



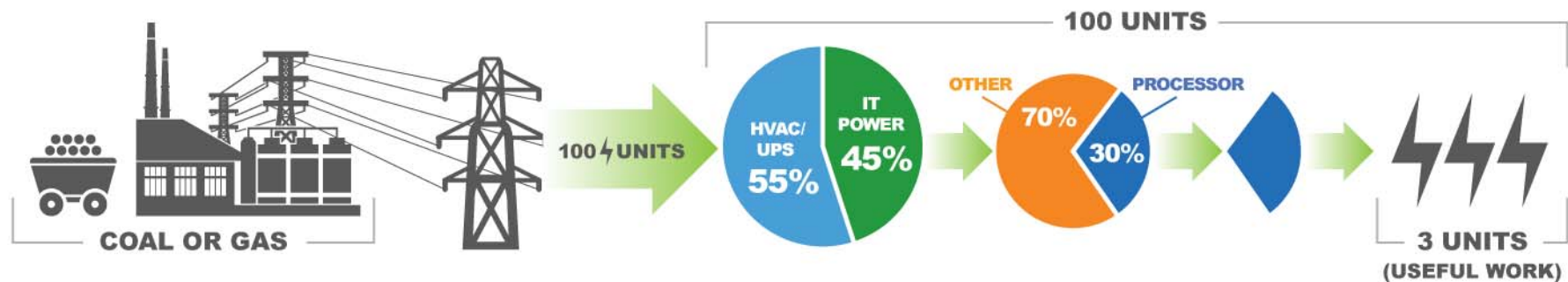
# Grid to Data Center – Room for Improvement

**Wasted energy burdens the environment and increases operational expenses**

## Carbon Footprint in IT Computing

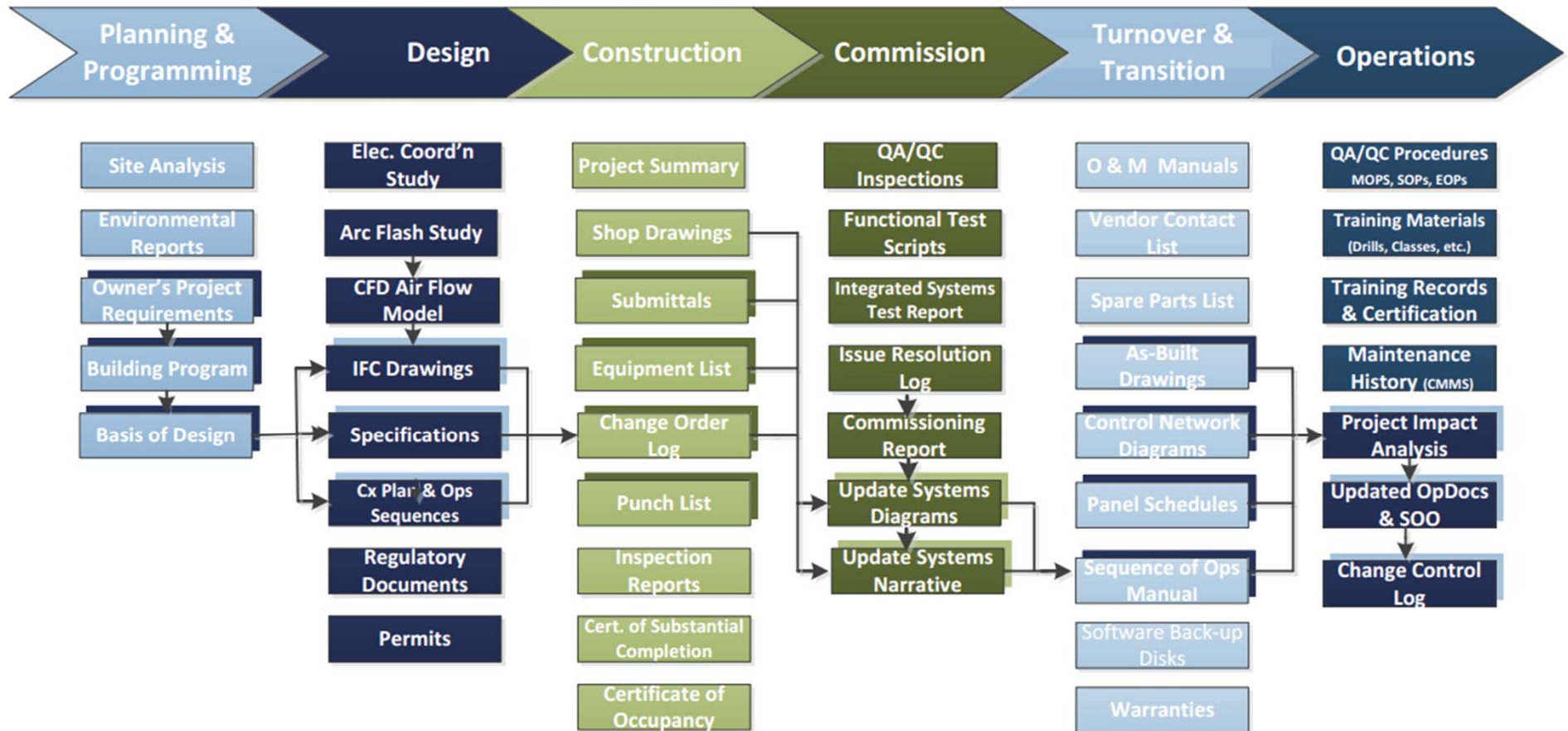
- » Only 3% of the energy entering a data center is used for net computing creating opportunities for efficiency improvements

