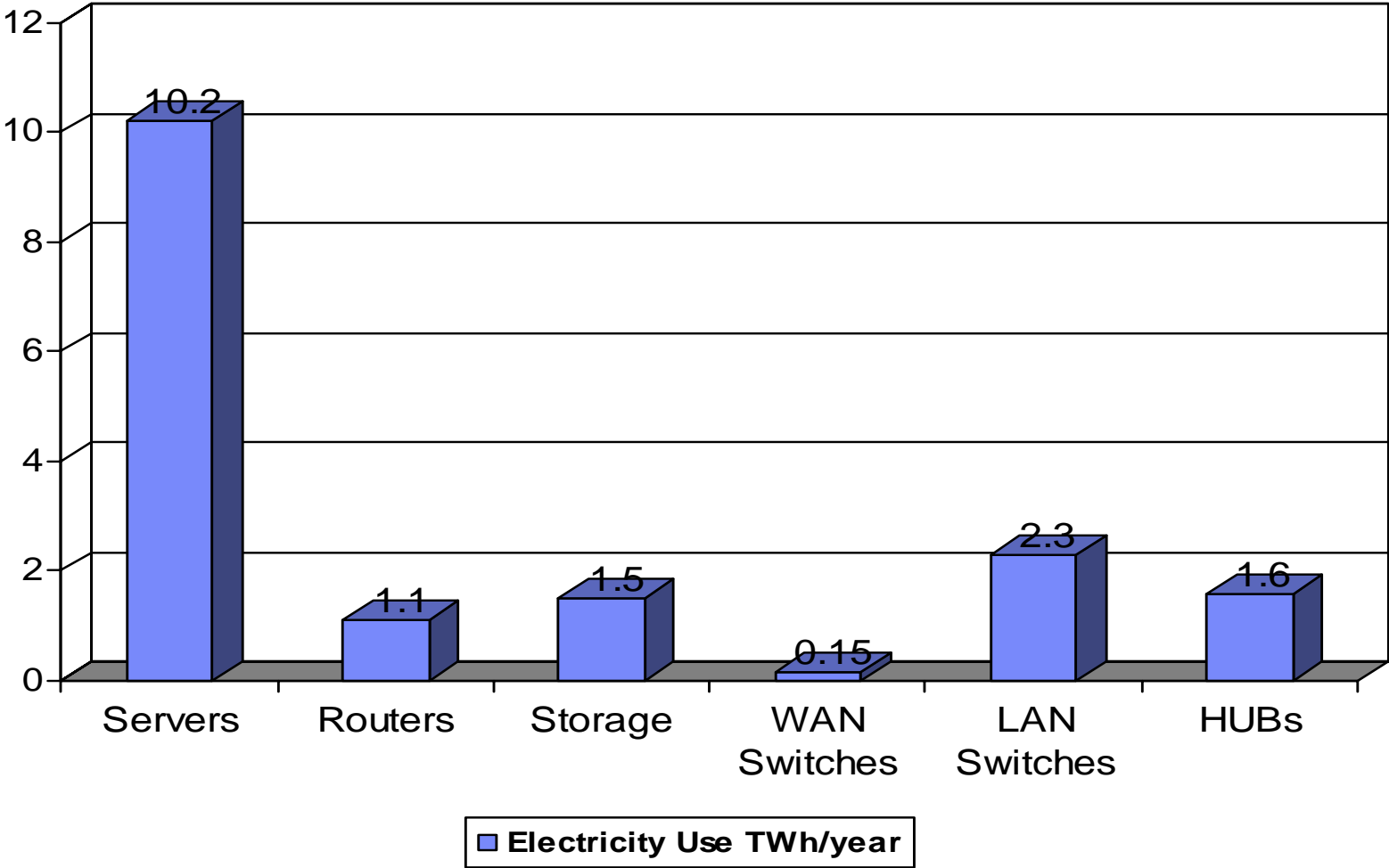
# Some Facts about a Typical Data Center

- **Consumption:** 10 to 100 times more energy per square foot than a typical office building
- **Electricity Used:** 45 billion kWh in 2005 – about 1.2% of all retail U.S. Electricity Consumption
- **Power Demand :** Expected to double in 10 years
- **Average Utilization :** 20 – 25% of the capacity
- **Overall Efficiency = IT Power / Power Input = 30%**
- **Carbon Footprint:**
  - Coal Fired Plants = 2 Lbs/KWh
  - Natural Gas = 1 Lb/KWh
  - Diesel = 2.19 Lbs/KWh



