Introduction to Data Centre Electrical Systems

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Agenda

1	UPS Technologies
2	Battery Technologies
3	Common UPS Configurations

UPS Technologies

IEC 62040 Operating Modes

IEC has identified 3 UPS topologies defined by relationships between input and output voltage and frequency characteristics.

VFI Mode

- Voltage & Frequency independent of input
- Eg. **Double conversion mode**

VFD Mode

- Voltage & Frequency dependent on input.
- No voltage regulation
- Only passive filtering
- Eg. **Standby mode**

VI Mode

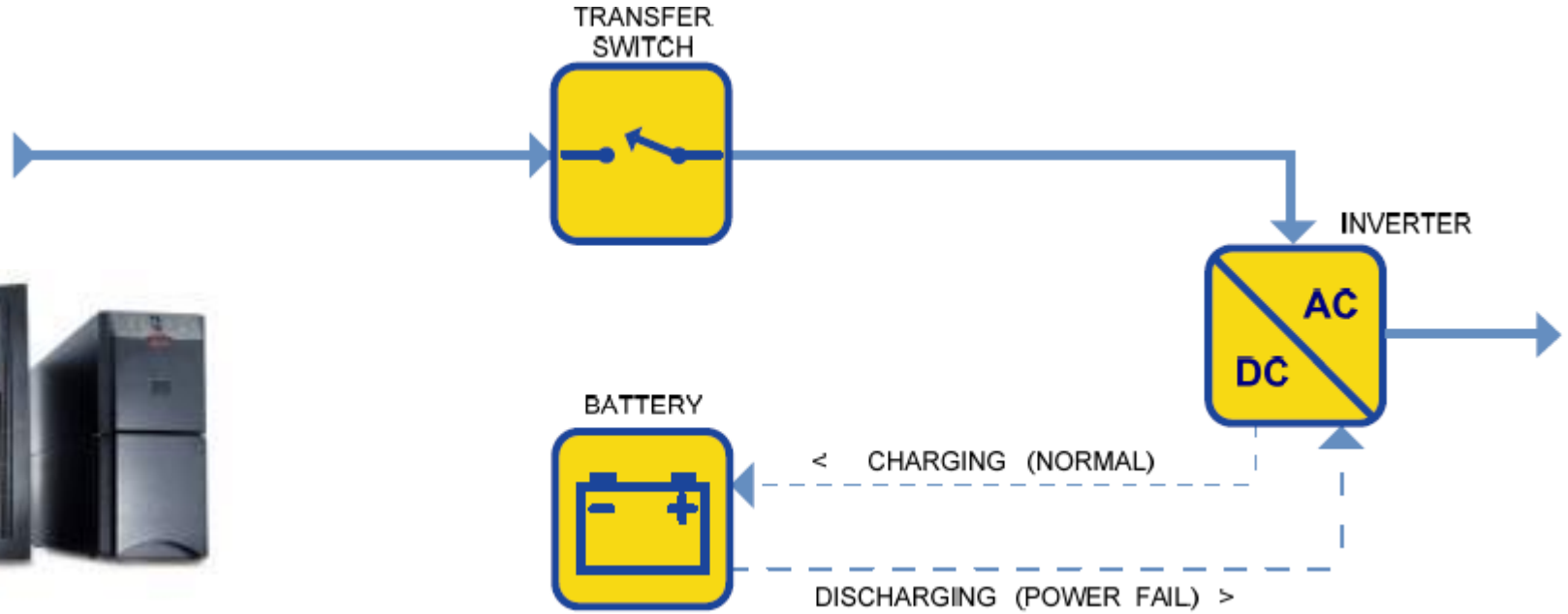
- Voltage independent of input
- Frequency is not regulated
- Eg. **Line interactive mode/eco mode**

IEC62040-1 - General and safety requirements for UPS

IEC62040-2 - Electromagnetic compatibility (EMC) requirements

IEC62040-3 - Method of specifying the performance and test requirements

Line Interactive UPS



- Common among small business, web and small server rooms (0.5 – 5kVA)
- Inverter is used to charge batteries when AC power is normal
- Transfer switch opens when power fails
- Typically includes a tap-changing transformer- minimizes battery usage
- Pros- High Efficiency, small size, low cost, low/high-line voltage correction
- Cons – Transformer losses (at low loads), cost increases as rating increases

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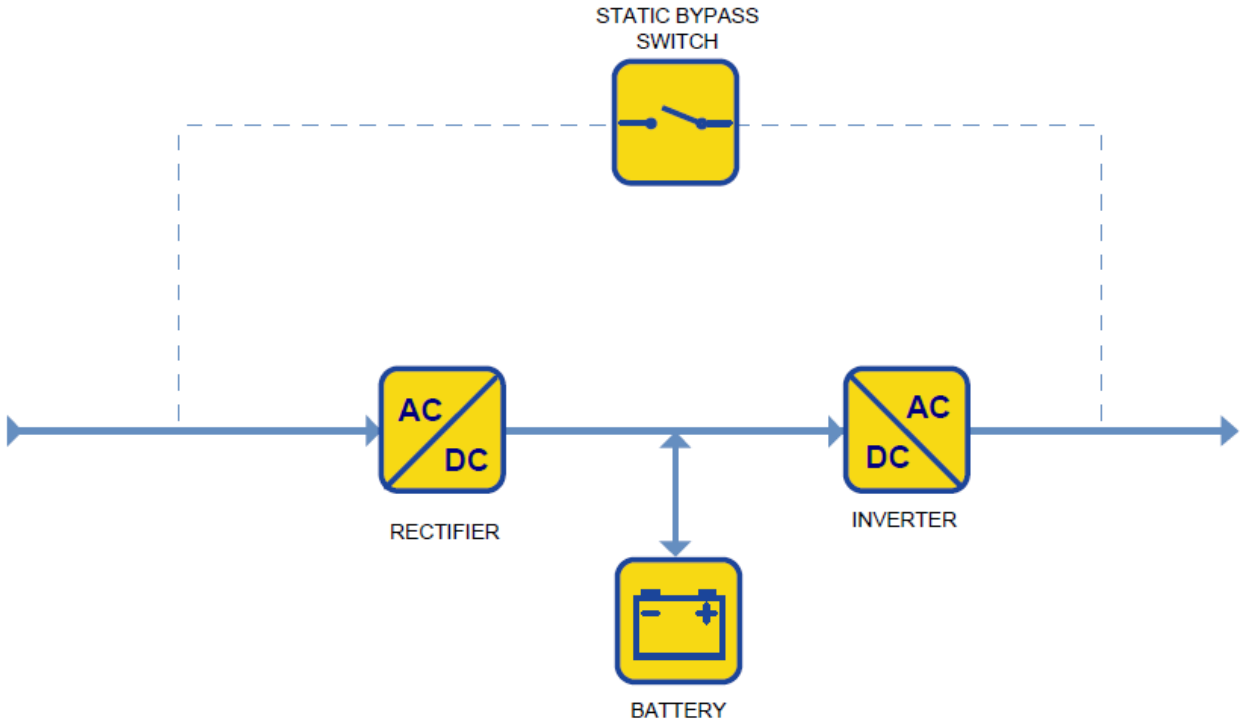
Online- Double Conversion UPS



- Common among 3 Phase 10kVA and above rating.
- Main power supply is from inverter.
- Batteries are always ready to power DC bus in event of power failure
- Pros- Near ideal output performance, isolated input and output, charger has higher rating capability.
- Cons – Reduced reliability due to multiple components, need to cater for higher input drawn power.

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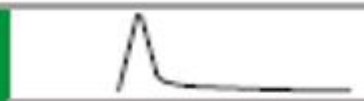
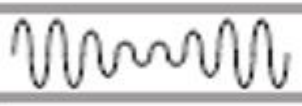
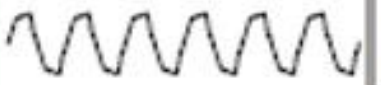
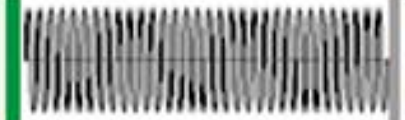
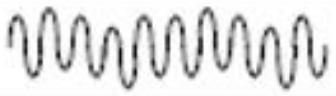
Power Quality Definitions as per IEC/IEEE

Disturbance category	Wave form	Effects	Possible causes	Possible solutions
1. Transient				
Impulsive		Loss of data, possible damage, system halts	Lightning, ESD, switching impulses, utility fault clearing	TVSS, maintain humidity between 35 – 50%
Oscillatory		Loss of data, possible damage	Switching of inductive/capacitive loads	TVSS, UPS, reactors/ chokes, zero crossing switch
2. Interruptions				
Interruption		Loss of data possible, damage shutdown	Switching, utility faults, circuit breaker tripping, component failures	UPS
3. Sag / undervoltage				
Sag		System halts, loss of data, shutdown	Startup loads, faults	Power conditioner, UPS
Undervoltage		System halts, loss of data, shutdown	Utility faults, load changes	Power conditioner, UPS
4. Swell / overvoltage				
Swell		Nuisance tripping, equipment damage/reduced life	Load changes, utility faults	Power conditioner, UPS, ferroresonant "control" transformers
Overvoltage		Equipment damage/reduced life	Load changes, utility faults	Power conditioner, UPS, ferroresonant "control" transformers

Power Quality Definitions as per IEC/IEEE

5. Waveform distortion				
DC offset		Transformers heated, ground fault current, nuisance tripping	Faulty rectifiers, power supplies	Troubleshoot and replace defective equipment
Harmonics		Transformers heated, system halts	Electronic loads (non-linear loads)	Reconfigure distribution, install k-factor transformers, use PFC power supplies
Interharmonics		Light flicker, heating, communication interference	Control signals, faulty equipment, cycloconverters, frequency converters, induction motors, arcing devices	Power conditioner, filters, UPS
Notching		System halts, data loss	Variable speed drives, arc welders, light dimmers	Reconfigure distribution, relocate sensitive loads, install filters, UPS
Noise		System halts, data loss	Transmitters (radio), faulty equipment, ineffective grounding, proximity to EMI/RFI source	Remove transmitters, reconfigure grounding, moving away from EMI/RFI source, increase shielding filters, isolation transformer
Voltage fluctuations		System halts, data loss	Transmitters (radio), faulty equipment, ineffective grounding, proximity to EMI/RFI source	Reconfigure distribution, relocate sensitive loads, power conditioner, UPS
Power frequency variations		System halts, light flicker	Intermittent operation of load equipment	Reconfigure distribution, relocate sensitive loads, power conditioner, UPS

UPS Specifications

UPS Rating/Capacity is indicated by it's **kVA** rating.
UPS load is determined by it's **kW** rating.

kW = kVA x power factor

UPS battery runtime is sized based on **kW rating.**

Example:

100kVA UPS with 10 minutes battery runtime at 80kW load.