(Source: IBM, 2009)



Item	Generation	The Grid	Data Center	Server	Processor	Server Load
Units Delivered	65 Steam 35 Electric	35	33 (45% DCiE, 2.2 PUE)	15	5	0.1- 4***

# Sequence of Operations and the Data Center Lifecycle



# Key Issues

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- Improve efficiency / lower TCO
- Improve reliability –
  - Look at it as a system, not parts and pieces – they interact
- Reduce startup time, costs & improve scalability

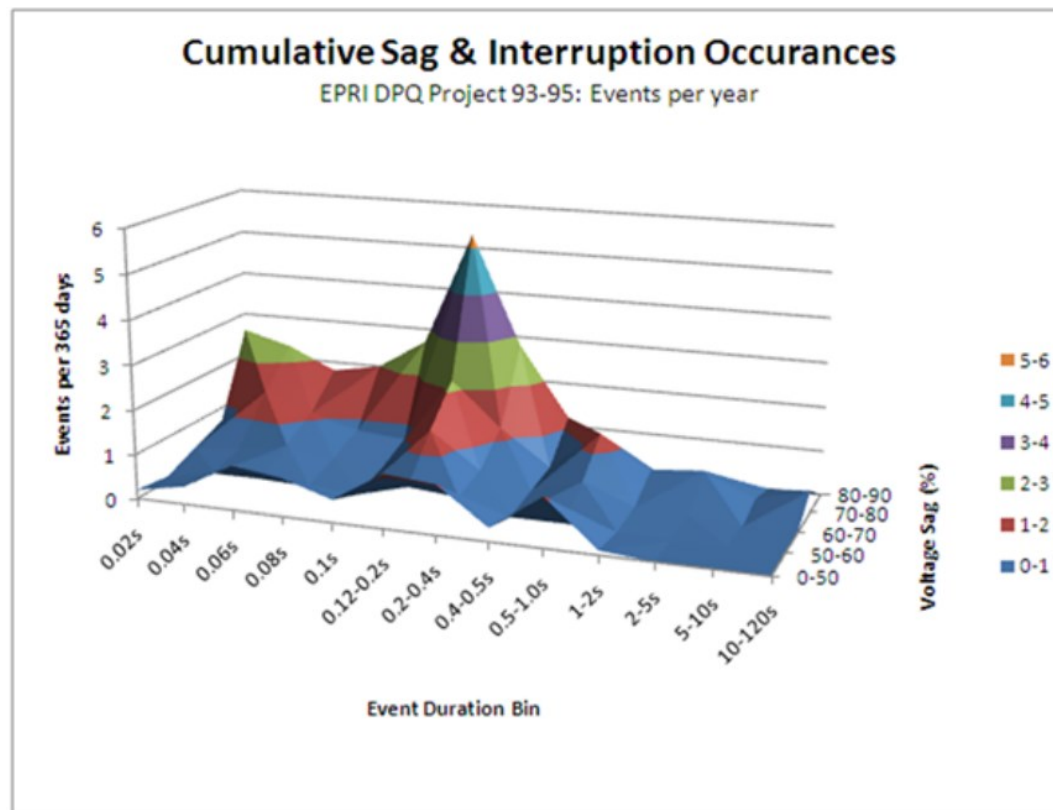
## IEC 62040-3 Section 5.3.4

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- **Voltage/frequency dependent (VFD)**
  - The UPS output voltage and output frequency are identical to the input voltage and frequency from the AC source. (Standby UPS)
- **Voltage independent (VI)**
  - The UPS provides a stable output voltage to the load[s], but its frequency is identical to the input AC source. (Line Interactive UPS)
- **Voltage/frequency independent (VFI)**
  - The UPS provides stable voltage and stable frequency to the connected loads independently of the input AC source. (Double conversion UPS)

