POWER AND COOLING CONSULTANTS MASTER CLASS 2016

HITTING THE GREEN MARK:

BEST PRACTICES IN DATA CENTER OPTIMIZATION

EMERSON
Network Power

Power Architectures and Designs that Enable Ffficiency in the Data Center

Arunangshu Chattopadhyay

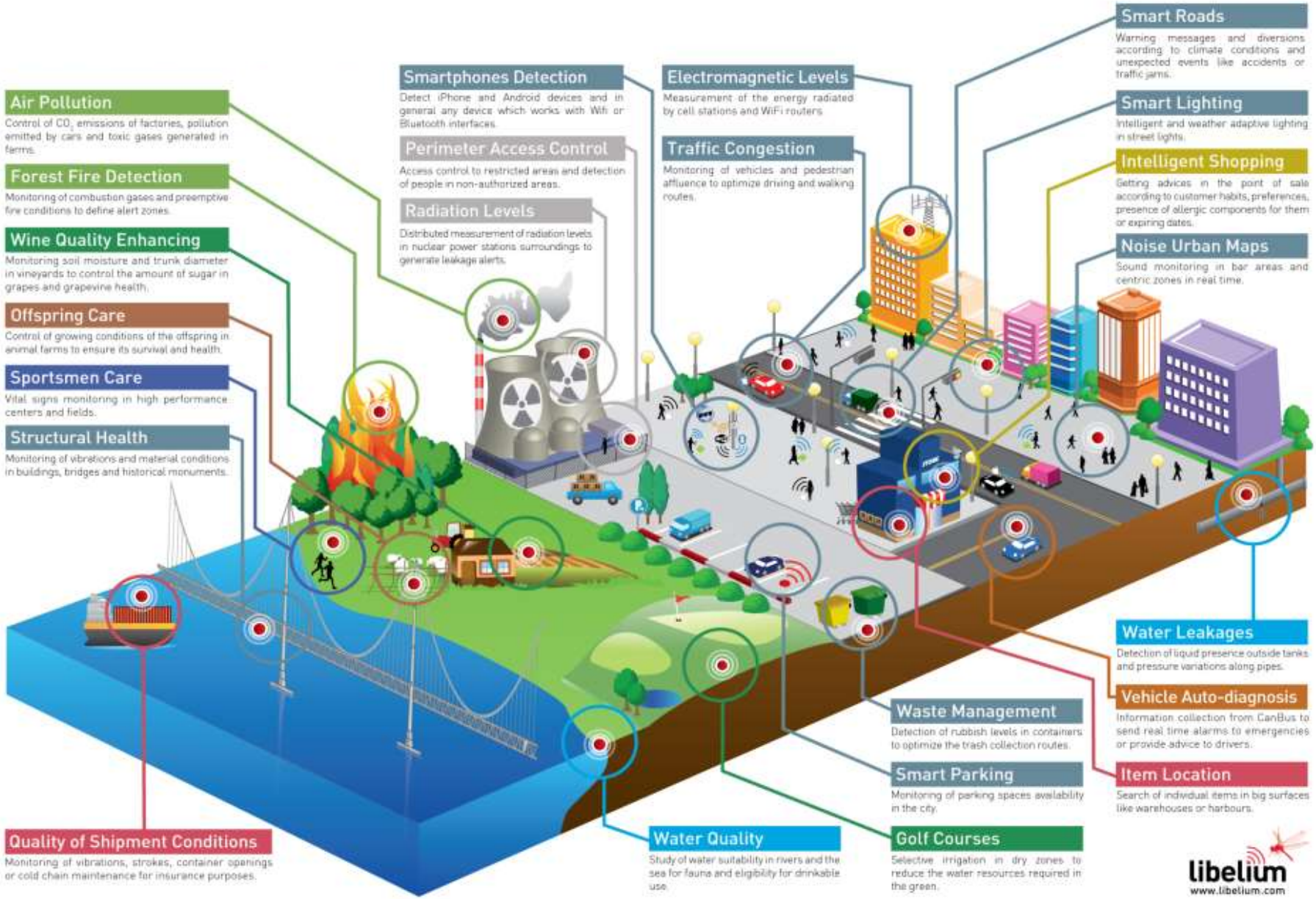
Director, Power Product Marketing and Head of Centralised Technical Support

EMERSON
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Today's Agenda

- State of the Data Center
- Efficiency Without Compromise®
- Efficient Architectures & System level view
- Cost Optimization thru right capacity selection
- DC Vs AC in Datacenters
- Summary

Virtual or Real world?



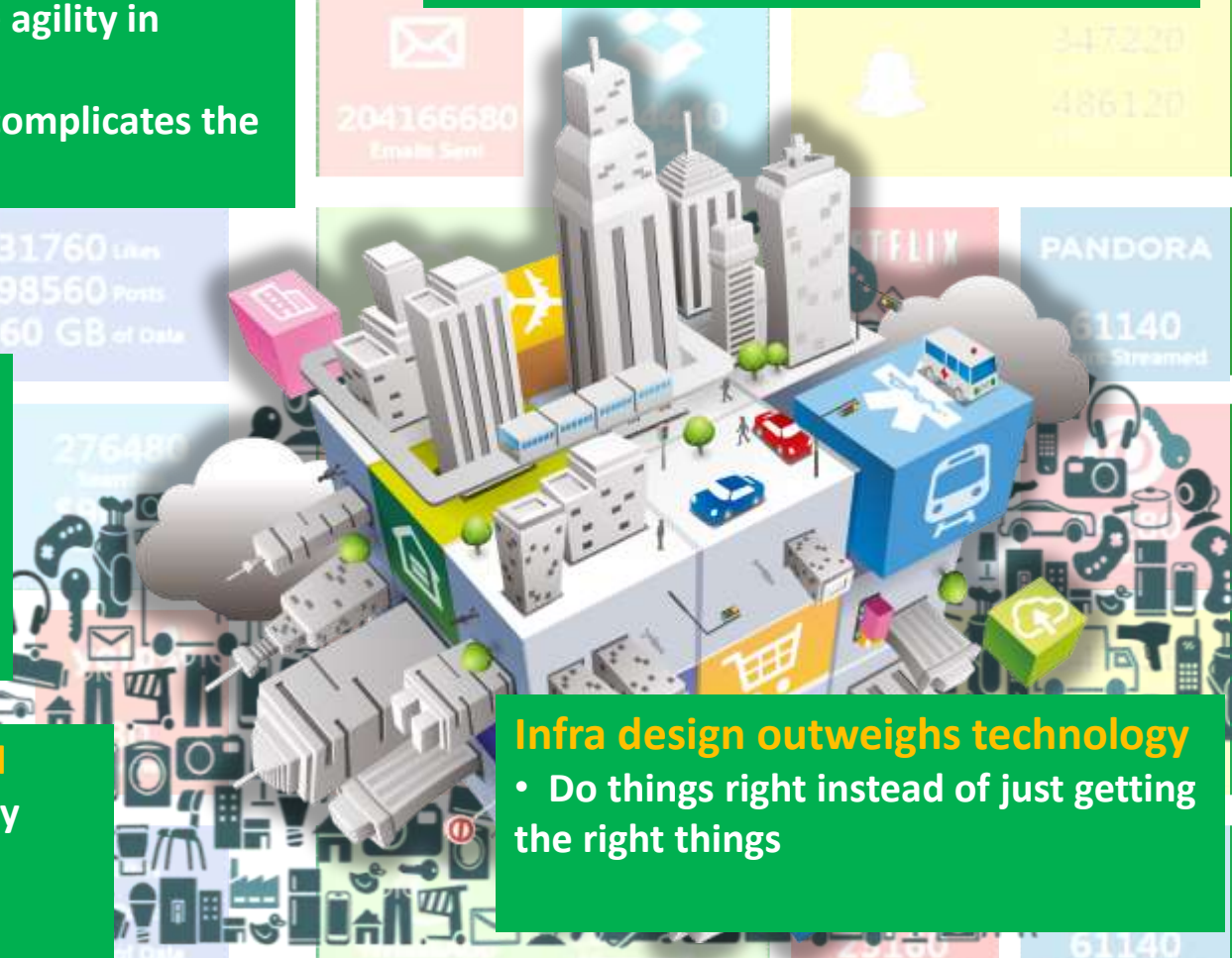
What is Driving the Future for IDC?

IoT redefines the Data Center

- Core-to-edge availability & management solutions to be the norm

Complicated Cloud

- Cloud is the "go to" tech to achieve agility in existing infrastructures
- Evolution to hybrid environments complicates the cloud



Sharpening the EDGE

- Virtualization no longer confined to the core DC, but extends throughout the network edge and on towards the Consumer

Infra design outweighs technology

- Do things right instead of just getting the right things

The new Green Data Center Standard

- Shift in efficiency focus from merely financial benefit to sustainability

Source: Five Data Center Trends by Emerson Network Power

Top Data Center Challenges

MARKET DRIVERS	INDUSTRY TRENDS

▪ **Higher Computing Utilization**
▪ **Computing Demand Growth**
  • Capacity
  • Storage
  • Networking
	▪ **Virtualization**
	▪ **Cloud Computing**
	▪ **Scalability**

▪ **IT Cost Pressures** ▪ **Rising cost of power, cooling, and space** ▪ **Higher density loads**	▪ **Migration & Consolidation** ▪ **Energy Efficiency Initiatives** ▪ **Data Center Modernization** ▪ **Operating with fewer people**

▪ **Increased Complexity of Infrastructure Management**
  • Keeping up with DC design
  • Fragmented technologies
  • No single view of data center
	▪ **DCIM**
	▪ **Outsourcing**

▪ **Outages / Downtime**	▪ **More Focus on Business Continuity and Availability**
▪ **More Regulatory Pressure** • Need for better measurements for power consumption	▪ **Increased emphasis on Green initiatives**
▪ **Ubiquitous Network Access** ▪ **Exploding Bandwidth Demand** ▪ **Technology Investments & Evolution to 4G/LTE…5G?**	▪ **Speed of Deployment** ▪ **Core Network IP Convergence**

Gartner

DATA CENTER KNOWLEDGE

DATA CENTER USERS' GROUP

CITO Research
Research to solve your problems

BLUE CANYON

Trend Impact

Larger Data Centers

- Bigger data center = bigger electric bill
- Higher criticality
- Looking for solution providers, not product vendors
- **More complexity for owners / managers**

Colo / Hosting

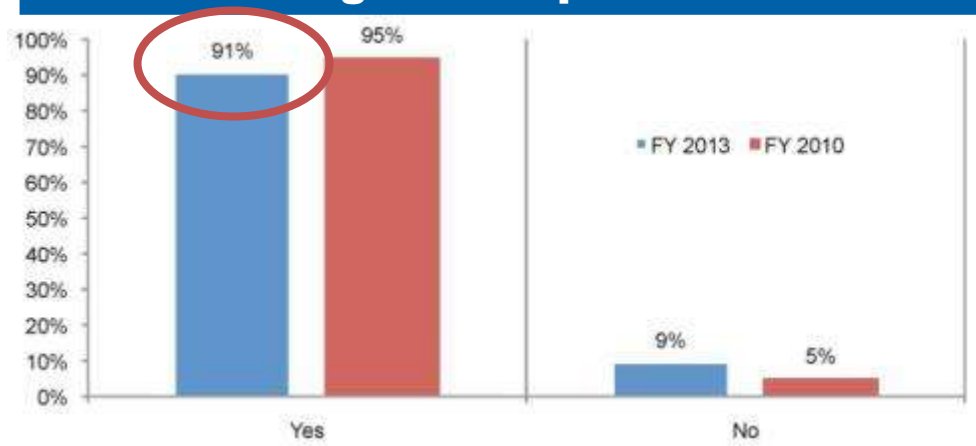
- Educated
- Bottom Line focus
  - Efficiency
  - Availability
  - Scalability
- Innovation
- Rapid Deployment
- **C-suite engagement**

Energy Efficiency Without Compromising Availability: A High Priority Concern

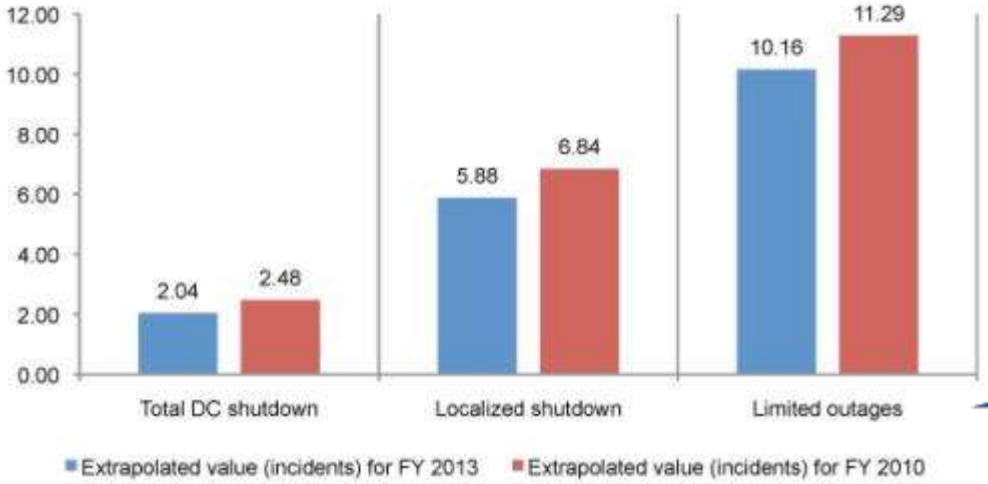
Downtime Is Expensive

National Survey on Data Center Outages

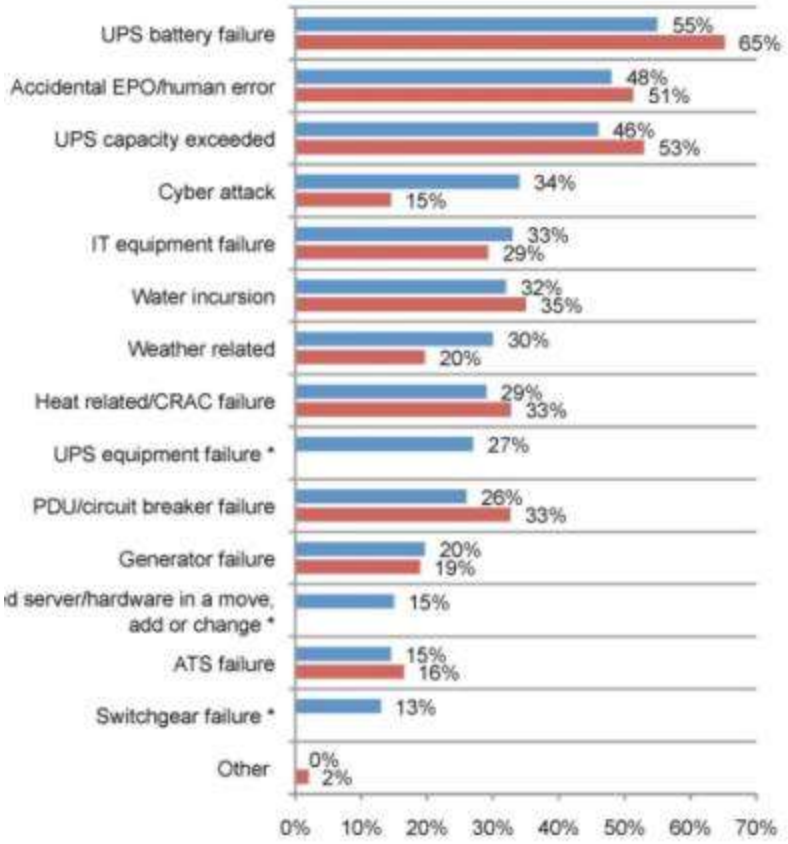
Have you experienced an unplanned data center outage in the past 24 months?



