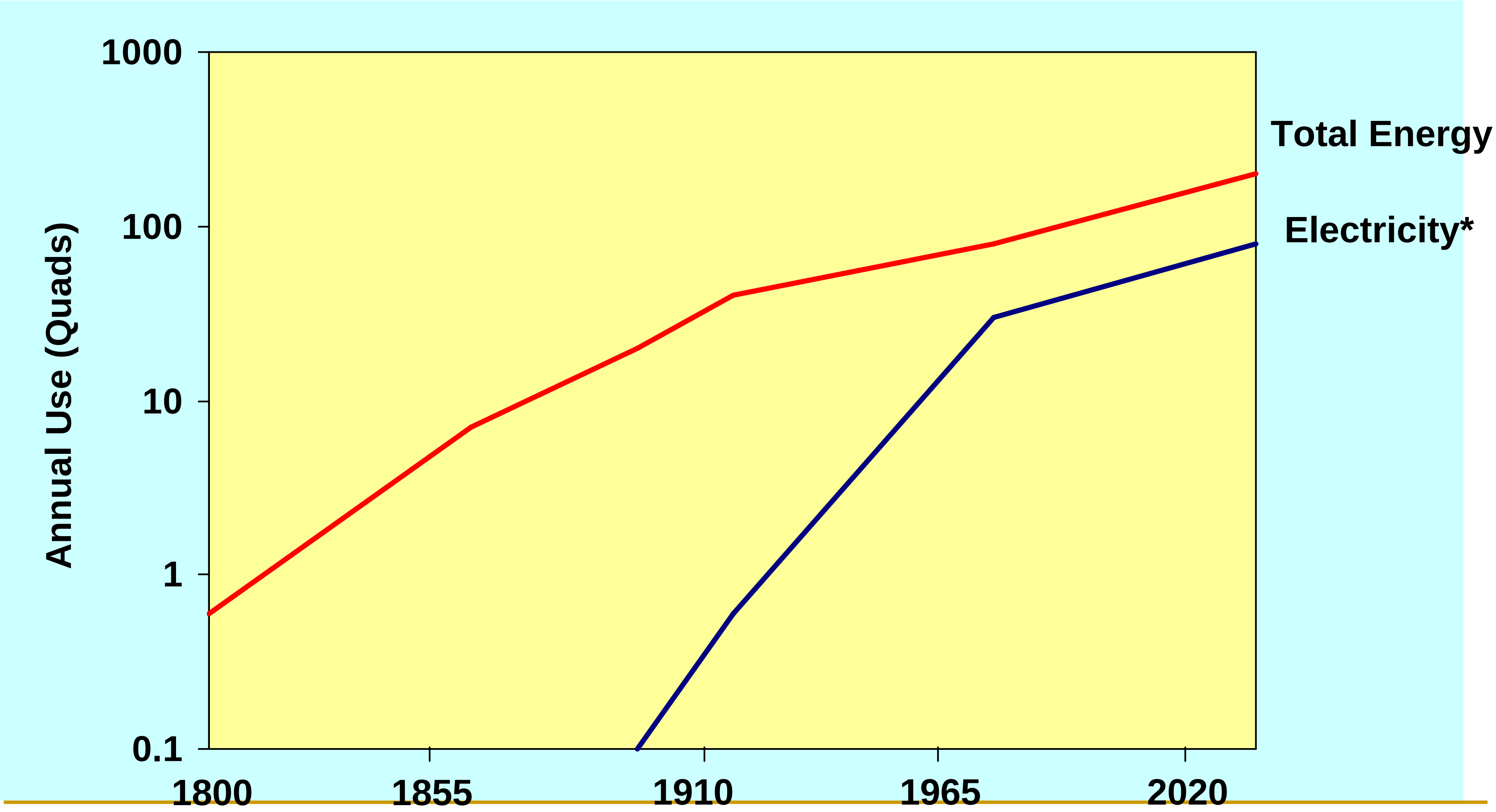
Maximizing Uptime in Mission Critical Facilities

Electricity as the Fuel for the Digital Economy

- Since 1980 >85% of growth in US Energy has been met by electricity
- 60% of US GDP comes from industries run by electricity
  - 1950 this only 20% of industry was run by electricity
- 60% of new capital spending is on IT equipment
- IT and telecom continue as fastest growing market segments
- Energy consumption is measured in Quads (Quadrillions of BTUs)
- US consumption of raw energy has risen 10 fold in the 20th century, electricity has risen 30 fold.

U.S Energy and Electricity Consumption



* Energy consumed to produce electricity

Improvements in efficiency = less energy consumption?

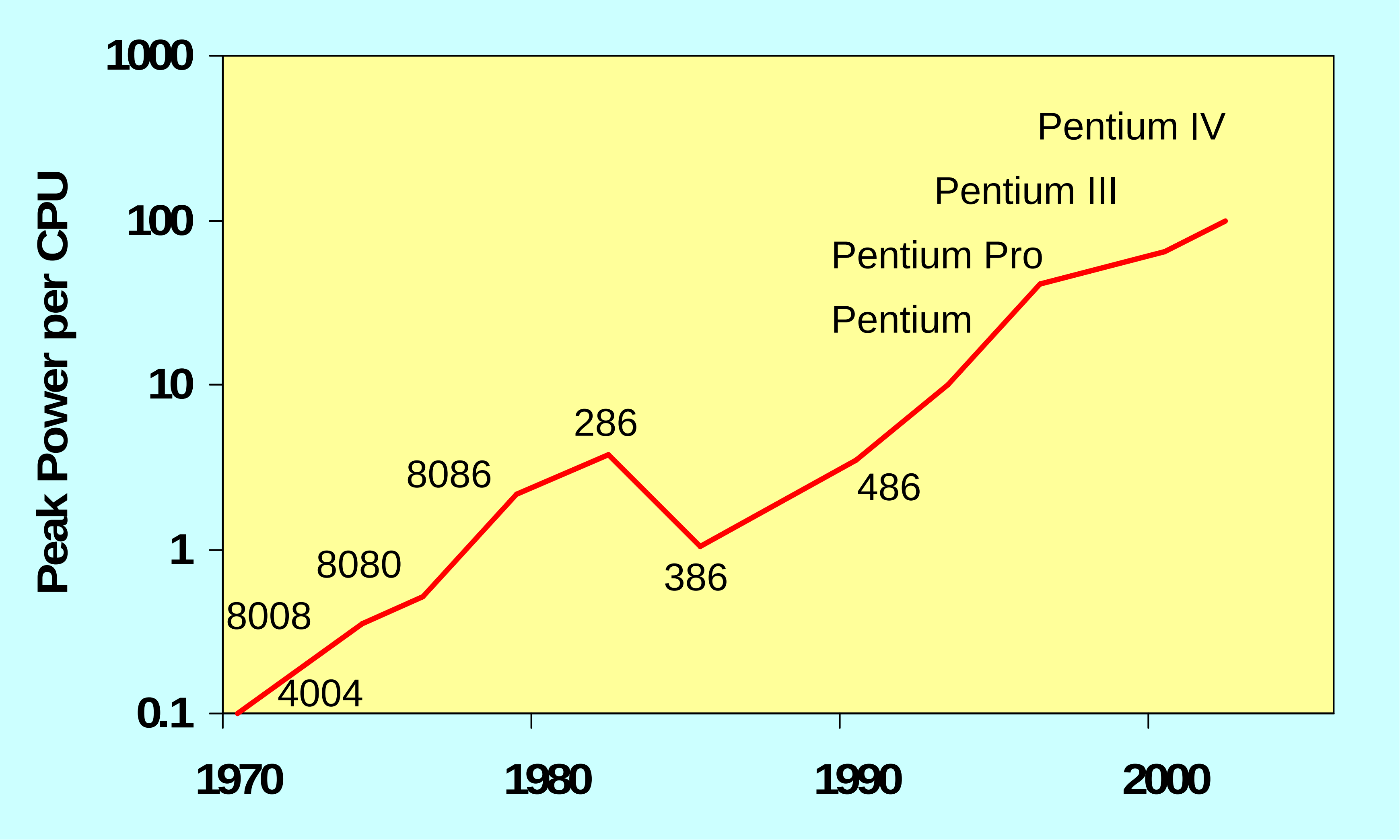
- In 1946 the Electrical Numerical Integrator And Calculator (ENIAC) was introduced as first computer contained 17,468 vacuum tubes,70,000 resistors, 10,000 capacitors, 1,500 relays, 6,000 manual switches, weighed 30 tons, consumed 174,000 Watts of Electrical Power, and could brownout parts of Philadelphia whenever it was started up.
- ENIAC required 10 watts/tube
- ENIAC compared to PlayStation would suggest reduced demand
  - PlayStation has 10,000 times the processing power
  - Consider (1) 70 watt PlayStation per teen age household
- *“The more efficient our technology, the more energy we consume”*

Improvements in efficiency = less energy consumption?

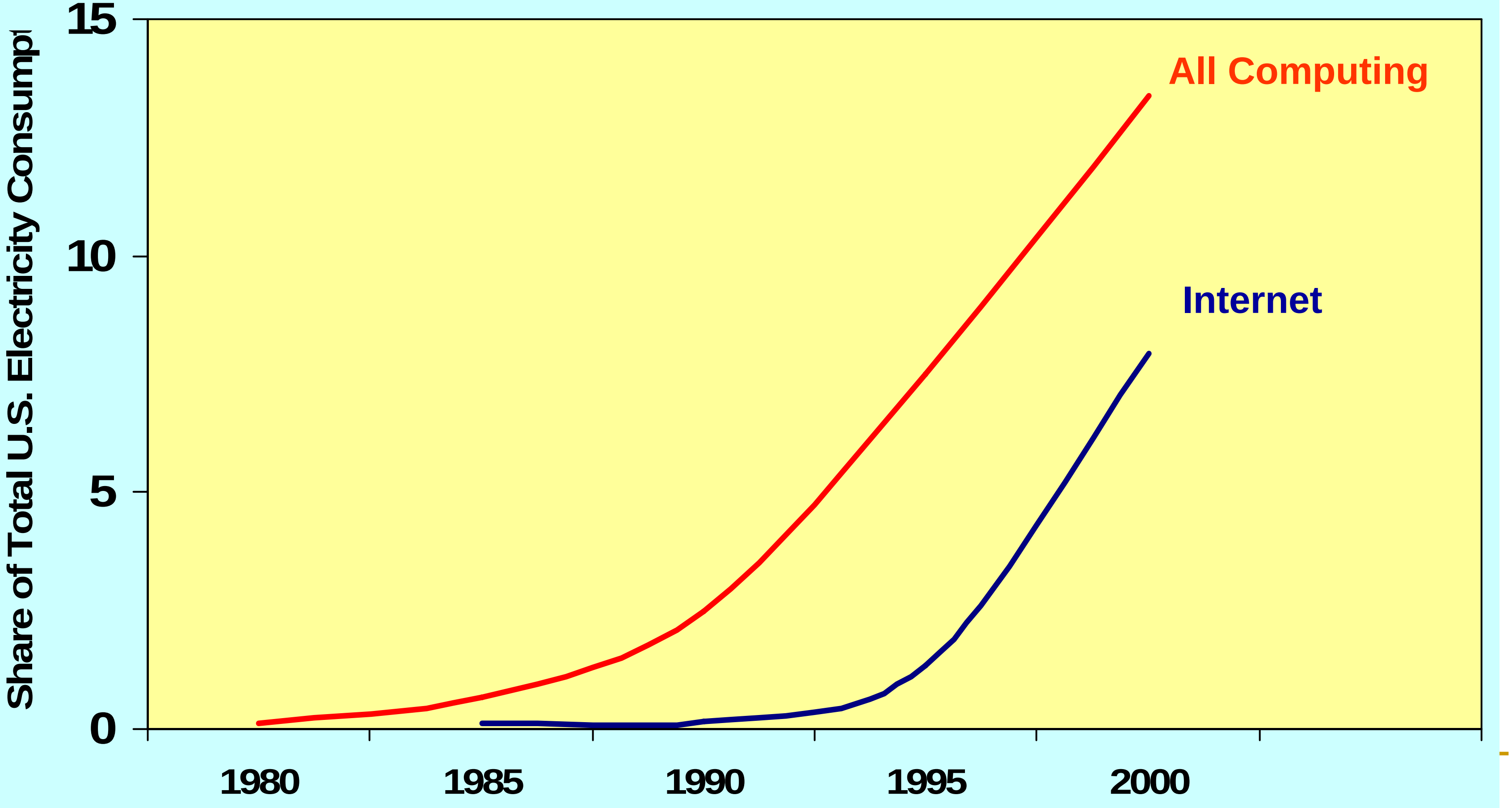
- Pentium 1/1,000,000 of a watt/transistor
- Energy required to process a single logic instruction is cut in half every 14 months
- Number of gates/chip rises as fast as gates themselves shrink
  - Chip area grows larger
  - Total power required/chip rises even faster
  - Cooling microprocessors to keep them from melting is already a challenge
- Intel engineer projection if trends were to continue