UPS kW rating > UPS calculated load

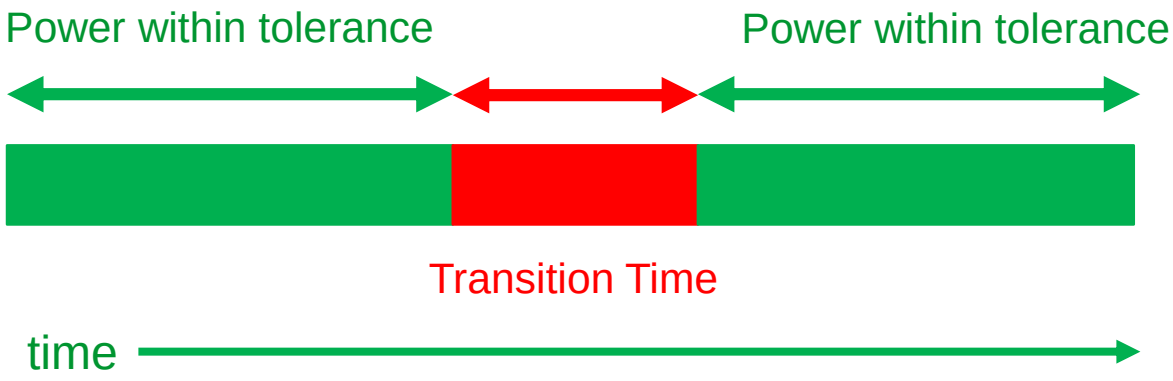
UPS load estimation = No. of Racks x Power Density (typically (3-4kW per rack)

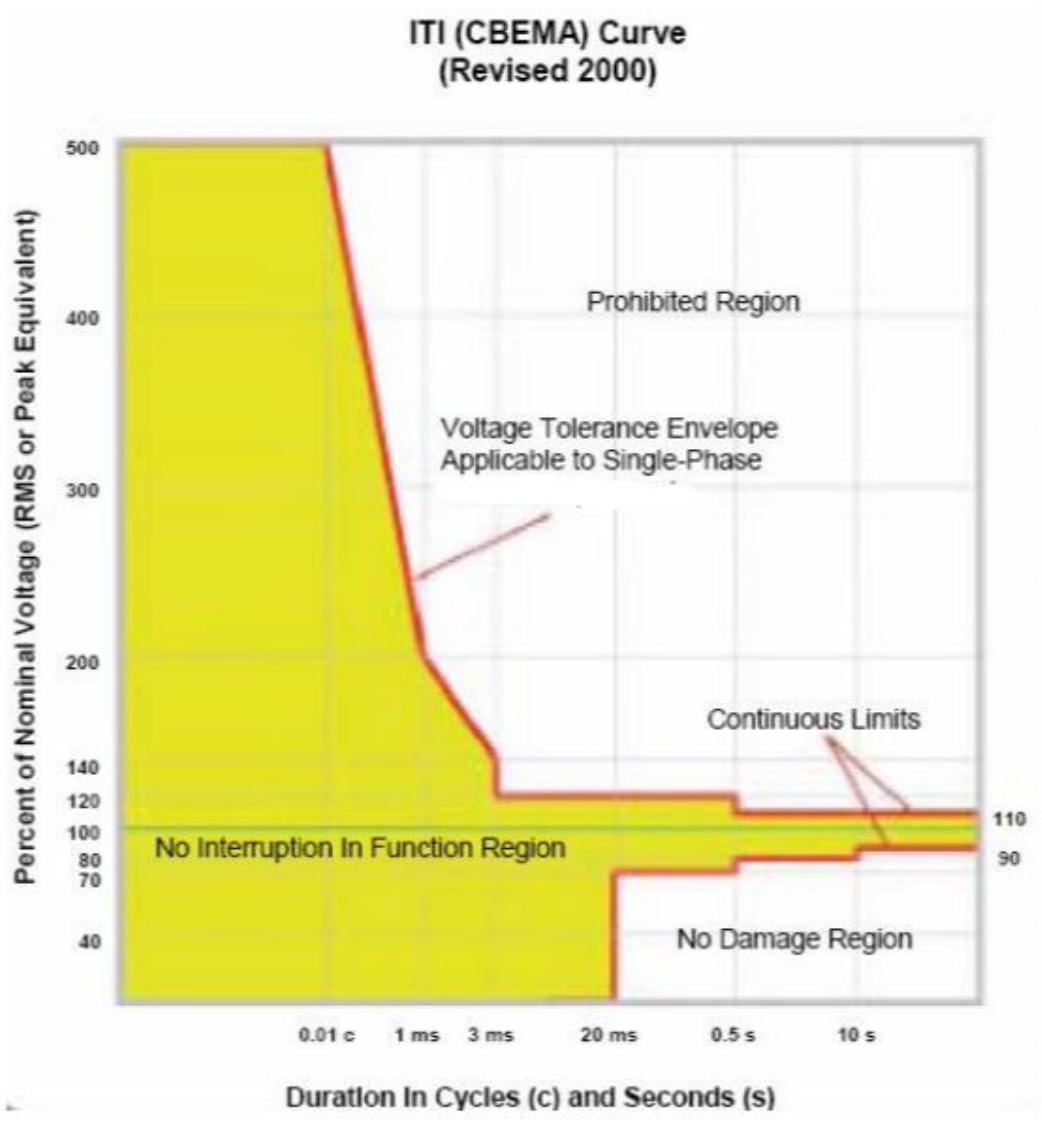
What happens when power is cut-off from IT equipment?

IEEE 1100-1999 standard rating references the ITI curve that recommends a power hold up of **21ms**.

ITI database observes that some devices to require 10-20ms.

Any break-before-make transfer is recommended to have a switching time **<10ms outside ± 10% of rated voltage.**





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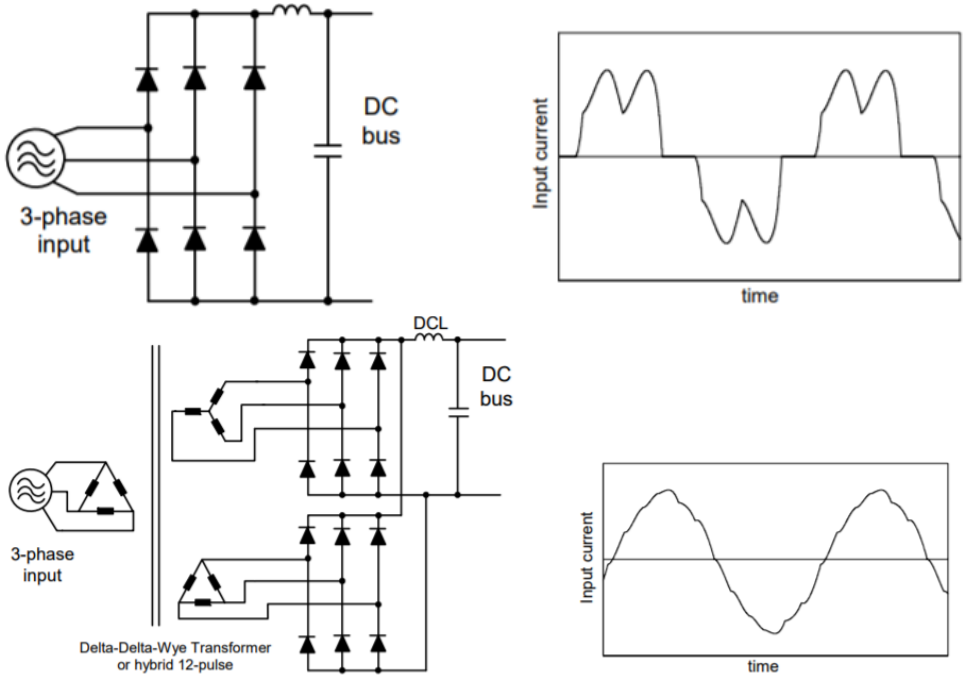
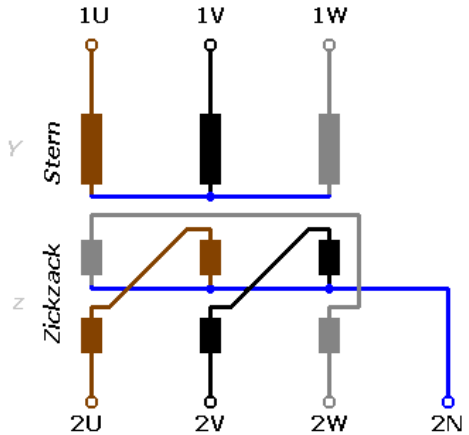
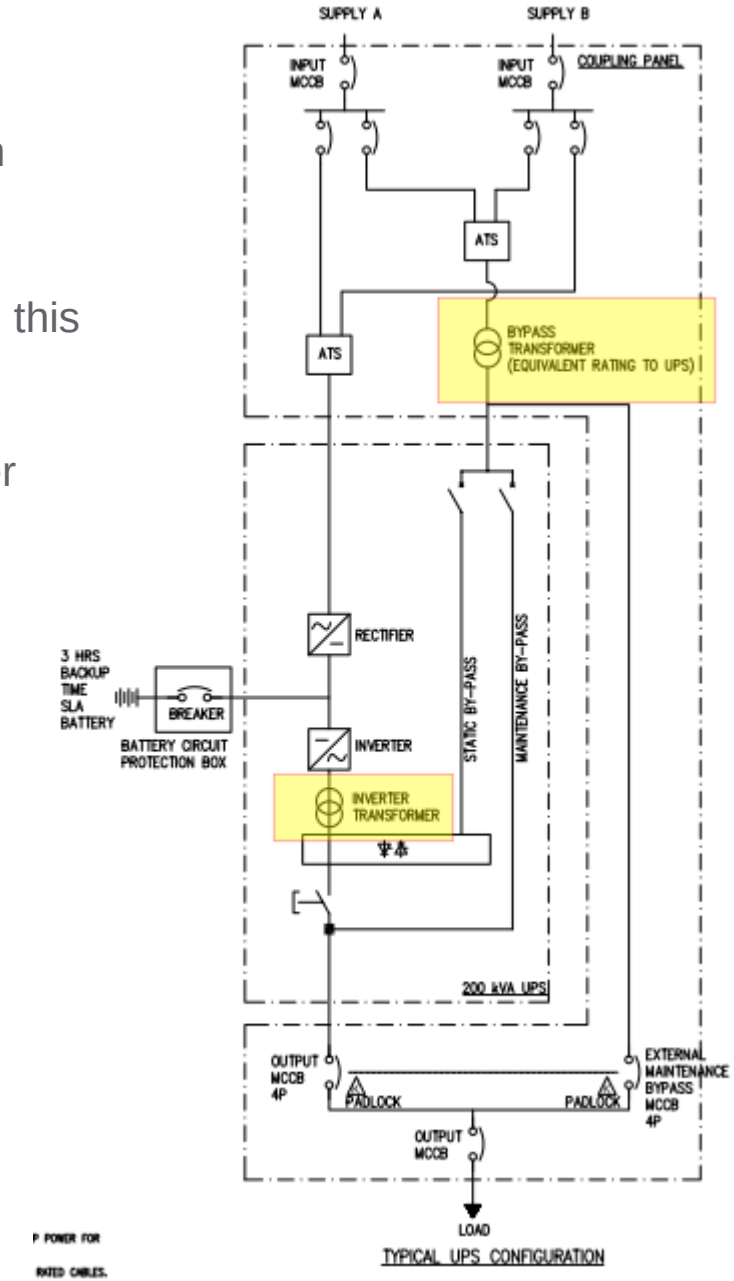
Transformer Vs Transformerless UPS

- UPS generate an abundance of 3rd and triplen harmonics (3rd, 6th, 9th *etc.*)
- The 3 phase zigzag transformers isolates these harmonics from reaching the main components of the UPS (SCRs on 6-pulse rectifier and inverter)
- Transformerless UPS IGBTs on rectifier and inverter are capable of operating with this harmonics minimizing the dependency on 3-phase transformers
- Transformerless UPS allows the UPS design to be more compact and will be lighter -more white space and eases deployment