Extrapolated frequency of data center outages over two years:



Top root causes of unplanned outages:

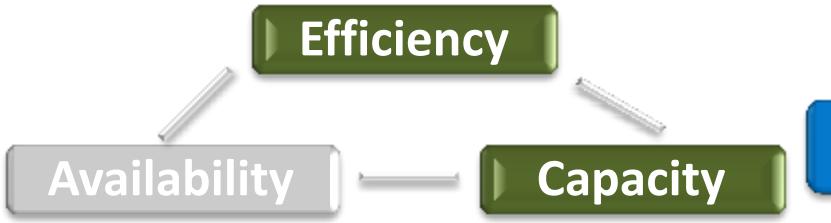


Ponemon INSTITUTE

Include Cost of Downtime When Determining Performance Based TCO

Generic TCO

Only covers CAPex and OPex

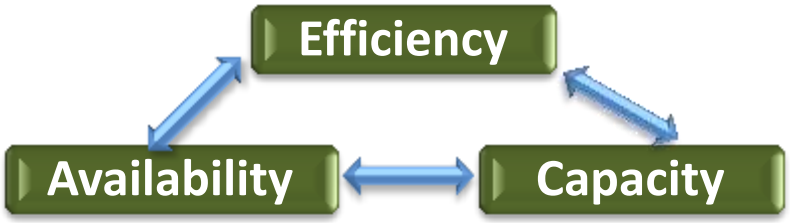


- Efficiency
- **Capacity**
- **Footprint**
- Price

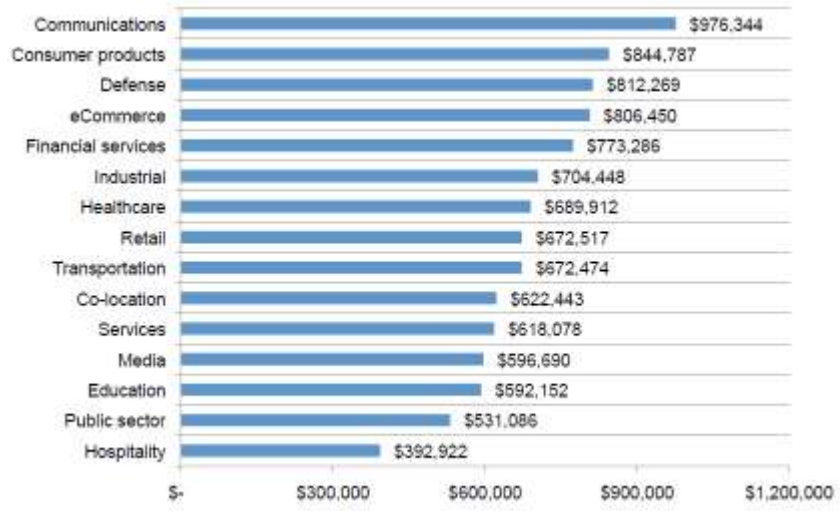
VS

Performance-Based TCO

Takes availability into account



- Efficiency
- **Capacity**
- **Availability**
  - Output fault management
- Footprint
- **Price**
- **Fault Tolerant**
  - DC Isolation



Average cost was $690,204 for the 67 data centers analyzed.

Average of 86 minutes of partial or total shutdown.

The Current 'Power Protection' Market…



Expectations / Demands:

- ✓ Protect against anything that could interrupt power to the critical load
- ✓ Burn-to-the-ground performance – Sacrifice itself to keep power on
- ✓ Highest reliability / Mean Time Between Failure (MTBF) and easy to maintain with fast Mean Time To Repair (MTTR)
- ✓ High Short Circuit Current Ratings (SCCR), withstand and bracing, yielding High Amps Interrupt Current rating (AIC)
- ✓ Rugged output short circuit / bolted fault capability, and the ability to start a PDU from inverter
- ✓ Complete and total electrical topology and battery isolation (input/output isolation transformers)

Maximum Protection

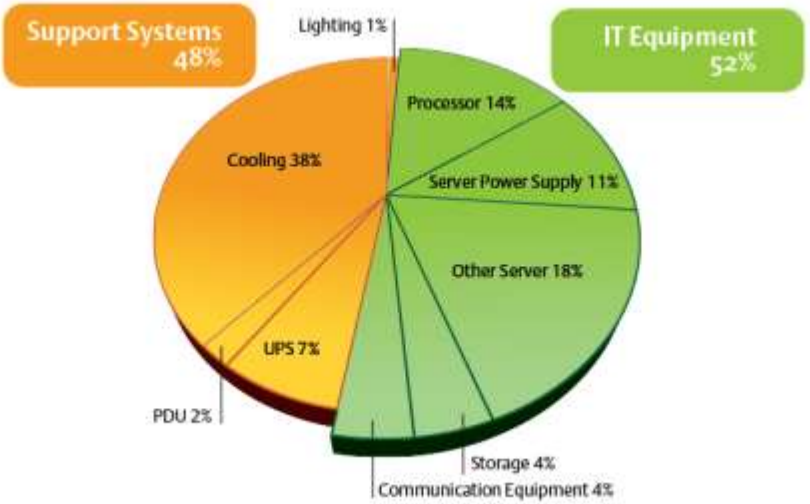
Expectations / Demands:

- ✓ Lowest possible first cost
- ✓ Highest possible dual-conversion efficiency and energy savings modes (AC-to-AC)
- ✓ Smallest footprint with high power density
- ✓ Scalable Architecture / Capacity on Demand without need of SHUTDOWN
- ✓ Add redundancy to the system architecture to offset vulnerabilities

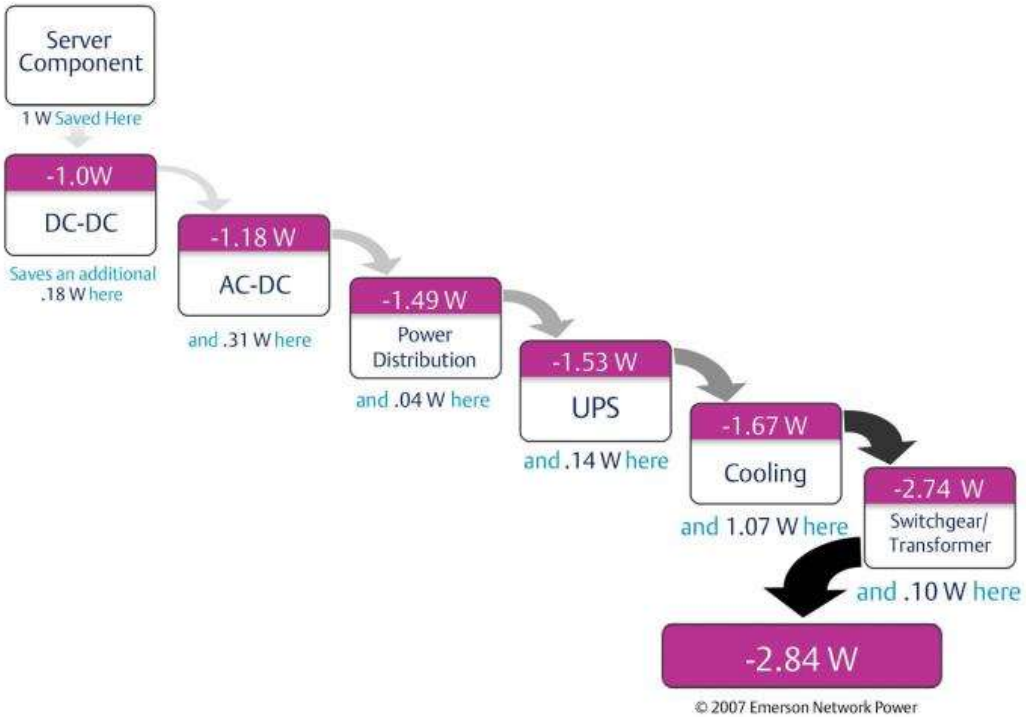
Maximum Efficiency

Emerson's Energy Logic 2.0

- Energy Logic 2.0 is a vendor-neutral roadmap of 10 strategies that can reduce a data center's energy use by up to 74 percent. It's an update of Emerson Network Power's original Energy Logic roadmap, released in 2007, that promised more than 50 percent savings.



Energy consumption in a typical data center



1 Watt saved at the server component level results in cumulative savings of about 2.84 Watts in total consumption

EMERSON Network Power

Source: Energy Logic

Calculating the Impact:
Energy Logic 2.0 Savings

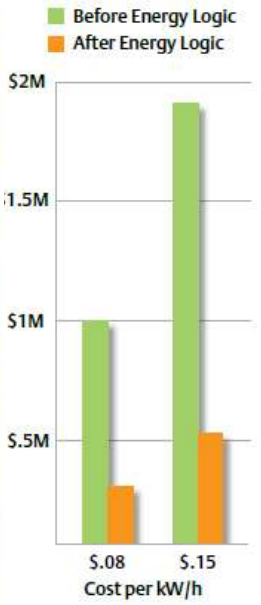
Annual Energy costs before and after Energy Logic

- Reduce energy consumption up to 74 percent
- Save potentially 83% in data center space (space, cooling, power)
- Deliver efficiency gains without compromising availability

ENERGY LOGIC 2.0

	LOAD	SAVINGS (KW)	SAVINGS %
Low-Power Components	1,543	172	11.2
High-Efficiency Power Supplies	1,371	110	7.1
Server Power Management	1,261	146	9.4
ICT Architecture	1,115	53	3.5
Virtualization and Consolidation	1,062	448	29
Power Architecture	614	63	4.1
Temperature and Airflow Management	551	80	5.2
Variable-Capacity Cooling	471	40	2.6
High-Density Cooling	431	23	1.5
Data Center Infrastructure Management	408	--*	
TOTALS	408	1135	73.6

* Because DCIM is integral to many Energy Logic 2.0 strategies, it isn't possible in this model to attribute an isolated savings percentage to DCIM.



EMERSON Network Power

Source: Energy Logic

Energy Logic 2.0 Strategies

Prioritized Energy Saving Strategies:

1. Low-Power Components
2. High-Efficiency Power Supplies
3. Server Power Management
   - Seek ENERGY STAR® rated, low idle power servers
4. ICT Architecture
   - Efficiency gains can be realized through new structural cabling technology – reduces heat load
5. Server Virtualization & Consolidation
   - 29% reduction in Data Center energy
6. Power Architecture
   - Standby units Idle & schedule based on load operations
7. Temperature and Airflow Management
8. Variable Capacity Cooling
   - Optimizing the cooling system to work more efficiency at partial loads
9. High Density Cooling
10. Data Center Infrastructure Management (DCIM)
    - DCIM impacts every step of Energy Logic – achieve maximum results at each strategy

EMERSON Network Power

Source: Energy Logic

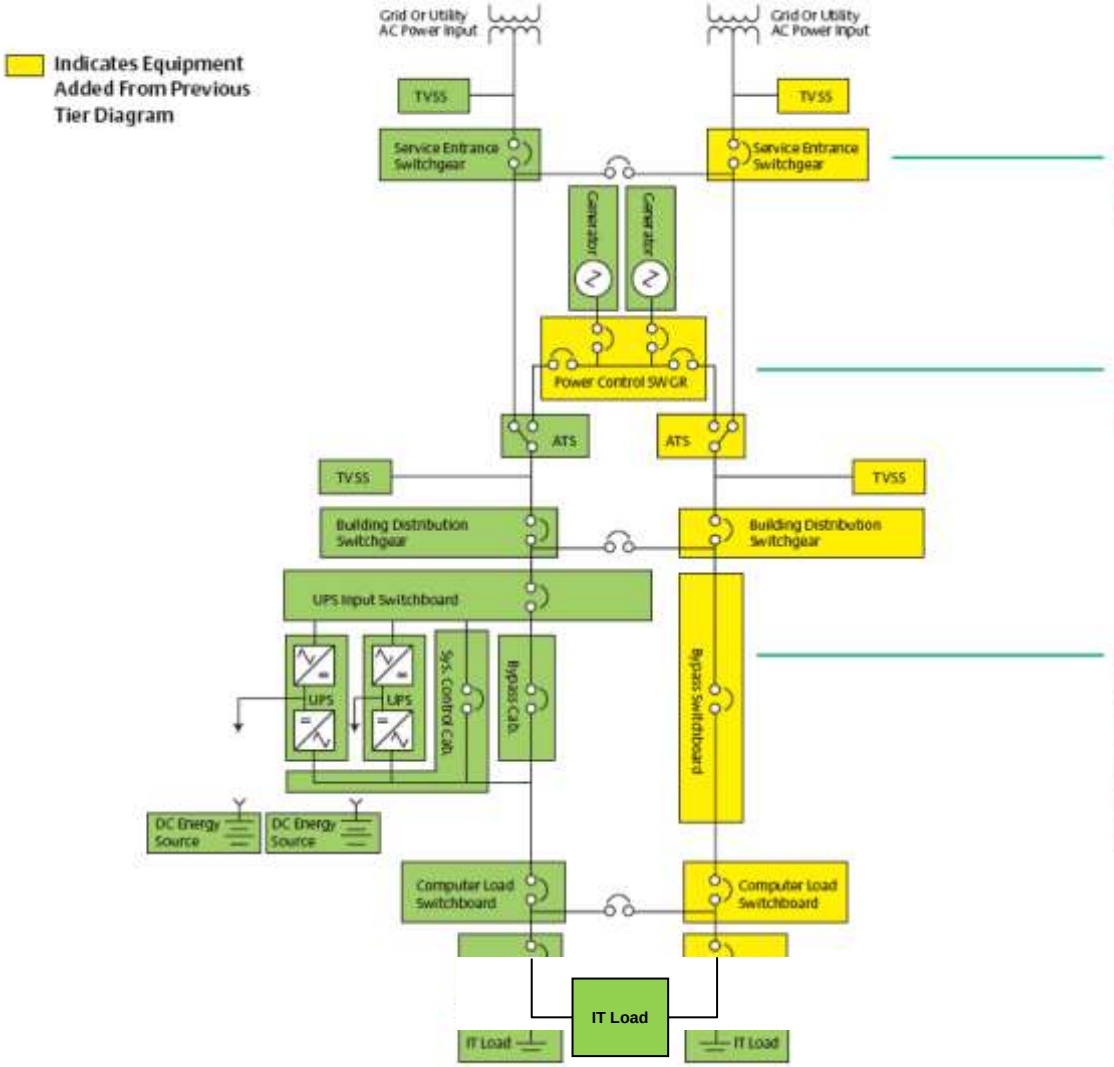
Tier Classifications/Definitions

	Definition	Description	Equipment Required
Tier 1	Basic Site Infrastructure	❑ N, Non-redundant capacity components ❑ Single non-redundant distribution path	❑ Dedicated IT Space ❑ UPS ❑ Dedicated Cooling ❑ Engine Generator
Tier 2	Redundant Capacity Components	❑ N+1, Redundant capacity components ❑ Single non-redundant distribution path	❑ Redundant UPS ❑ Redundant Cooling ❑ Redundant Engine Generator
Tier 3	Concurrently Maintainable	❑ N+1, Redundant capacity components ❑ Multiple distribution paths (but only one actively serving IT equipment)	❑ IT Equipment has Dual power/switching means ❑ Every system/comp taken offline for PM
Tier 4	Fault Tolerant	❑ 2N, Capacity Systems ❑ Multiple, independent, diverse distribution paths	❑ All Equipment is Dual Powered (may be via STS) ❑ Separated Distribution

Source: The Uptime Institute

Tier 3, Concurrent Maintenance

UPS System w/Redundancy and Multiple Power Delivery Paths for Concurrent Maintenance



Concurrently Maintainable

- Further reduction in downtime from planned and unplanned activity over Tier 2.
- Includes redundant UPS and engine generators
- Dual power path to the load, although only one with UPS protection.
- A few maintenance activities may require load shutdown
- UPS system maintenance *may* require the load to be powered by utility (in bypass mode)
- N+1 or 1+N UPS system configurations