  Current Chip → Nuclear Reactor → Rocket Nozzle → Suns Surface

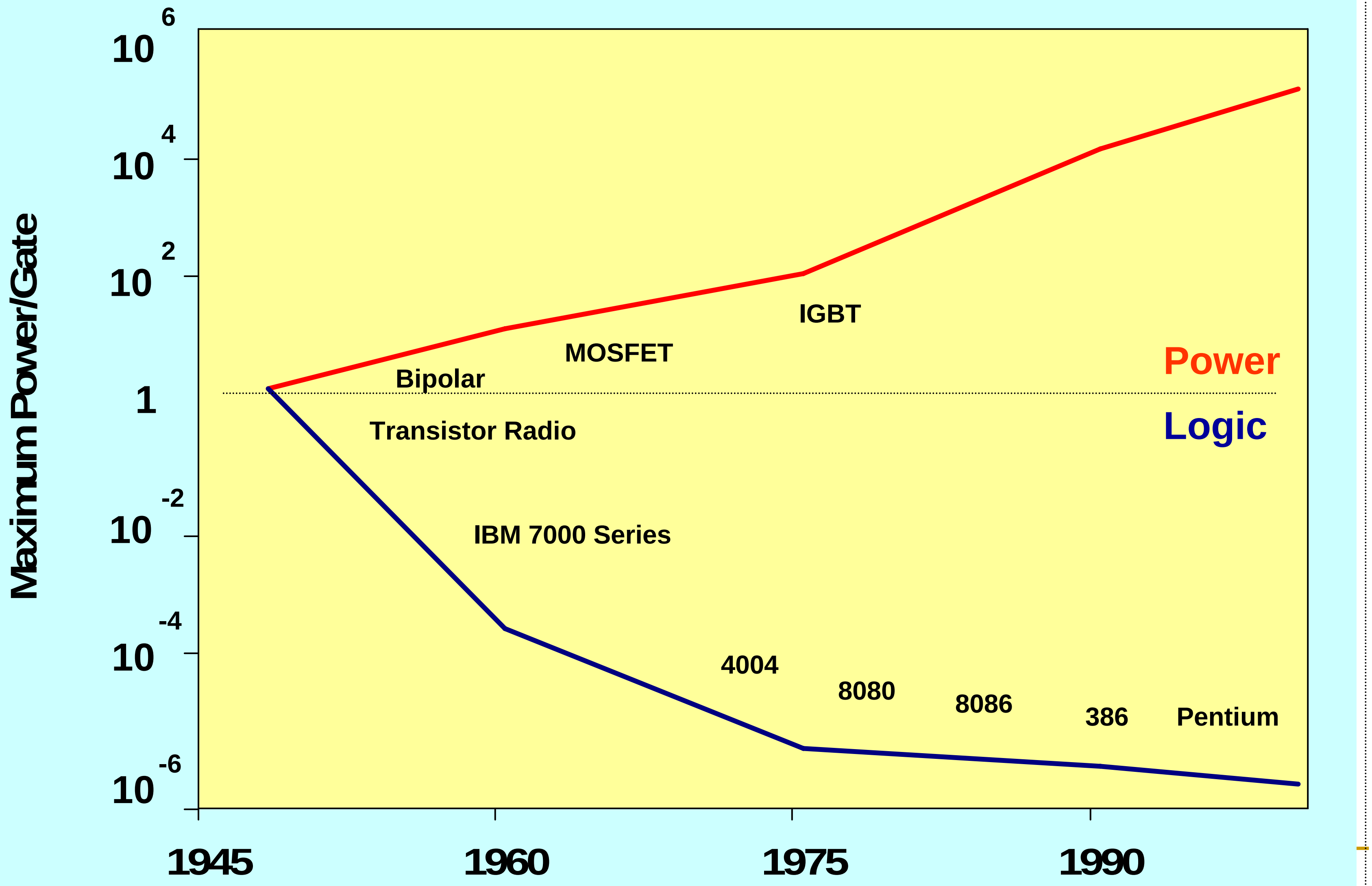
Microprocessor Peak Power



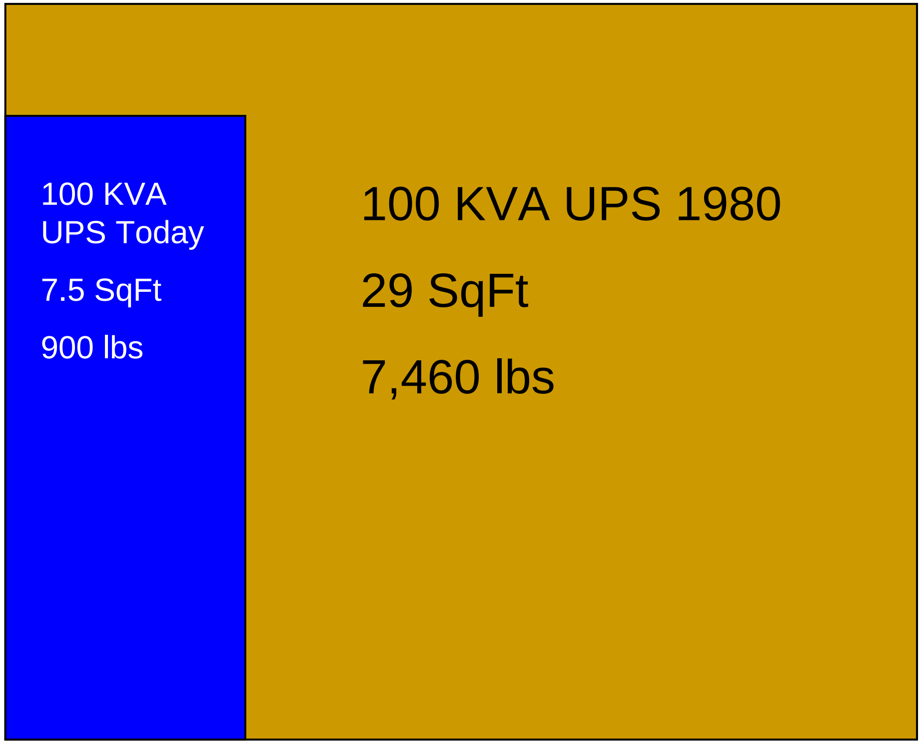
Computing and the Internet: Aggregate U.S. Electricity Consumption



Transistors for Logic and Power



Technology Improves Efficiency, Reduces Footprint



100 KVA
UPS Today

7.5 SqFt

900 lbs

100 KVA UPS 1980

29 SqFt

7,460 lbs

Energy Production and Distribution

- Environmental zoning regulations make it increasingly difficult to locate smoke stacks, cooling towers, substations and distribution lines where we live.

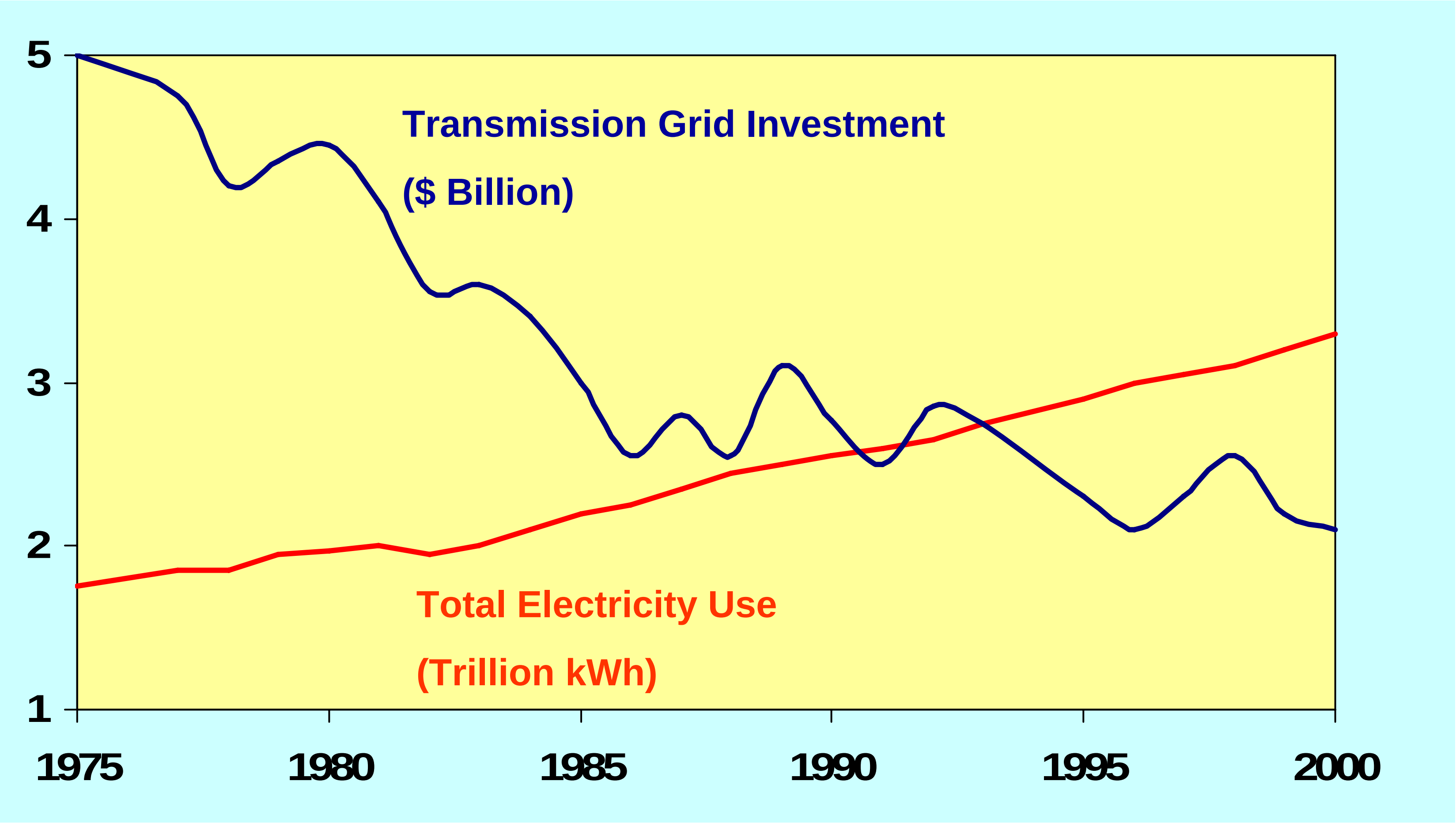
- Electricity is relatively easy to transmit

- Power plants are located further from point of use with elaborate transmission

- Power generation plants have not and are not being built

- Minimal investments are being made in upgrades of transmission grid

U.S. Electricity Transmission



Power consumption will continue to increase with minimal investment in power generation or grid upgrades. US corporations will need to monitor internal MISSION CRITICAL power needs.