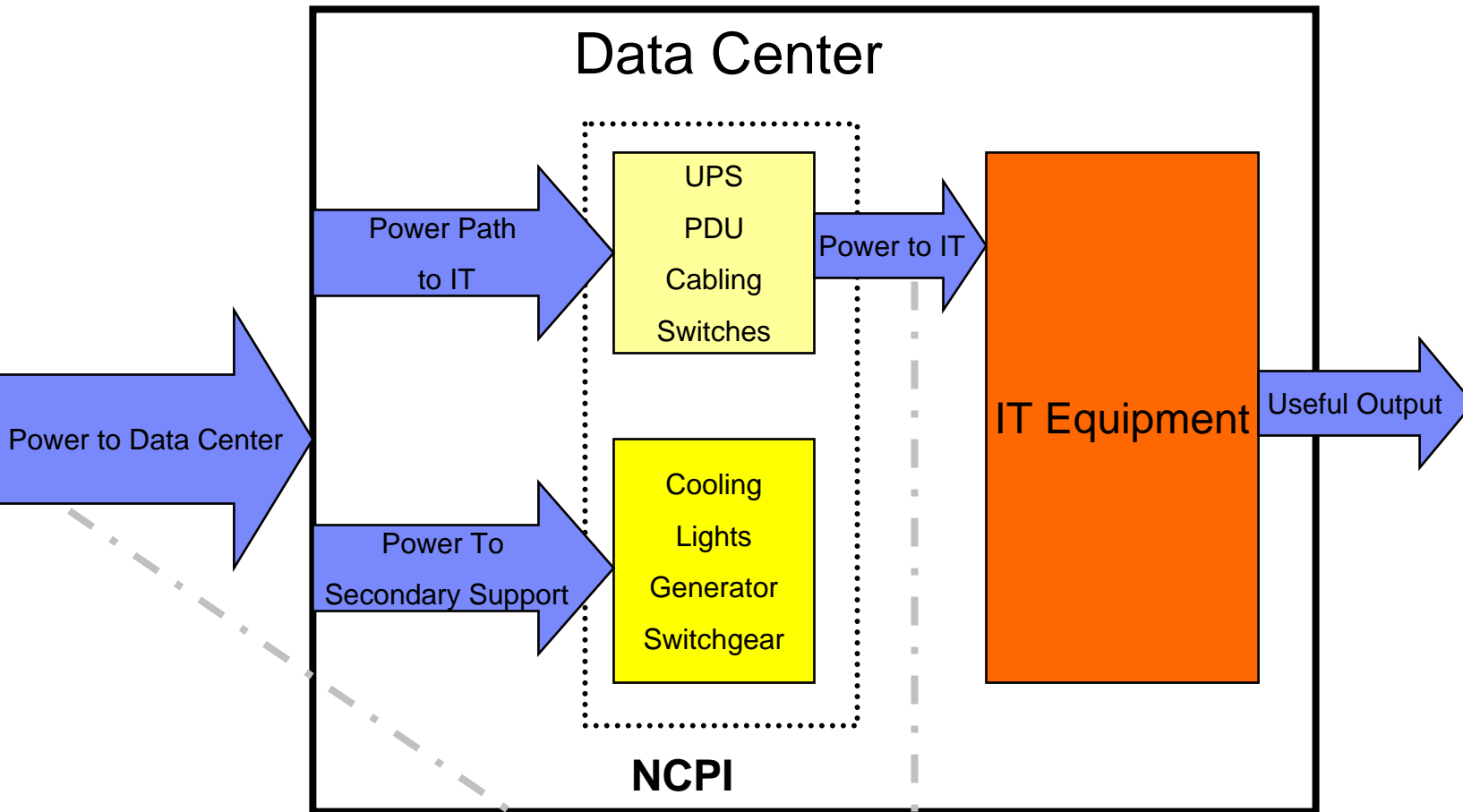
Source: Emerson Corporation

# Energy Consumption by Office and Telecom Equipment in Commercial Buildings



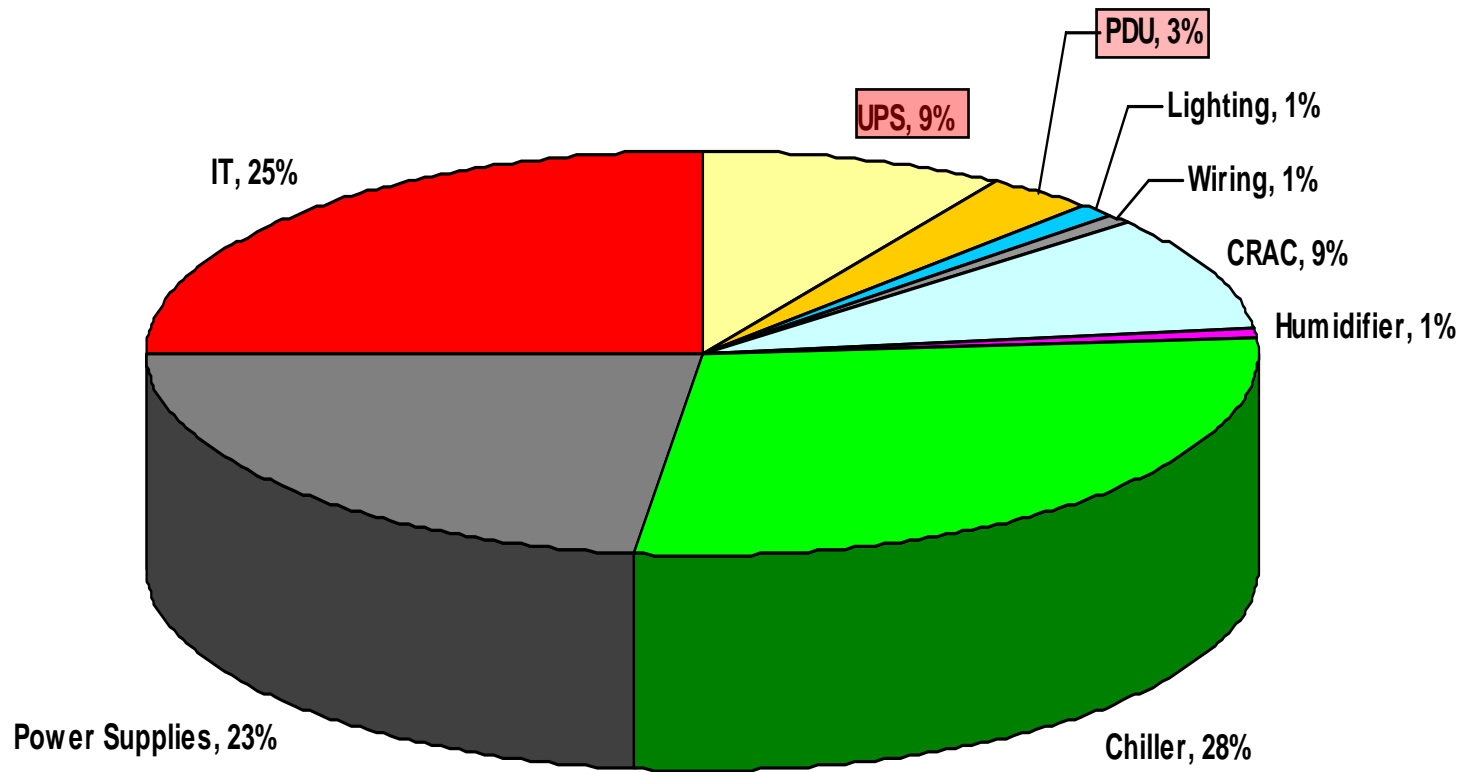
Source: Roth K. Goldstein, F. Kleinman J(2002) Energy Consumption by Office and Telecommunication Equipment in Commercial Buildings

# Data Center Efficiency considering NCPI Losses



$$\text{Data Center Efficiency} = \frac{\text{Power to IT}}{\text{Data Center Power IN}}$$