Performance

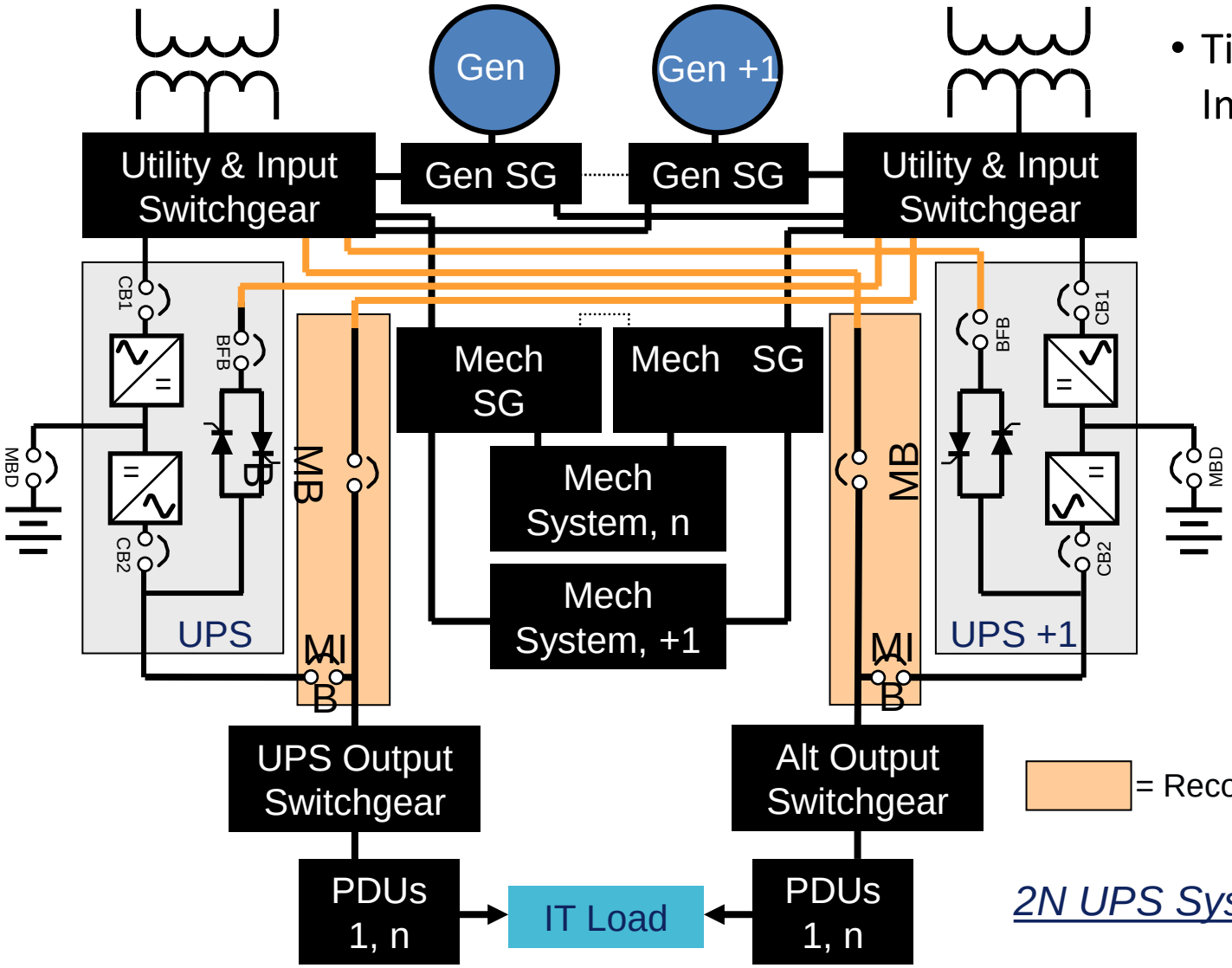
- 99.99999% availability ("7 Nines")
- Planned maintenance will not require a shutdown.
- Every system/component can be taken offline without shutting down load

Characteristics

- Redundant capacity components
- Multiple distribution paths to load
- IT Equipment has dual power or STS

Tier 3, Concurrent Maintenance

UPS System w/Redundancy and Multiple Power Delivery Paths for Concurrent Maintenance

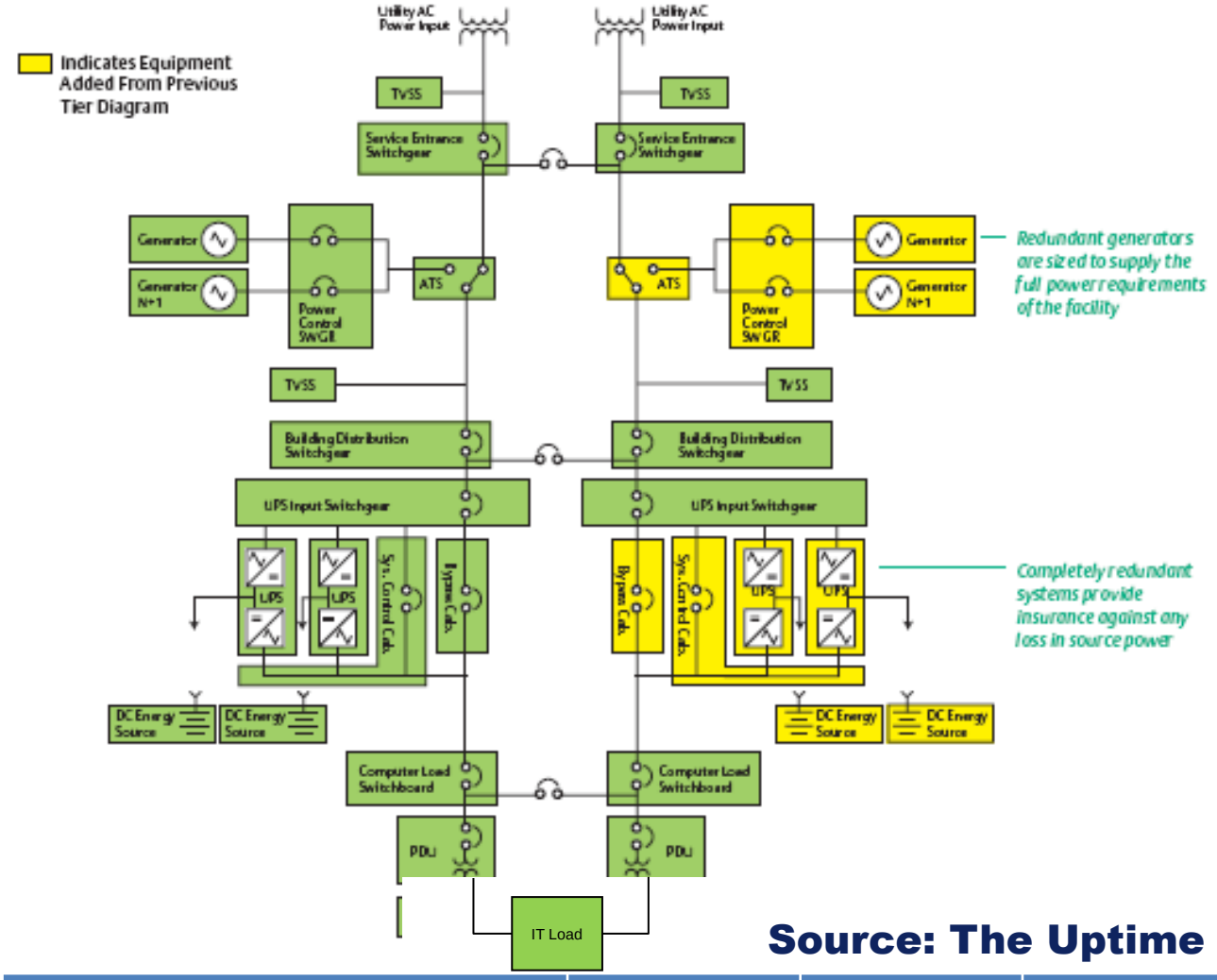


- Tier 3 Typical Implementation
  - Dual Bus or 2N UPS System
  - Redundant Engine Generator
  - Redundant Cooling System

2N UPS System

Tier 4, Fault Tolerance

Fully Redundant UPS System with Redundant Power Delivery Paths for Fault Tolerance



Fault Tolerant

- Ultimate reduction in downtime from planned and unplanned activity
- Includes redundant UPS and engine generators
- Dual power path to the load
- Rarely do maintenance activities require load shutdown
- Normal UPS system maintenance does not require the load to be powered by utility or shutdown.
- N+1 or 1+N or N UPS system configurations

Performance

- 99.999999% availability ("8 Nines")
- Any single failure will not impact the data center
- Every system/component can be taken offline without shutting down load while still having UPS protection

Characteristics

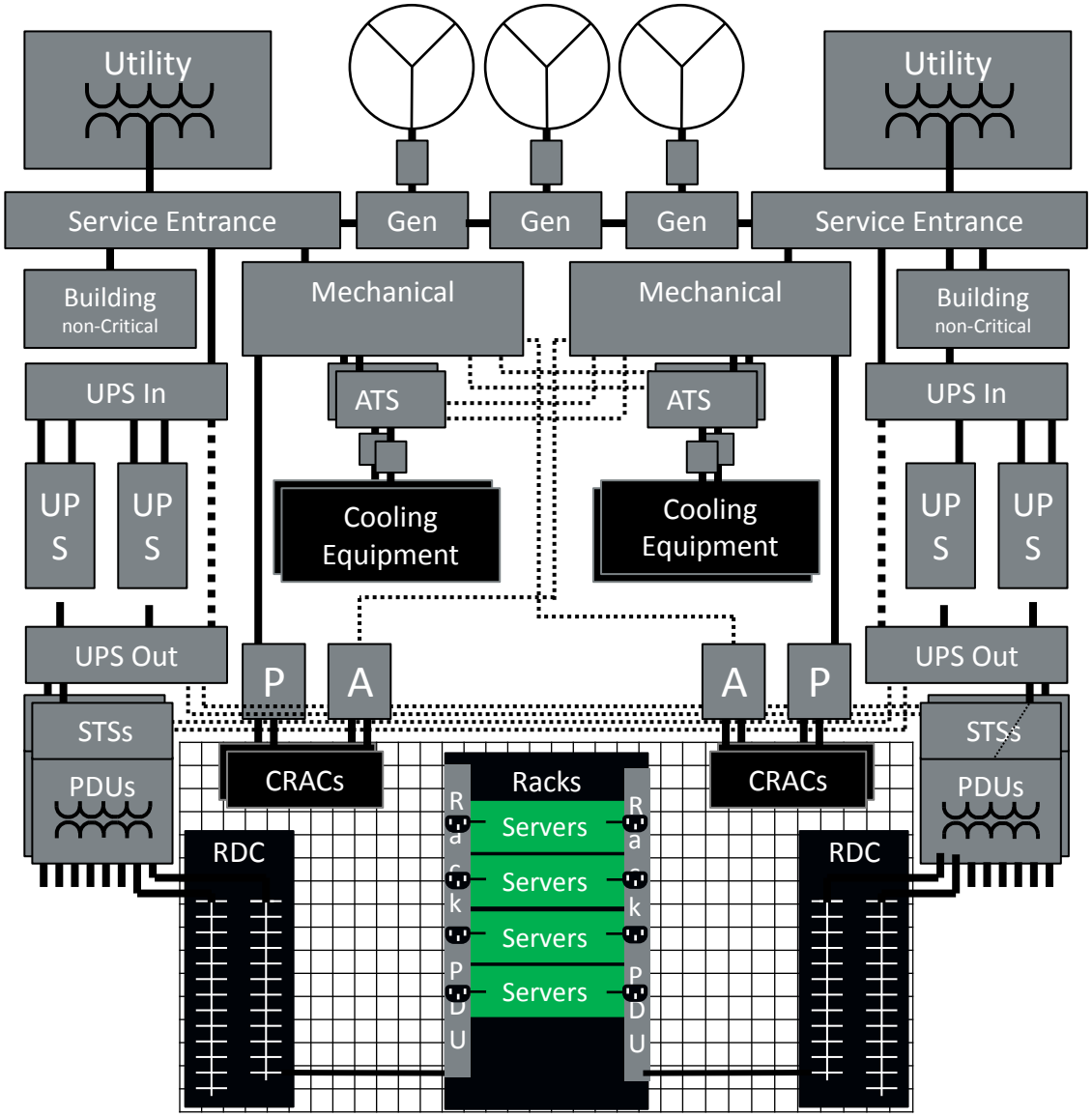
- Separate, redundant distribution Paths, Optional redundant capacity systems
- All critical equipment is normally dual powered (can be via STS)

Source: The Uptime Institute

	Tier I	Tier 2	Tier 3	Tier 4
Availability Experience (typical)	99.67%	99.75%	99.98%	99.99%

Data Center Power Architecture

2N Electrical, Tier 3-4



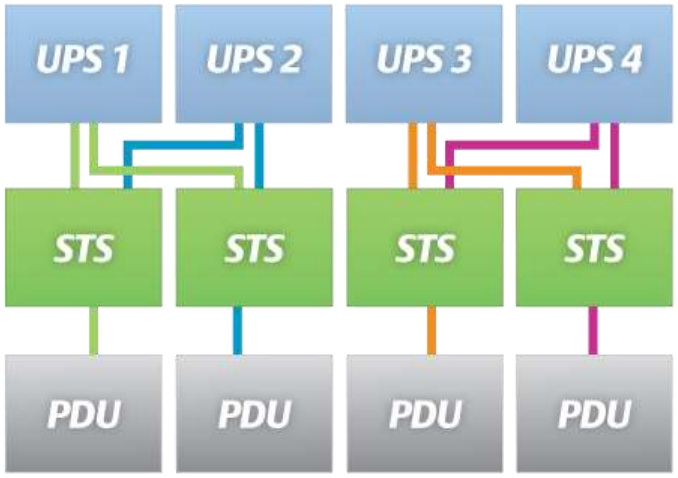
Performance:

- Concurrent Maintenance
  - Every system/comp can be taken offline
- Fault tolerant UPS, mechanical and downstream distribution

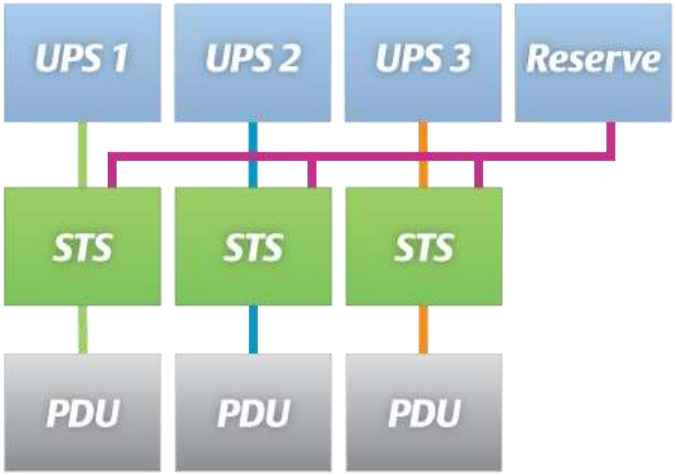
Typical Characteristics:

- 2N Utility, 2N UPS and 2N Distribution
- Redundant Generator(s)
- N+x Cooling
- ATS and STS used for enhanced reliability and improved maintenance
- IT equip dual powered

Strategies to Improve Utilization



2 x 2N Dual Bus Data Center
~50 % Utilization Rate

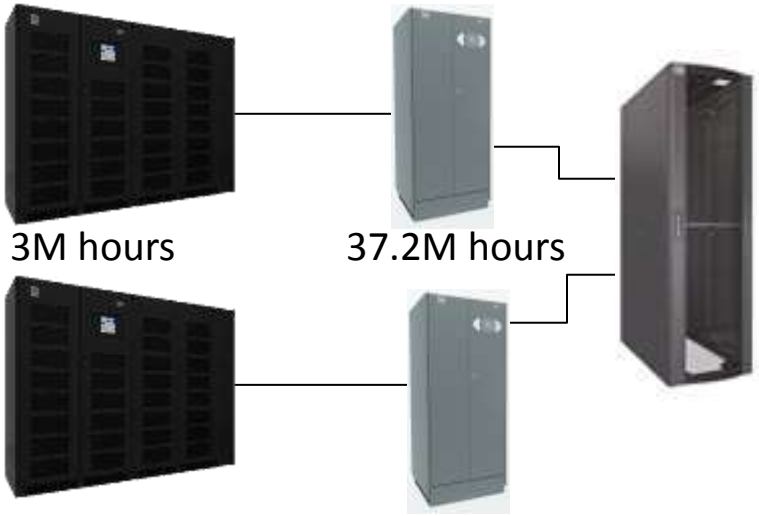


Reserve Bus Data Center
~75 % Utilization Rate

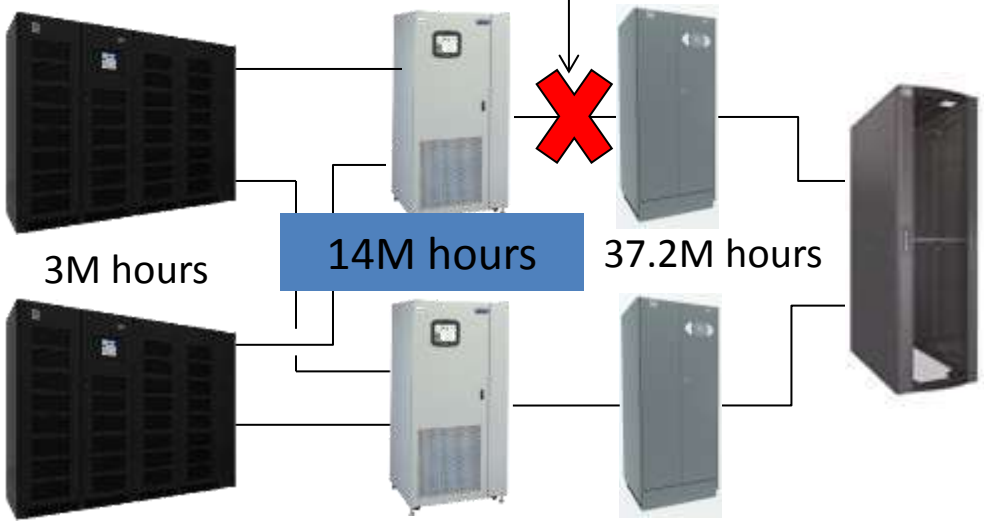
- Enterprise traditionally utilizes high availability dual bus architecture
- Business models that demand higher utilization rates and can accept lower availability are turning to reserve ("catcher") architectures
- **Helps you move up the efficiency curve**.