Excerpts from The Bottomless Well by Peter Huber and Mark Mills

Data Center Challenges

- The load is unpredictable
- Reduced impact of Harmonics
- Energy efficiency is becoming important again
- Continuous deterioration of the power grid reliability
- Increased government regulation (Sarbanes-Oxley) for maintaining the viability of business operation and information
- Managing single and dual cord loads
- Increases in power density

Factors Affecting Data Center Performance

- Location
- Overall system design
- Construction Quality
- Equipment Quality
- Thoroughness of Initial Commissioning
- Age
- Maintainability
- Operations and Maintenance Program
- Personnel Training

Tier 1-IV Data Center Design

- Benchmarking done over several years with large DC input
- Initial concept started with United Parcel (the other UPS) Windward DC
- Worked with IBM and other hardware companies towards dual-powered hardware
- Top 10% of sites used for benchmark meaning only 10% performed at reliability levels
- Goal was to achieve 5 nines in reliability, 99.999%

Tier 1-IV Data Center Design

Tier I-Basic

- No redundancy in components, Single Power Path
- Support space to raised floor ratio, 20%
- Initial Watts/Ft², 20-30 with ultimate of 20-30
- Raised floor height, 12”
- $/Ft², $450
- IT downtime due to site, 28.8 hours
- Availability, 99.671%

Tier 1-IV Data Center Design

Tier II-Redundant Components

- N+1 redundancy in components, Single Power Path
- Support space to raised floor ratio, 30%
- Initial Watts/Ft², 40-50 with ultimate of 40-50
- Raised floor height, 18”
- $/Ft², $600
- IT downtime due to site, 22 hours
- Availability, 99.749%

Tier 1-IV Data Center Design

Tier III-Concurrently Maintainable

- N+1 redundancy in components, 1 Active and 1 Passive Power Path
- Support space to raised floor ratio, 80-90%
- Initial Watts/Ft^2, 40-60 with ultimate of 100-150
- Raised floor height, 30-36”
- $/Ft^2, $900
- IT downtime due to site, 1.6 hours
- Availability, 99.982%

Tier 1-IV Data Center Design

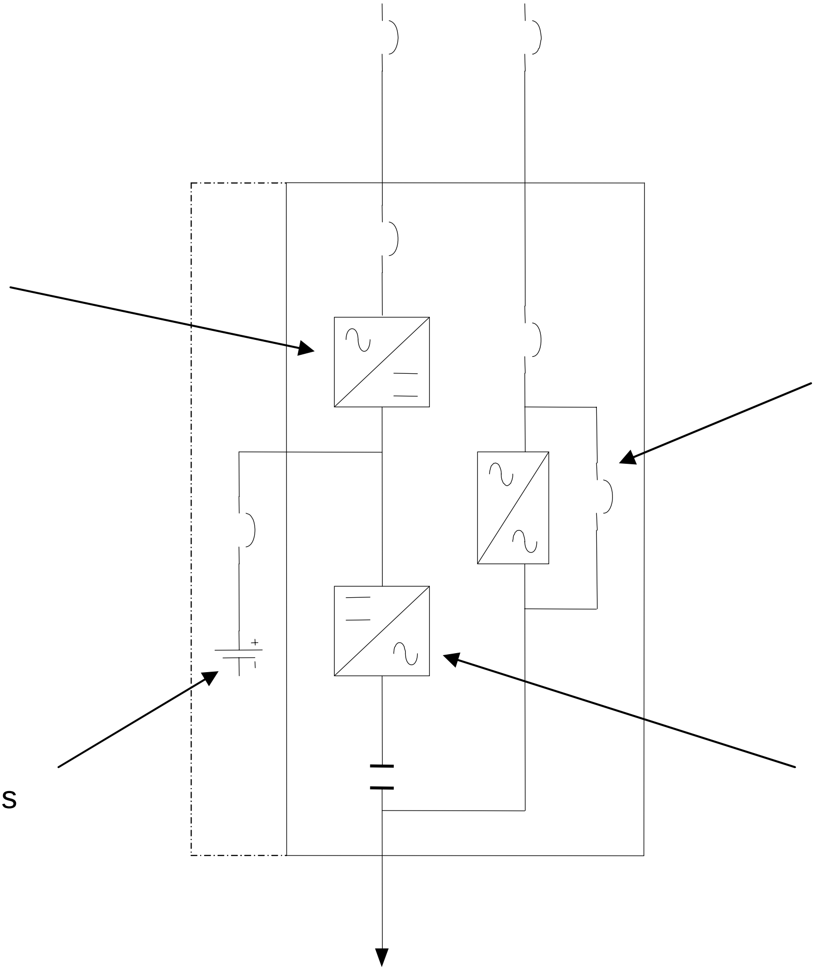
Tier IV-Fault Tolerant

- Must be able to sustain 1 unplanned worst case infrastructure failure
- Must be concurrently maintainable
- 2(N+1) or S+S redundancy in components, 2 Active Power Paths
- Support space to raised floor ratio, 100%
- Initial Watts/Ft^2, 50-80 with ultimate of 150+
- Raised floor height, 30-36”
- $/Ft^2, $1,100+
- IT downtime due to site, .4 hours
- Availability, 99.995% (**Could not reach 5 Nines)**

Tier I and II

Single Module and Parallel Redundant

Single Module UPS



Rectifier,
Converts AC
to DC Power

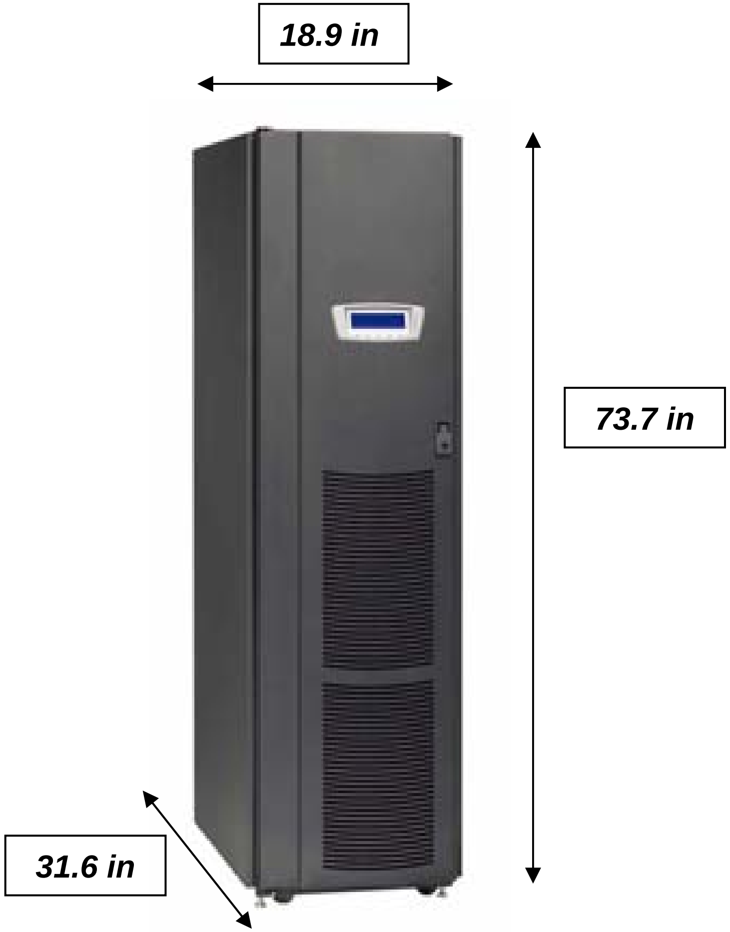
Static Bypass
Provides
Alternate
Power Path

Battery, Provides
Emergency
Back-up

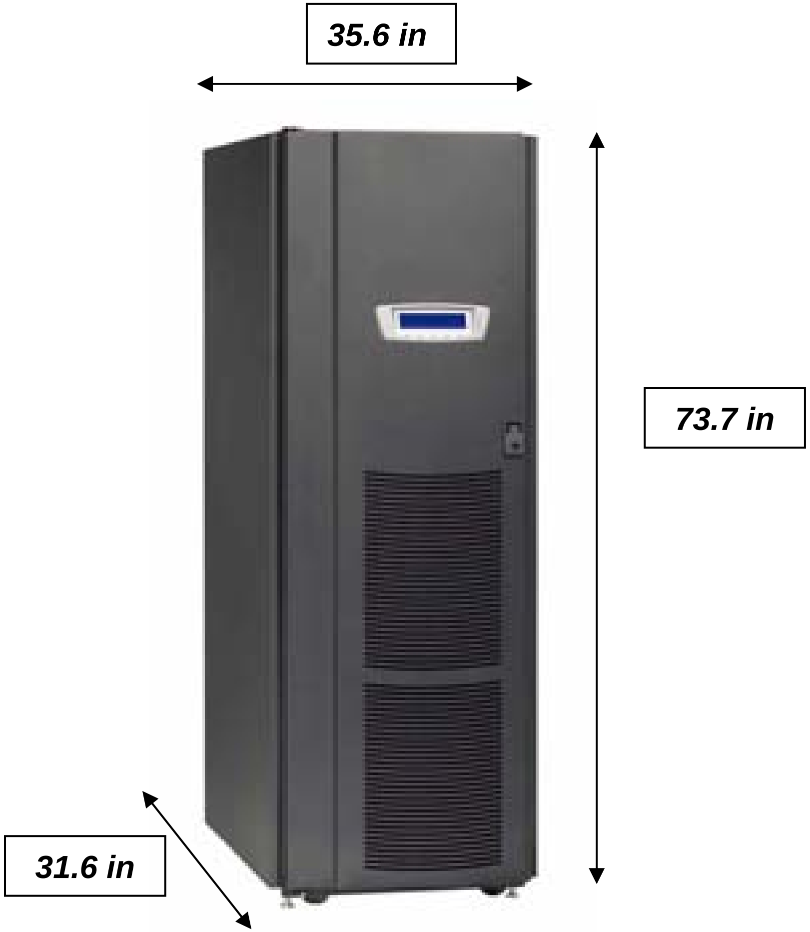
Inverter,
Converts DC
to AC Power

40-160 KVA

40 and 80 kVA



120 and 160 kVA



225 – 500 KVA

225-300 KVA

Dimensions: 64” W, 32” D, 73” H

Weight: 3,900 – 4,300 lbs.

400-500 KVA

Dimensions: 74” W, 32” D, 73” H

Weight: 6,200 lbs.

625-750 KVA

625-750 KVA

Dimensions: 149” W, 32” D, 73” H

Three Shipping Splits

Weight: 13,400 lbs.

225kVA to 1.1MVA Scalable

Up to 4 x275 KVA Power Modules

Paralleled for Capacity or Redundancy

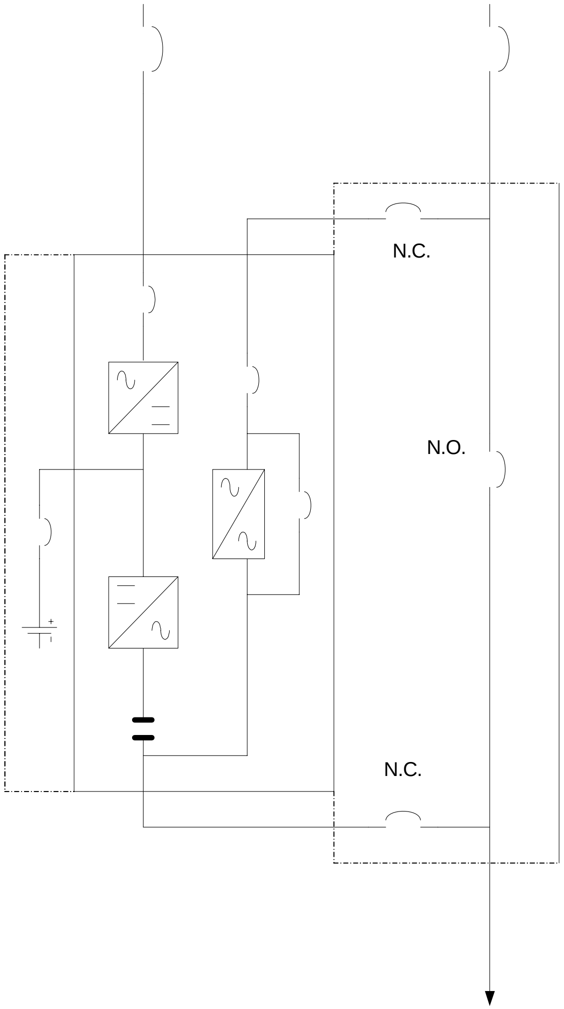
Dimensions: 60 to 108” W, 32” D, 73” H

1 Shipping Split

Weight: 3,000 lbs. (@550 kVA)

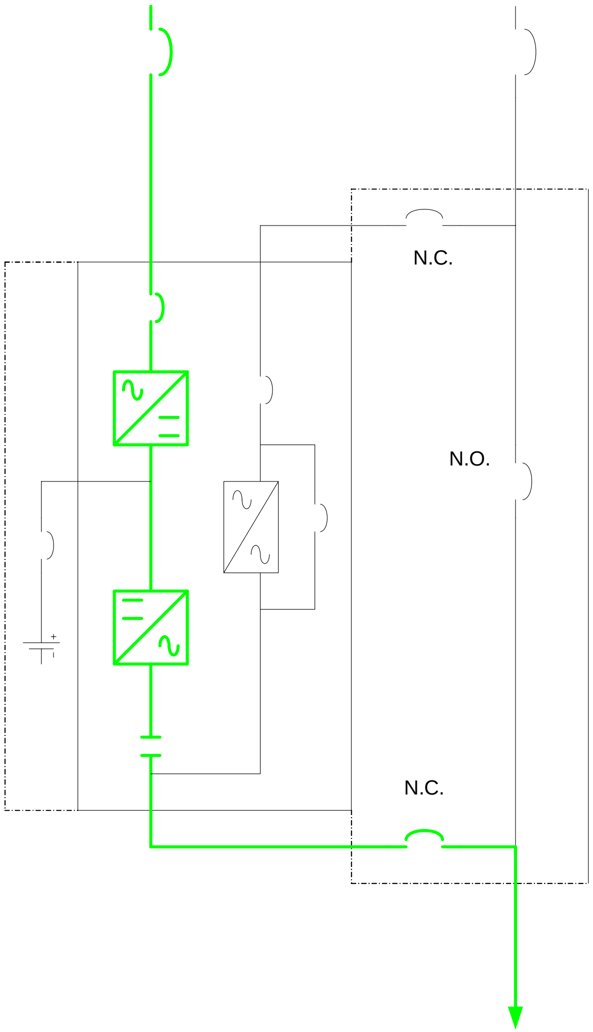
Single Module with Maintenance Bypass (MBP)