Modular Design

- **Modular power module** for optimal MTTR
  - Front access to power module for easy maintenance
  - Includes a pull-out shelf for easy power module removal
  - Recommended to place UPS on bypass mode during replacement
- **Modular hot-swappable batteries**
  - Slide-in / slide-out batteries for flexible runtime or instant battery replacement
  - Faulty battery identification

Modular power modules Galaxy VS

Modular power modules Symmetra PX

3 Phase Modular UPS

Legacy/Conventional

Modular

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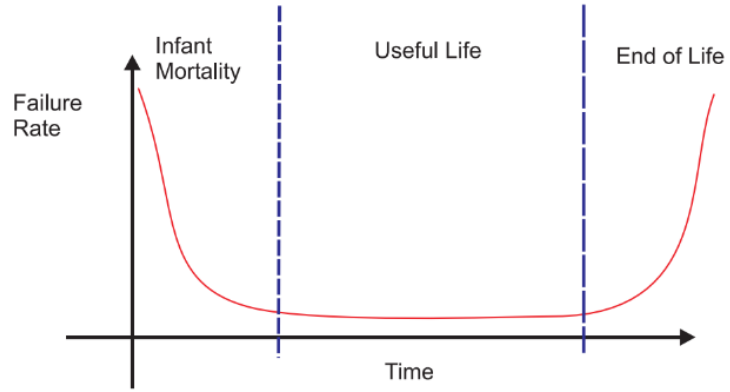
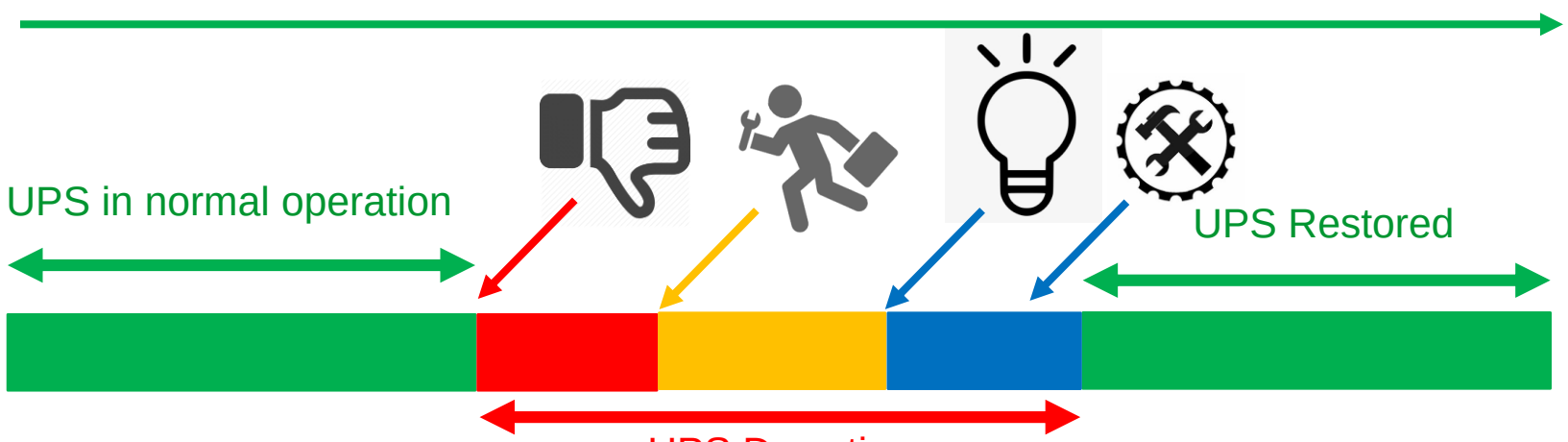
500kW of High-Efficiency Scalable Power Protection

MTTR – Mean Time To Repair

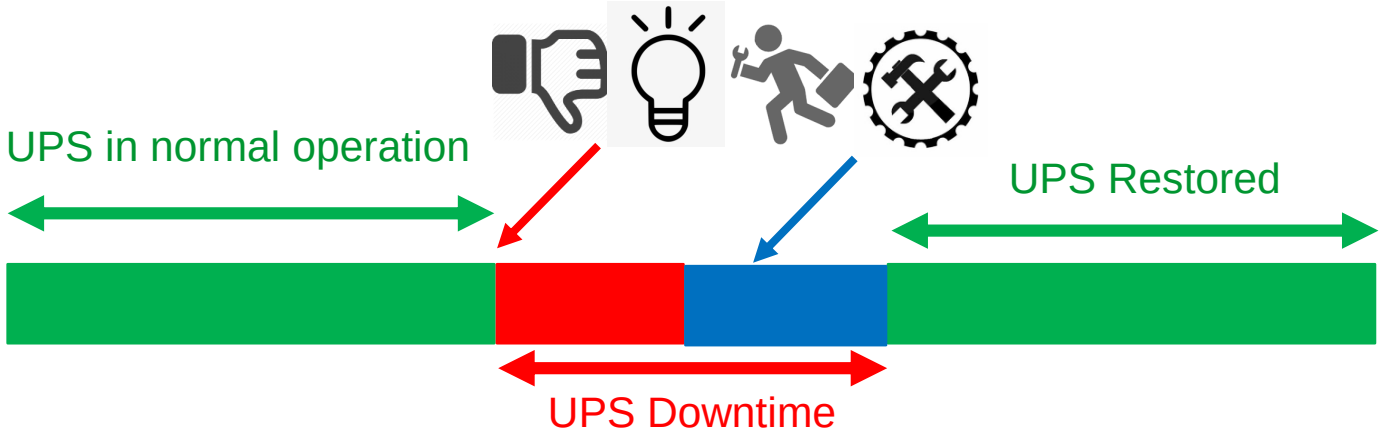
- The mean time required to replace a failed hardware module.
- External factors – Spare part availability, service agreement *etc.*
- Internal factors – Product design, ease to replace failed parts *etc.*



Conventional UPS



Modular UPS



Quiz

Question 1

What is the most common UPS type for ratings above 10kVA with 3 phase power?

A. Delta Conversion UPS.
B. Line Interactive UPS.
C. Rotary type UPS.
D. Online-Double Conversion UPS.

Quiz

Question 2

What is the recommended switching time for break-before-make power switching according to ITI curve and IEEE?

A. 20 miliseconds.
B. 1 minute.
C. 10 miliseconds.
D. Any amount of time.

Quiz

Question 3

A newly built server room requires 10 racks each with a rack power density of 4kW per rack. What is the estimated UPS capacity required for this server room?