# Power Consumption in a Data Center

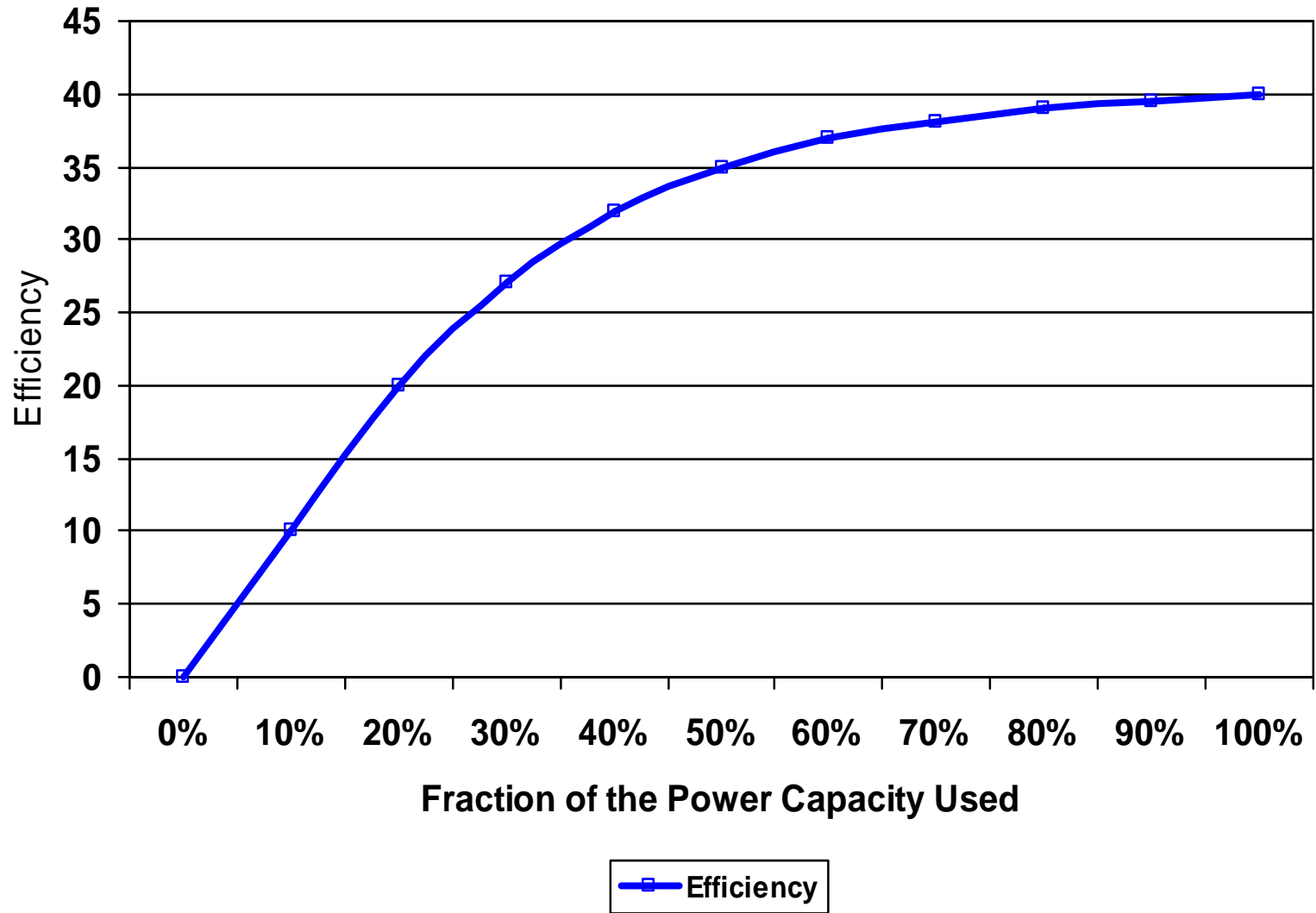


■ UPS ■ PDU ■ Lighting ■ Wiring ■ CRAC ■ Humidifier ■ Chiller ■ Power Supplies ■ IT

# Power Pathway to Data Center Efficiency

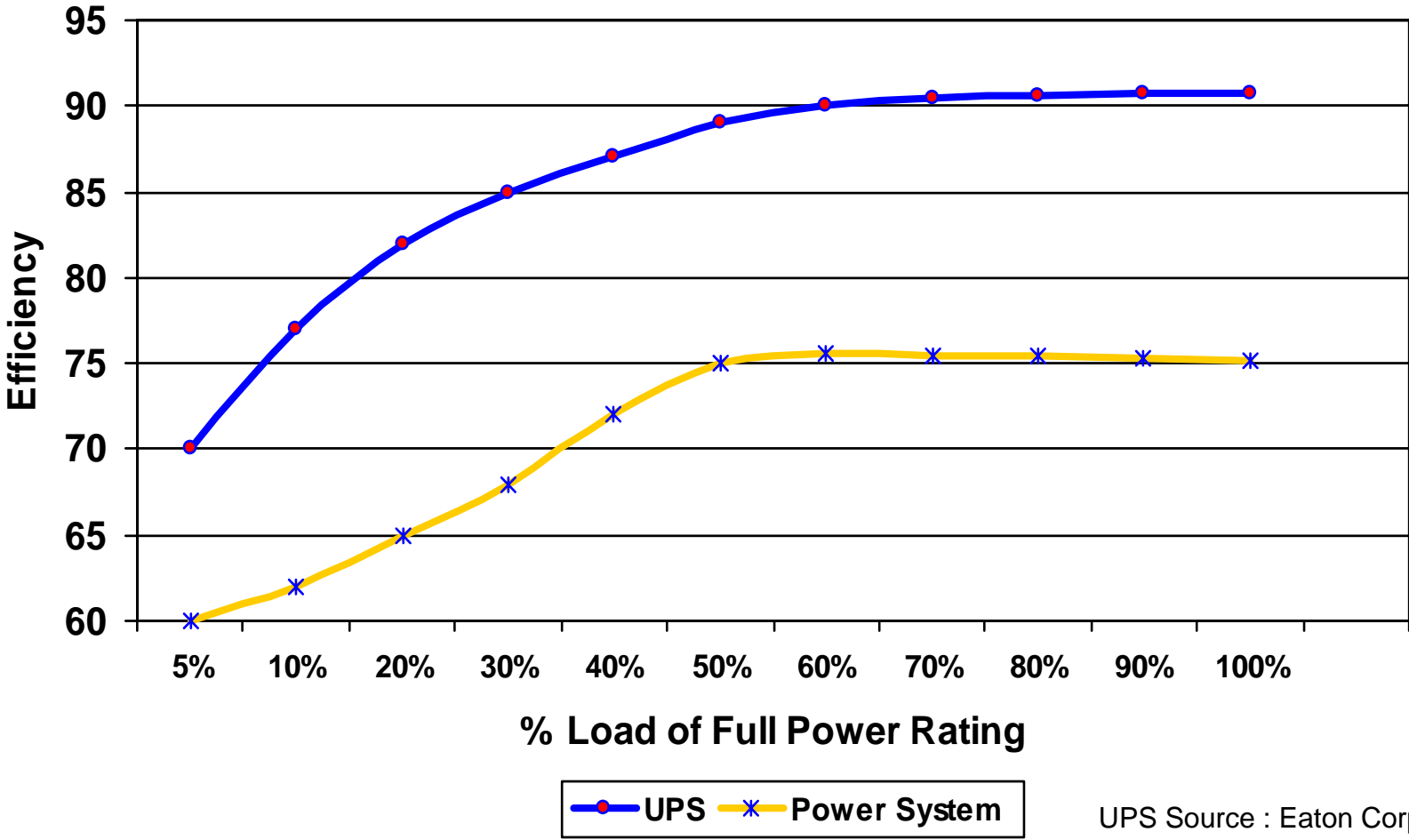
- **Create a strategy for enhancing Tech utilization**
  1. Server consolidation and virtualization
  2. Grid Computing
  3. High Efficiency Processors
  - ✓ 4. High Efficiency Server Power Supplies
- **Size the Power System for Optimum Efficiency**
  - ✓ 1. Modular Approach
- **Consider alternate distribution methods**
  1. 600V AC to 208V AC to the racks
  - ✓ 2. 480V AC direct to the racks
  3. 415V AC to 240V AC to the racks
  - ✓ 4. 480V AC to 380VDC within the racks