Deploy STS To Increase Utilization and Improve Maintainability, Reliability and Fault Isolation

Dual bus, Dual Input
without STS2



Dual bus, dual input
with the STS2
Fault here is isolated.
Alternate bus and other loads not affected.



Load Calculated MTBF
321B Hours

13 x Increase

Load Calculated MTBF
4298B Hours

System MTBF Increase

*MTBF assumes routine maintenance

Key Concept, Values and Benefits:
AC Power System

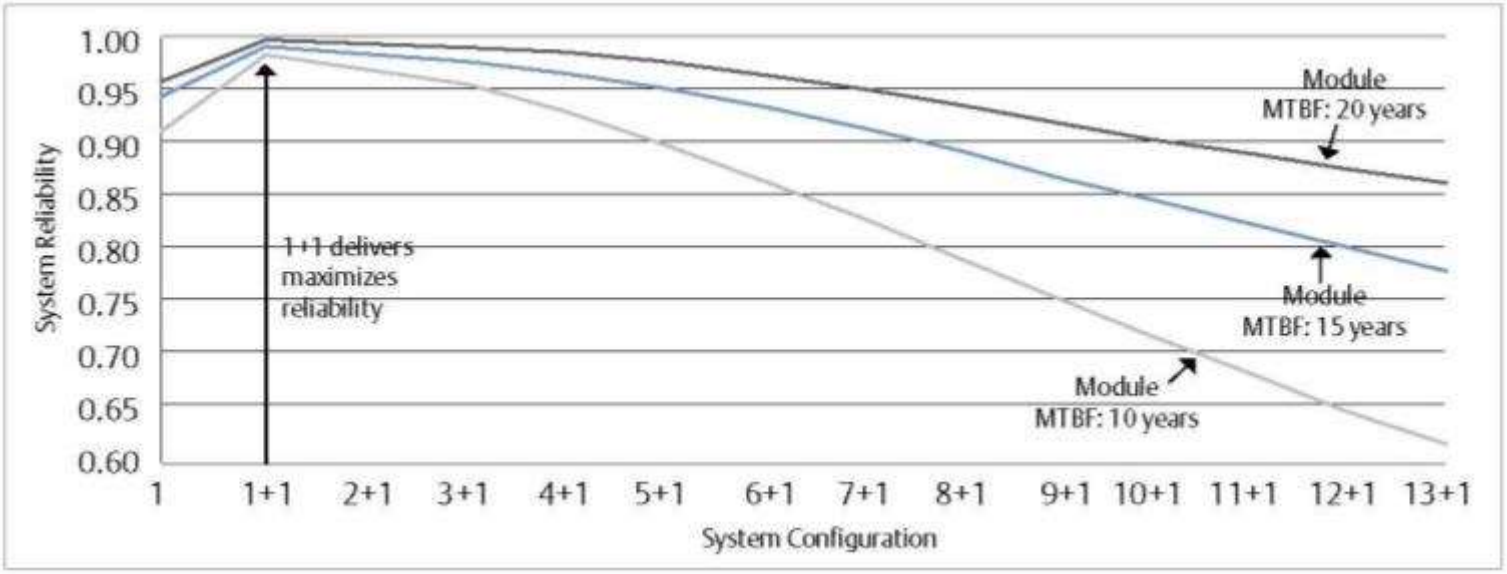
- AC Power solution are designed based on innovative architectures architecture
  - Improve Utilizations, Efficiency Maximization
- Modular UPS solution e.g Trinergy Cube, a UPS system designed to operate with the maximum energy efficiency in the minimum footprint for the protection of data center.
- Scalable solution to permit reduced Capex demands – install only when required for Revenue generation.
- Large, single UPS' to minimize upstream/downstream infrastructure Capex.
- High efficiency AC Power solution had been proposed to minimized the cooling system requirement and concurrently minimize long term energy Opex.

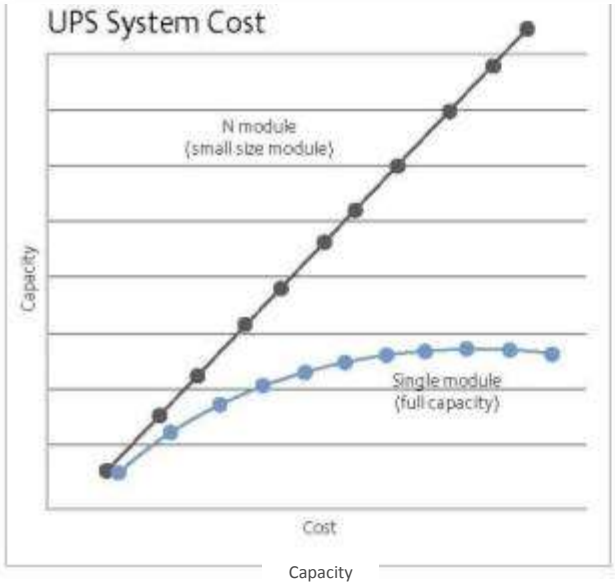


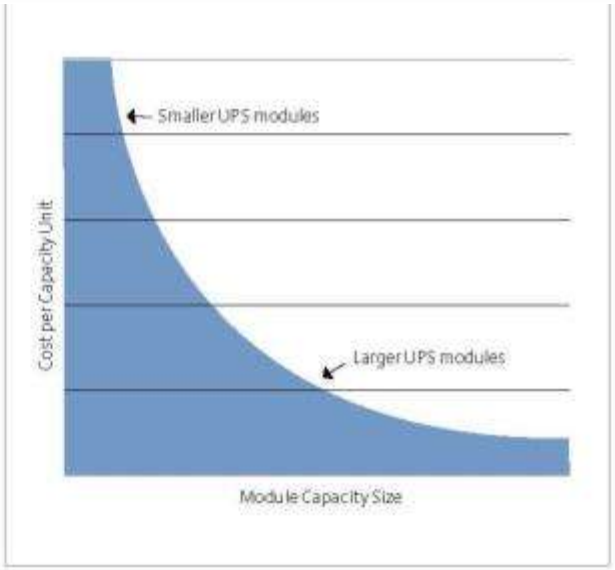
Installation Flexibility & Infrastructure Optimization

- Modularity – Right Size Building Block
- Three and four wire
- Flexible layout
- Centralized and distributed parallel configuration
- Hot scalability Electrical infrastructure optmization
- Infrastructure Optimization : System level cost computation

Building High Availability
Power Architectures





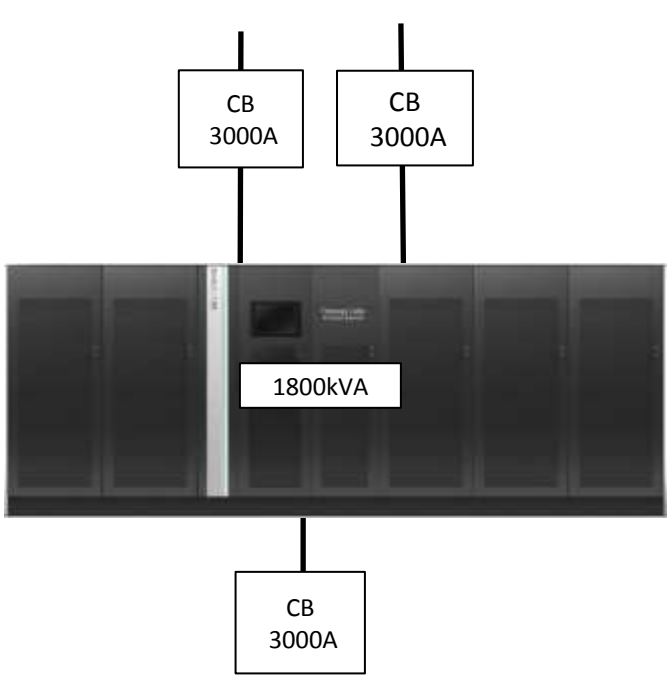


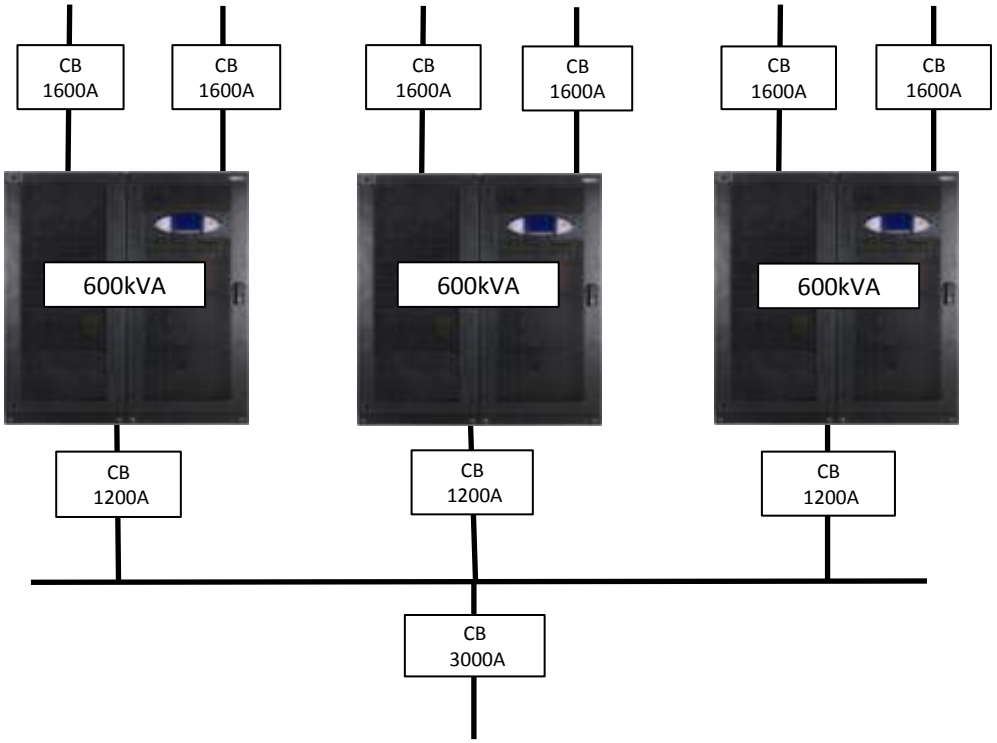
For 1+1: $R=R^2+2R(1-R)$ For 5+1: $R=R^6+6R^5(1-R)$

Case Illustration:

Associated Infrastructure Savings

System power requirements > 600 kVA → can present huge saving on the electrical infrastructure by using one unit versus multiple parallel UPS





* 8 groups of 1 x ***Trinergy***™ ***Cube*** 1800kVA/1620kW vs 8 groups of 3 x 600kVA/540kW

Case Illustration:

Associated Infrastructure Savings

Trinergy Cube	Qty	Price/unit	Est Total Price
Breakers			
Mains Input Breakers 3000A 3P	8	$10,233.63	$81,869.05
Bypass Input Breakers 3000A 3P	8	$10,233.63	$81,869.05
UPS Output Breakers 3000A 3P	8	$10,233.63	$81,869.05
System Output Breakers	0	$0.00	$0.00

Trinergy Cube	Qty	Tot. cable meters/unit	Price/meter	Est Total Price
Cables				
Mains Input Cables XLPE 400mm2 x 3C x 4 sets	8	40	$287.00	$91,840.00
Bypass Input Cables XLPE 400mm2 x 3C x 4 sets	8	40	$287.00	$91,840.00
UPS output Cables XLPE 400mm2 x 3C x 4 sets	8	40	$287.00	$91,840.00

***Assume 10m per C**

Grand Tot. **$521,127.16**

Other UPS Unit	Qty	Price/unit	Est Total Price
Breakers			
Mains Input Breakers 1600A 4P	24	$8,962.87	$215,108.88
Bypass Input Breakers 1600A 4P	24	$8,962.87	$215,108.88
UPS Output Breakers 1200A 4P	24	$8,207.25	$196,974.02
System Output Breakers 3000A 4P	8	$12,587.36	$100,698.88

Other UPS Unit	Qty	Tot. cable meters/unit	Price/meter	Est Total Price
Cables				
Mains Input Cables XLPE 400mm2 x 4 x 2 sets	24	20	$364.00	$174,720.00
Bypass Input Cables XLPE 400mm2 x 4 x 2 sets	24	20	$364.00	$174,720.00
UPS output Cables XLPE 240mm2 x 4 x 2 sets	24	20	$228.00	$109,440.00
System UPS output Cables XLPE 400mm2 x 4 x 4 sets	8	40	$374.00	$119,680.00

***Assume 10m per C**

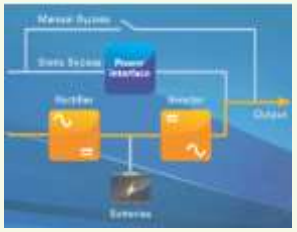
Grand Tot. **$1,197,010.66**

Savings **$675,883.50**

* 8 groups of 1 x ***Trinergy***™ ***Cube*** 1800kVA/1620kW vs 8 groups of 3 x 600kVA/540kW

Three Dynamic Functioning Modes

Unprecedented Efficiency Levels



Maximum Power Control (VFI)

> 96.5%



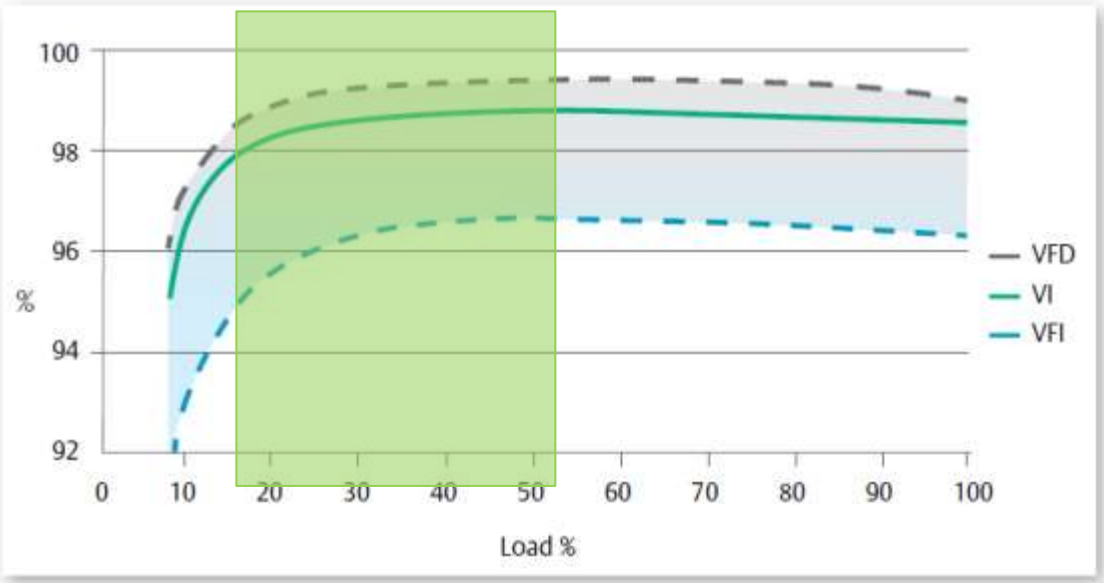
Maximum Energy Saving (VFD)

> 99%



High Efficiency & Power Conditioning (VI)

> 98.5%



Trinergy Cube's average operational efficiency at 98.5%

Average Operating Efficiency 98.5%

*Related to BCA 1-2-2

Case Illustration:

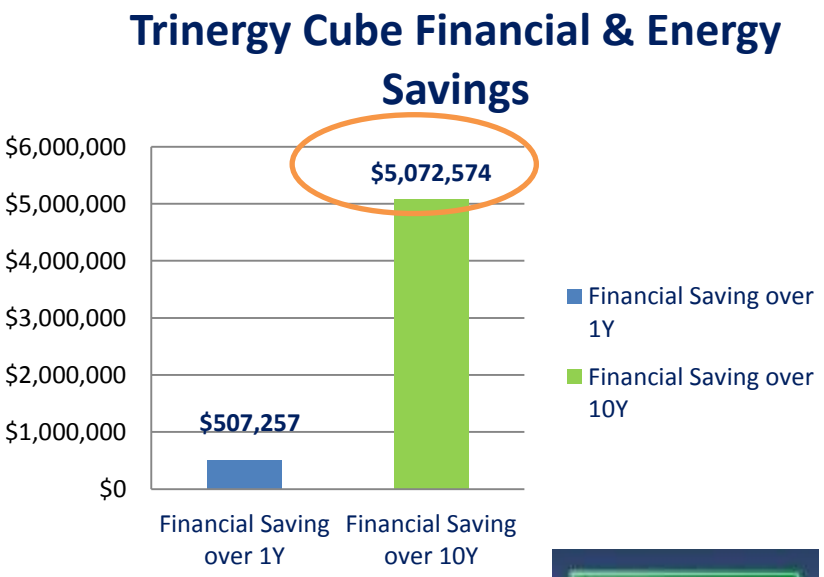
Optimized TCO: Efficiency

Energy Cost $/kWh	Load Applied	Air conditioning coefficient
0.26	50%	1.3

Trinergy Cube	1800	kVA
Number of units	**8**	System configuration
Output PF	0.9	
Active Power	1620	kW
AVG Efficiency AC/AC	**98.5%**	
Power Losses	98.68	kW
Energy Losses (per year)	1,123,770	kWh
Financial cost (per year)	$292,180	$
Energy Losses (10 year)	11,237,702	kWh
Financial cost (10 year)	$2,921,802	$

Other UPS	600	kVA
Number of units	**24**	System configuration
Output PF	0.9	
Active Power	540	kW
AVG Efficiency AC/AC	96.0%	
Power Losses	270	kW
Energy Losses (per year)	3,074,760	kWh
Financial Cost (per year)	$799,438	$
Energy Losses (10 year)	30,747,600	kWh
Financial Cost (10 year)	$7,994,376	$

Comparison Trinergy Cube vs Other UPS		
Diff. between Power Losses	171.32	kW
Energy Saving (per year)	1,950,990	kWh
Financial Saving (per year)	$507,257	$
Energy Saving (10 year)	19,509,898	kWh
Financial Saving (10 year)	$5,072,574	$





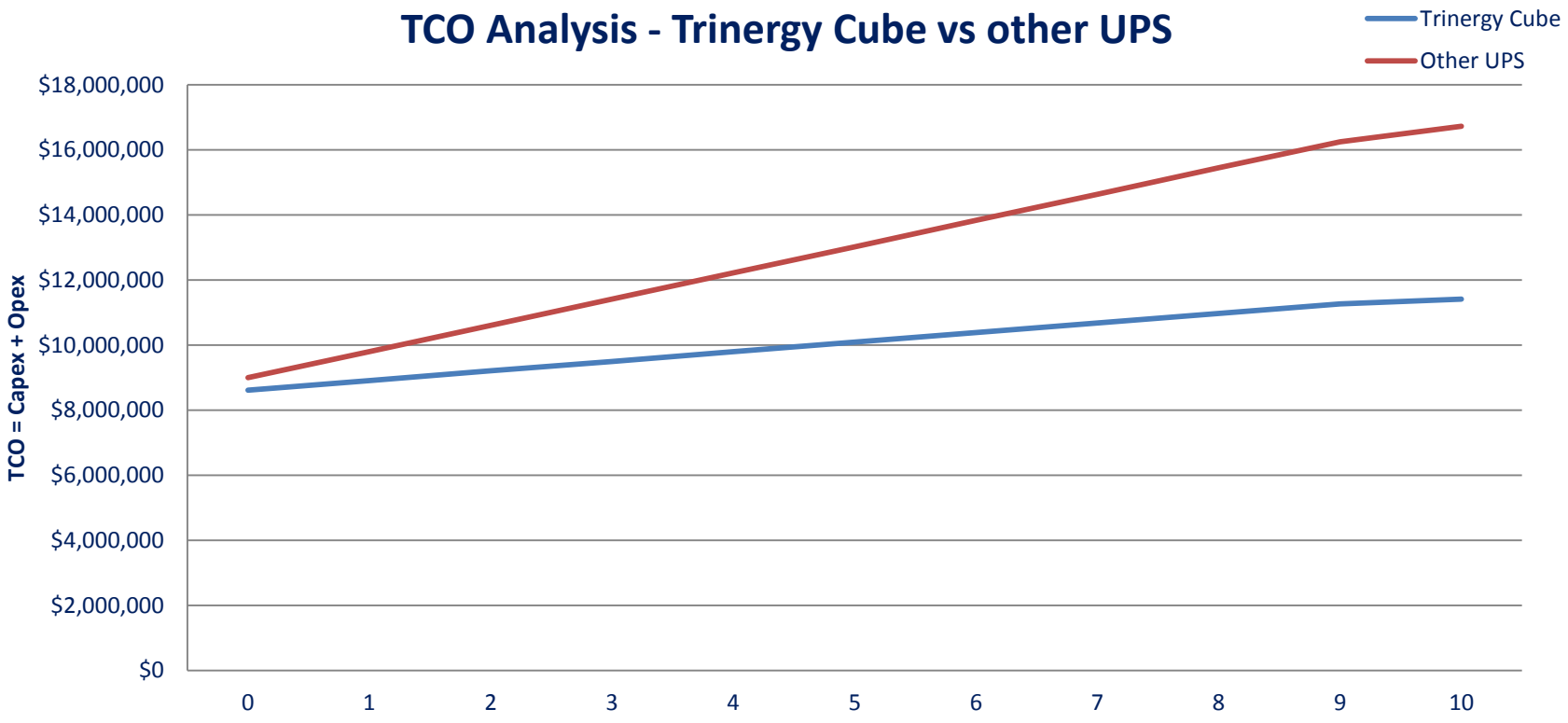
* 8 groups of 1 x ***Trinergy***™ ***Cube*** 1800kVA/1620kW vs 8 groups of 3 x 600kVA/540kW

Case Illustration:

Optimized TCO – Fast Payback Time

	CAPEX cost	Financial cost per year
Trinergy Cube	$8,491,527	$292,180
Other UPS	$8,735,051	$799,438

Trinergy Cube Financial Saving (per year)	**$507,257**



* 8 groups of 1 x ***Trinergy***™ ***Cube*** 1800kVA/1620kW vs 8 groups of 3 x 600kVA/540kW

Neutral Management is Most Important!

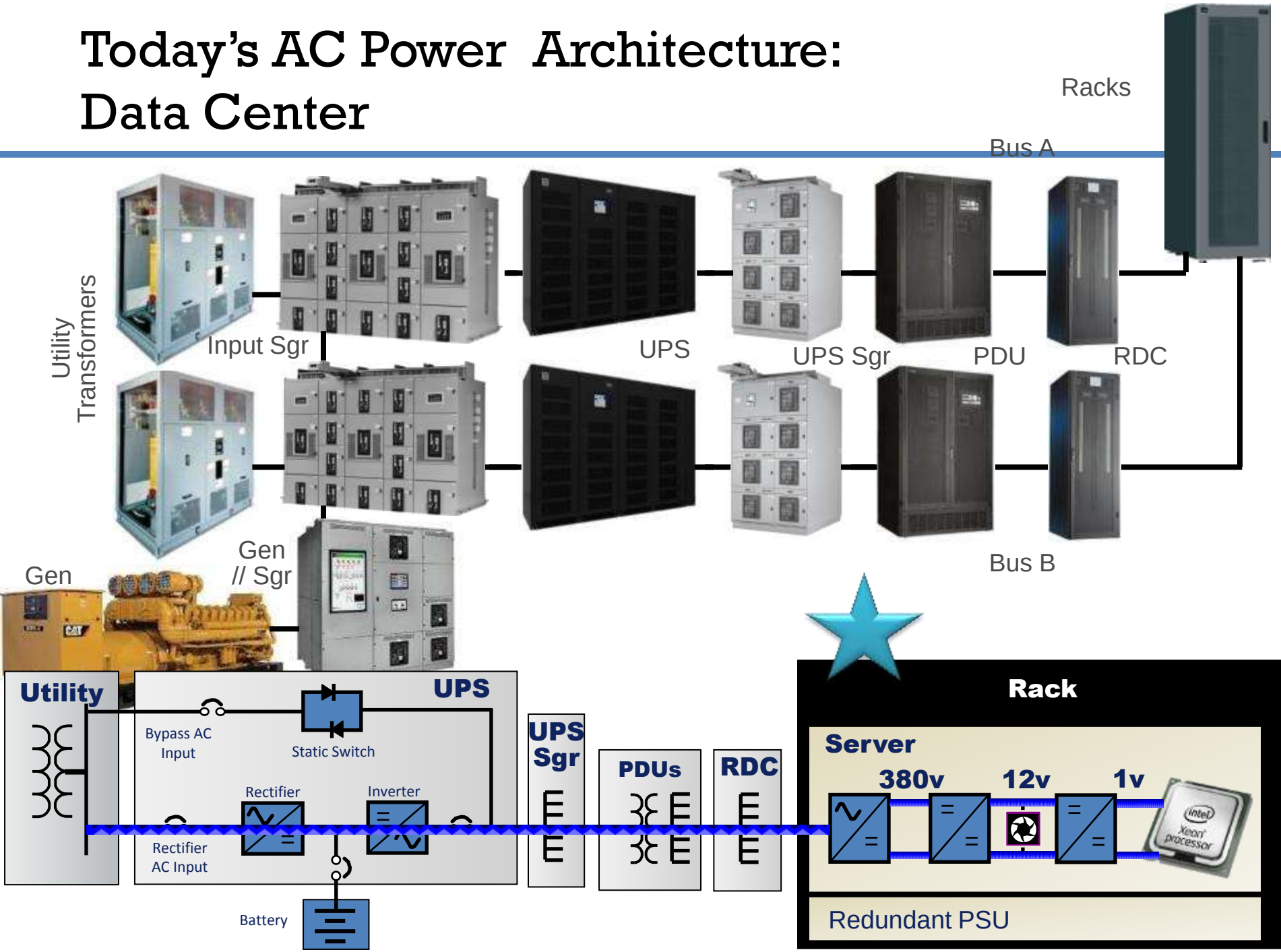
Grounding System:

- A good grounding system will eliminate many of the common electrical disturbances such as nuisance tripping, common mode noise interference, etc.
- The grounding system of the Data Center shall be design to achieve less than 5 Ohm.

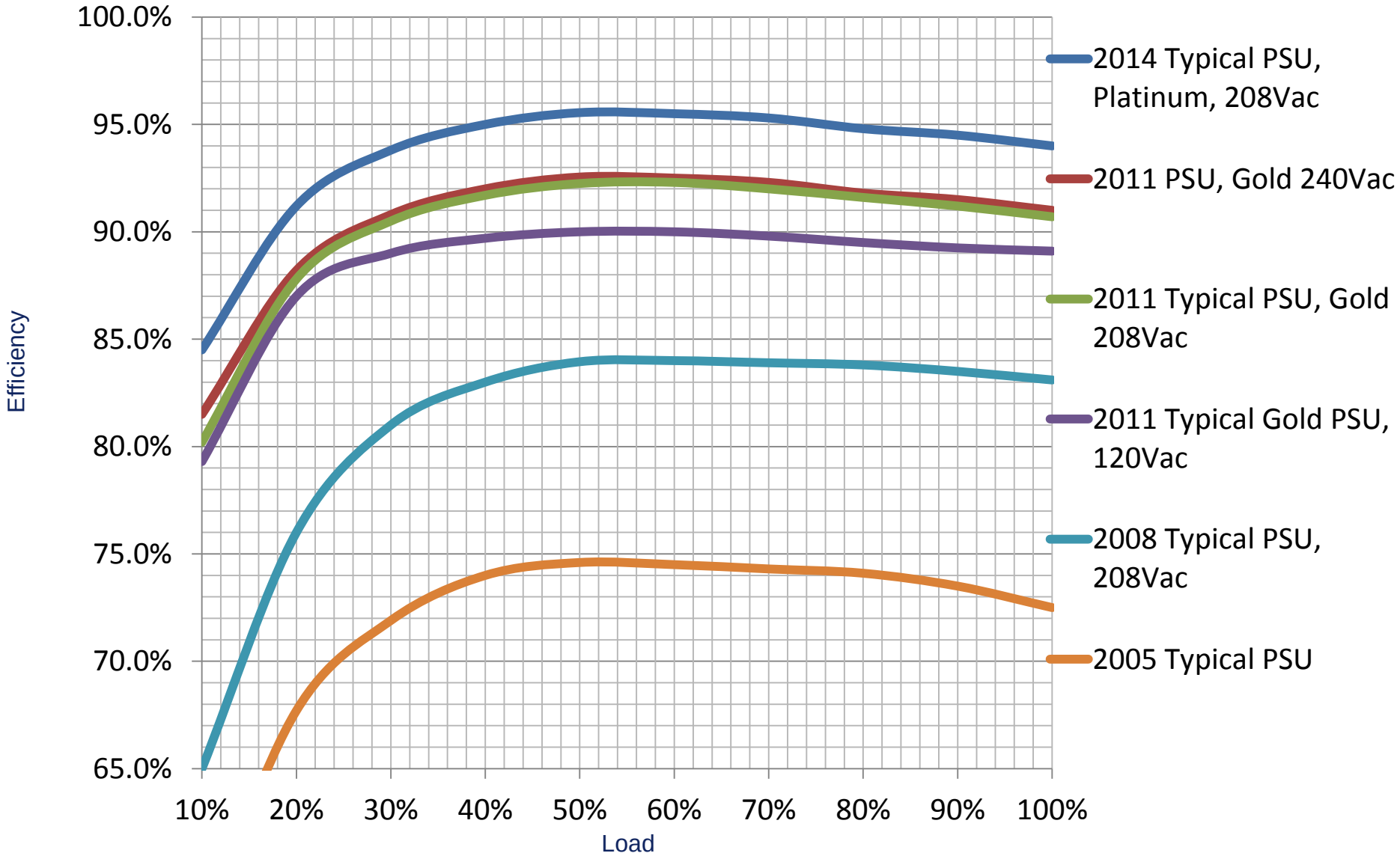


EMERSON
Network Power

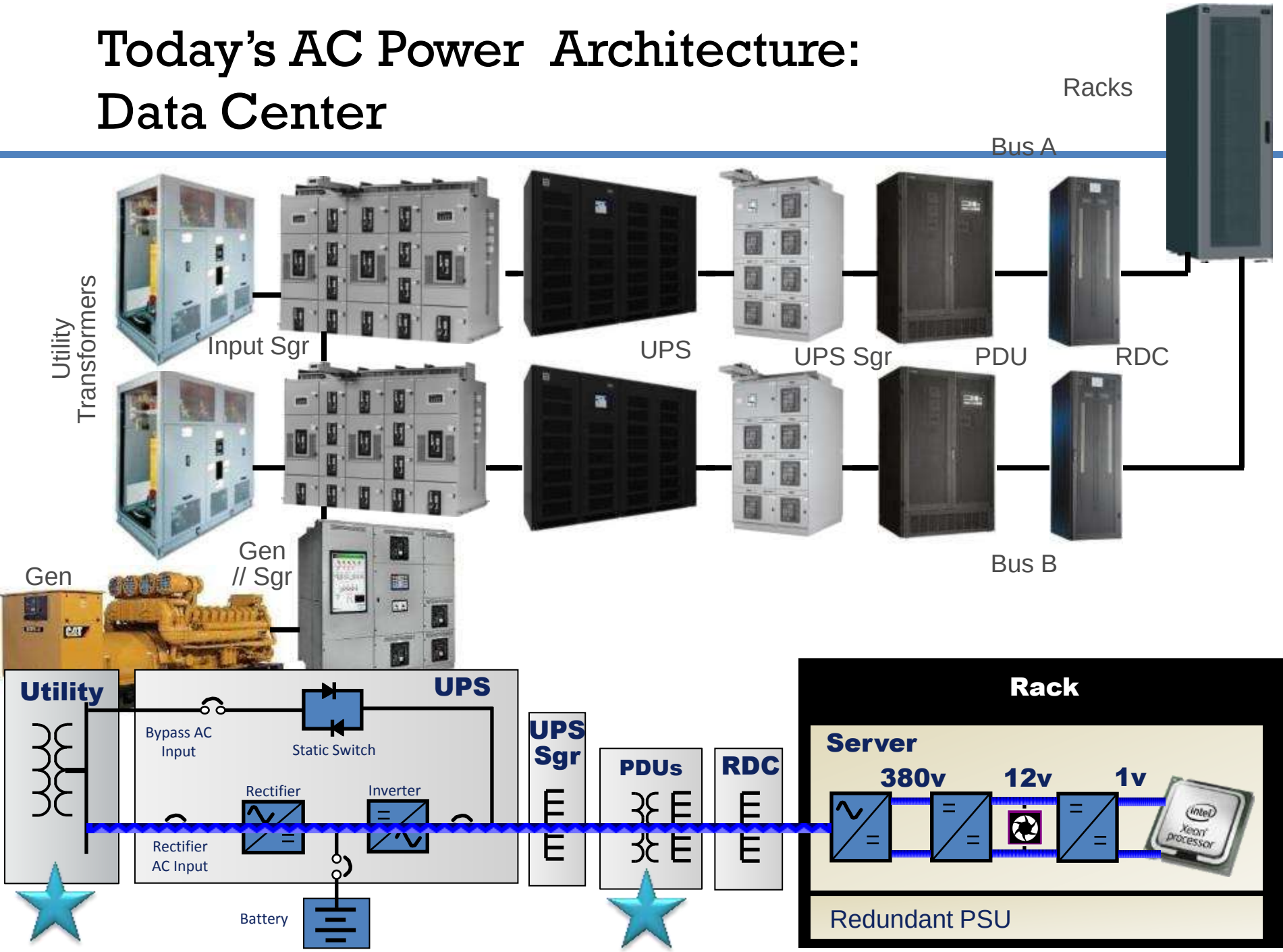
Today's AC Power Architecture: Data Center