A. 2.5kW.
B. 14kW.
C. 40kW.
D. 6kW.

Quiz

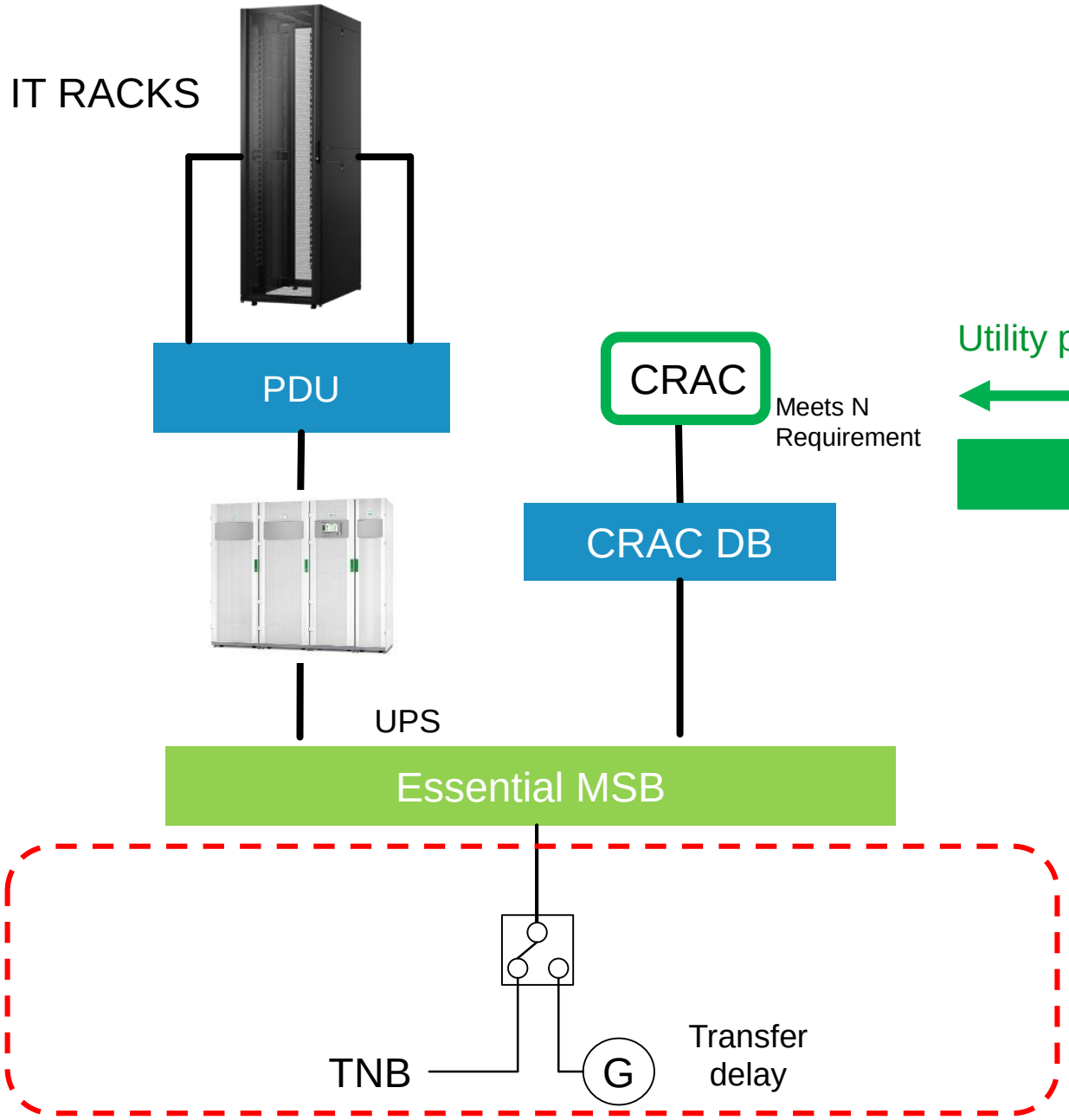
Question 4

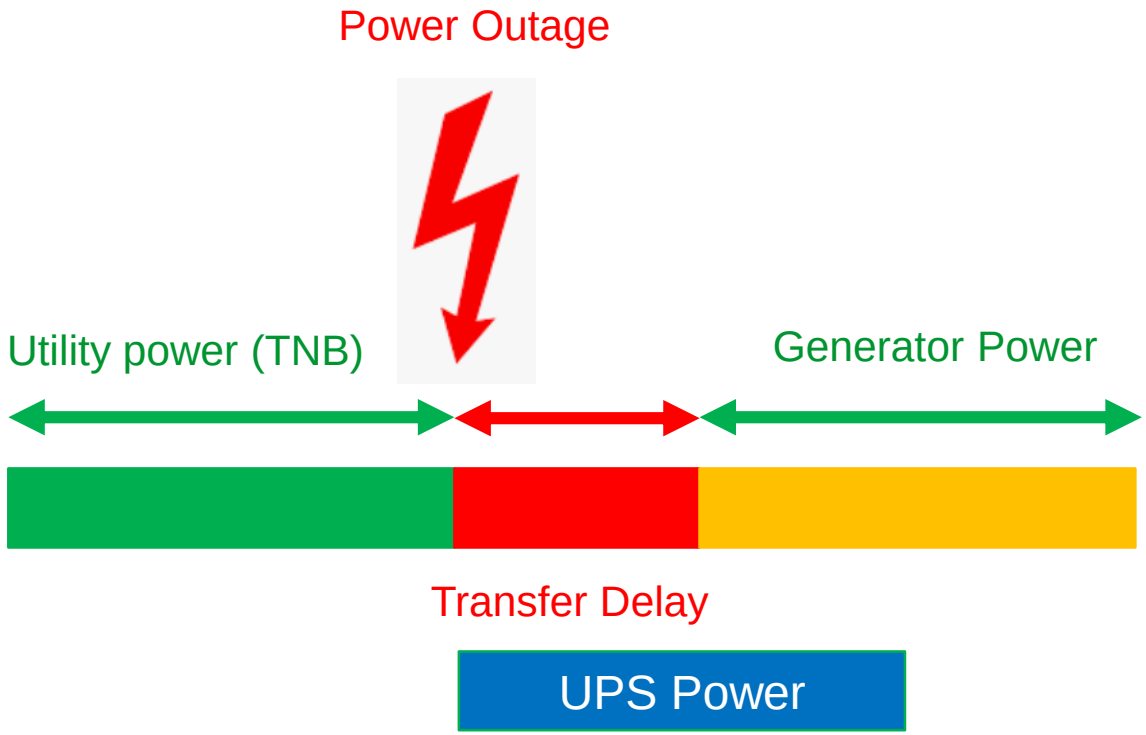
What is the main advantage of using a modular UPS?

A. Green technology UPS.
B. Reduced time UPS downtime.
C. Sleek design.
D. Update to latest technology.

Battery Technologies

How long should your battery runtime be?





Factors that effect UPS battery runtime:

- Generator power availability.
- Duration required for device soft shutdown.
- Standard Operating Procedures.
- Cost.

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Battery Technologies

Vented (Flooded/Wet Cell)

- Non-Sealed system
- Continuously emits Hydrogen and Oxygen
- Requires water replenishment
- Typically heavier solution
- Lower energy density per block
- Available in lower voltage per block. (1-1.7V)
- Specific site planning/design. (Racks require larger footprint).
- Requires equalization charging from UPS.
- Typical 15-20 year service life*
- Typically costs 2-3X more than VRLA.

VRLA

- Sealed System for electrolyte
- Hydrogen and oxygen recombine internally
- “Maintenance-free”
- Weighs less
- Greater energy Density per block
- Available in 6V-12V monoblocks.
- More flexible site planning
- Typical 5 years service lifespan*
- Most common batteries configuration for commercial markets.

Modular

- VRLA batteries enclosed on modular cartridge
- Easily attached to UPS DC bus.
- Contains temperature and voltage sensors.
- Plugged into pre-manufactured cabinets.
- Easily replaced with minimum downtime.
- Costs slightly more than VRLA batteries.

Battery Technologies (Enclosures

Vented (Flooded/Wet Cell)

VRLA

Modular

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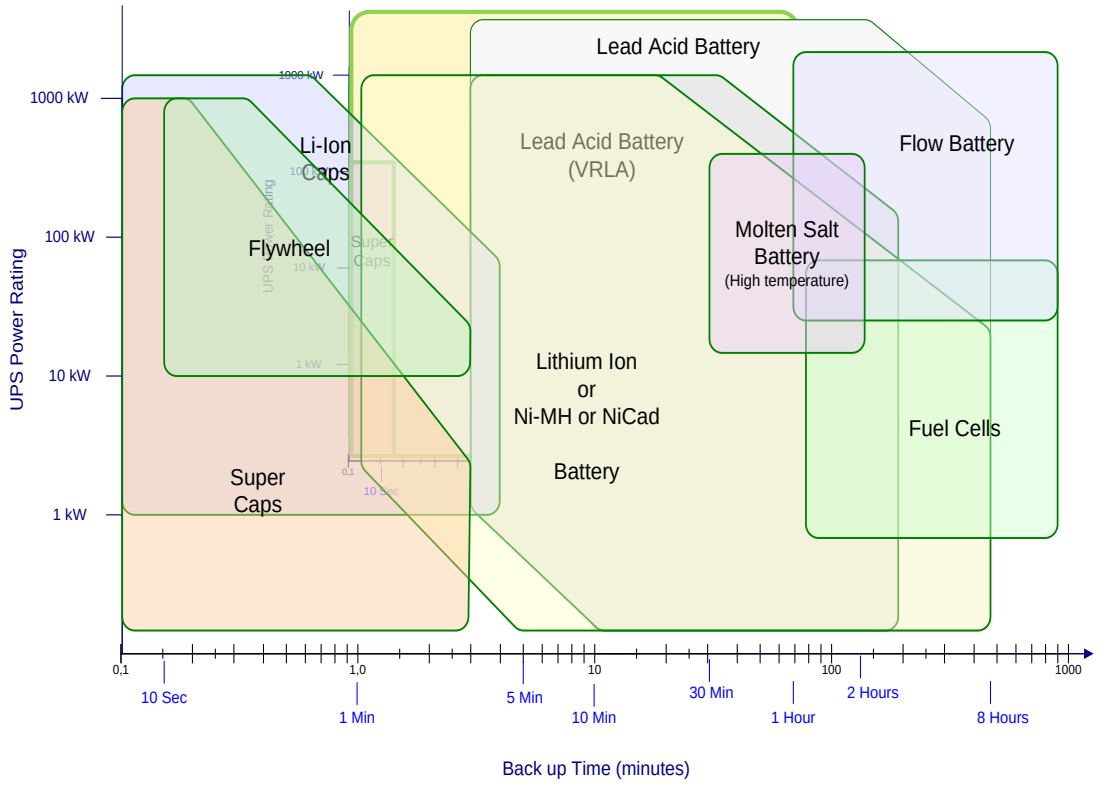
Why Lithium-Ion

Energy Storage Technology Map

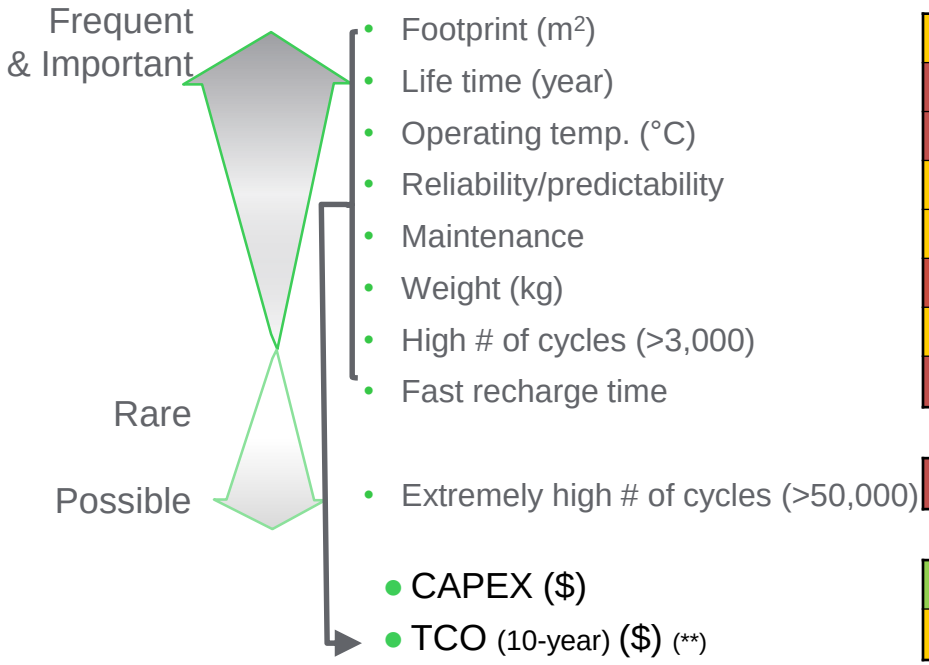


Technology with best 10 year TCO

- Most relevant for 3-phase UPS applications
- A proven and mature technology
- The enabler for key growth initiatives such as energy storage, software-defined power, and Open Compute Project
- Dramatically reduced cost in the past years
- Many benefits to be taken advantage of to reduce TCO

Li-ion Battery Technology vs. VRLA

Customer needs/pain points of lead-acid batteries (esp. large load requirements)



Example: « need 2min » 600KW

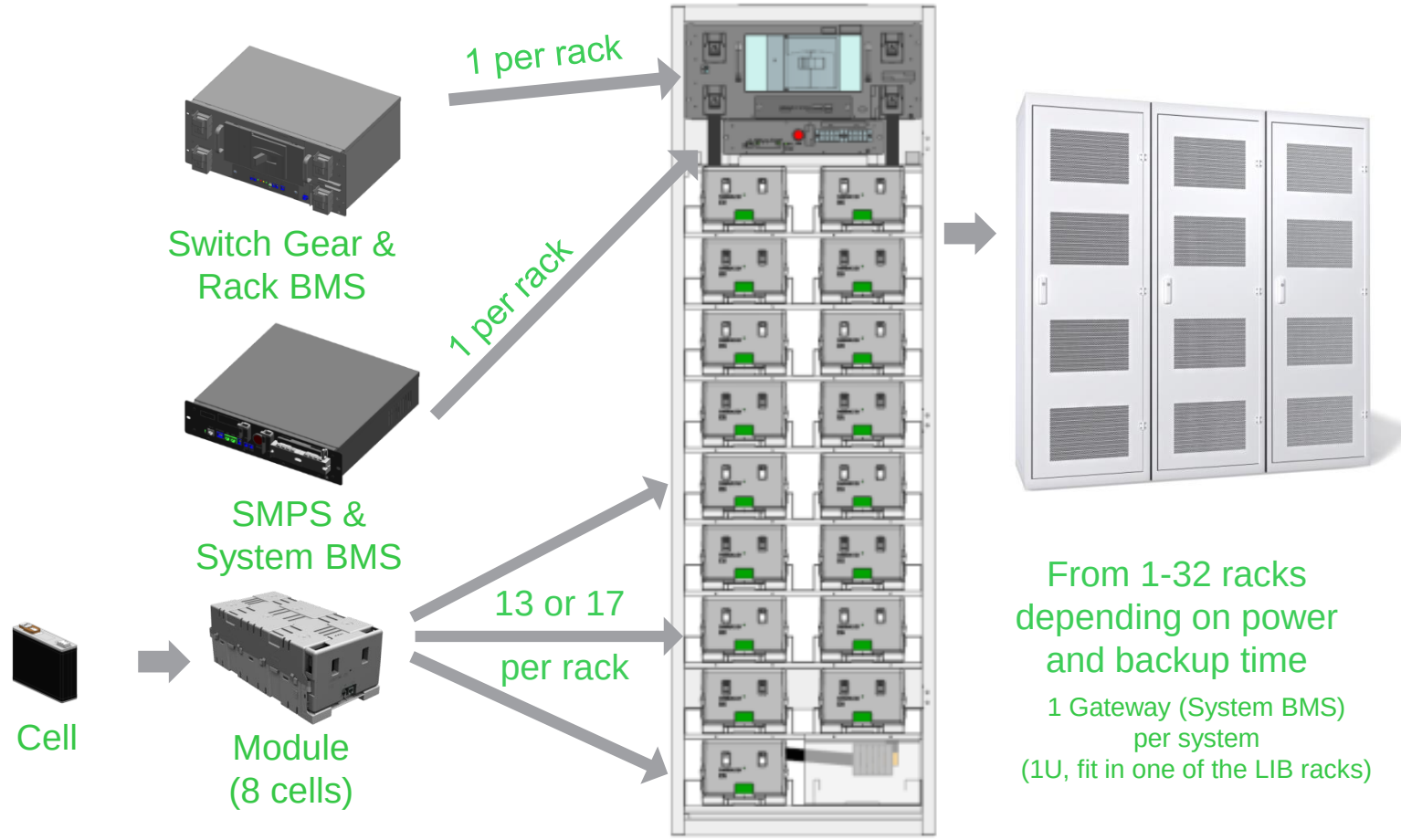
VRLA (EMEA) (5 min)	Li-ion (7 min)	Flywheel (20s)	Flywheel (2min)	Ultracaps (20s)	Ultracaps (2min)
4.3	1.6	2.3	8.1	1.8	9.0
5	12	15	15	15	15
20-25 °C	0-35 °C	-20-40 °C	-20-40 °C	-40-40 °C	-40-40 °C
Medium	High	High	High	High	High
Medium	Low	Medium	Medium	Low	Low
10,500	1,920	3,400	11,900	3,000	15,000
500	>5,000	>30,000	>30,000	>100,000	>100,000
Low	Medium	High	High	High	High
500	>5,000	>30,000	>30,000	>100,000	>100,000
1X	1.9X	8.5X	29.6X	6.7X	33.4X
1X	0.75X	3.1X	10.0X	2.2X	11.0X