# Improving Efficiency

- > 99.9% of time power is acceptable

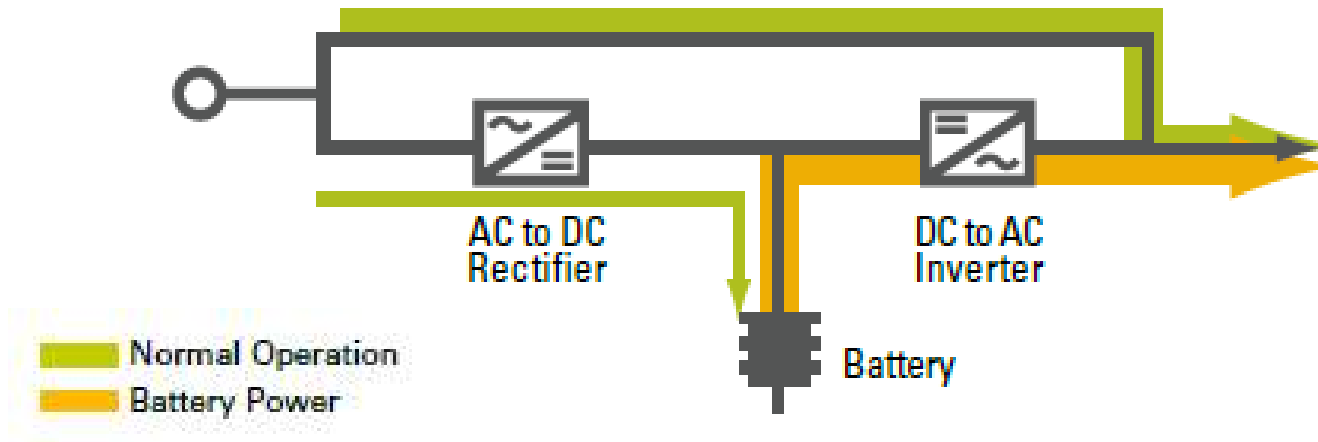


# EPA Energy Star

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- **Single-normal-mode UPS**
  - A UPS that functions within the parameters of only one set of input dependency characteristics, i.e., a UPS that functions only as VFI.
- **Multiple-normal-mode UPS**
  - A UPS that functions within the parameters of more than one set of input dependency characteristics, i.e., a UPS that can function as either VFI or VFD.

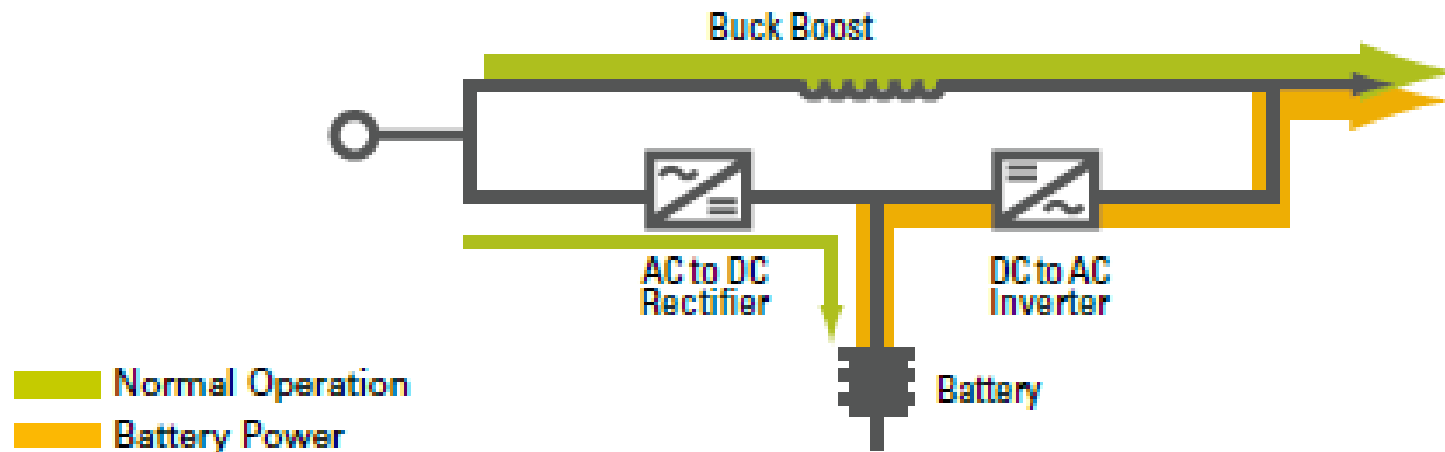
# UPS topologies: standby UPS



- Equipment uses utility power until UPS detects problem (sag, surge or outage)
- When problem occurs UPS switches to battery
- UPS uses batteries frequently
  - Reduces runtime and service life