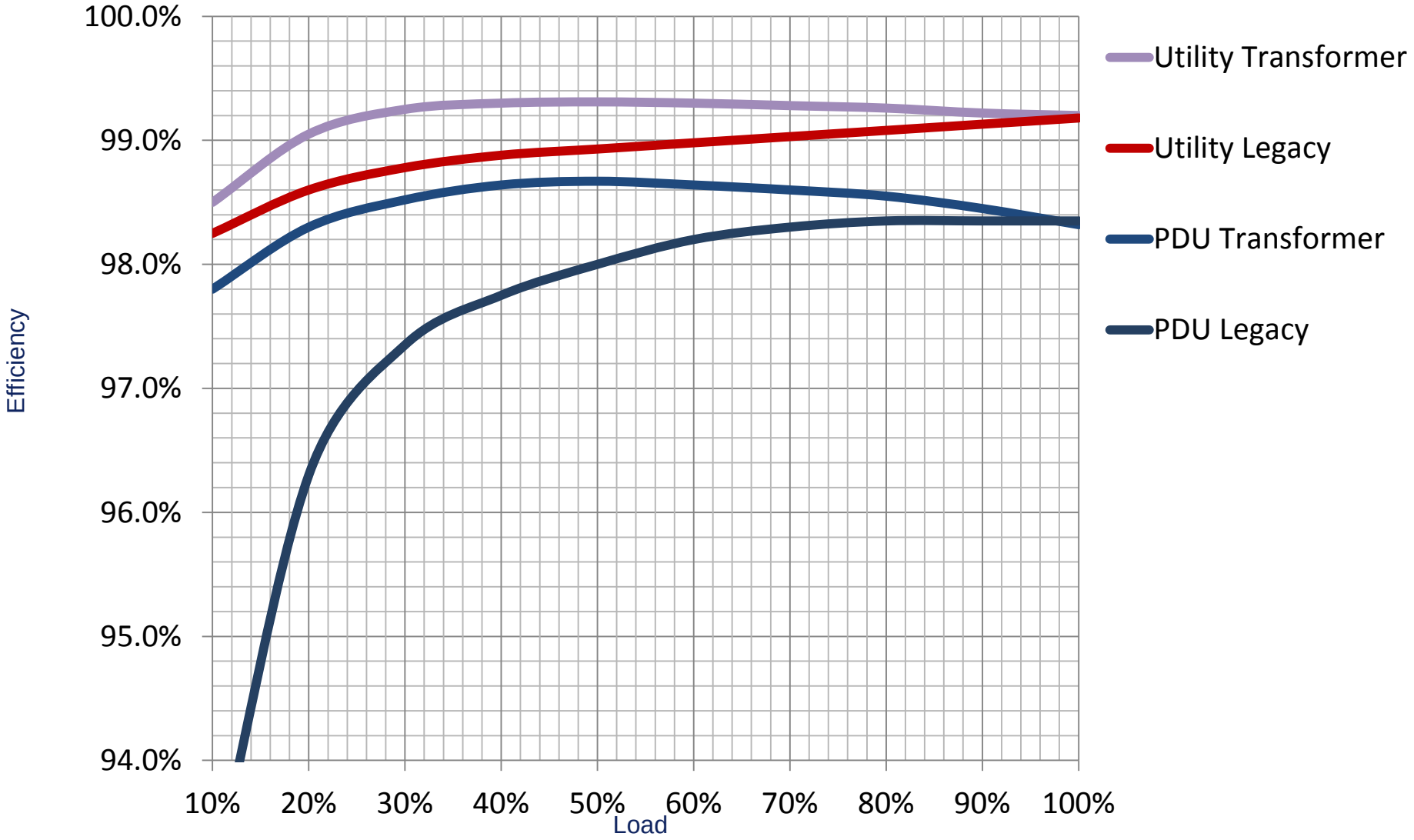
Server Power Supply Efficiency, 12Vdc



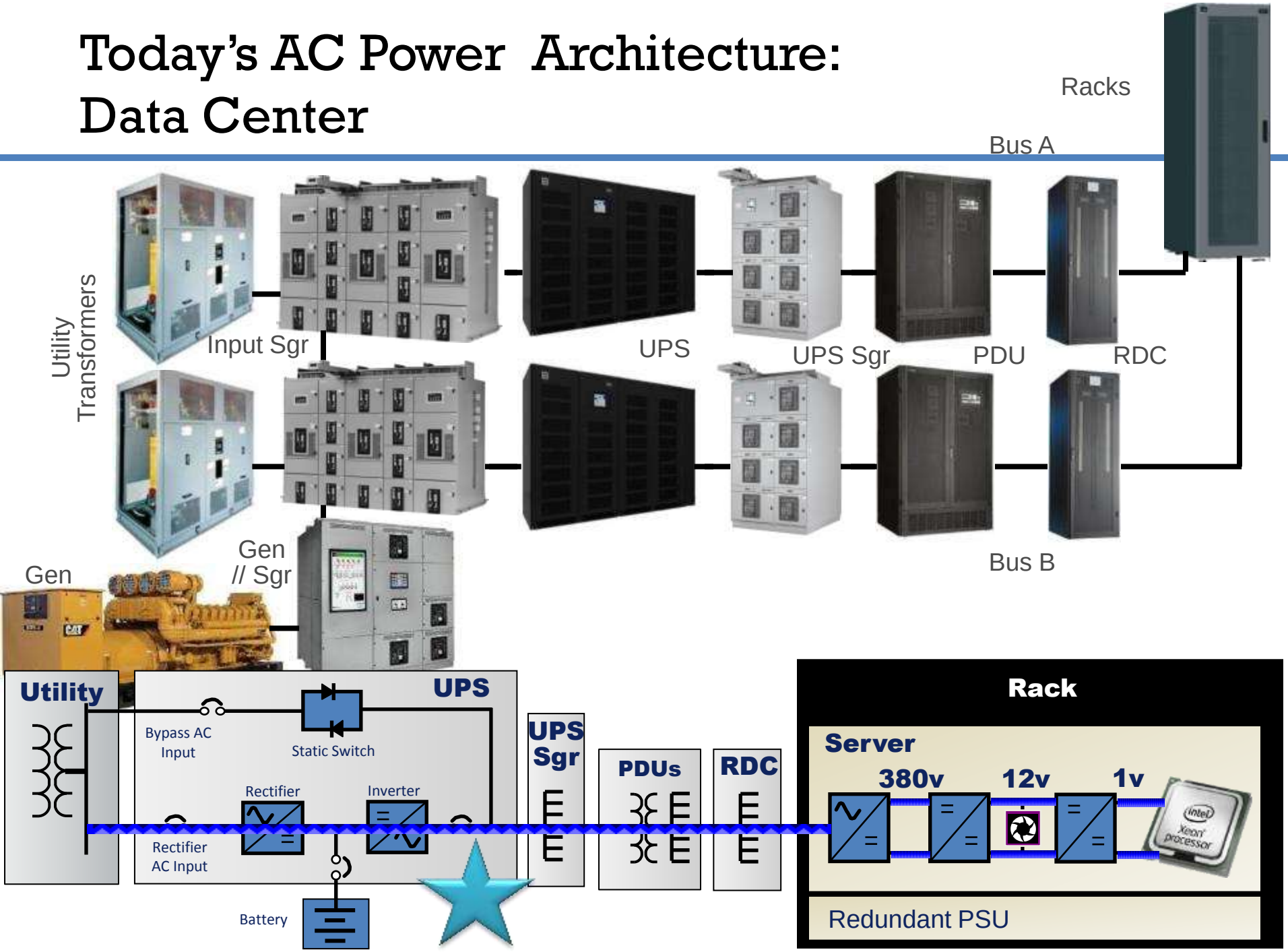
Today's AC Power Architecture: Data Center



Utility & PDU Transformer Efficiency



Today's AC Power Architecture: Data Center



Maximum Efficiency UPS Systems Available: Trinergy Cube, NX, 80.Net

- Industry's highest operational efficiency
- 415/240 volt system
- Systems up to 24 MW using 3MW modules
  - Single modules up to 3MW
- Unity power factor rating
  - Can handle leading/lagging PF loads without de-rating
- State of the art input performance
  - Low Input Current Distortion, less than 3%
  - High Input Power Factor, 0.99 over full operating range
- Robust overload capability
  - 125% for 10 minutes, 150% for 1 minute







World Class large Transformer-*free* UPS

Small footprint/light weight

Modular construction

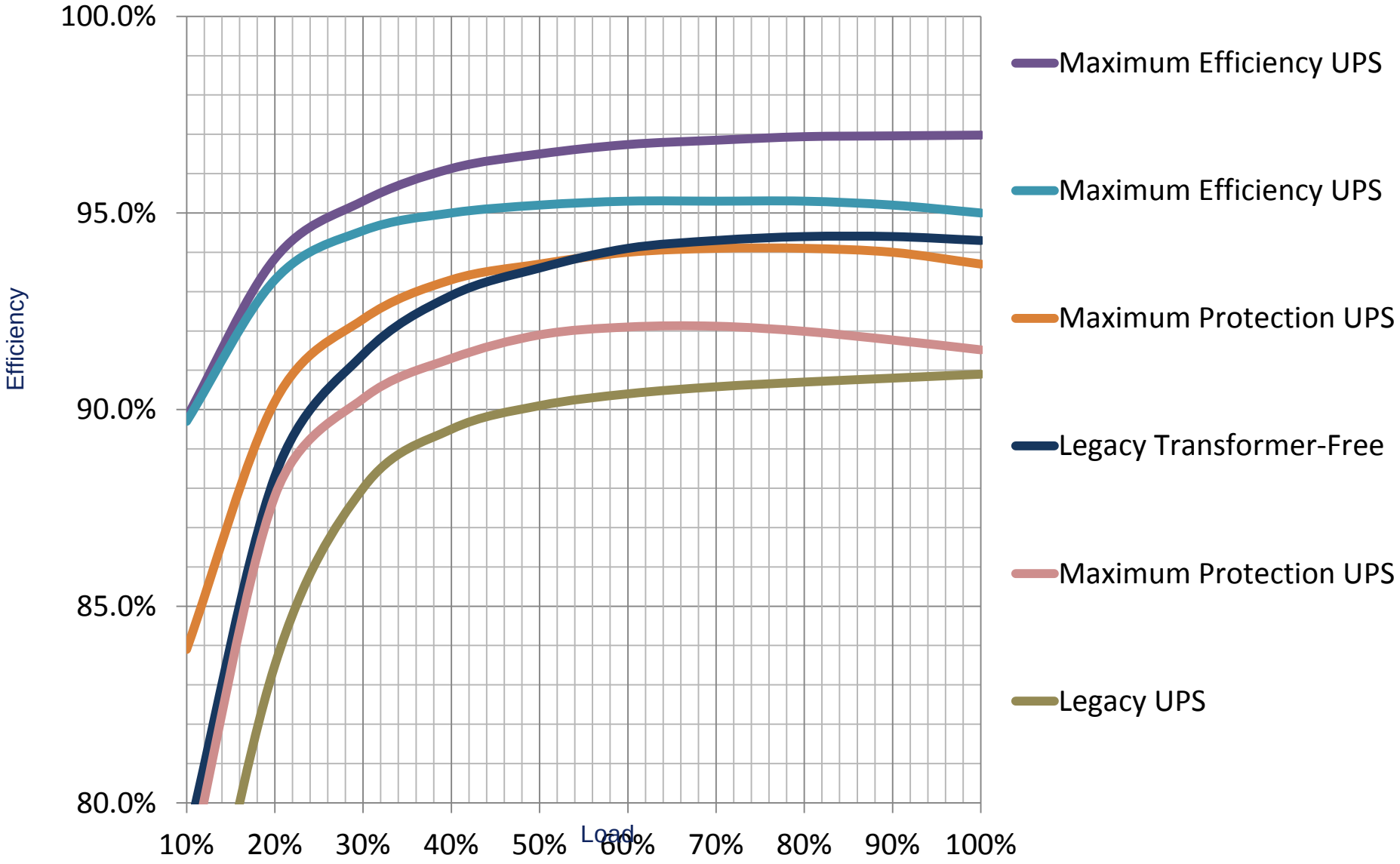
80-NET

- Ratings up to 500kW
- High Efficiency
  - 95+% Dual Conversion
  - 98+% Intelligent Eco mode

Liebert NX

- Ratings up to 800kVA
- Highest Efficiency
  - 96+% Dual Conversion
  - 98+% Active Inverter Intelligent Eco mode

UPS System Efficiencies

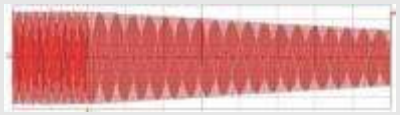
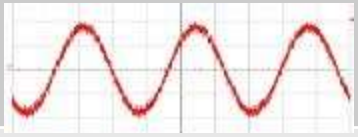
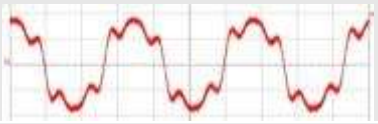
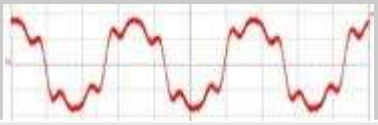


UPS Topologies – Defined

- IEC 62040-3: Uninterruptible power systems (UPS) Part 3: Method of specifying the performance and test requirements

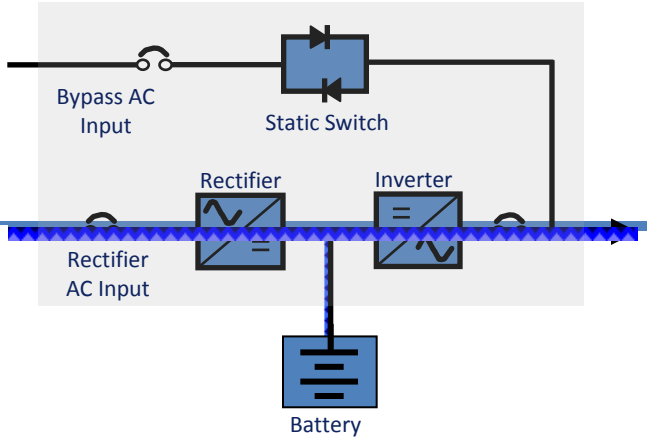
IEC	Description	Topology
VFI	Voltage and Frequency of the Output are Independent of the Input	Dual Conversion
VI	Voltage of the Output is Independent of the Input (Frequency in = Frequency Out)	Line Interactive
VFD	Voltage & Frequency of the Output are Dependent on the Input	Off-Line