LIB Requirements for UPS application

- Top safety technology
- High energy and power density: 35kWh and up to 230kW per rack
- Backup time from 5/6min to 30+min
- 15-years design life
- Competitive CapEx (~2X VRLA)
- Breakthrough TCO (-10-40%)
- Partnership with leading li-ion manufacturer

Schneider Electric's LIB Solution

A modular solution accomodating a wider range of needs



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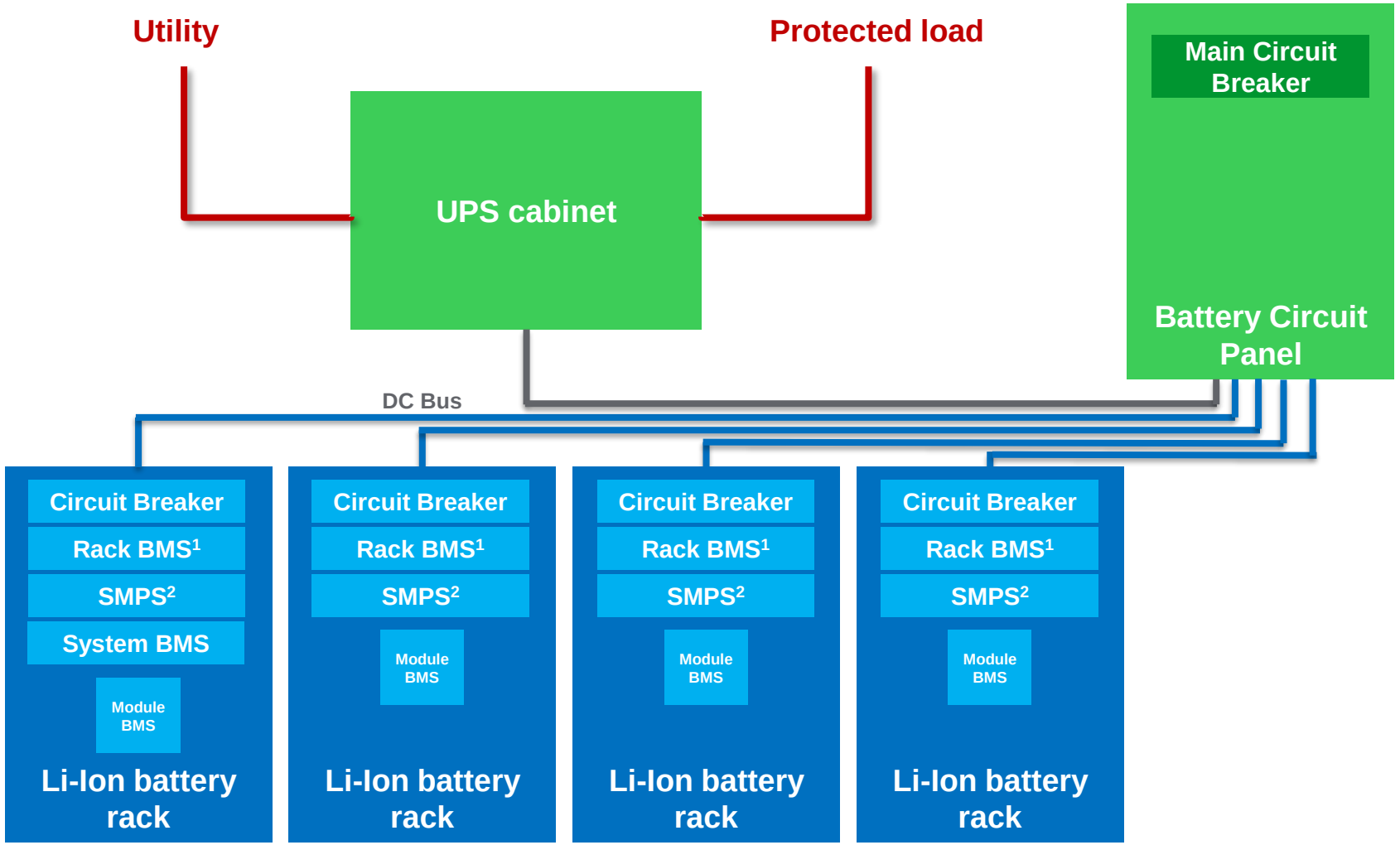
Solution design – Multiple Battery Racks

Schneider product

Samsung SDI products



[1] BMS = Battery Management System
[2] SMPS = Switched-Mode Power Supply

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Runtime Table

Actual Calculated Runtime (at 77 deg F)

Rack Type	# of cells/rack	SE UPS	Power	1 rack	2 racks	3 racks	4 racks	5 racks	6 racks	7 racks	8 racks
G	136	G7K (PF=0.9)	300kVA	#N/A	13.0	20.5	27.5	35.0	42.5	49.5	57.0
G	136		400kVA	#N/A	9.5	15.0	20.5	26.0	31.5	37.0	42.5
G	136		500kVA	#N/A	#N/A	11.5	16.0	20.5	25.0	29.5	34.0
G	136	GVM (PF=0.9)	160kVA	12.5	27.0	41.0	55.0	69.0	83.0	97.0	110.0
G	136		180kVA	11.0	23.5	36.0	48.5	61.0	73.5	86.0	98.5
G	136		200kVA	10.0	21.0	32.5	43.5	55.0	66.0	77.5	88.5
G	136		225kVA	7.2	18.50	28.5	38.5	48.5	58.5	68.5	78.5
G	136	GVX (PF=1.0)	500kW	#N/A	#N/A	10.5	14.5	18.5	23.0	27.0	31.0
G	136		625kW	#N/A	#N/A	5.1	11.5	15.0	18.0	21.0	24.5
G	136		750kW	#N/A	#N/A	#N/A	9.4	12.0	14.5	17.5	20.0
G	136		1000kW	#N/A	#N/A	#N/A	#N/A	7.5	10.5	14.5	16.5
G	136		1250kW	#N/A	#N/A	#N/A	#N/A	#N/A	4.8	10.0	11.5
G	136		1500kW	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.6	9.3

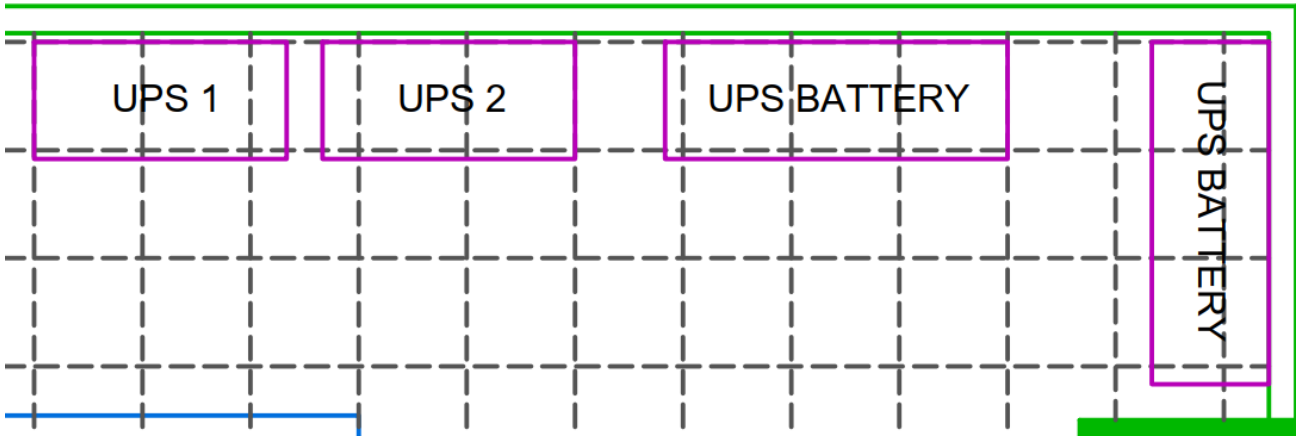
Rack Type	# of cells/rack	SE UPS	Power	2 racks	4 racks	6 racks	8 racks	10 racks	12 racks	14 racks	16 racks
S	104	SyMW (PF=1.0)	400kW	#N/A	14.0	21.5	29.0	37.0	44.5	52.5	60.0
S	104		600kW	#N/A	8.2	14.0	19.0	24.0	29.0	34.5	39.5
S	104		800kW	#N/A	#N/A	10.0	14.0	17.5	21.5	25.5	29.0
S	104		1000kW	#N/A	#N/A	1.5	10.5	14.0	17.0	20.0	23.0
S	104		1200kW	#N/A	#N/A	#N/A	8.2	11.0	14.0	16.5	19.0
S	104		1400kW	#N/A	#N/A	#N/A	#N/A	9.6	11.5	14.0	16.0
S	104		1600kW	#N/A	#N/A	#N/A	#N/A	4.6	10.0	12.0	14.0

Runtimes are subject to tolerances (+/- 5%) and may vary

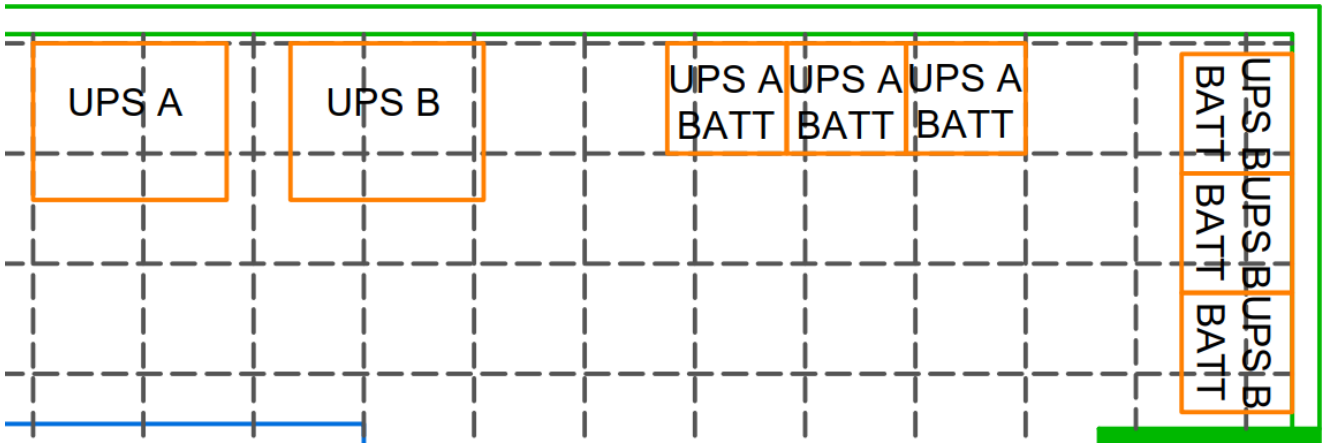
(Please confirm with application engineering team for different temperature and load configurations)

Space Reduction

Considering a 200kVA UPS that has a battery runtime of 10 minutes



UPS can achieve 3 times the battery runtime with same space!