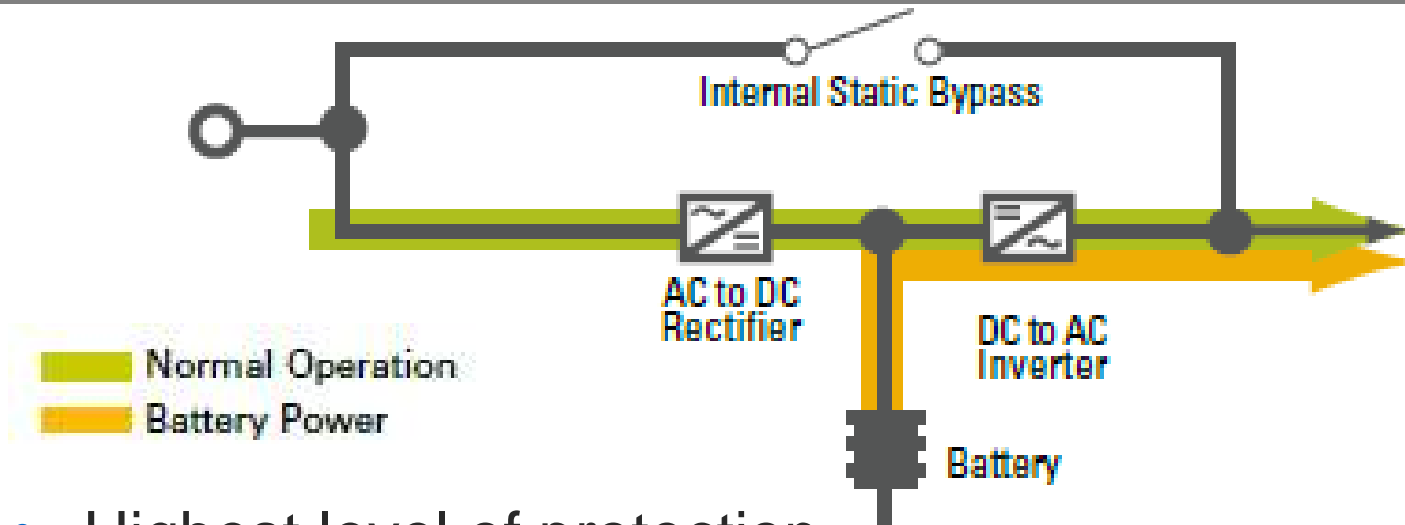


# UPS topologies: line interactive



- Regulates voltage by boosting/decreasing utility power or resorting to battery power
- Transfer to battery within 3-8 ms
- Battery use less than standby but greater than online

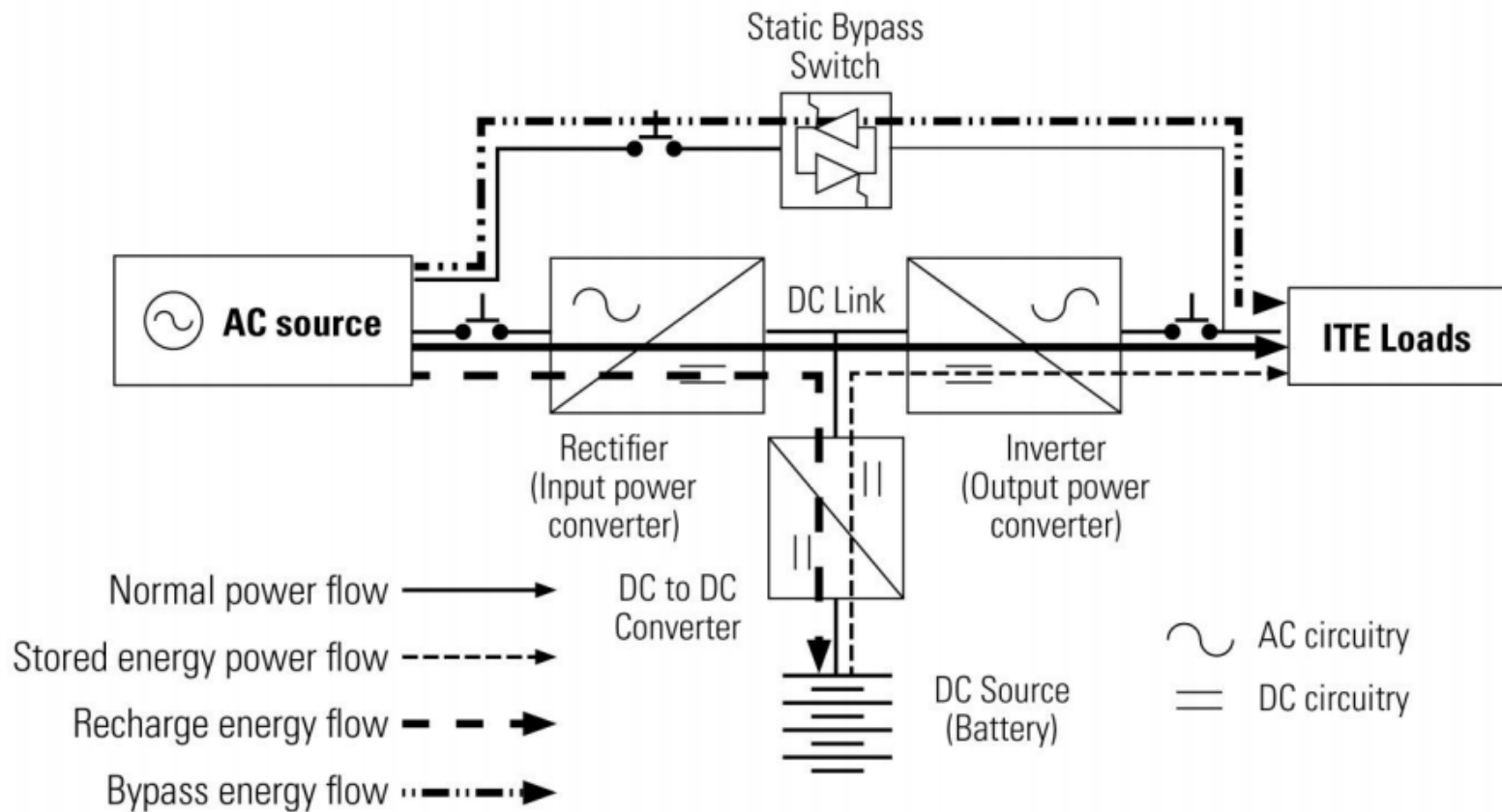
# UPS topologies: online



- Highest level of protection
- Isolates equipment from raw utility
- AC to DC to AC
- If input voltage within tolerances, output is regulated w/o battery
- Uses batteries < standby and line interactive