- Tier I design
- MBP allows for manual transfer for maintenance
- Can be internally upgradeable



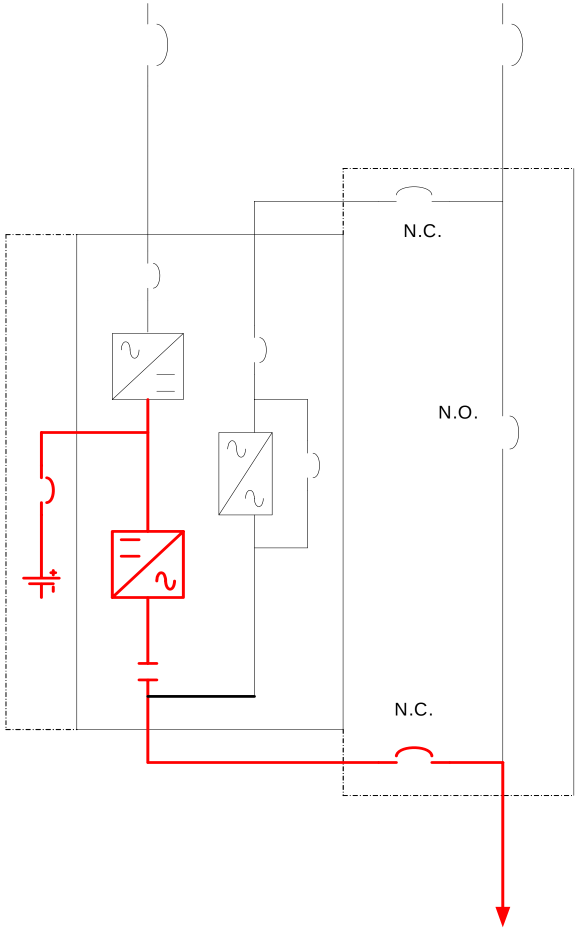
Normal Power Flow

- Total Power conditioning by double conversion



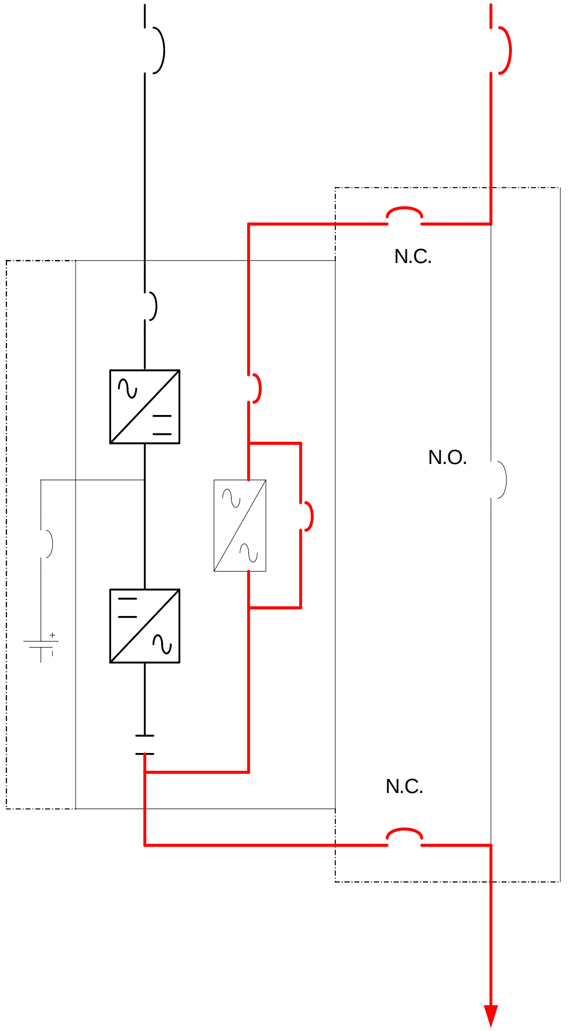
Power Flow Loss of Utility Power

- No Interruption of power to critical load
- No switching required
- May or may not be genset
- If no genset, AC is lost



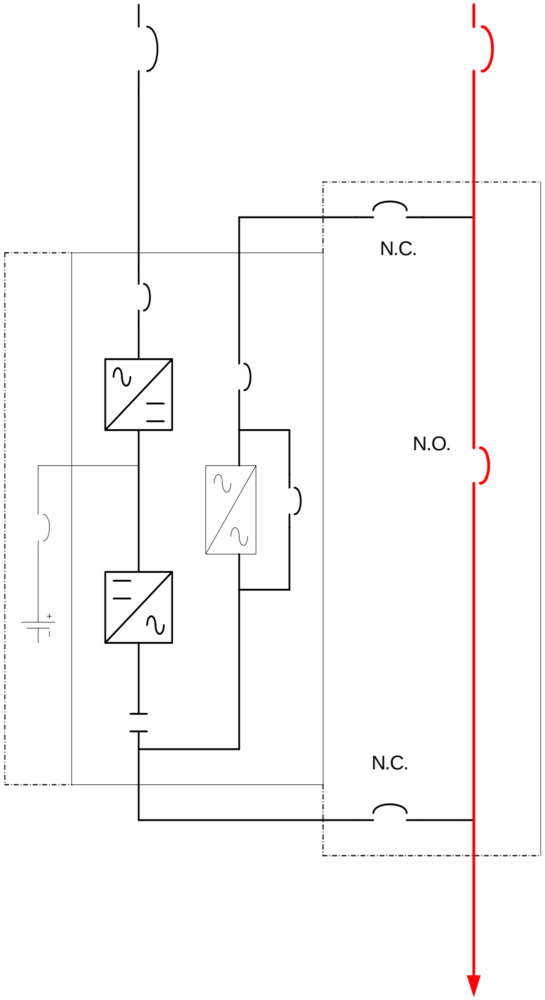
Static Bypass Power Flow

- No interruption to load
- Transfer is automatic during failure can also transfer manually from UPS control panel
- Should have alarm at site for notification of key personnel



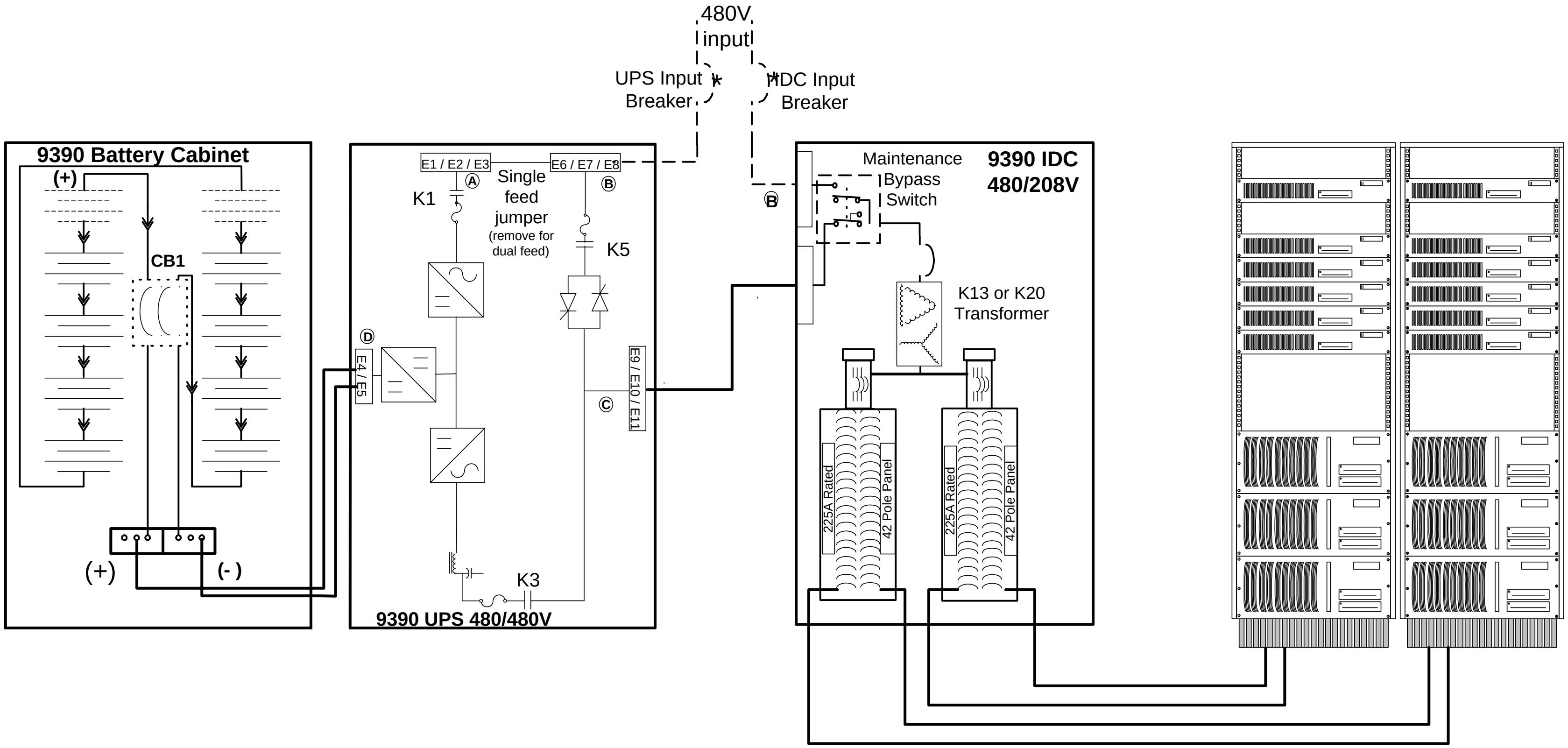
Maintenance Bypass Power Flow

- Manual function, no interruption
- Allows full maintainability of UPS
- Relatively low cost
- Should include interlock!

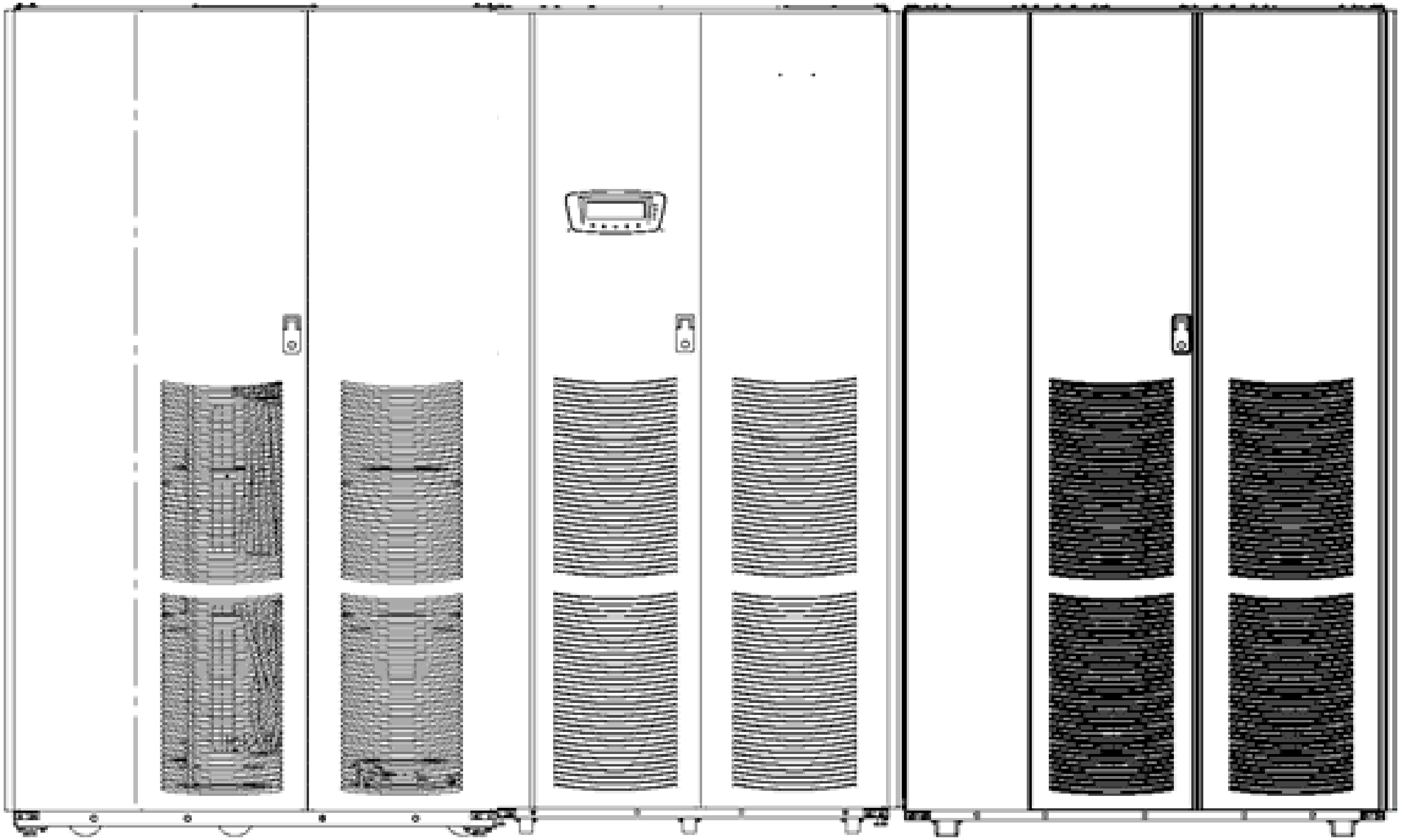


Tier I Designs

- Single path for power and cooling (no redundancy)
- Provides 99.671% availability