UPS Configurations

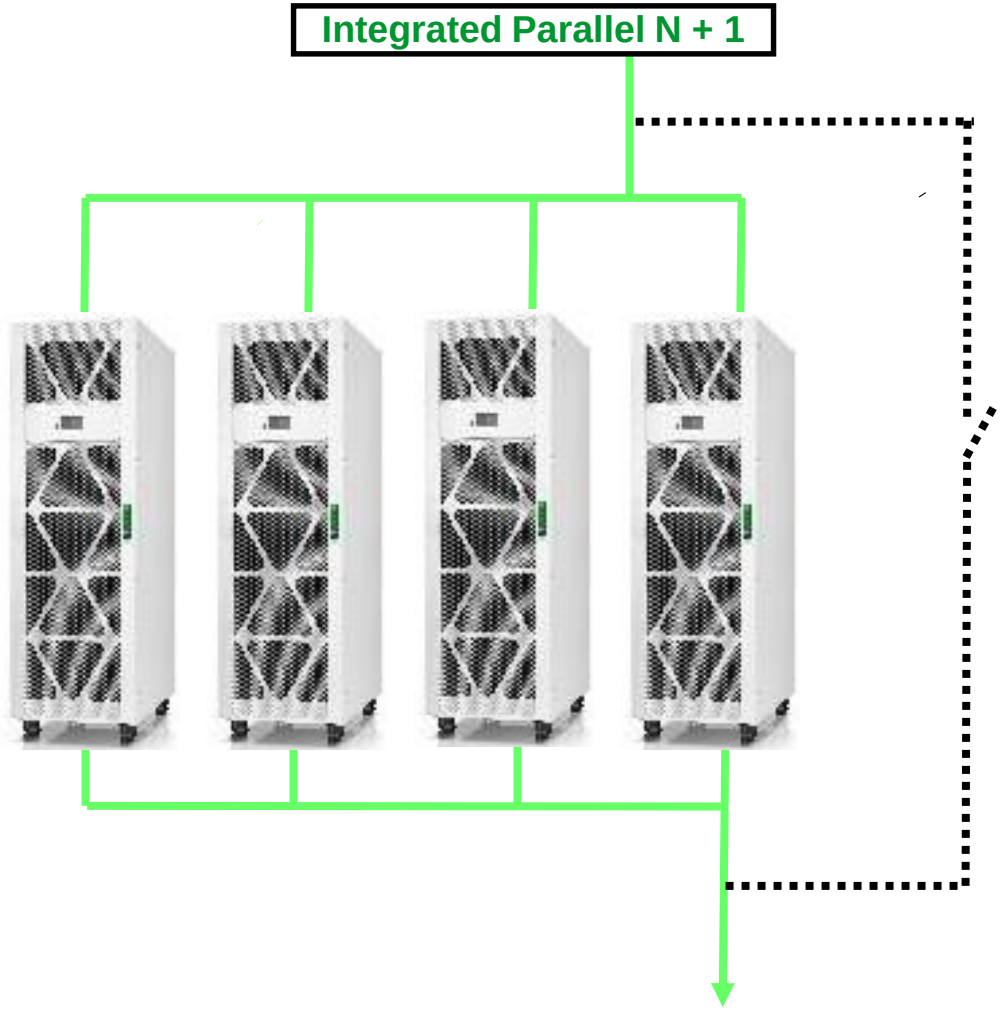
Common UPS Configurations (UPS Availability)