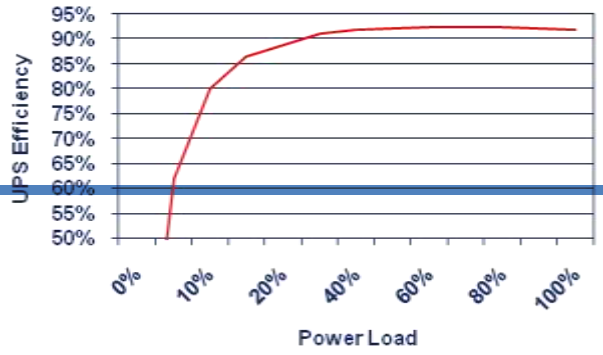
Power Quality Response Summary

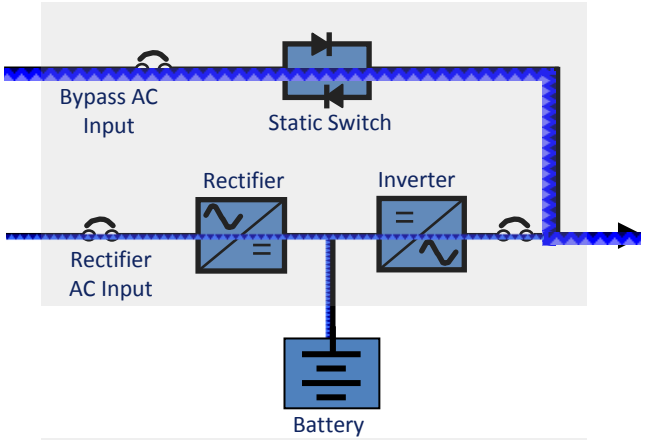
Condition	Waveform	VFD, Off-Line	VI, Line Interactive	VFI, Dual Conversion
Power Disturbance				
Sag or Swell				
Input Noise				
Load Distortion				
Utility Distortion				
Frequency Deviation				

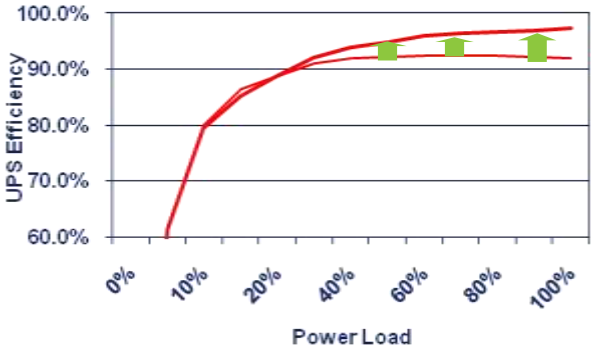
IEC 62040-3

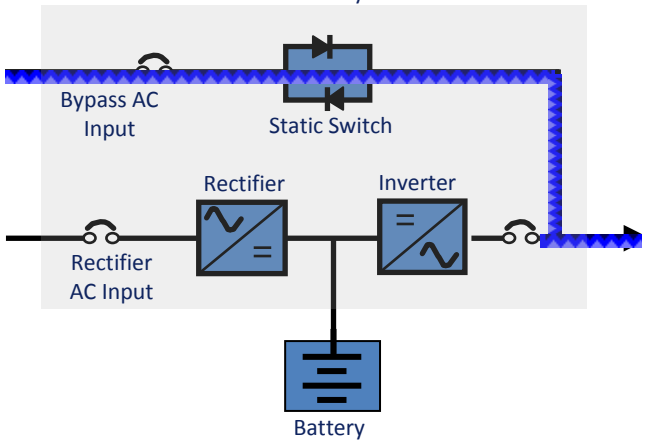
- VFI, Dual Conversion
  (V/F-Independent)
- VI, Line Interactive
  (V-Independent)
- VFD, Off-Line
  (V/F Dependent)

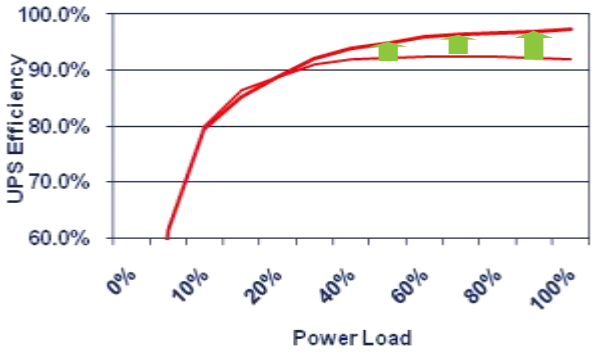




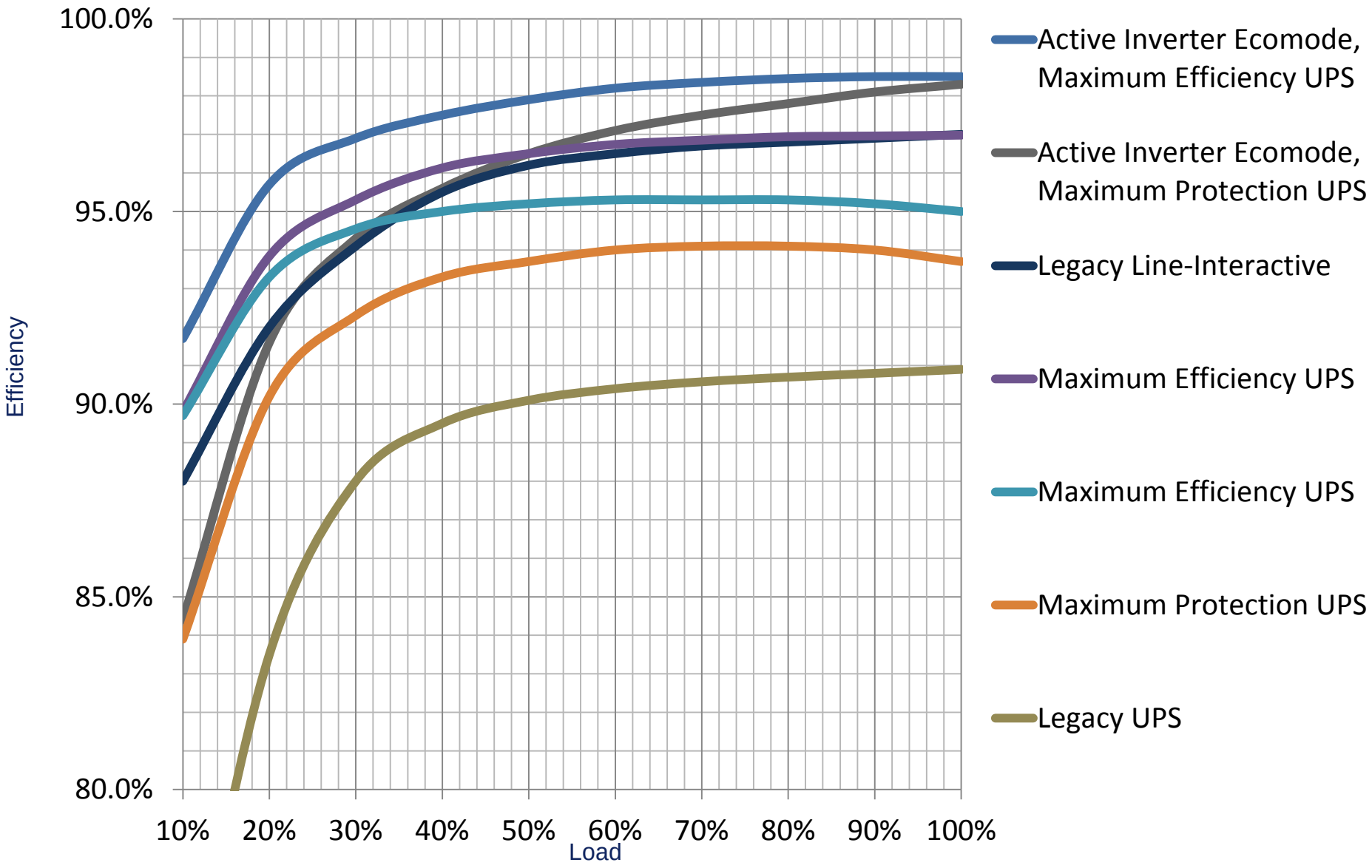




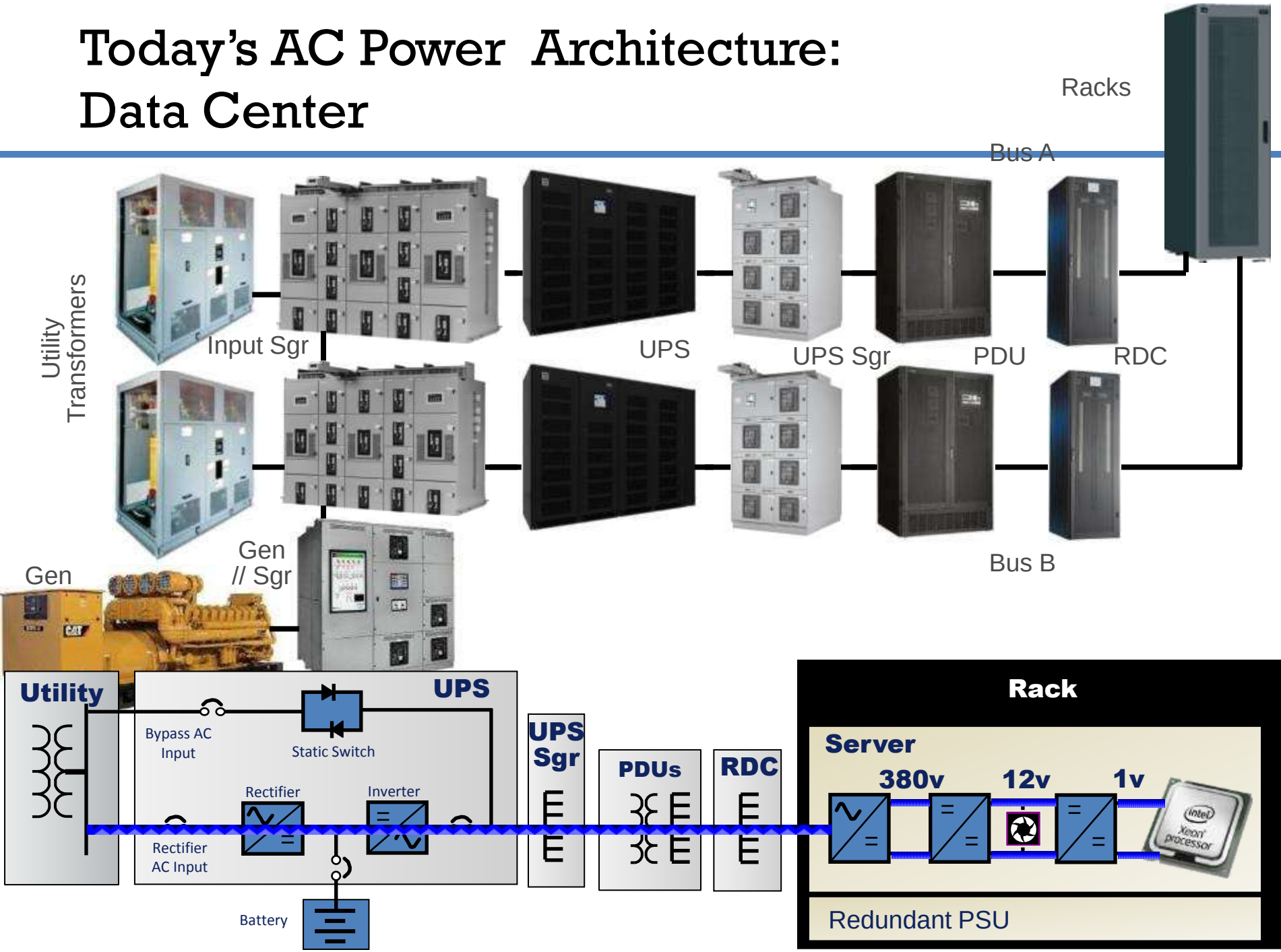




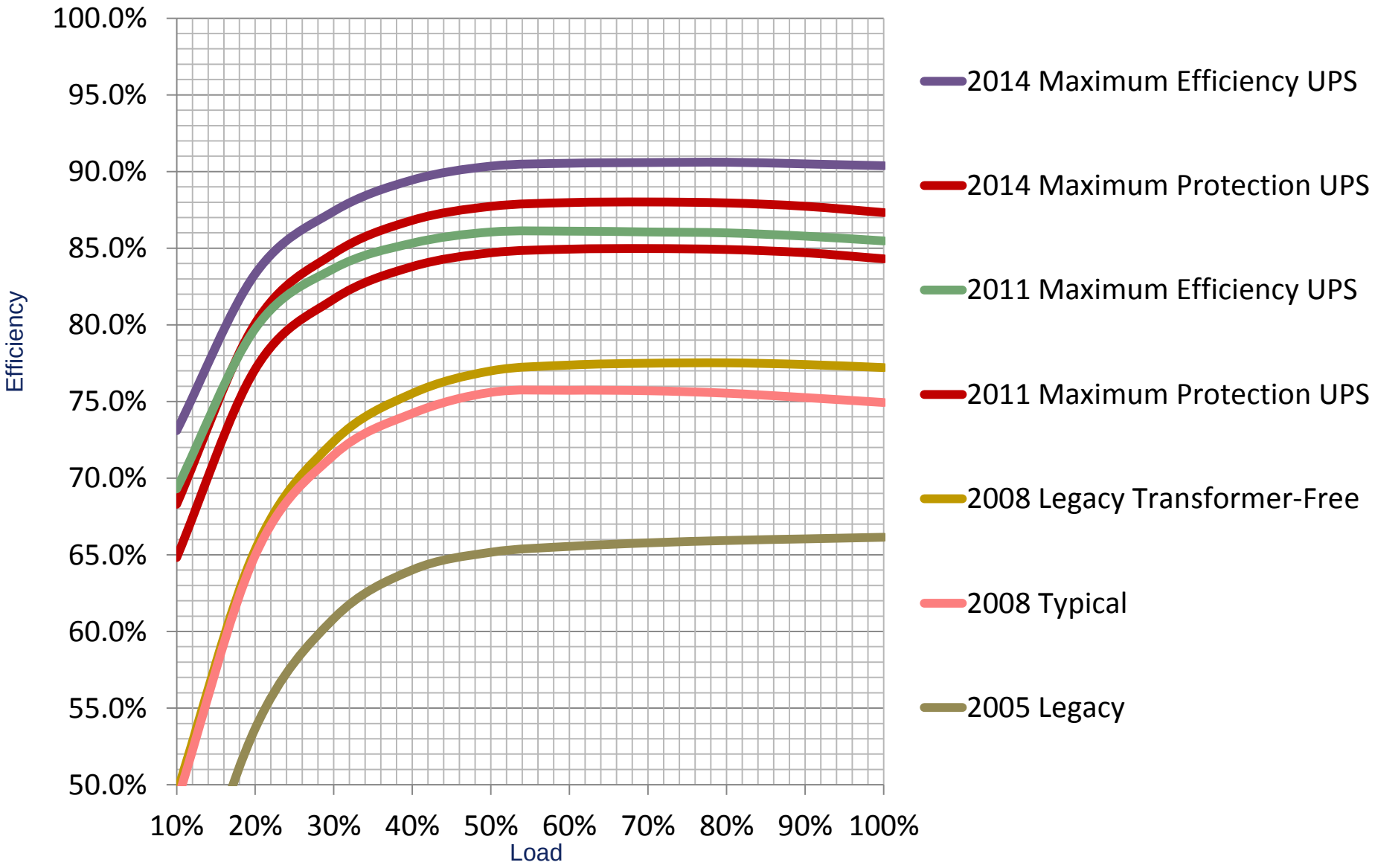
UPS System Efficiencies



Today's AC Power Architecture: Data Center



End-to-End Efficiency



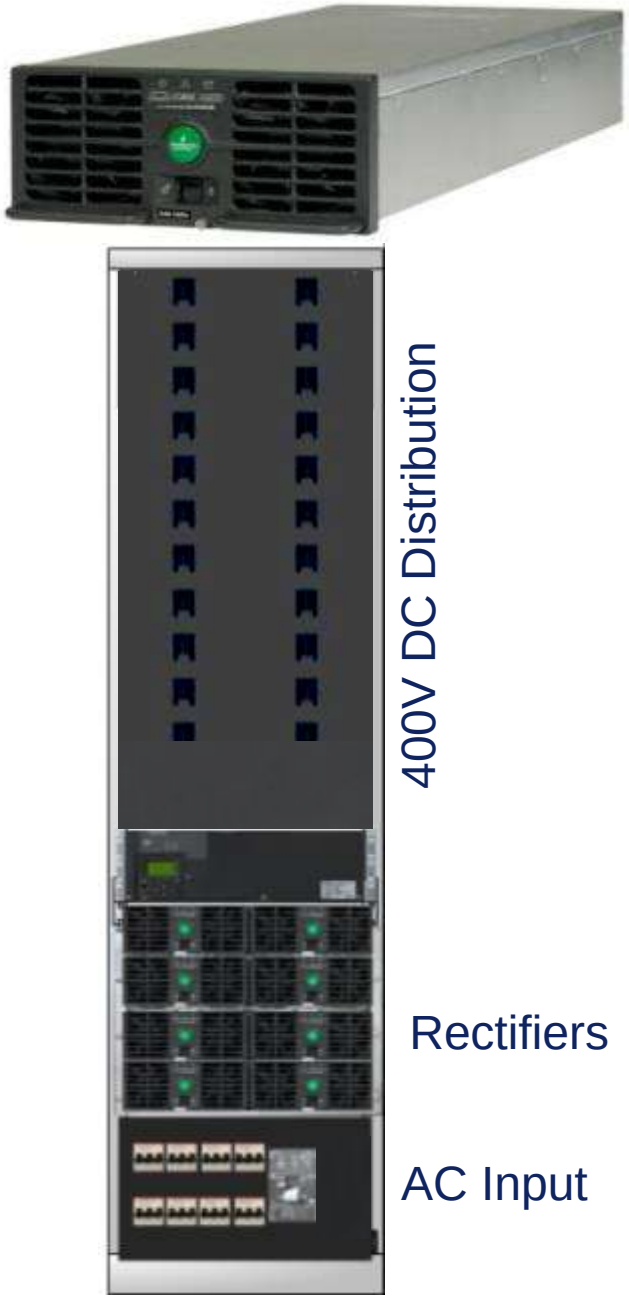
400Vdc Systems in the Data Center?