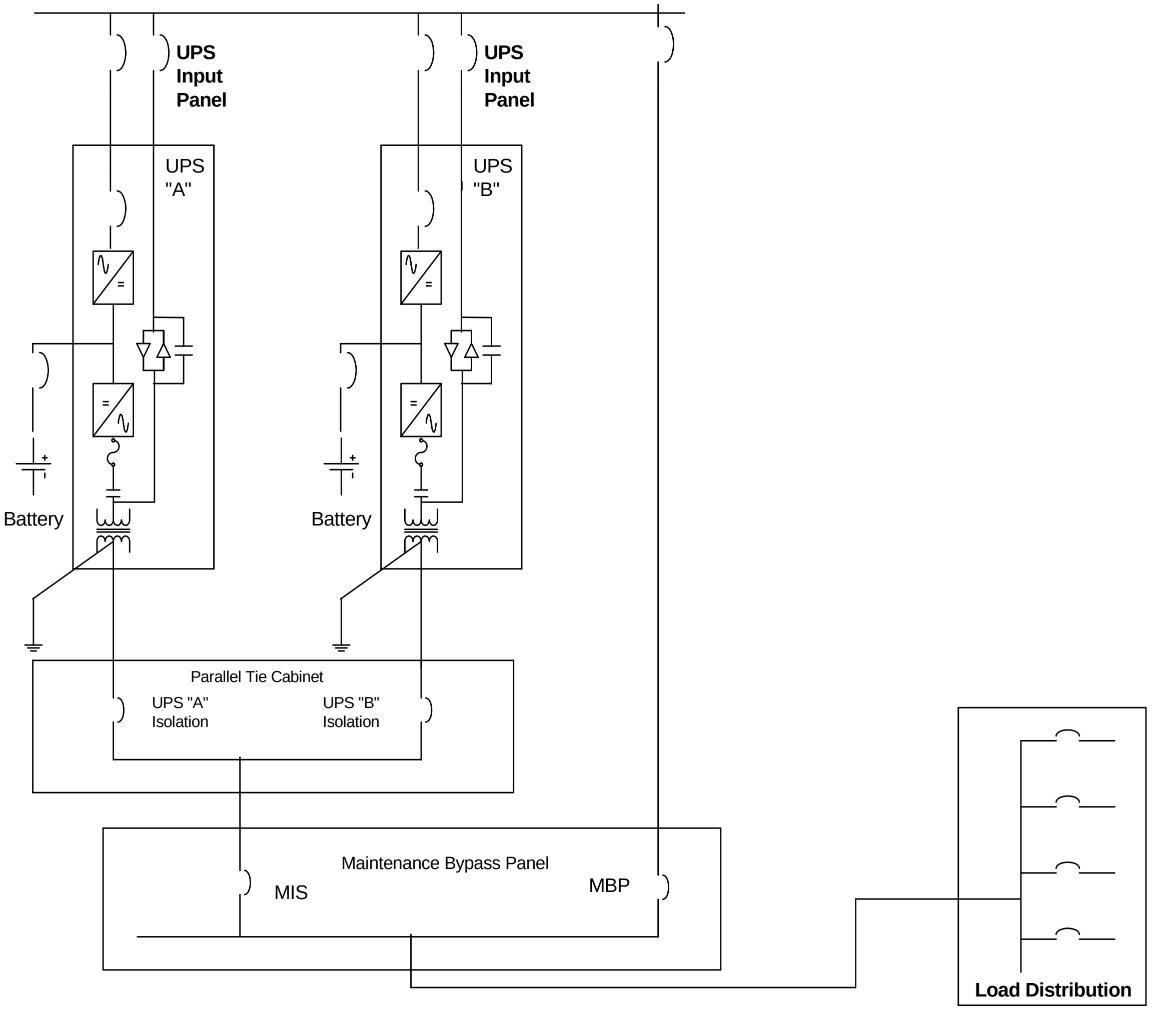
Tier I Applications



160kVA UPS with IDC 480/208V with 84 poles distribution

Two Module Parallel Redundant

- Tier II design
- Any one module can fail
- Capacity may be achieved by internal upgrade only
- Lowest cost means of achieving redundancy



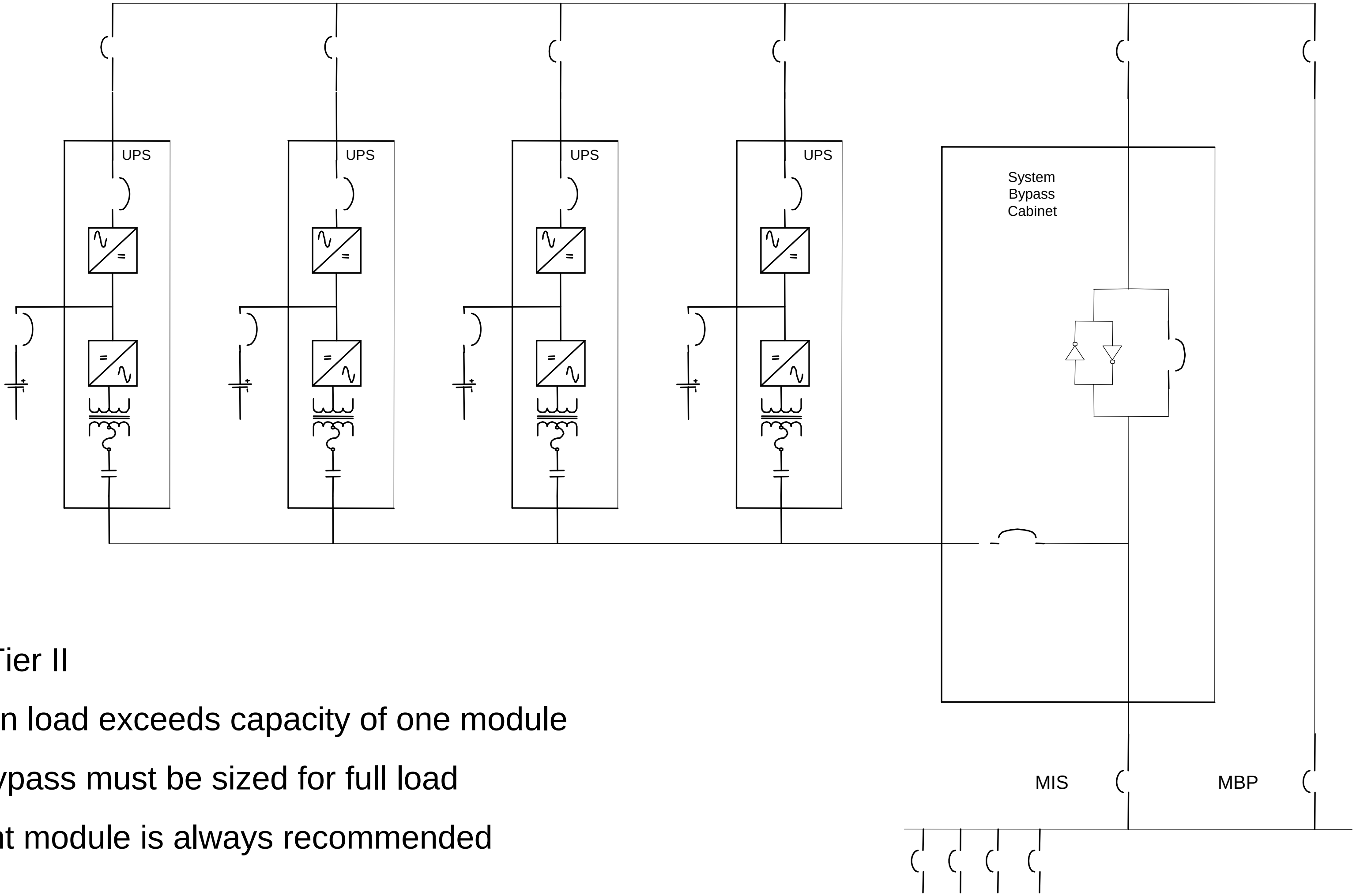
Two Module Parallel Redundant

UPS
Module

Parallel Tie Cabinet

UPS
Module

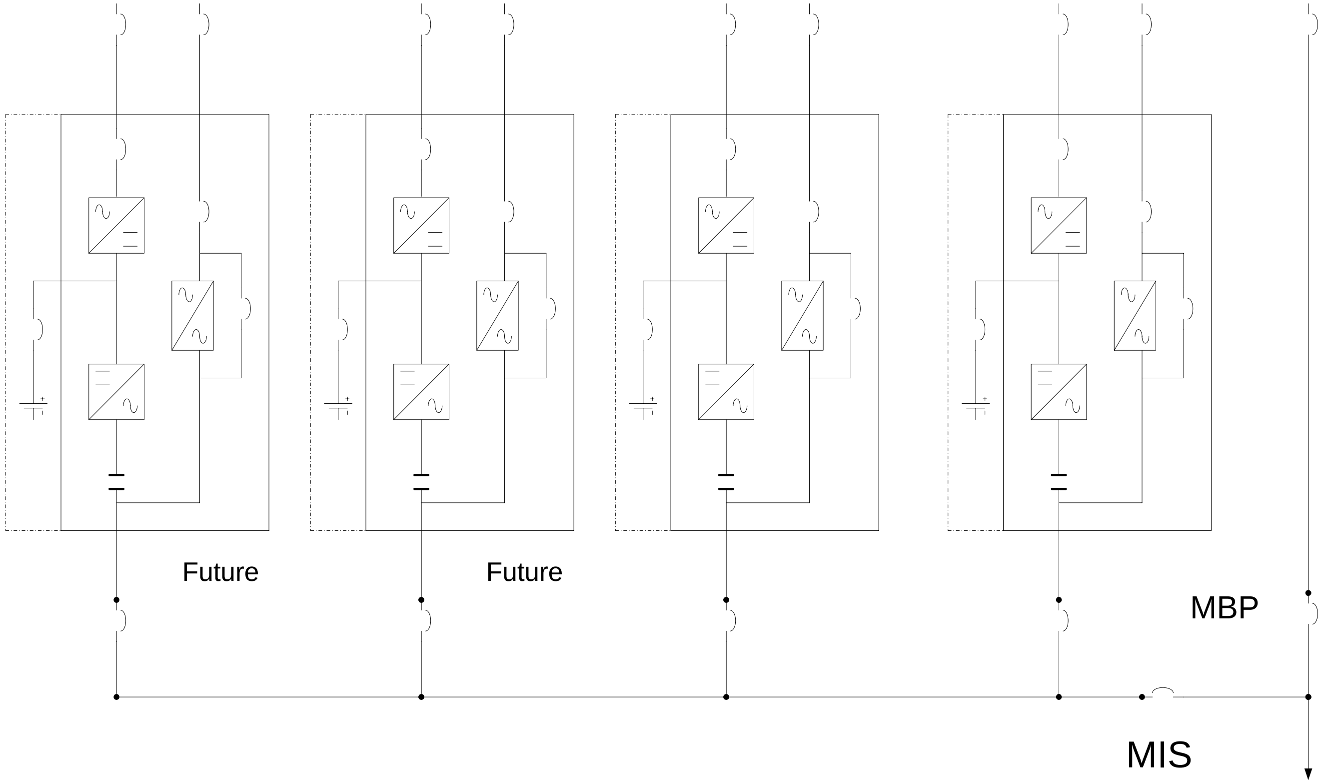
Parallel for Increased Capacity



- Still only Tier II
- Used when load exceeds capacity of one module
- System bypass must be sized for full load
- Redundant module is always recommended