# Efficiency of A typical Data Center

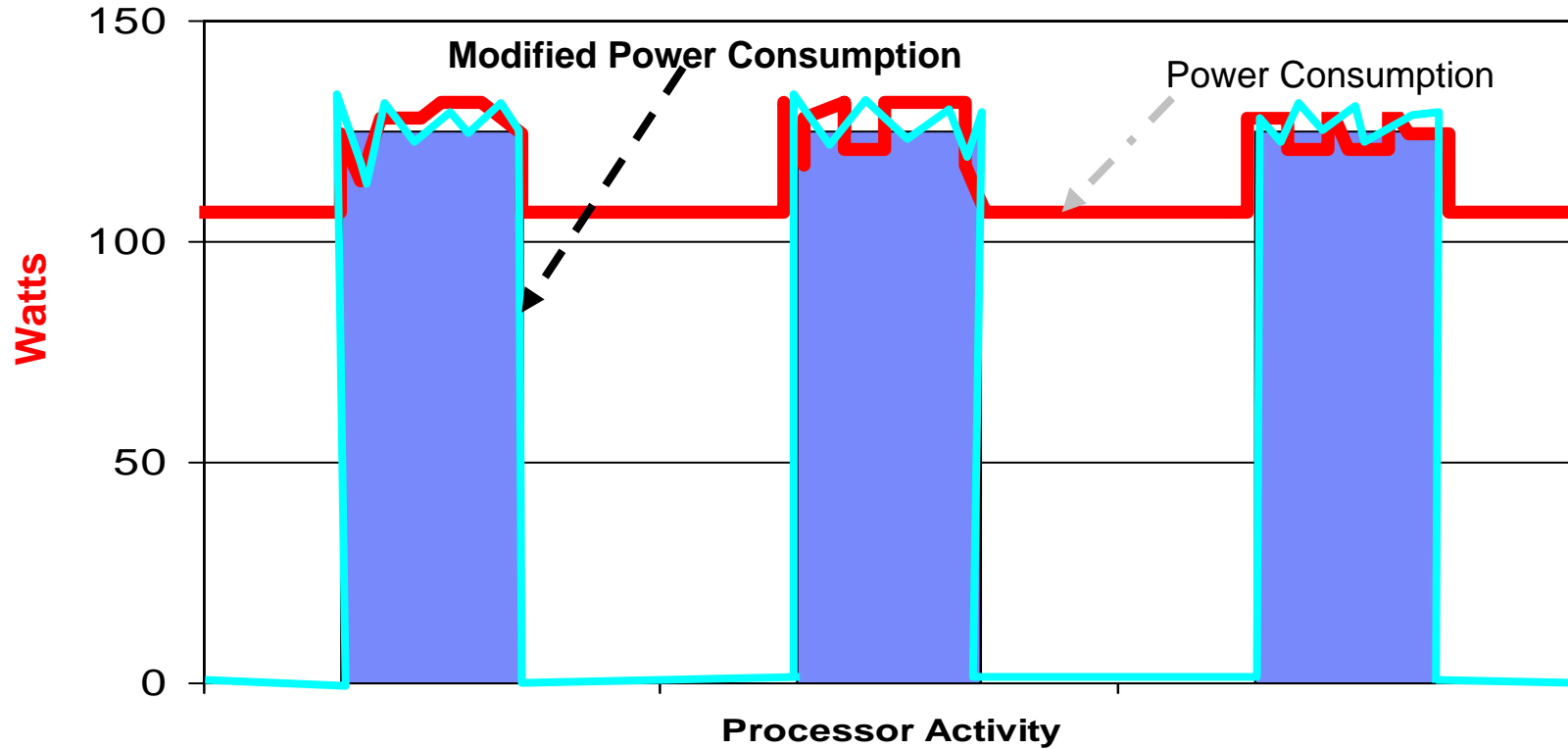




# Efficiency of UPS & Power System as a function of Load



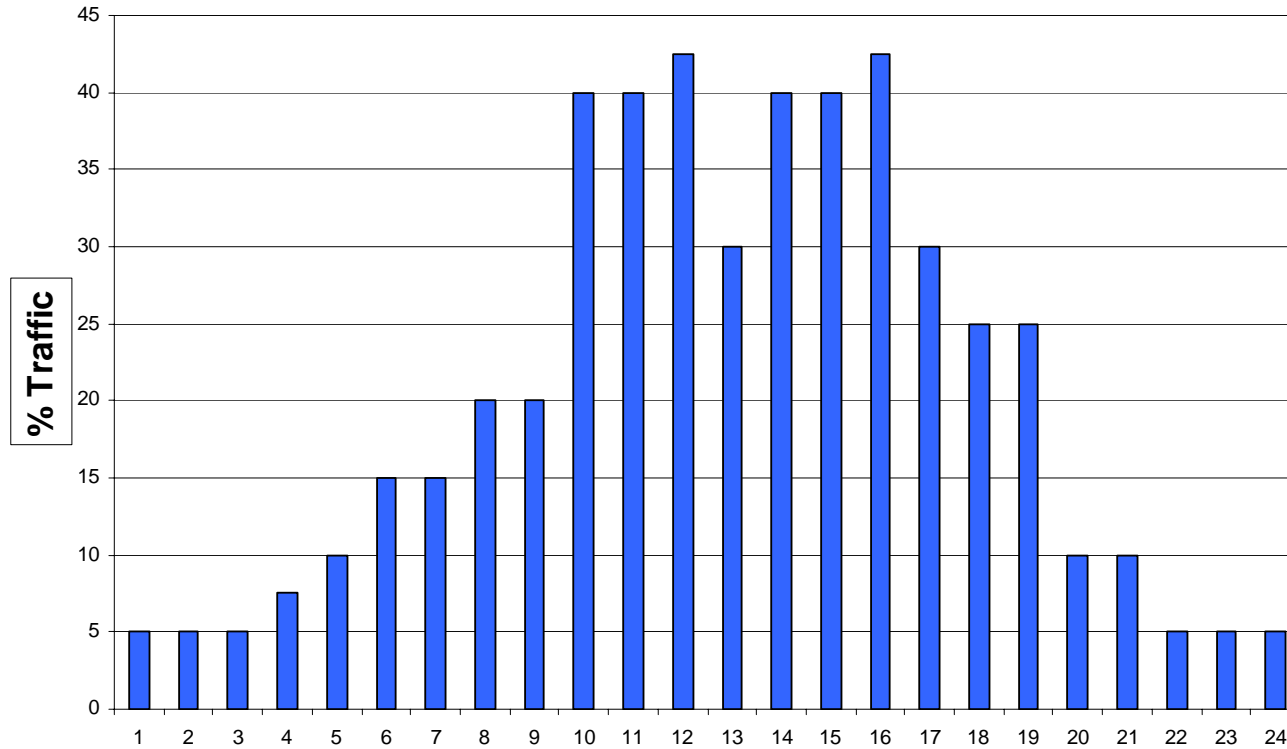
## Power Consumption by a Processor during Active and Idle Mode