- Unitary — N="Needed" UPS
- Parallel (N+X) — X=No. of redundant UPS
- 2N

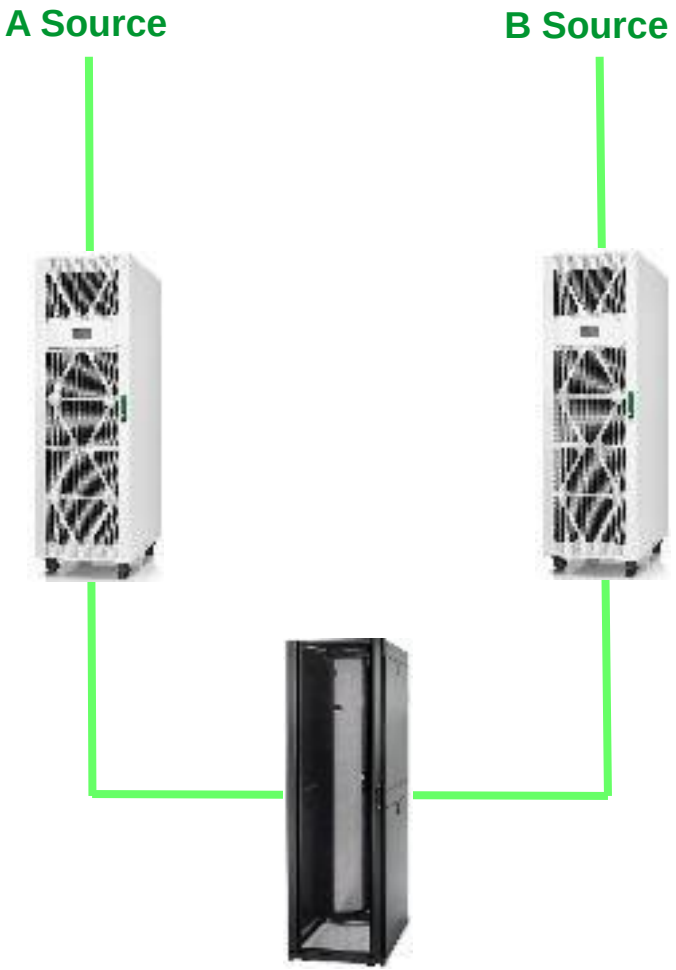
Uptime Institute

Integrated Parallel 1 + 1

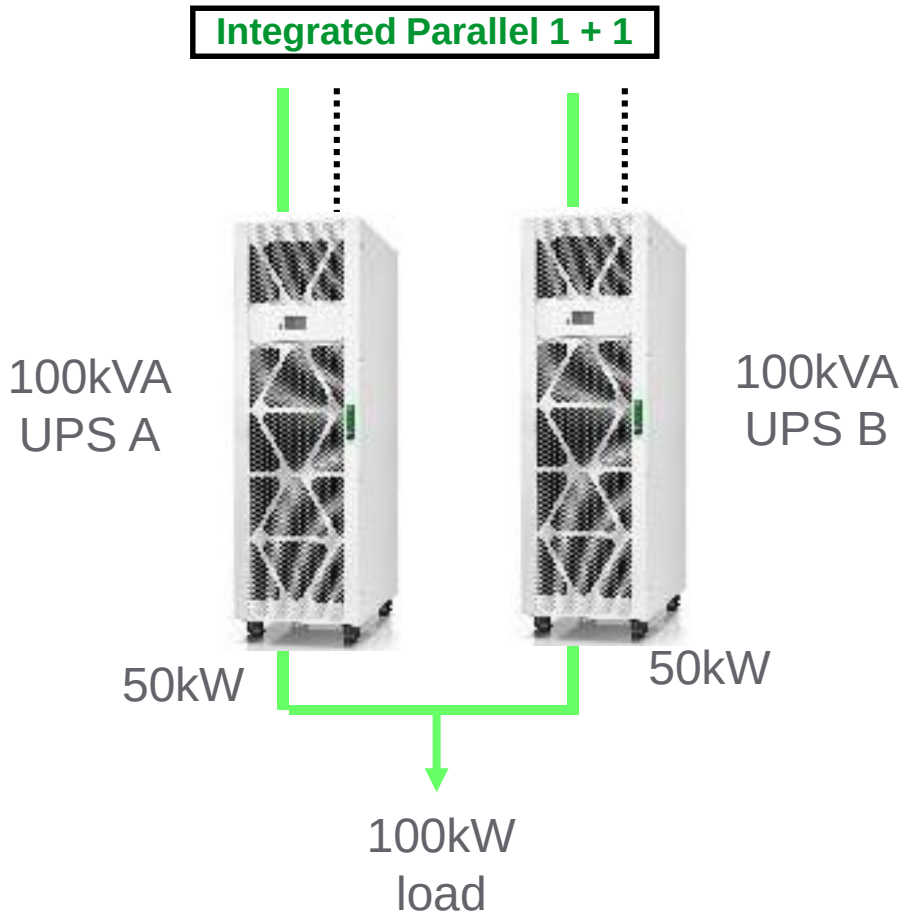
Integrated Parallel N + 1



2N Topology

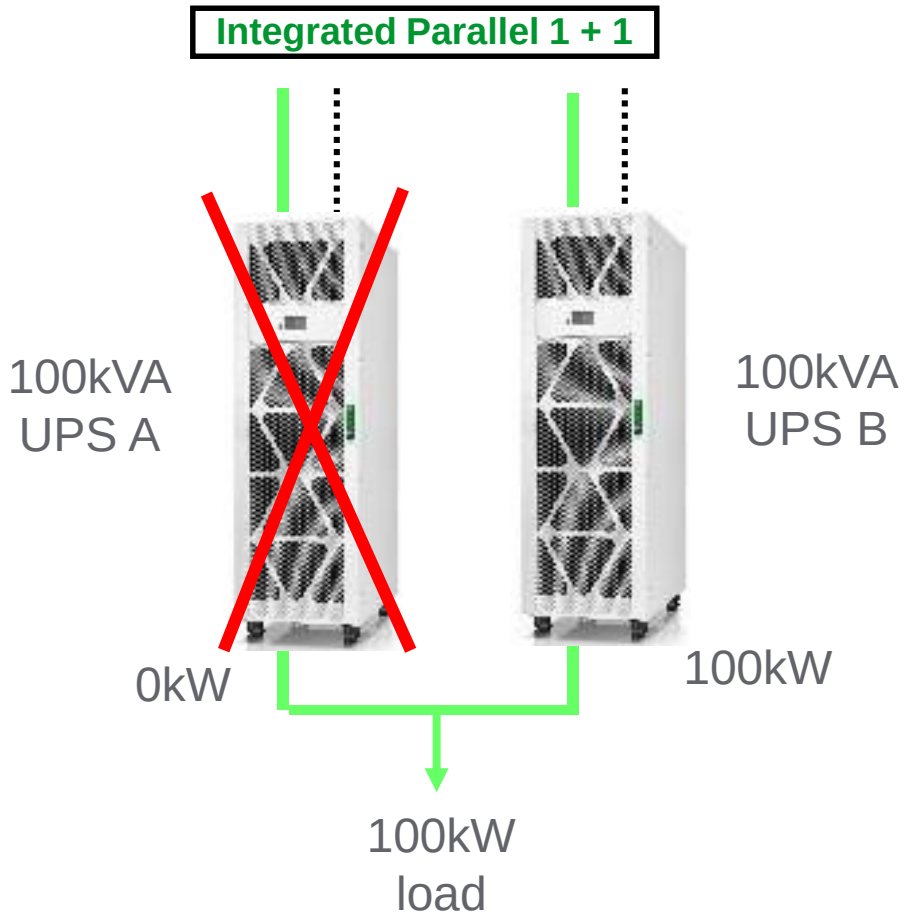


N+1 Redundancy



UPS Power Factor = 1

N+1 Redundancy



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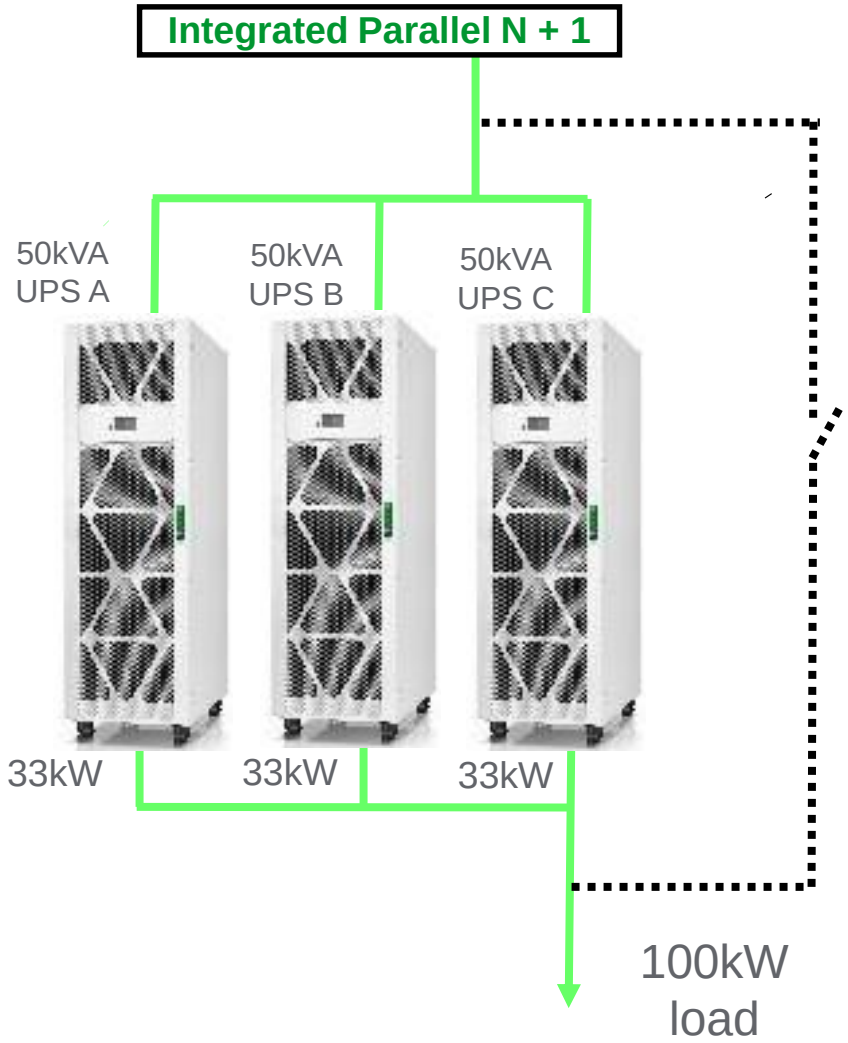
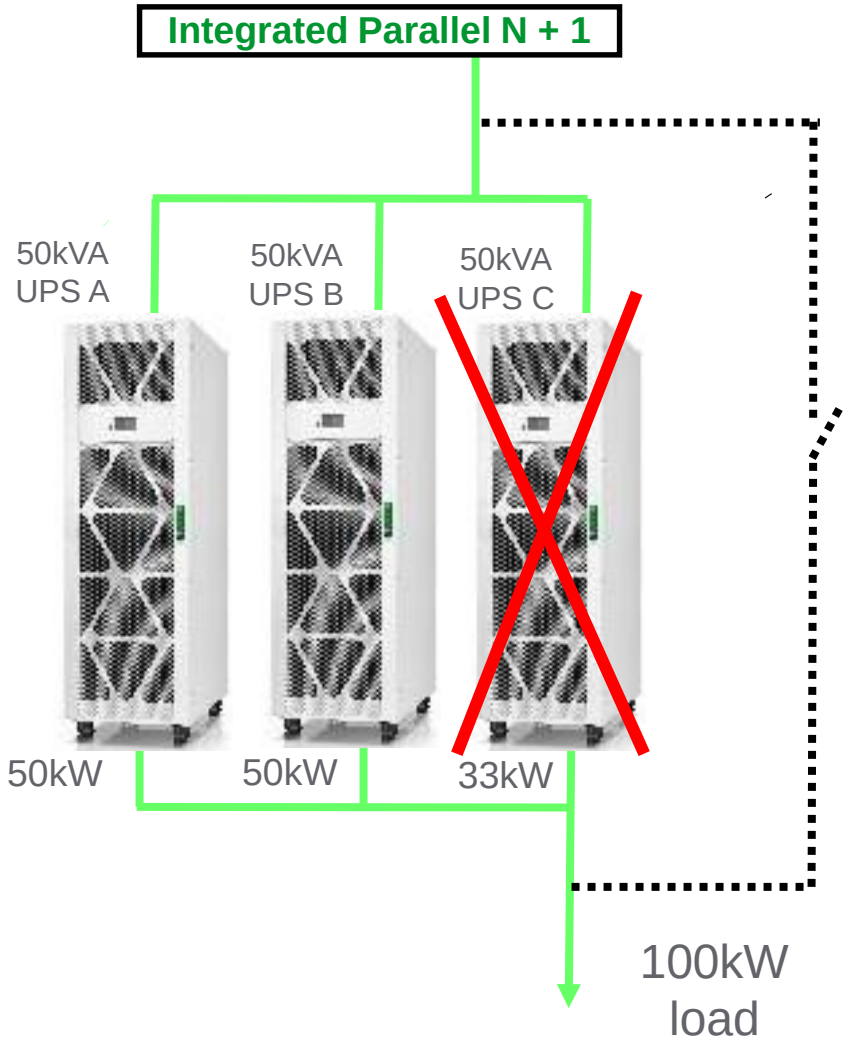
N+1 Redundancy