System Parallel Cabinet

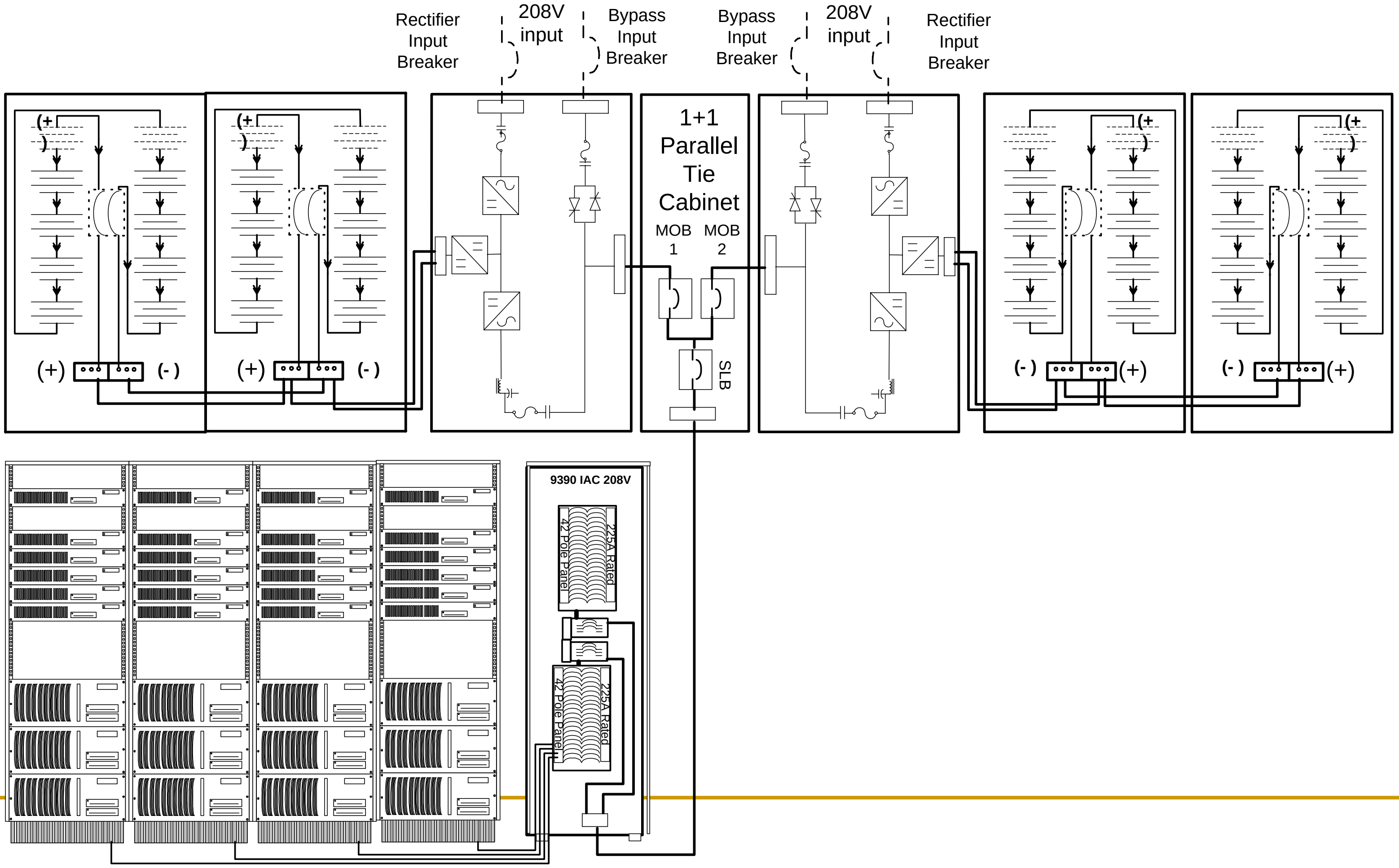
Parallel and Scalable



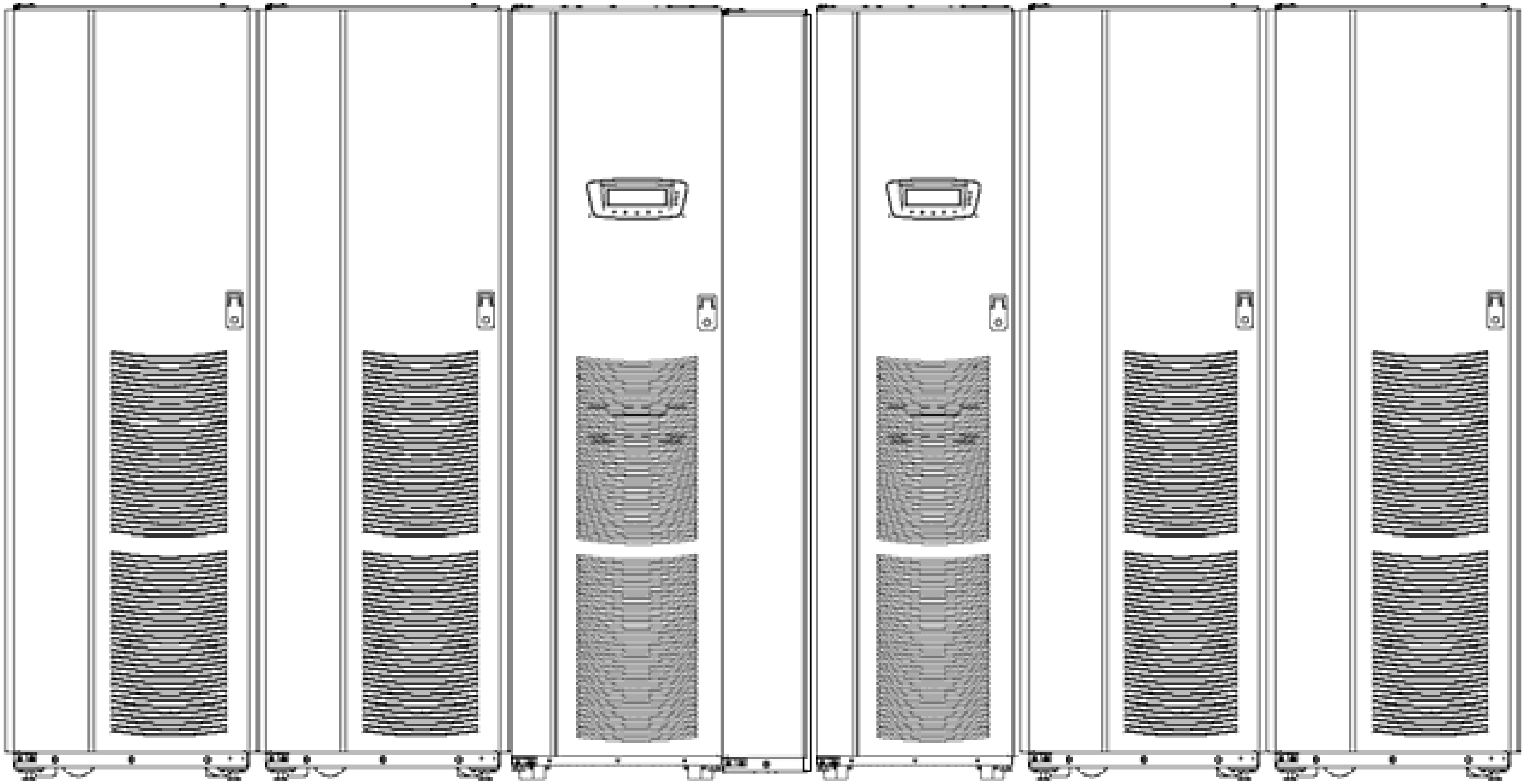
- Recent design capability in low end systems
- Simple and cost effective
- Provides redundancy and scalability
- MBP must be sized for ultimate capacity

Tier II Designs

- Single path for power and cooling with redundant components. Provides 99.741% availability



Tier II Applications



80kVA Two module redundant system using IAC-ST

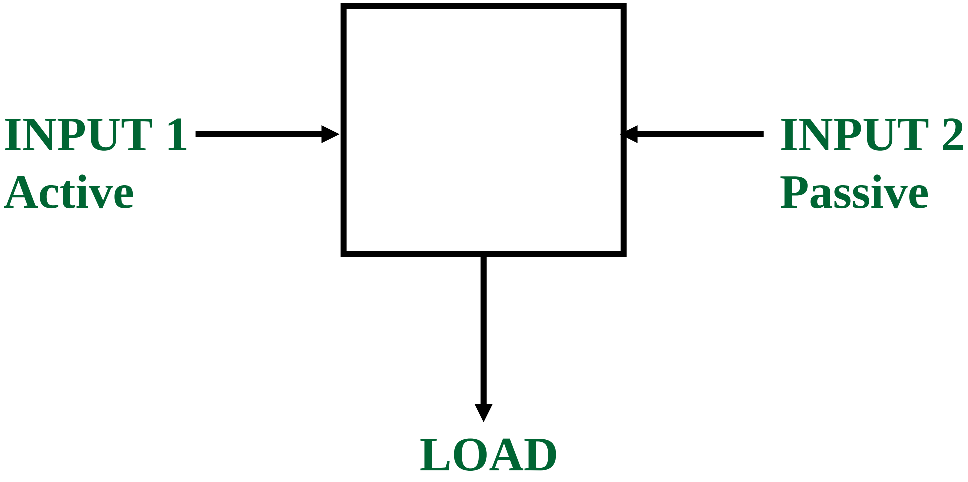
Power System Fundamentals

Tier III and IV

1 Active and 1 Passive Power Path

2 Active Power Paths

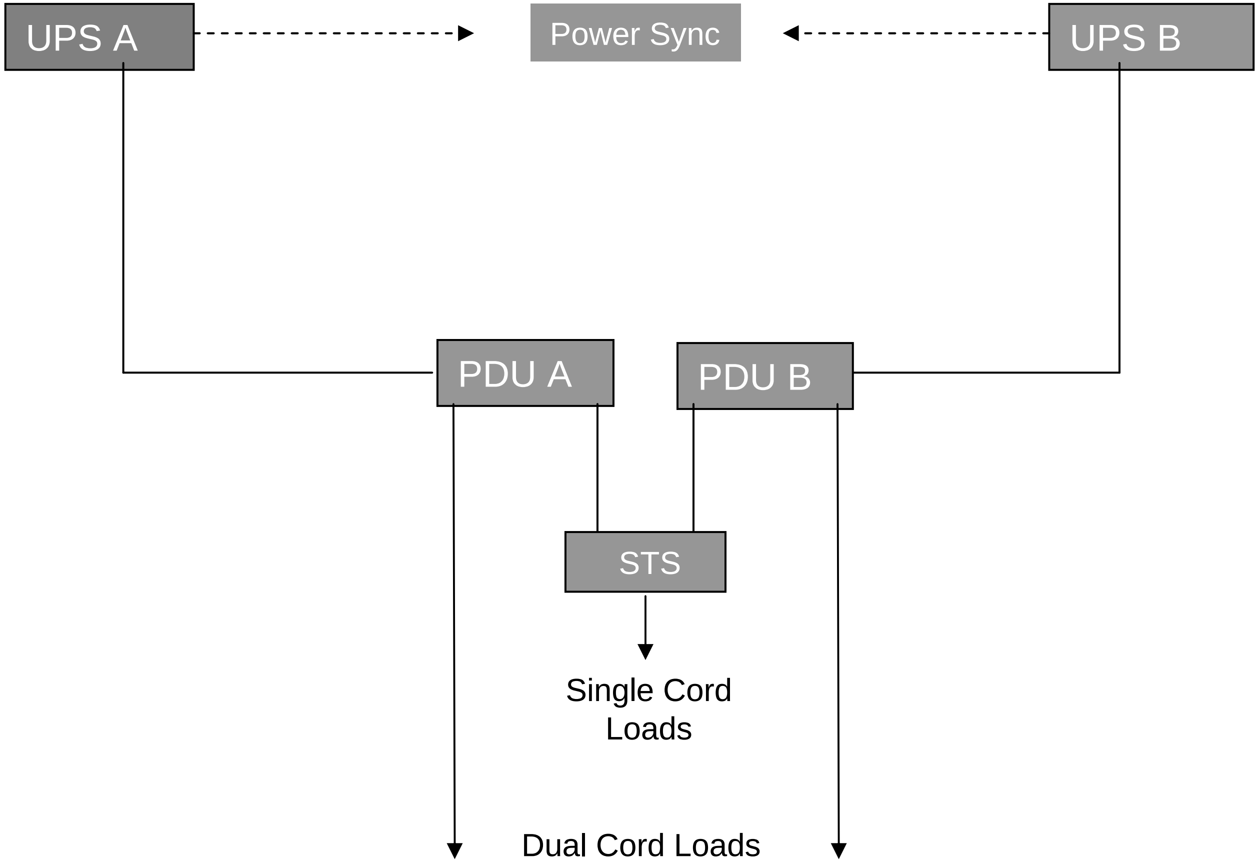
Static Switch



- Redundancy is a dual source power path to the load
- The closer the redundant element is to the load the better the system redundancy