Note: Lower Activity by the processor does not mean lower power consumption

# A typical Work Load for a Data Center for a 24 hour period

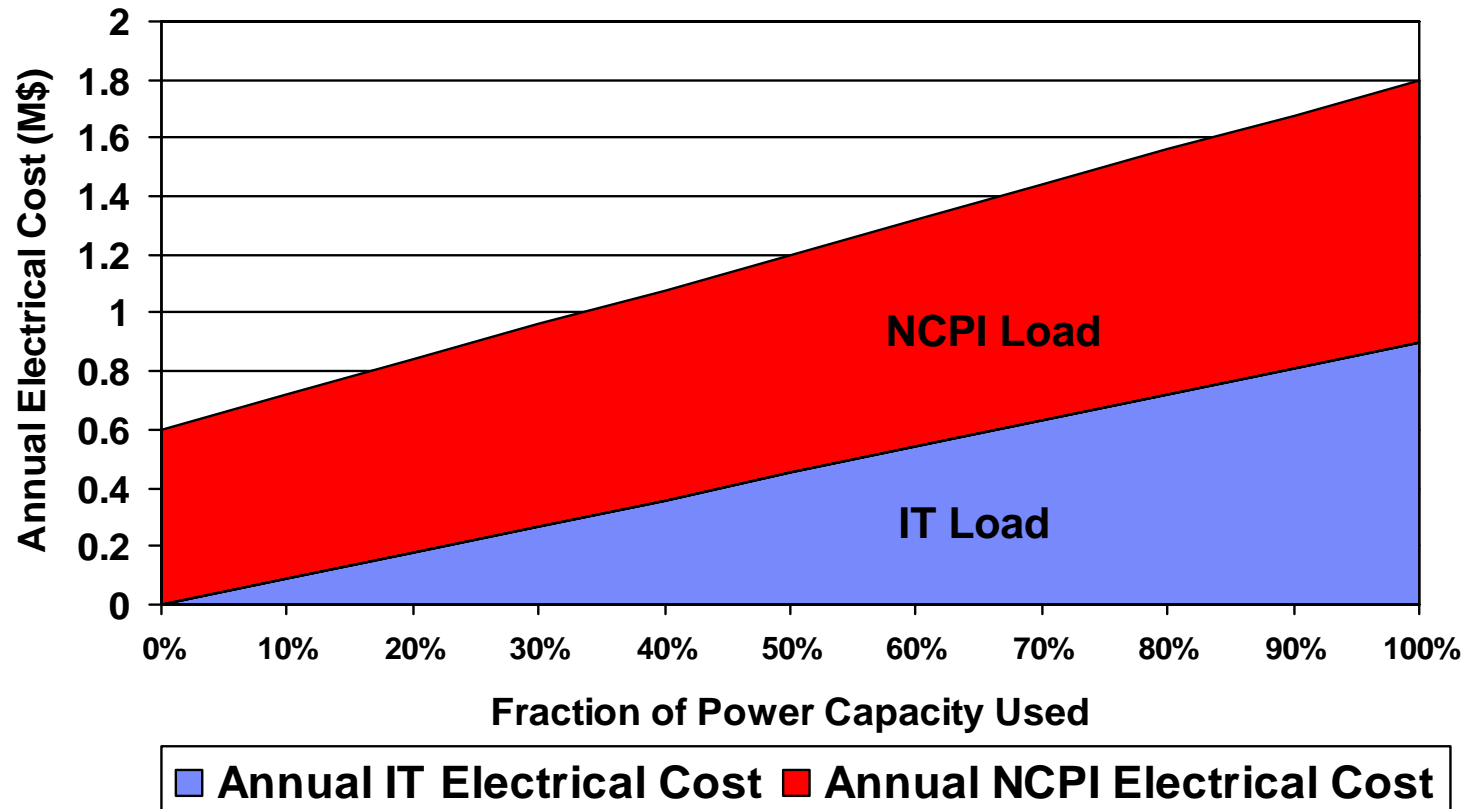
Time of Day Work load



Source: 2006/2007 Discussions with several NYC Financial Services firms

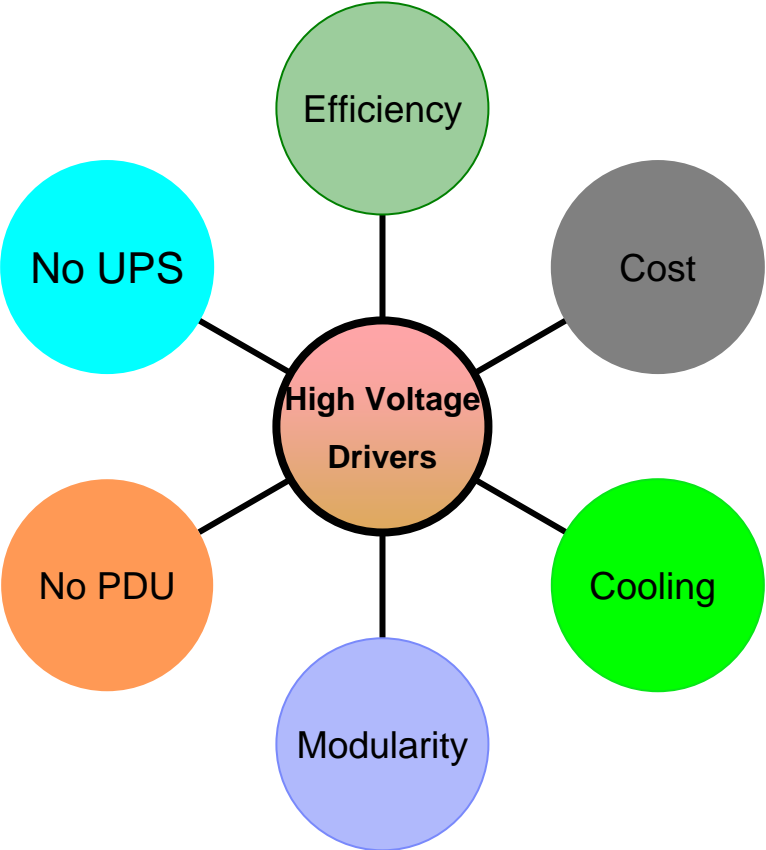
# Electrical Energy Cost of Powering a Data Center

Annual Electrical Cost of a 1 MW data center ( \$0.10/kWh)