# Review Terminology

- Multi-Mode UPS topology



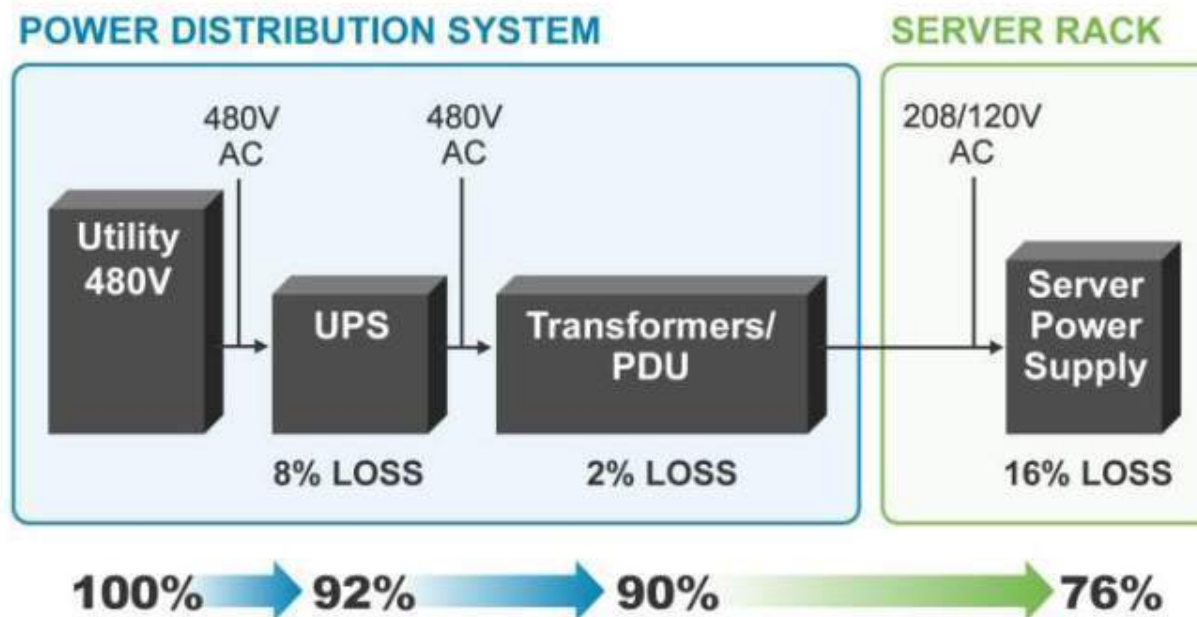
# Tips to consider to improve efficiency

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- Higher voltages to servers (e.g. no more 208Y/120)
  - Remove transformers
- Powering dual corded servers on one side with raw utility power or eco-mode UPS -- “Free Power Quality”
- Using “eco-mode” / “multi-mode” (what Eaton calls ESS for Energy Saver System) on single-corded systems
  - Be careful of the terminology
  - Some “eco-mode” UPSs require 12 ms to transfer
    - Can be a problem for downstream STSs

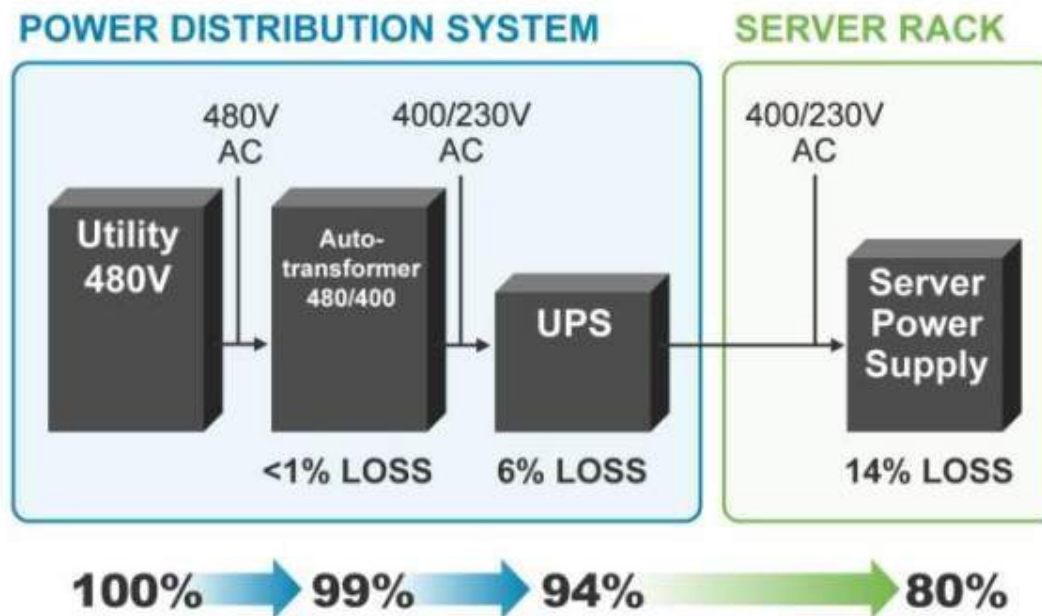
# Increasing Voltage / Removing Transformers

- Transformer losses are a substantial percentage of the power chain efficiency



# Increasing Voltage / Removing Transformers

- If willing to give up PDU isolation, a 400Y/230 system can give 4% higher efficiency.