1 Active and 1 Passive Power Path, Tier III

Each UPS can be N or N+1



UPS A

Power Sync

UPS B

PDU A

PDU B

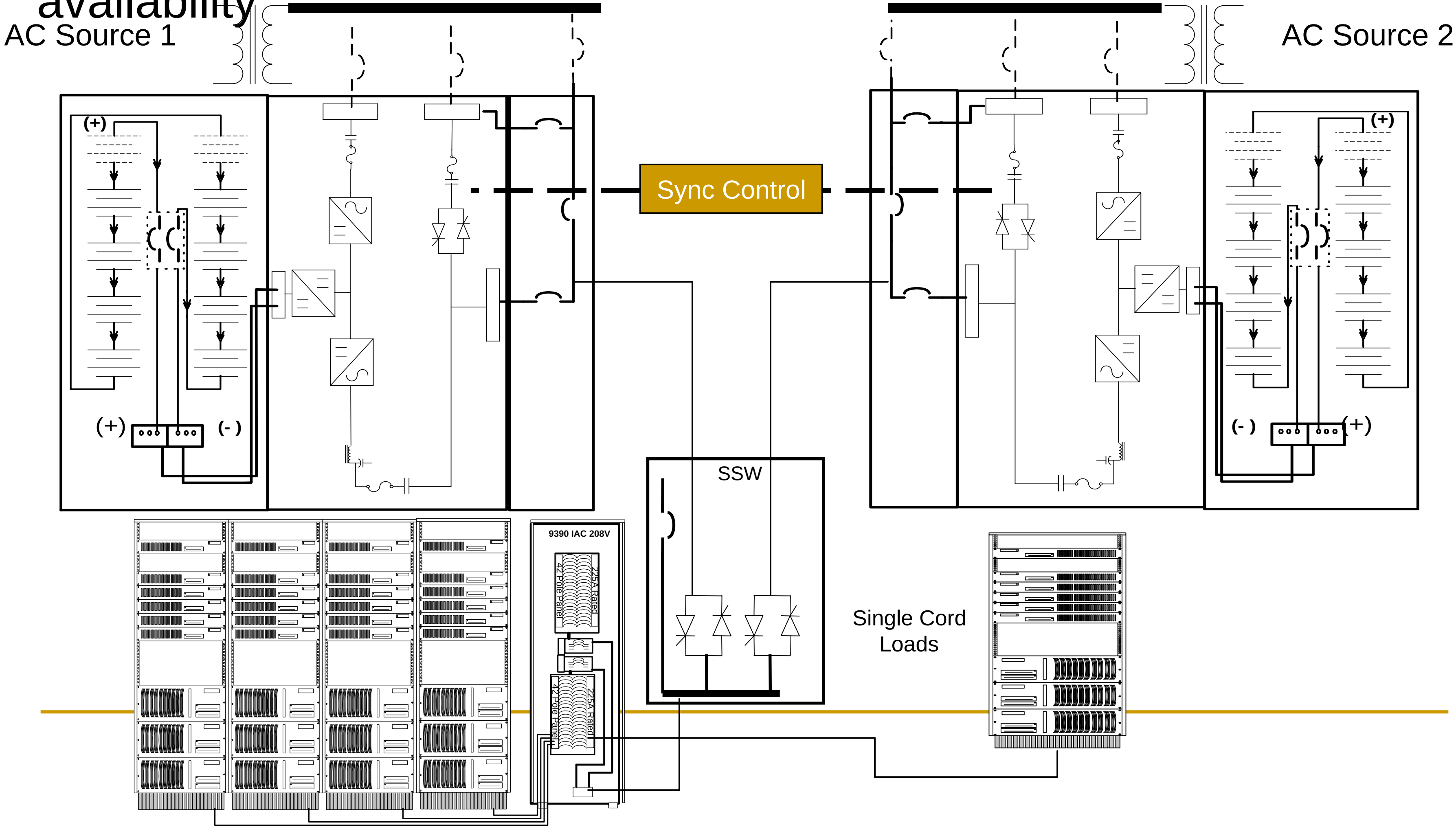
STS

Single Cord Loads

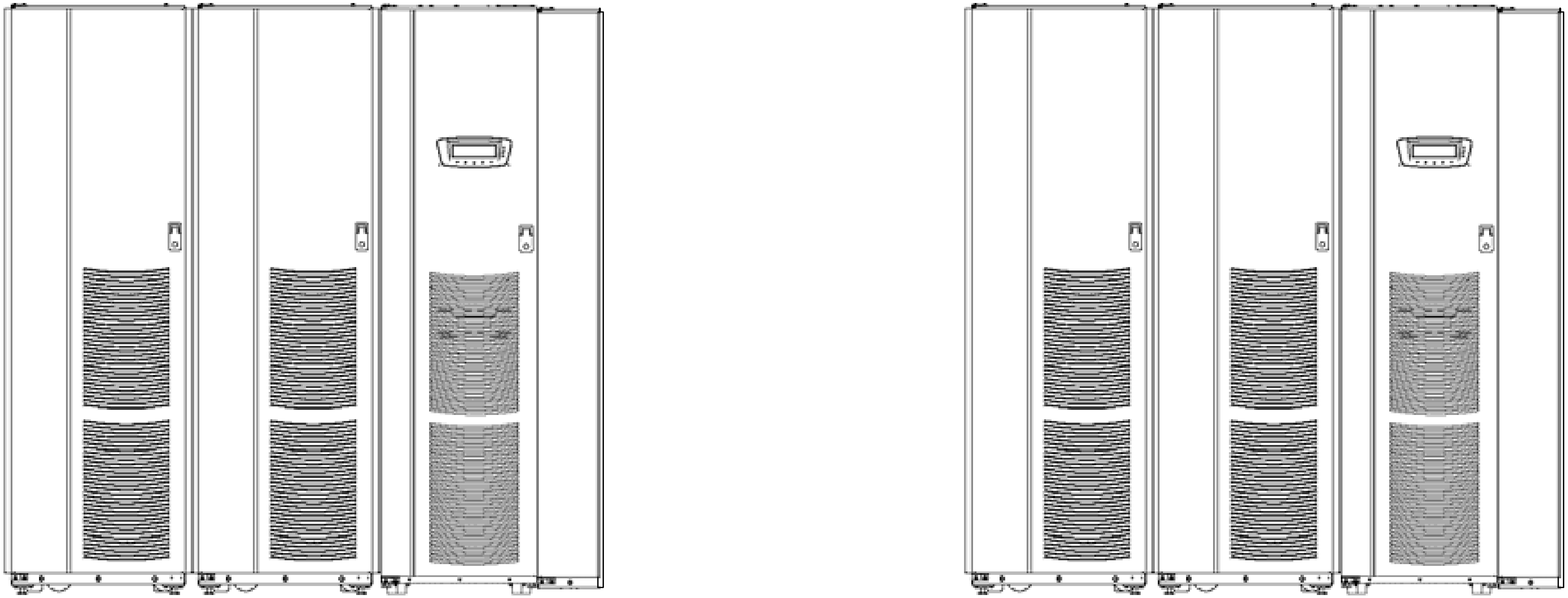
Dual Cord Loads

Tier III Designs

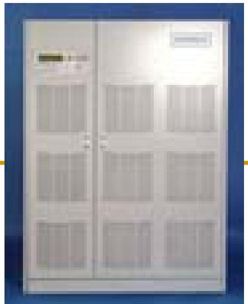
- Multiple path for power and cooling with only one path active. Redundant components, concurrently maintained. Provides 99.982% availability



Tier III Applications



Two independent 80kVA UPS systems using IAC-SB maintenance bypasses.

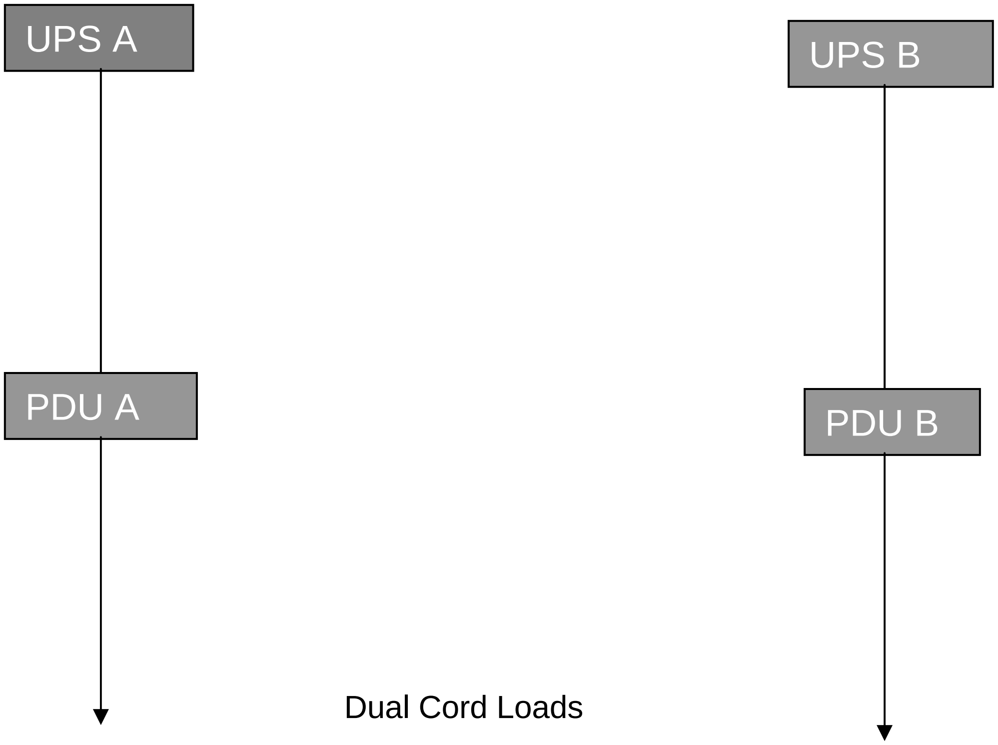


Static transfer switch

Distribution cabinet

Two Active Power Paths, Tier IV, 2N

Each UPS can be N or N+1



UPS A

UPS B

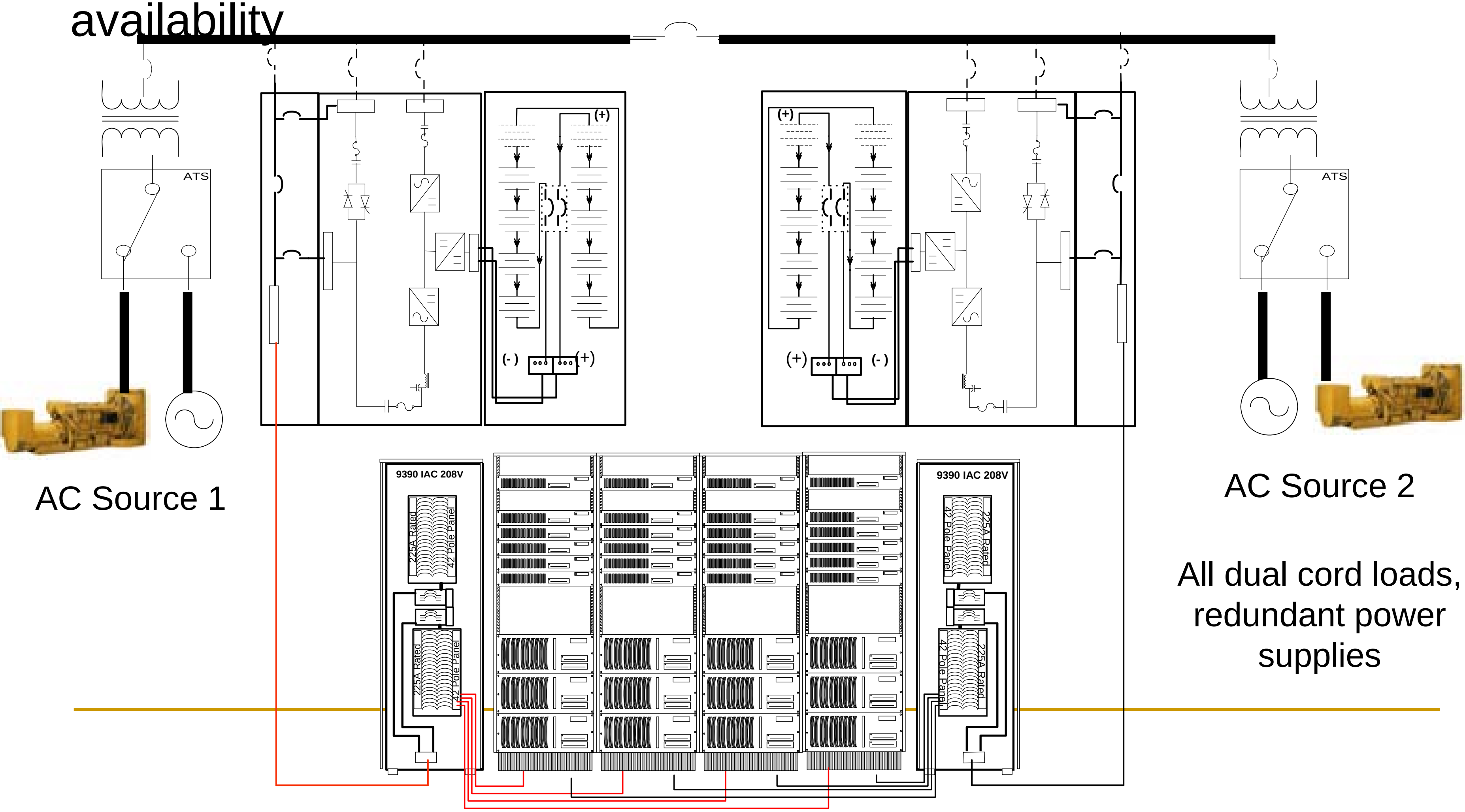
PDU A

PDU B

Dual Cord Loads

Tier IV Designs

- Multiple active power and cooling distribution paths, with redundant components, and designed-in fault tolerance. Provides 99.995% availability