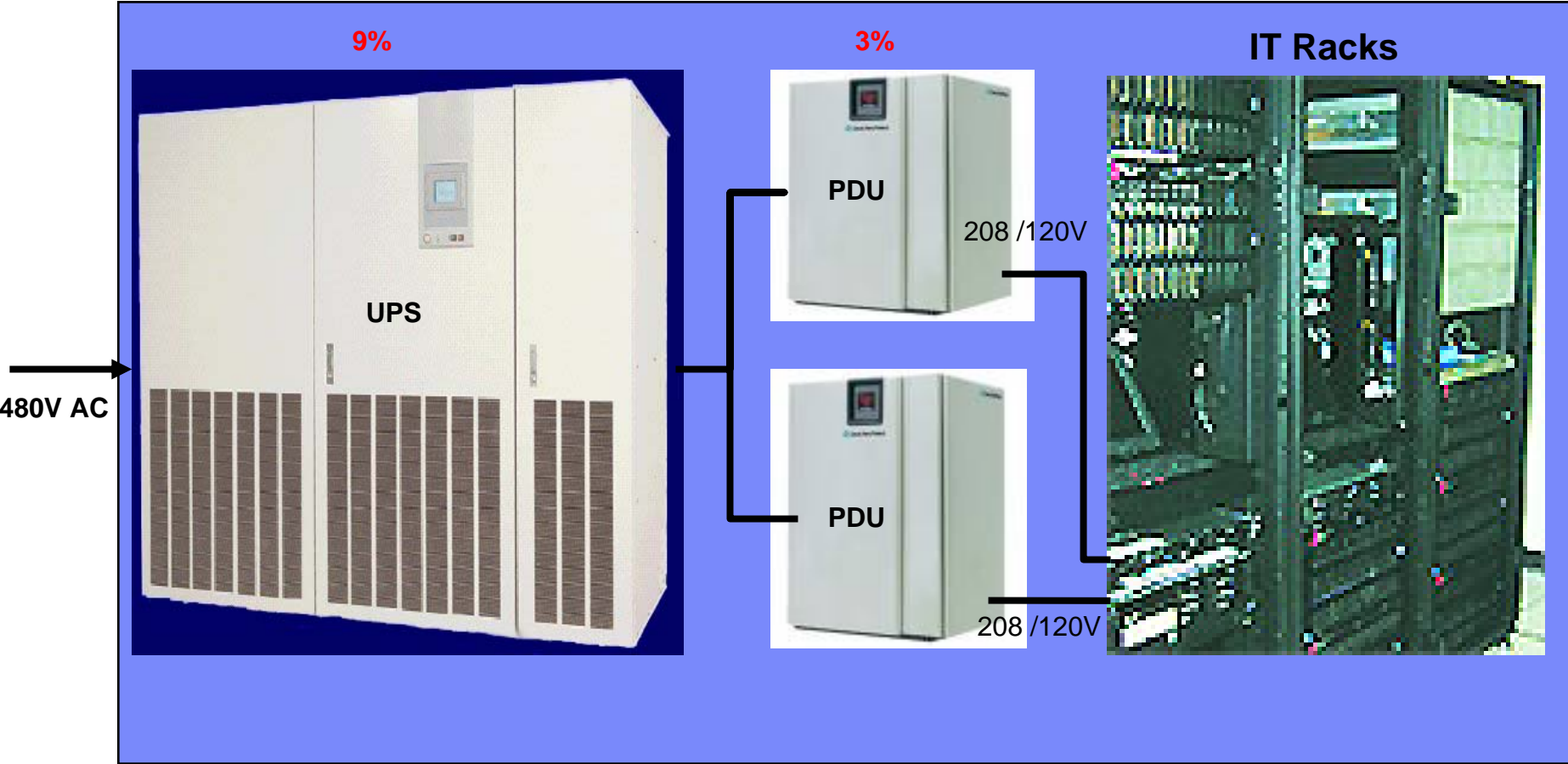


Source: APC

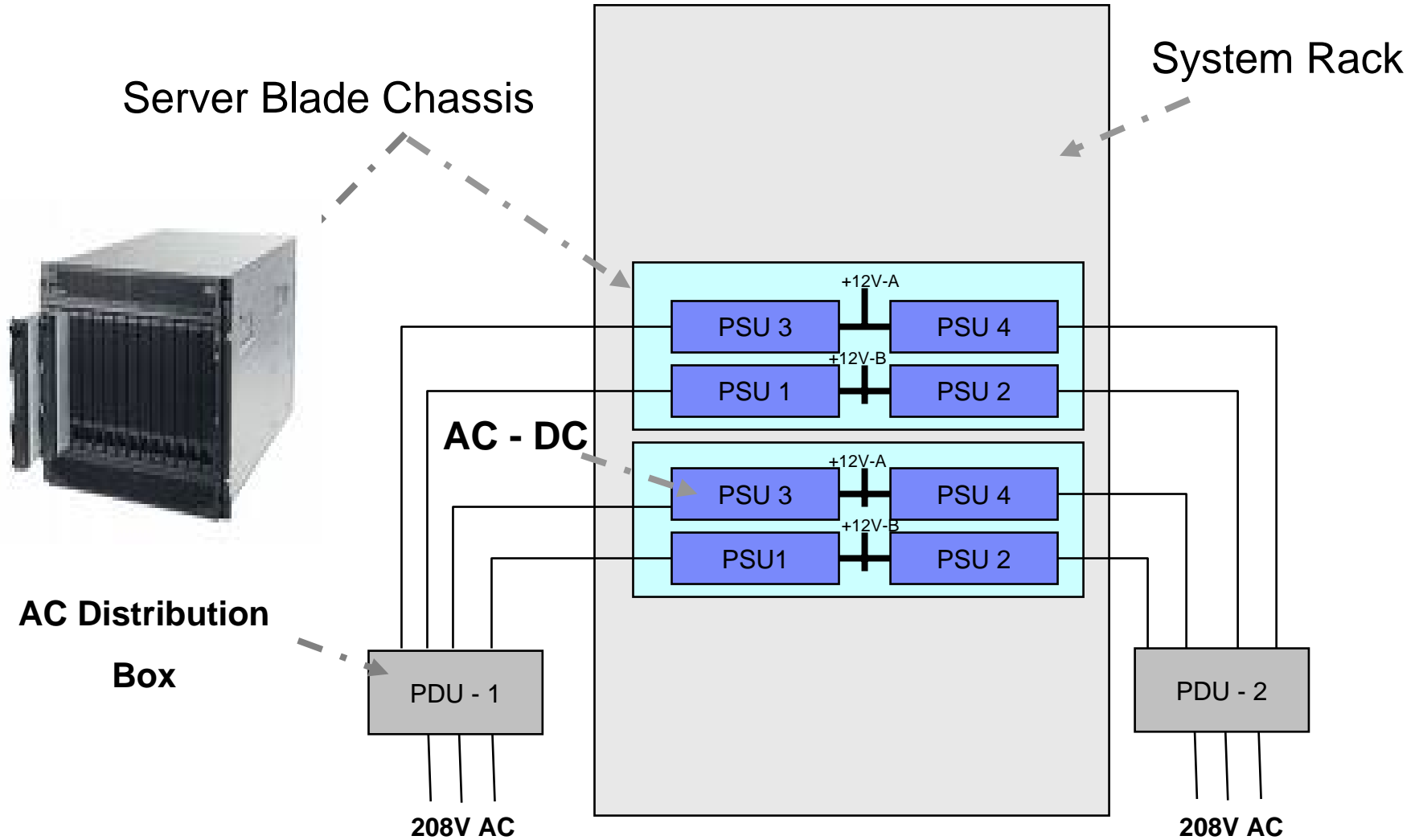
# Drivers for Rack Centric - High Voltage Distribution



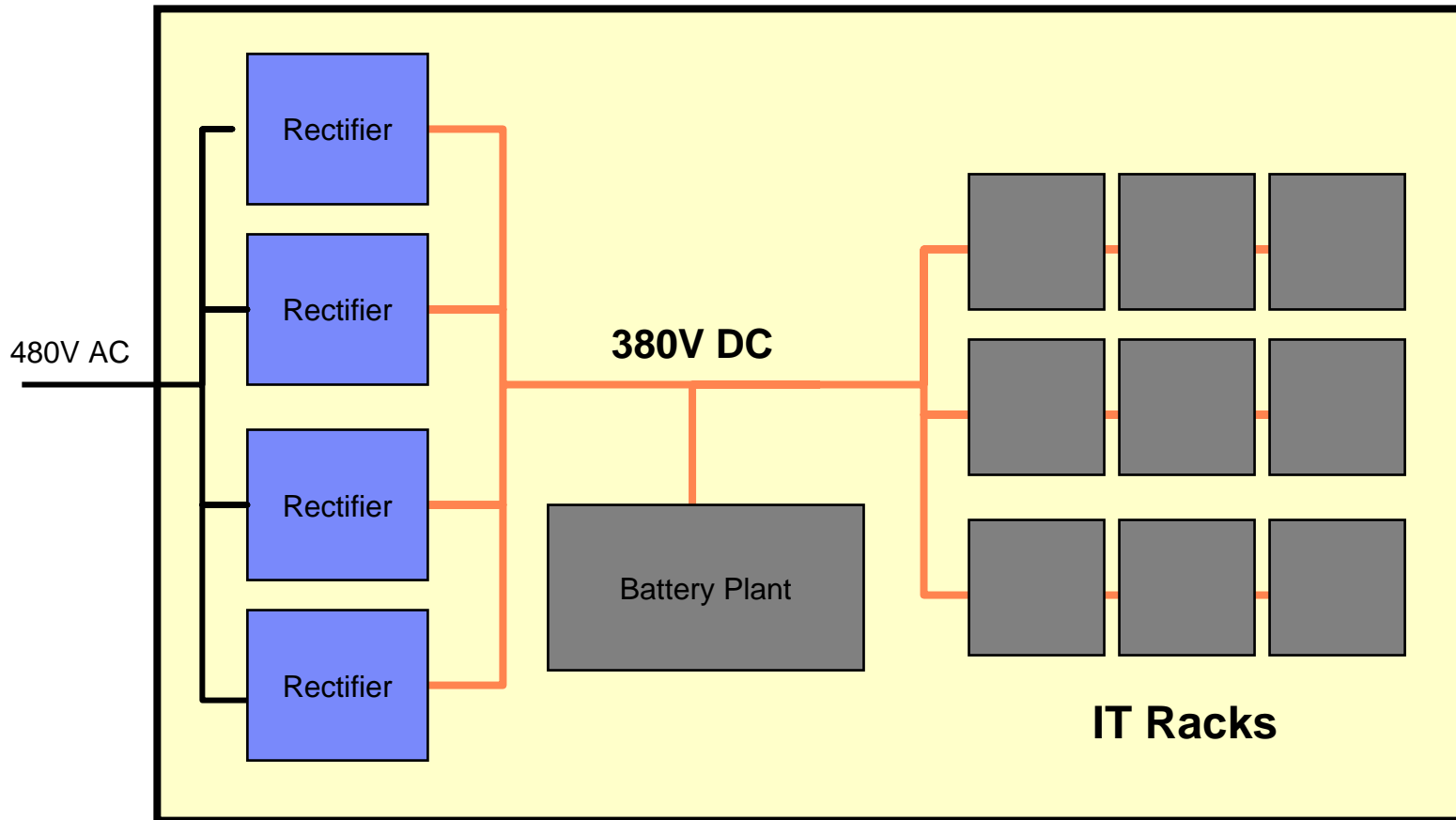
# Power Path for IT Racks in a Typical Data Center