# What is that worth?

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- 1 MW data center load
  - \$0.10/kWh, \$12/kW, 8760 hrs./yr (continuous)
    - 17520000 kWh
  - \$36K/yr savings (\$277K, 10 years, 5% cost of money)

	%eff	Power Loss	Energy Loss	\$ kWh Loss <sup>1</sup>	\$ kW (demand) <sup>1</sup>
208Y/120	0.76	240 kW	2.1 MWh	\$210K	\$35K
400Y/230	0.80	200 kW	1.8 MWh	\$180K	\$29K
Annual difference				\$30K	\$6K

<sup>1</sup>annual

# Understanding Operating Modes

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- **Energy Saver System (ESS):** UPS can switch between modes to reduce losses
- **Energy Saver System Plus (ESS Plus):** Able to inject compensating harmonic currents to cancel distortion
- **Variable Modular Management System (VMMS):** Used in large UPSs to switch on and off banks of rectifiers / inverters as needed.

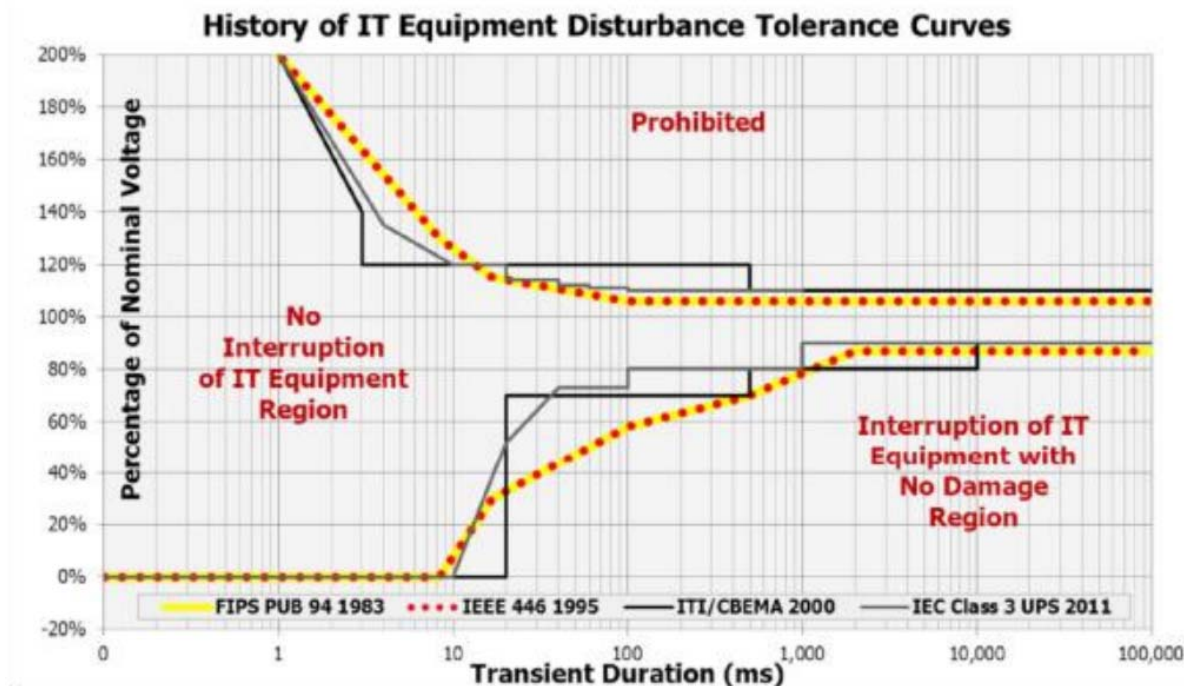


# Key Issues

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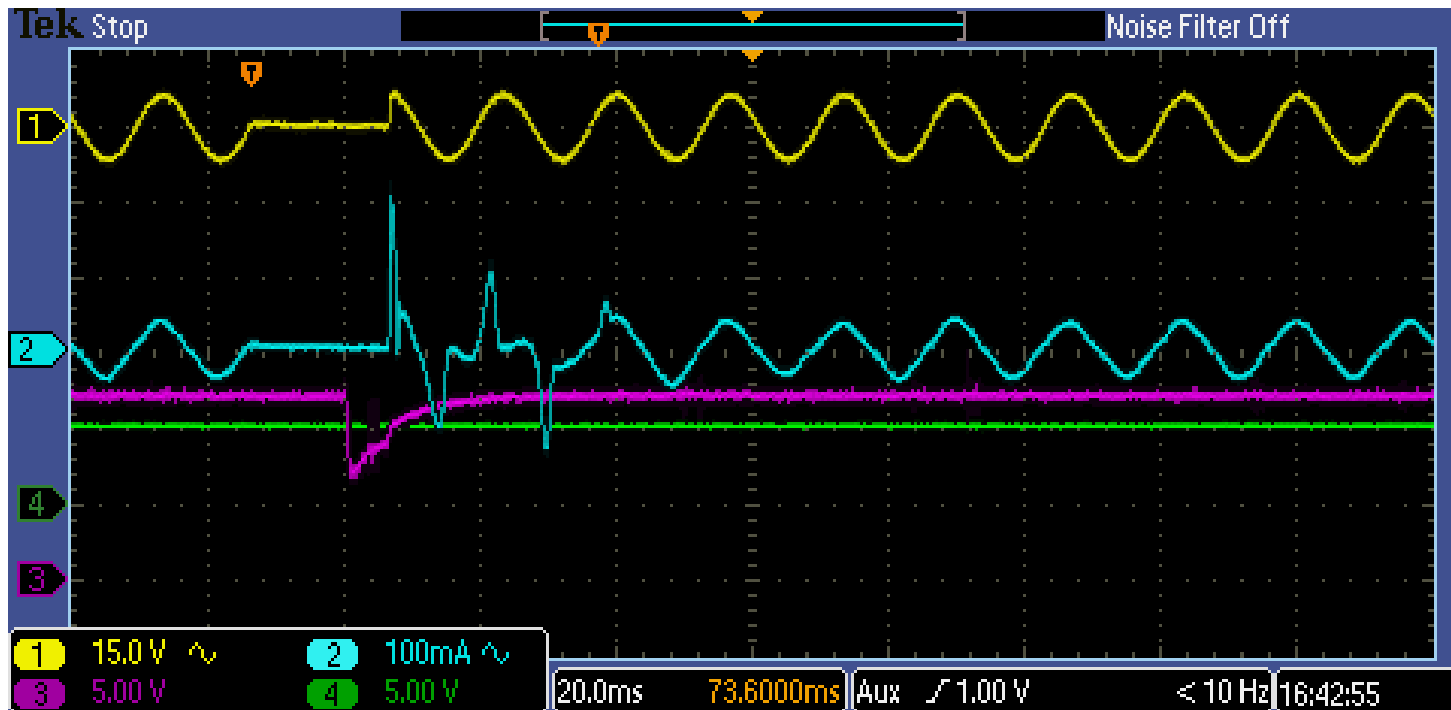
- Improve reliability
  - Virtualized environments
  - Tolerance of leading PF
  - DRUPS vs battery reliability issues

- How much time can a server tolerate 0 volts?
  - Could be as short as 0.01 sec (10 ms)



# PSU bench test

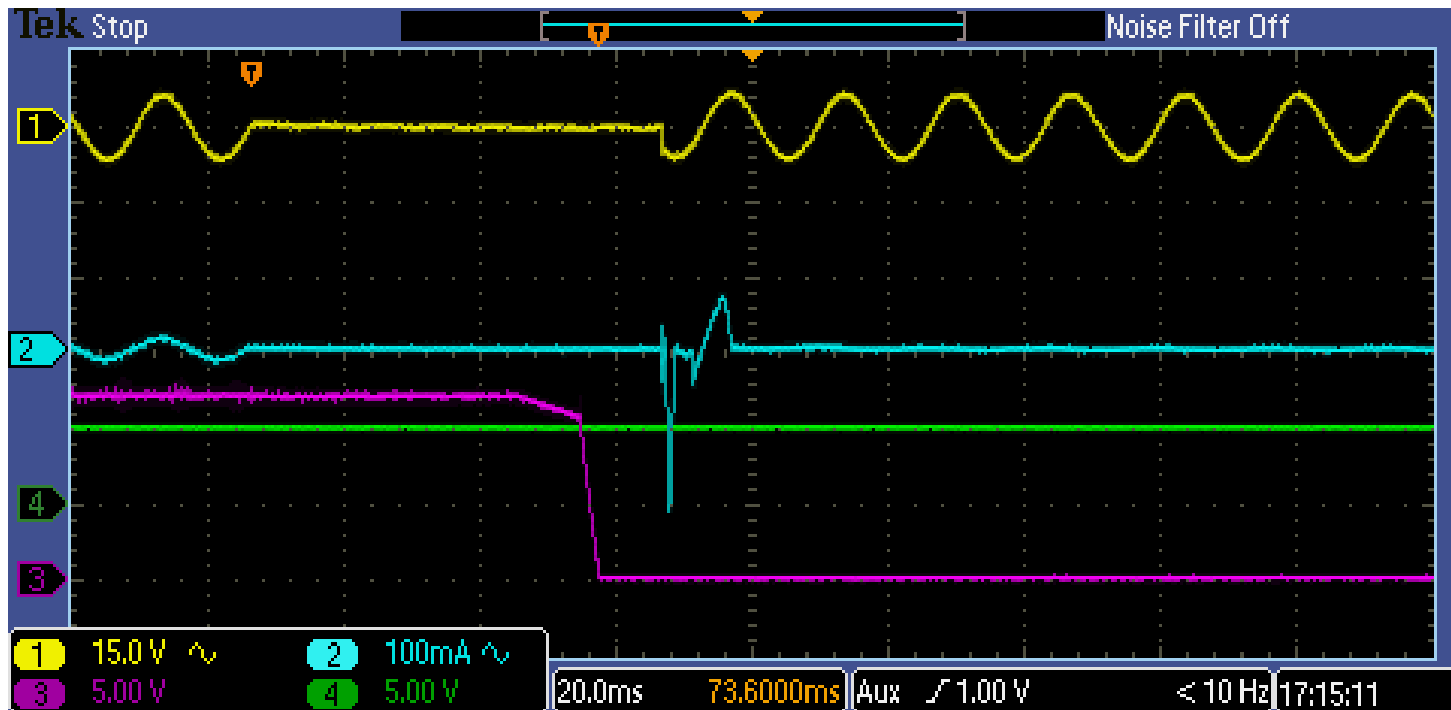
AC Voltage
AC Current
DC Main Voltage
Power OK Signal