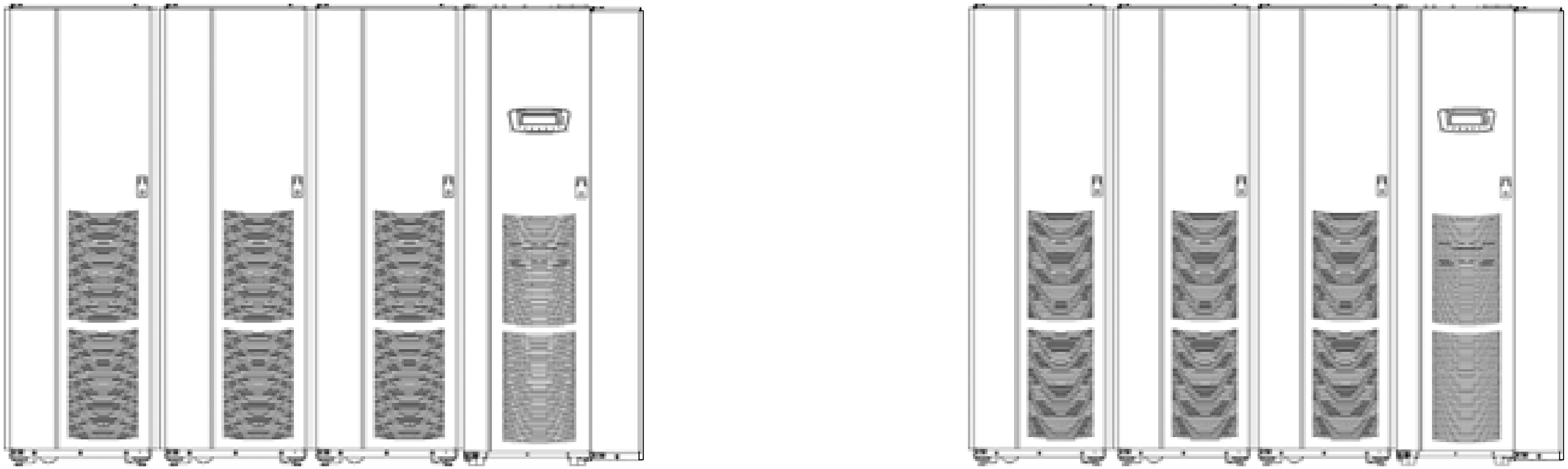


AC Source 1

AC Source 2

All dual cord loads, redundant power supplies

Tier IV Applications

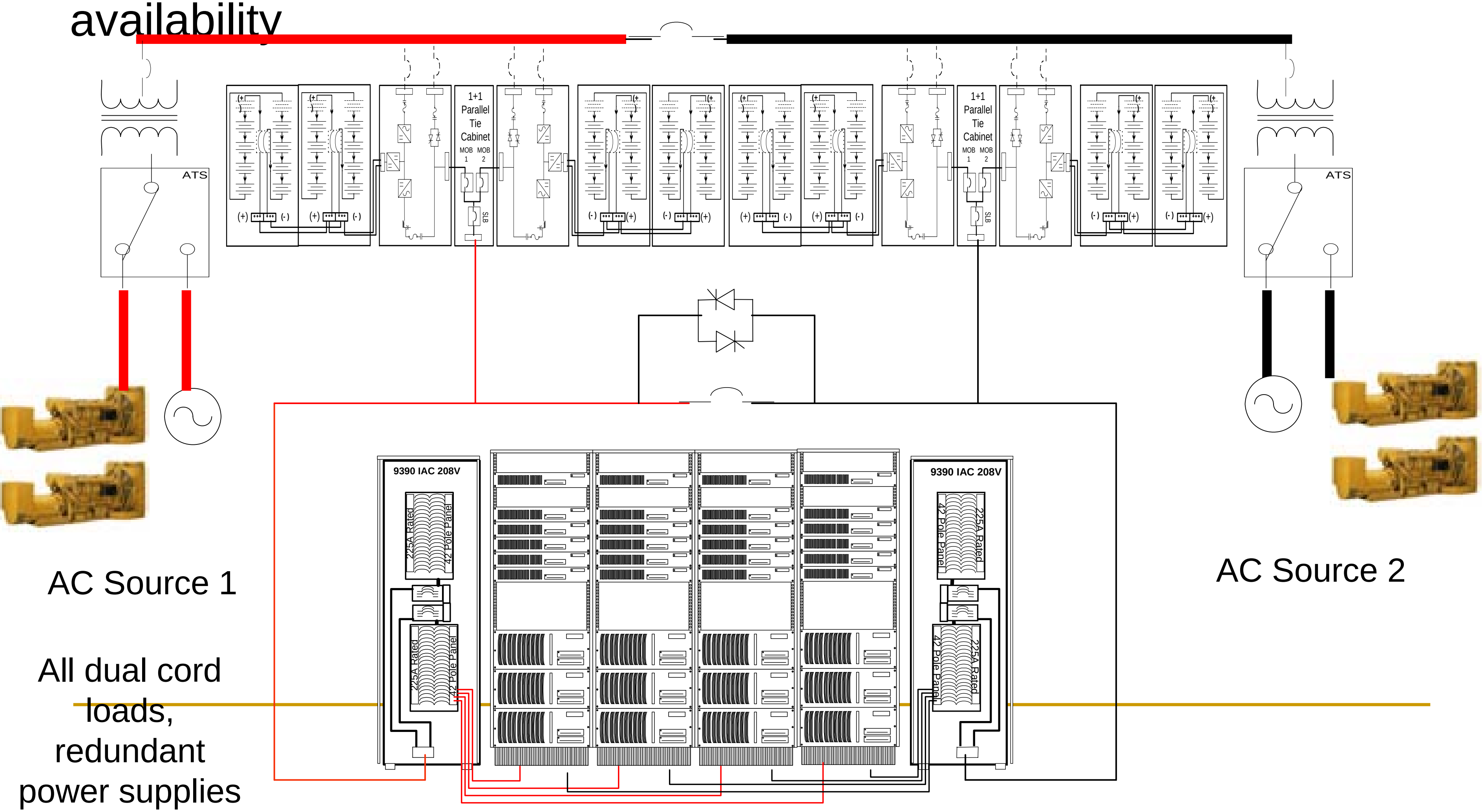


Two independent 80kVA UPS systems using IAC-SB maintenance bypasses.

Distribution cabinets

Tier IV + Designs

- Multiple active power and cooling distribution paths, with redundant components, and designed-in fault tolerance. Provides 99.995% availability

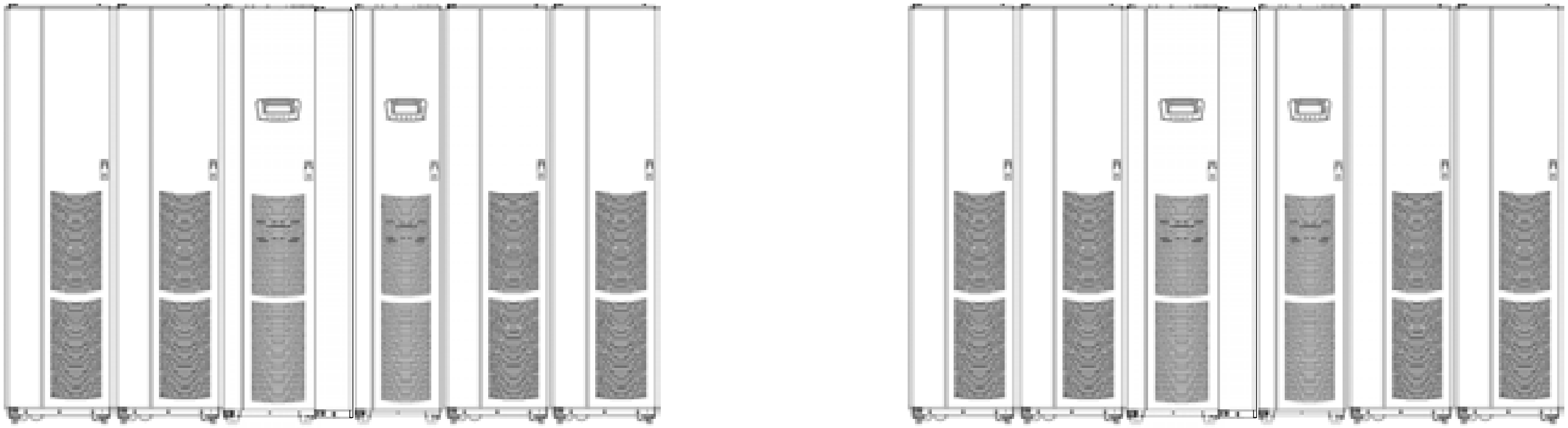


AC Source 1

AC Source 2

All dual cord loads, redundant power supplies

Tier IV + Applications



Two independent 80kVA N+1 UPS systems using IAC-ST HotSync parallel tie cabinets, and redundant battery strings on each module.

Distribution cabinets

Battery Systems

- Valve Regulated (VRLA) or wet-cell
- 15 – 30 minute back-up is typical
- Constructed of jar, lead plates and electrolyte (acid)
- Temperature impacts time and life if outside 77º F.
  - 15º over cuts life in half
  - Cooler temperature decreases runtime
- Shelf life before needing freshening charge is 6 months

Battery Systems-Valve Regulated (VRLA)

- Installed in Cabinet or Rack, Typically Cabinet
- 5-year design life
- Sealed via a pressure relief valve
- Do not require spill containment, eye wash or special ventilation
- Smaller footprint
- Less weight
- Initial cost is less
- Temperature impacts time and life if outside 77º F.
  - 15º over cuts life in half
  - Cooler temperature decreases runtime

Battery Systems-Valve Regulated (VRLA)

- Can weigh up to 4,800 lbs.
- Annual maintenance is required
- Location should maintain 77º

Battery Systems-Wet Cell-Vented

- Installed on open racks
- Most are 20-year design life
- During charge cycle hydrogen gas is released
- Require spill containment, eye wash and ventilation to outside air
- Recommend separate battery room
- Significant floor loading
- Should be installed by experienced contractor
- Temperature impacts time and life if outside 77º F.
    - 15º over cuts life in half
    - Cooler temperature decreases runtime

Battery Systems-Wet Cell-Vented

Operational Procedures and Monitoring

- Most failures occur due to change of state events
- Training, training, training
- Clear and concise test and operational procedures
- Observe and understand and document all changes to the DC infrastructure
- Some type of alarming/monitoring; Alarm panel, SNMP, Web or facility monitoring

Service and Support

- Know the service organization and how to reach them
- Know response time
- On site spares; storage and inventory
- Focus on adequate and proper maintenance
- Keep accurate records
- More maintenance does not mean higher reliability

Summary

- Electrical reliability will become increasingly important due to lack of utility infrastructure investment
- Corporate DC designs will evolve to allow 7x24x365 operation
- Design the DC to meet Corporate objectives: Tier I – Tier IV
- Adhere to Quality Construction
- Assure adequate and thorough commissioning
- Train your internal staff
- Develop and maintain accurate operational procedures
- Document any changes
- Assure proper maintenance
- Monitor critical systems