# Typical Power Distribution for Blade Server Racks



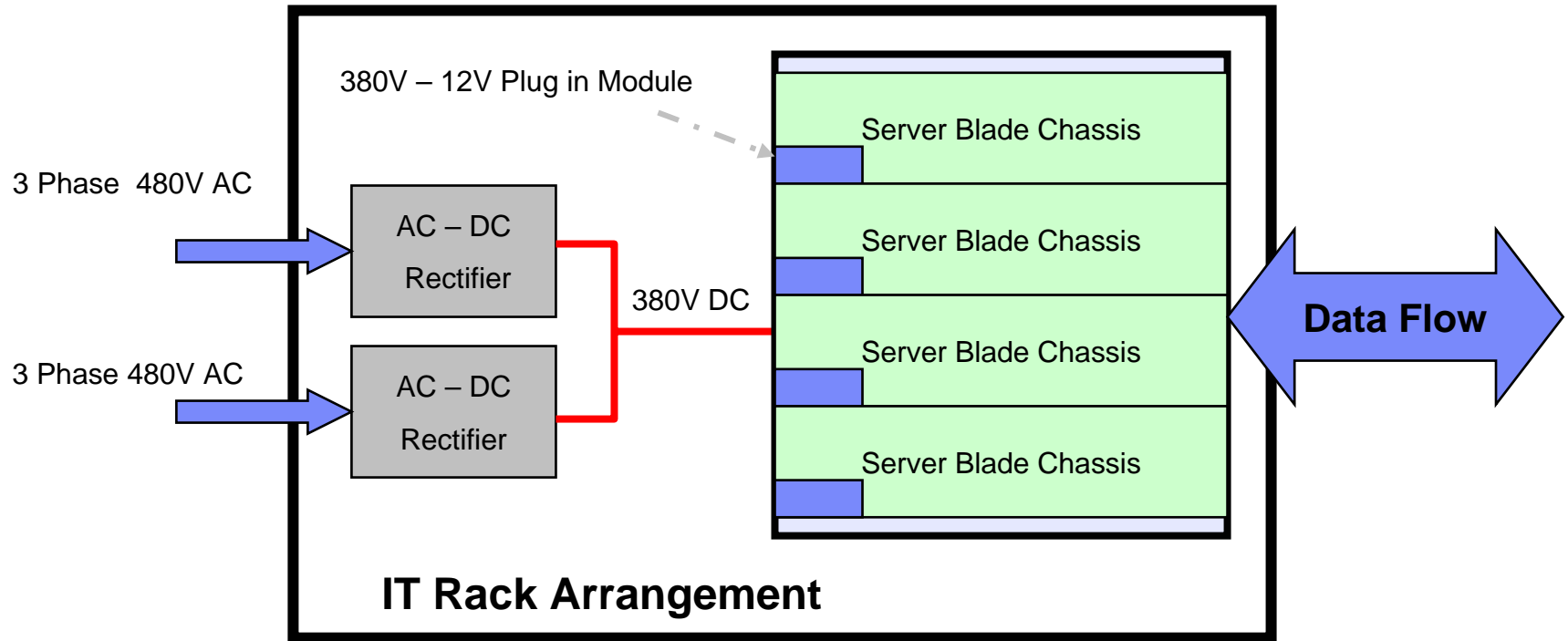
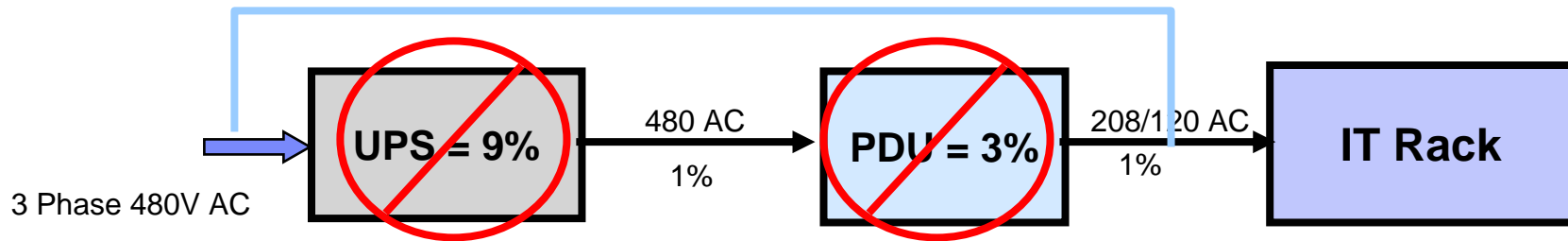
# High Voltage DC Distribution in a Data Center