- 400W supply, fully loaded
- At  $< 12$  ms started dropping dc bus

# PSU bench test

AC Voltage
AC Current
DC Main Voltage
Power OK Signal



- 400W supply, 1/2 loaded
- 40 ms started to drop dc bus (no restart, POK issues)

# Option to trade efficiency for reliability

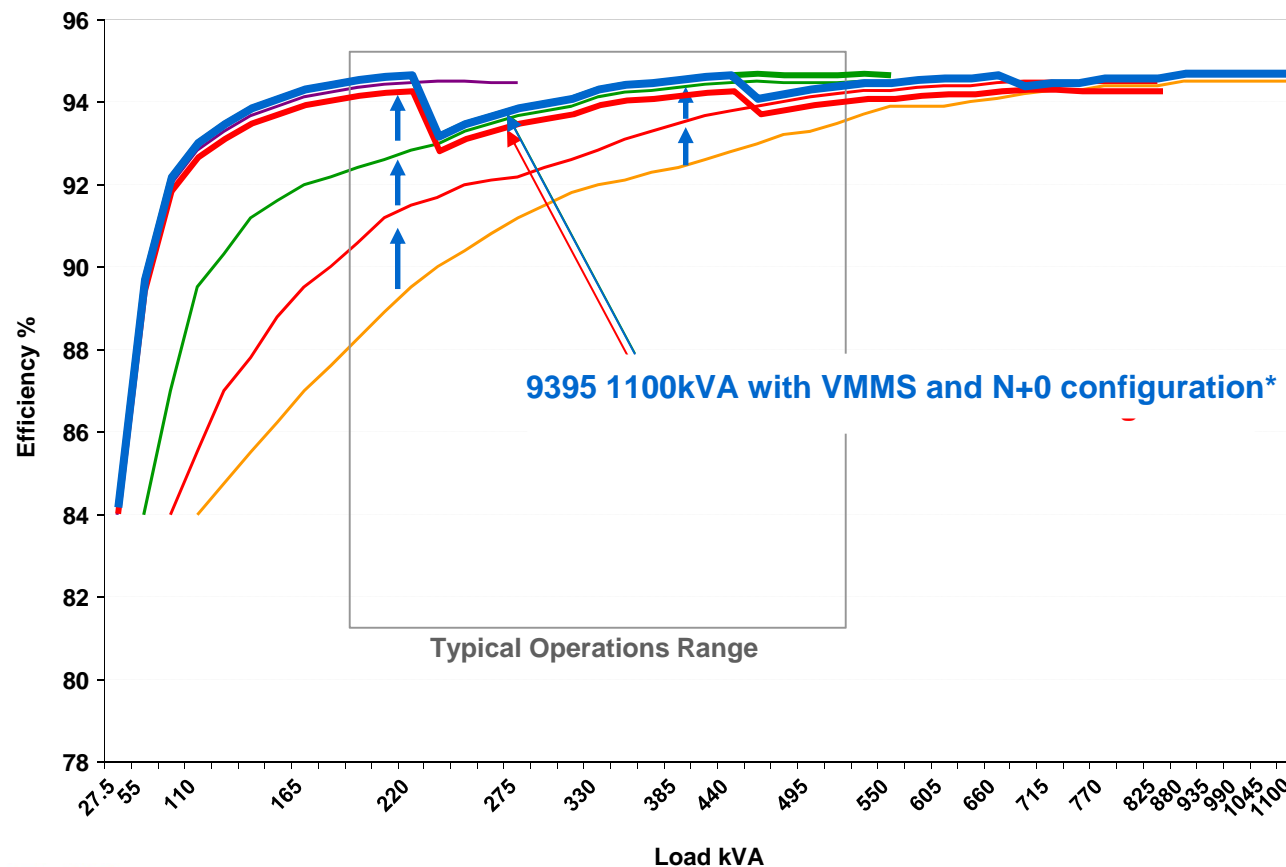
**Example with 440kVA load**  
(A 220kVA + B 220kVA)



UPS Configuration	Without VMMS	VMMS on N+1 Redundancy	VMMS on N+0 Redundancy
<b>Efficiency</b> @ 440kVA load	<b>91.2%</b>	<b>92.8%</b>	<b>94.3%</b>
<b>UPS Energy Savings</b>	<i>Used as reference for savings calculation</i>	56 MWh / year	108 MWh / year
<b>Additional Benefits &amp; Comments</b>	<ul style="list-style-type: none"> <li>✓ Industry-leading UPS efficiency in double conversion</li> </ul>	<ul style="list-style-type: none"> <li>✓ Additional energy savings from reduced cooling in VMMS (typically +30-40% to UPS energy savings)</li> <li>✓ UPM's in VMMS ready state available for redundancy</li> </ul>	
	<p>A Feed 220kVA</p> <p>B Feed 220kVA</p>	<p>A Feed 220kVA</p> <p>B Feed 220kVA</p>	<p>A Feed 220kVA</p> <p>B Feed 220kVA</p>

# Switched Inverter Blocks

- Dual bus data centers don't fully load a UPS
  - ... but have to be ready to provide if called upon



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