- Today's power demand is mostly for electronic loads which inherently consume DC power
  - Telecom – significant copper reduction versus 48V distribution lowers installation and operational costs
  - Data centers – simplifies the power chain
- Elimination of conversion stages compared to AC
  - Reliability – fewer components in series
- Interest in mandates to introduce distributed generation
  - DC sources more easily integrated into main DC bus

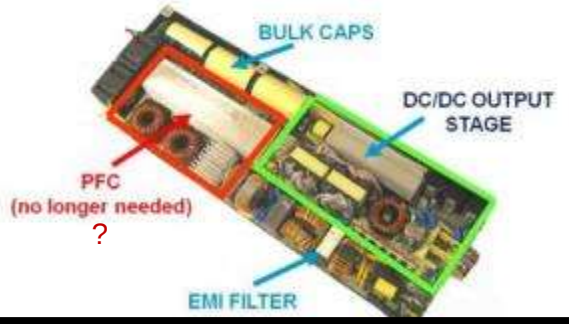
Industry Drivers	Telecom	Datacom	Micro-grids
Reduce distribution losses	✓	✓	
Reduce overall copper required; cost, weight	✓	✓	✓
Increase end-to-end power chain efficiency	✓	✓	✓
Easy integration with renewable sources	✓	✓	✓
Smaller footprint per kW	✓	✓	
Simpler architecture, fewer components		✓	✓
No phase/voltage balancing		✓	✓

400V DC Power System

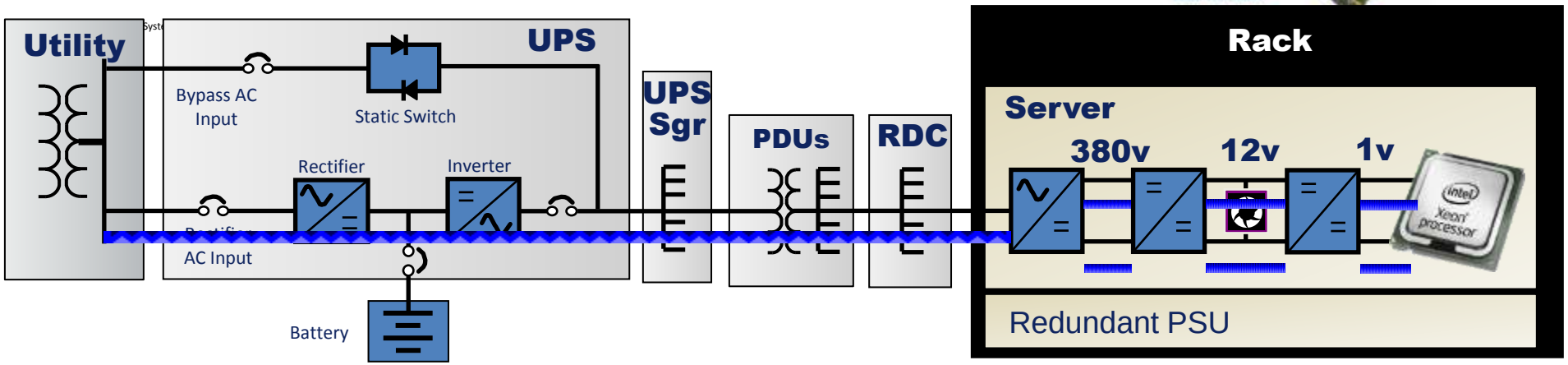
- Power System:
  - 120kW base system; bulk or integrated output
    - Incorporates branch ground fault detection for High-Resistance Midpoint Ground configuration
    - cUL/CE 60950 Listed; FCC class B
    - 2000mm x 600mm x 1100mm footprint
    - Top or bottom cable entry
    - Battery cabinets available
  - Expand with additional 120kW System
- 15kW Rectifier Module:
  - 15kW output capacity / 40A @ 380V DC
    - Full galvanic isolation
    - Full performance operating range: -5º to +45ºC
  - Output range: 290V to 400V DC
    - Three-phase AC input; wide input range



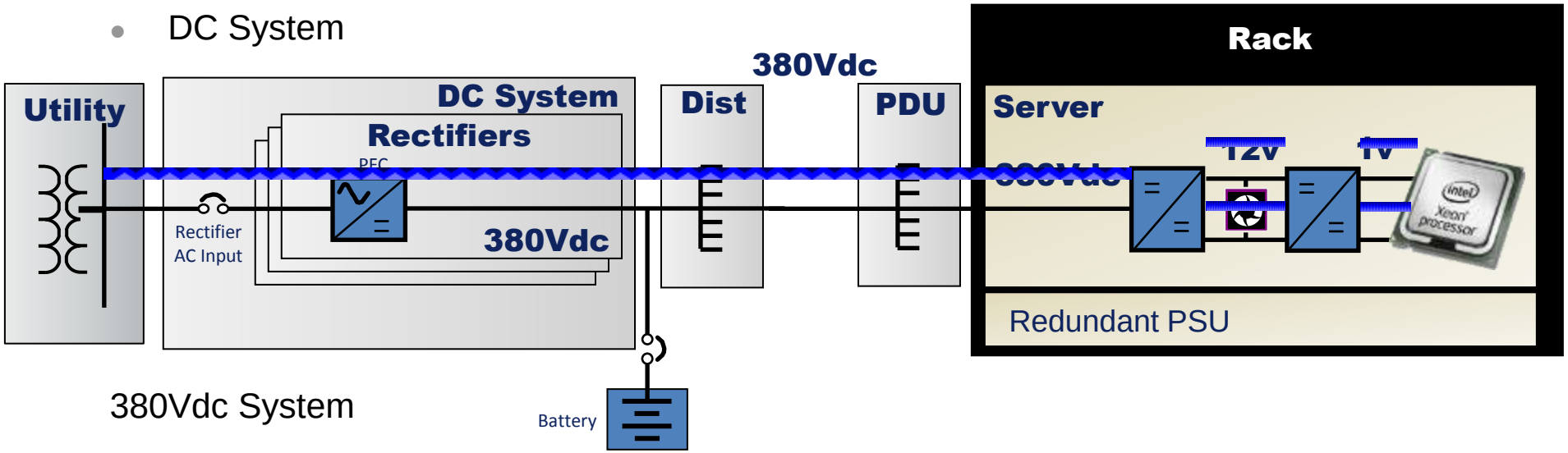
400Vdc Architecture



- AC System

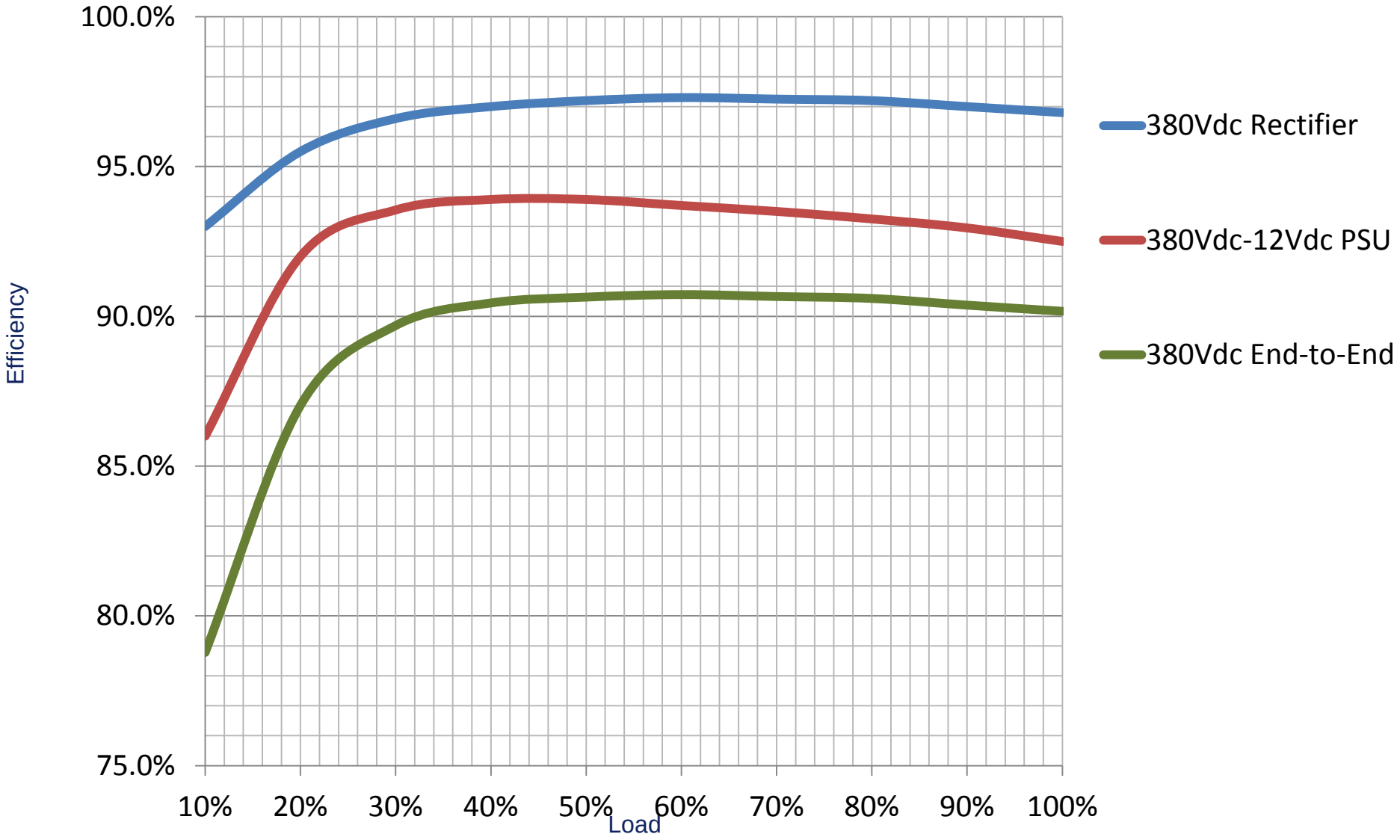


- DC System

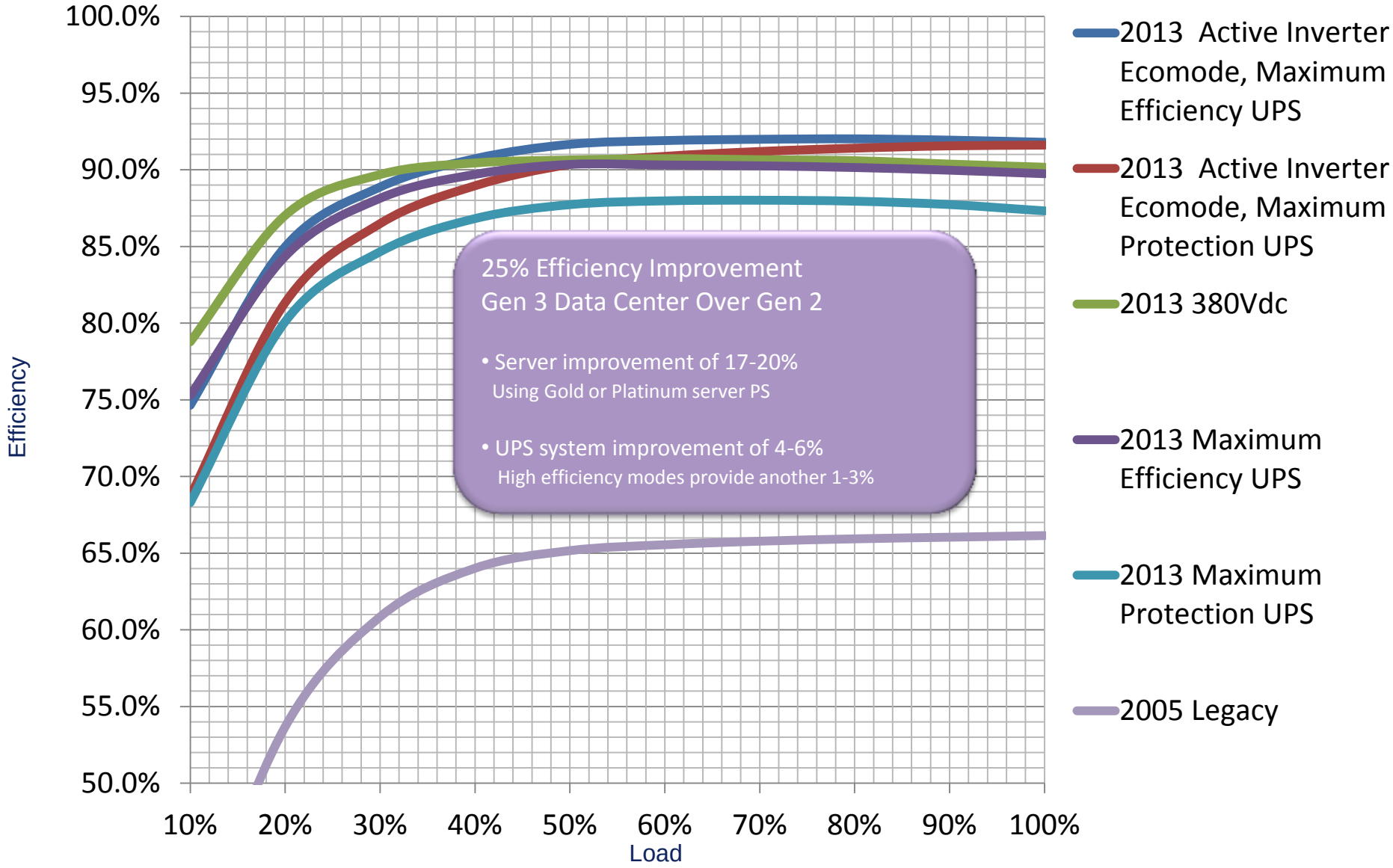


380Vdc System

400Vdc Efficiency, End-to-End



End-to-End Power Efficiency



Summary

- DC demand is growing big, fueled by IoT
  - Complicated and extremely critical
  - Efficiency drive => Innovation; product and solution
- Efficiency without Compromising Availability
- Architectures and building blocks are key
- Need to be ready for Technology change; flexibility is the key

POWER AND COOLING CONSULTANTS MASTER CLASS 2016

HITTING THE GREEN MARK:

BEST PRACTICES IN DATA CENTER OPTIMIZATION

EMERSON
Network Power