Source: Lawrence Berkley National Laboratory

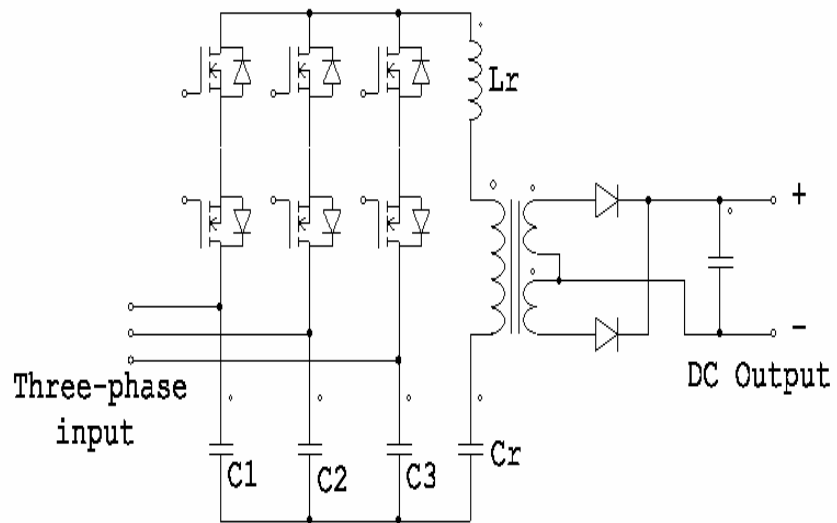


# High Voltage DC Distribution in the Rack



# Three Phase Single Stage Series Resonant Cyclo Converter

Three-phase series-resonant half-bridge cyclo-converter

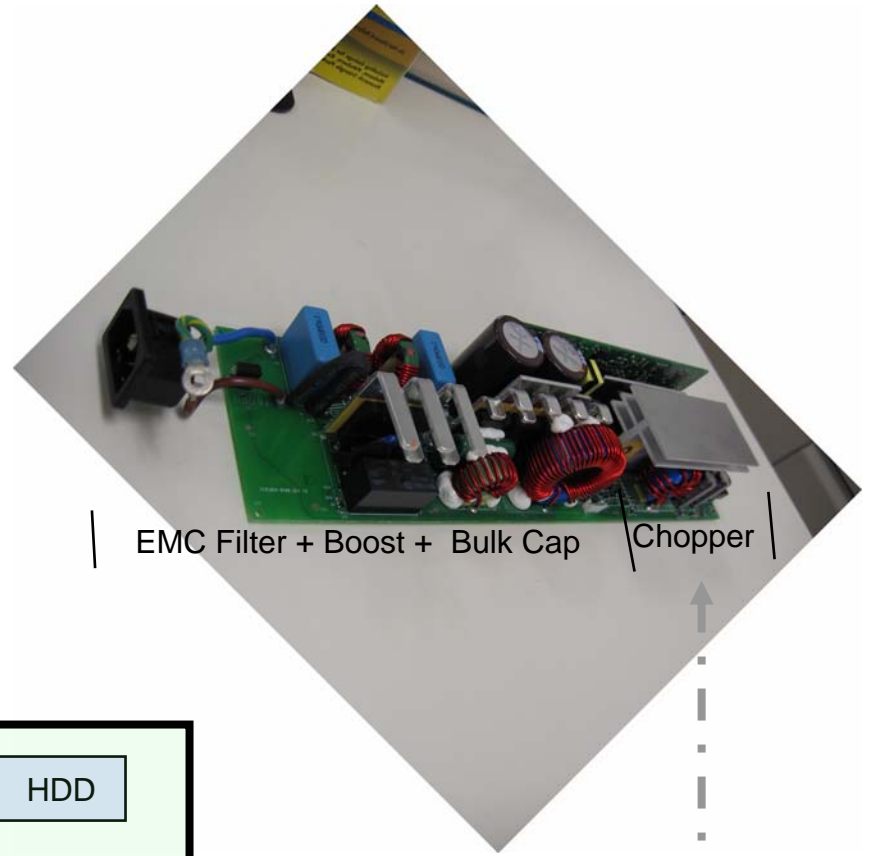


Source: Tomasz Kotula Eaton Development Centre

# 380V - 12V Regulator



Source: Vicor Corporation, Andover, USA  
Power Density = 1000W/in<sup>3</sup>



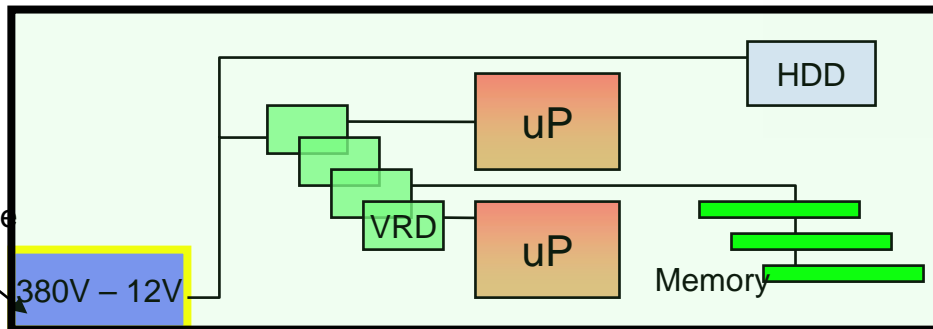
EMC Filter + Boost + Bulk Cap

Chopper



380V - 12V DC = 100W/in<sup>3</sup>

Source: Astec/Artesyn

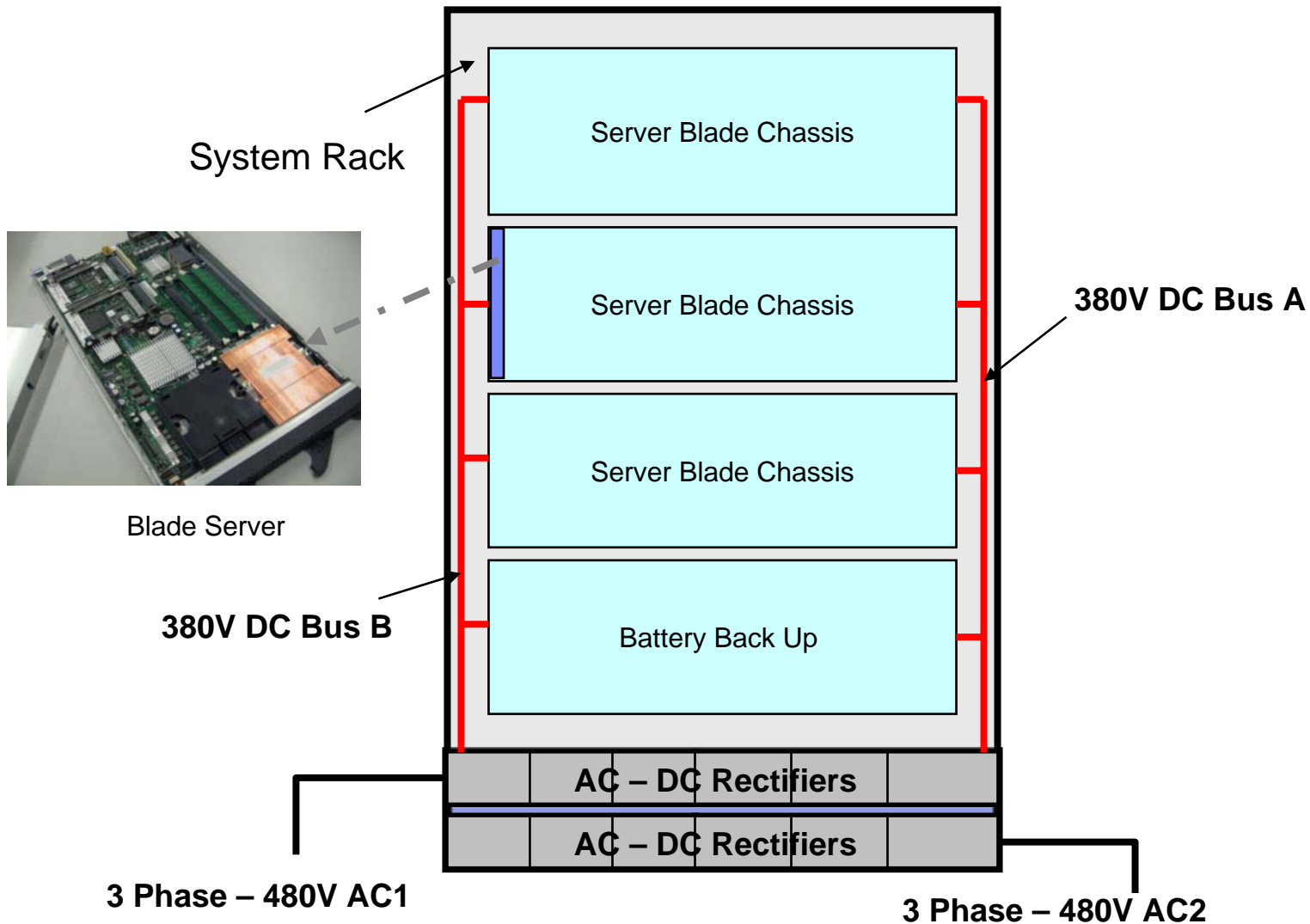


Server Blade

Plug in Module

380V - 12V

# Rack Centric High Voltage Distribution Bus Proposal



# Rack Centric High Voltage Distribution, Why?

- ✓ Lower Overall Cost
- ✓ Higher Overall Efficiency