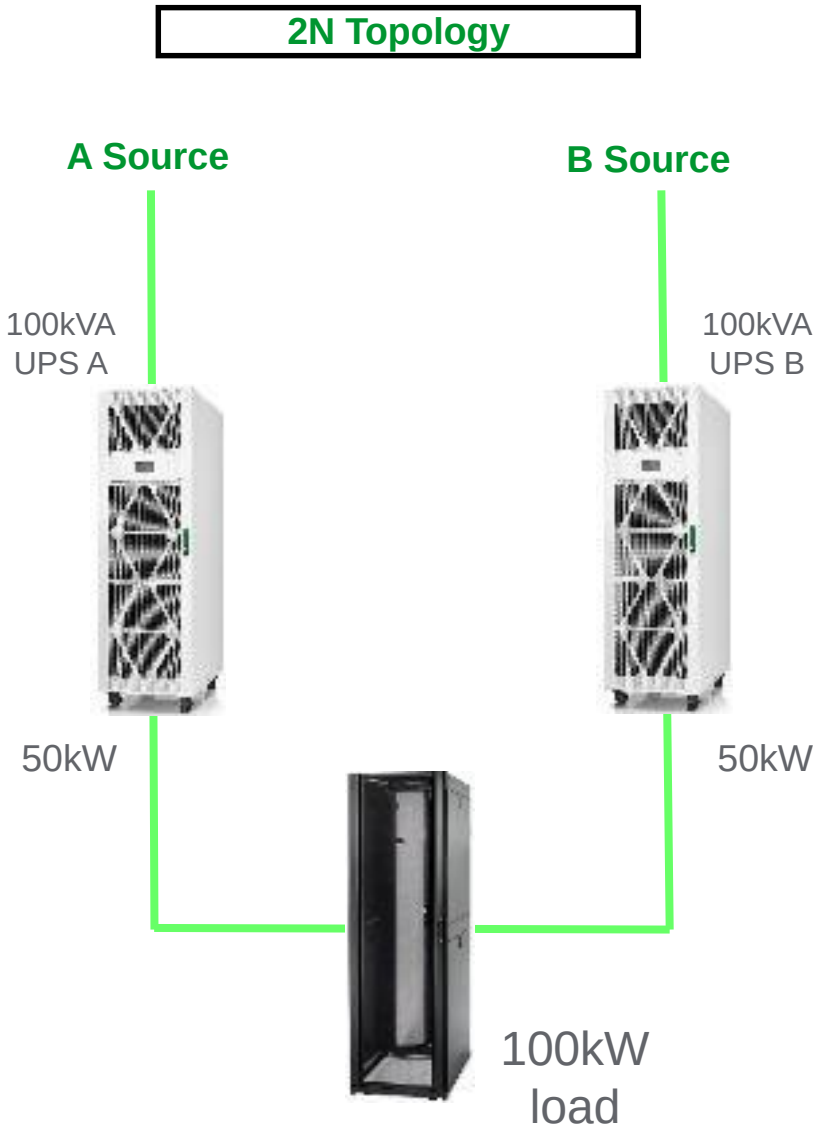
UPS Power Factor = 1

N+1 Redundancy

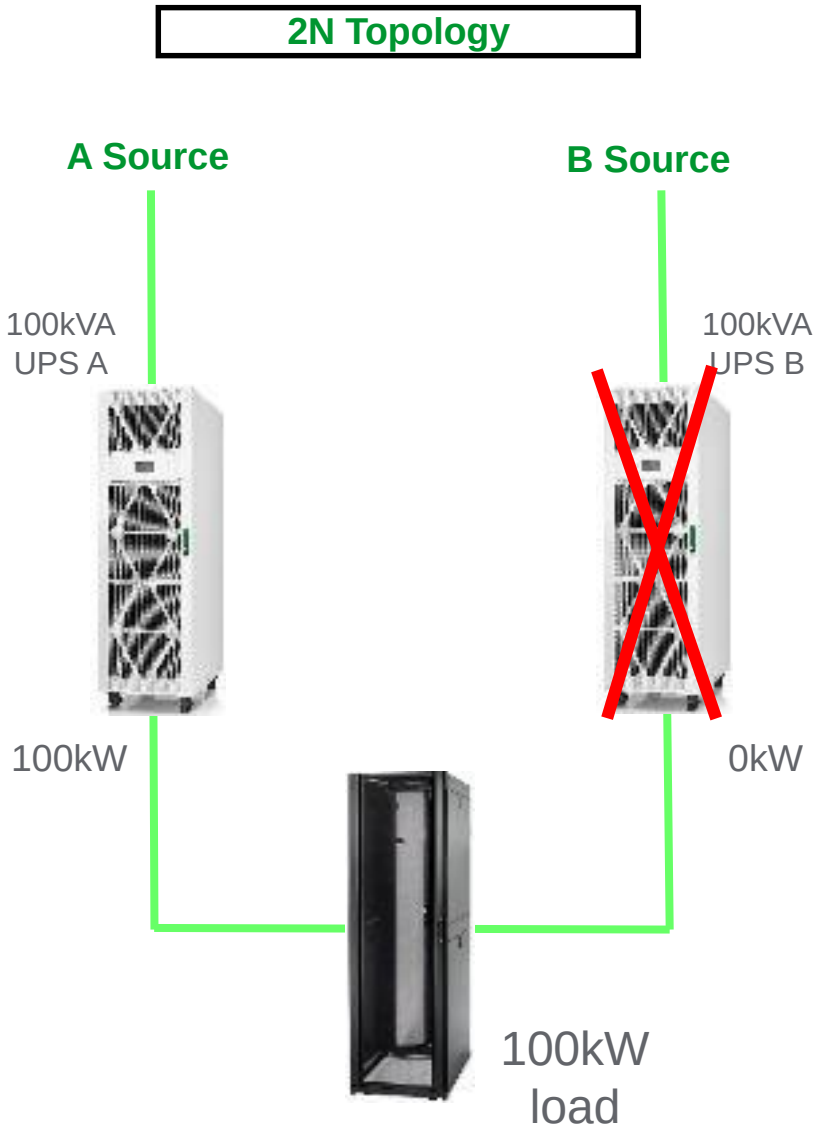


UPS Power Factor = 1

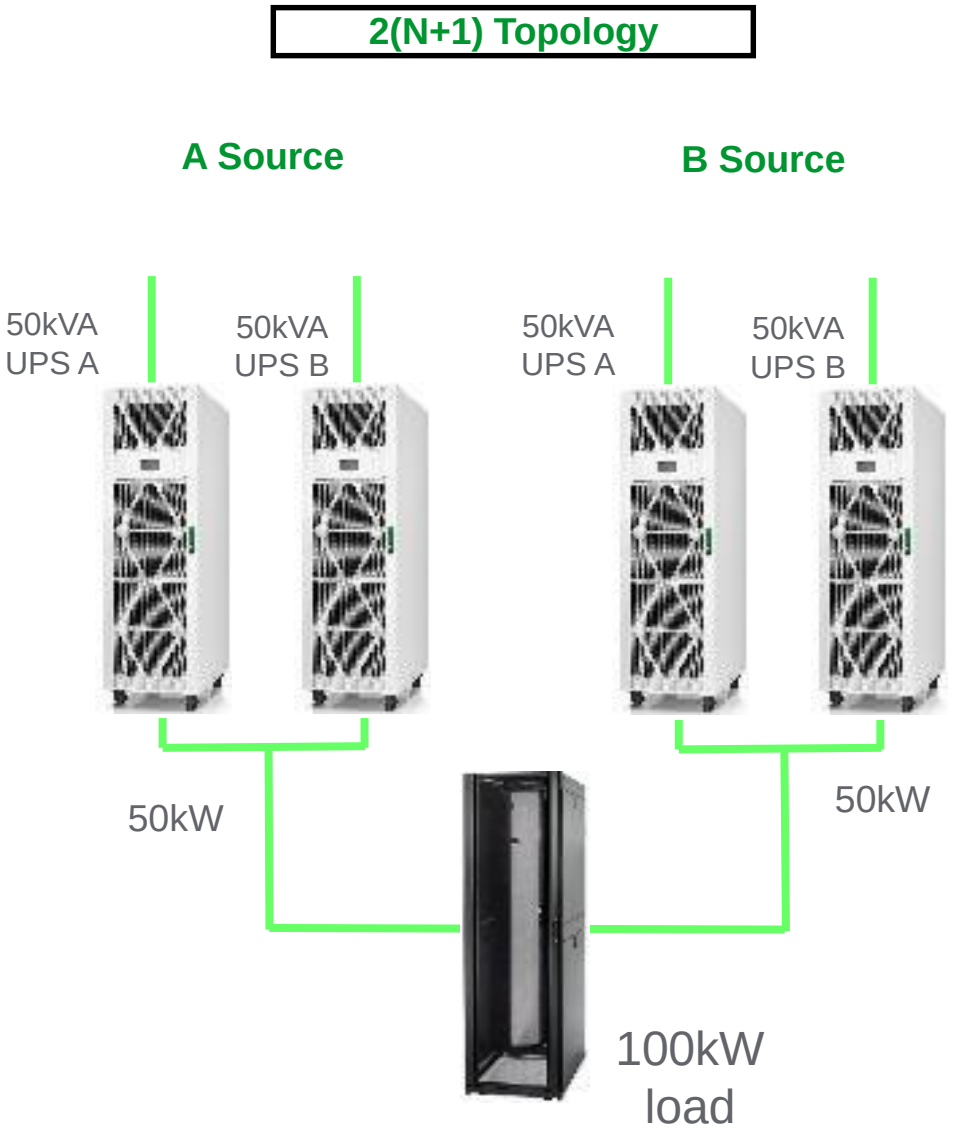
2N Redundancy



Common UPS Configurations



2N Redundancy



Scalable and Modular UPS

- Range from 48kW, 96kW, 160kW, 250kW & 500kW
- Double the power
  - Power factor: 1.0
  - High Efficiency
  - Parallel up to 2MW
- Smaller Footprint
  - 63% less foot print to comparable to legacy UPS
  - Integrated PDU-XR
  - High Power Module Power Density (16kW)
- True Hot-Scalability
  - User Scalable Modular Power distribution
  - Eliminates Downtime
  - Reduces TCO

Symmetra PX 250kW Product Design Benefits

Symmetra PX250
Three frame design available with or without integrated PDU

High Density Footprint
Three frame design allows you to scale from 16kW to 160kW (power & runtime), saving valuable floor space for your IT equipment

High Performance Battery Unit
More powerful batteries help reduce overall system footprint while the extended life expectancy (5 – 8 years) reduces total cost of ownership

Battery Module
Connected in parallel for increased availability, and hot swappable for easy replacement by a trained user

Premium Line-Up and Match Enclosures
Matches the look of other IT equipment in your data center

Efficiency independently verified by TÜV

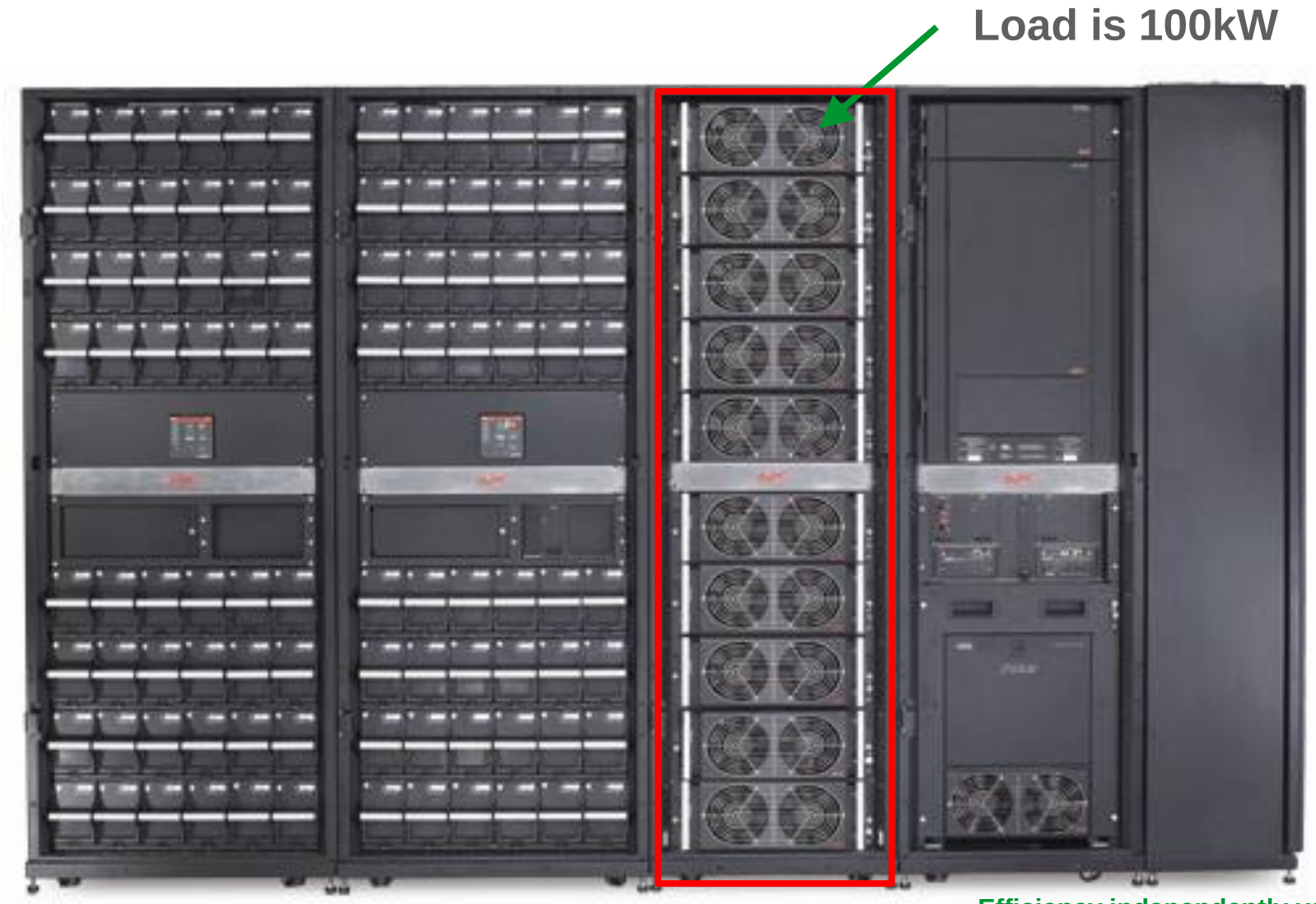
Symmetra PX 250kW Product Design Benefits

10 slots = 25kW x 10

= 250kW UPS capacity

Efficiency independently verified by TÜV

Symmetra PX 250kW Product Design Benefits



4 PM = 25kW x 4

= 100kW UPS capacity

For N+1, 1 redundant power module added.

4 PM + 1 redundant PM = 5 PM

Efficiency independently verified by TÜV

Quiz

Question 1

What is the most common type of batteries in the market for commercial UPS?

A. Wet cell batteries.
B. Valve Regulated Lead Acid (VRLA) Batteries.
C. Lithium-ion batteries.
D. Modular batteries.

Quiz

Question 2

What is the recommended minimum duration of battery backup time for UPS connected to an essential power supply?

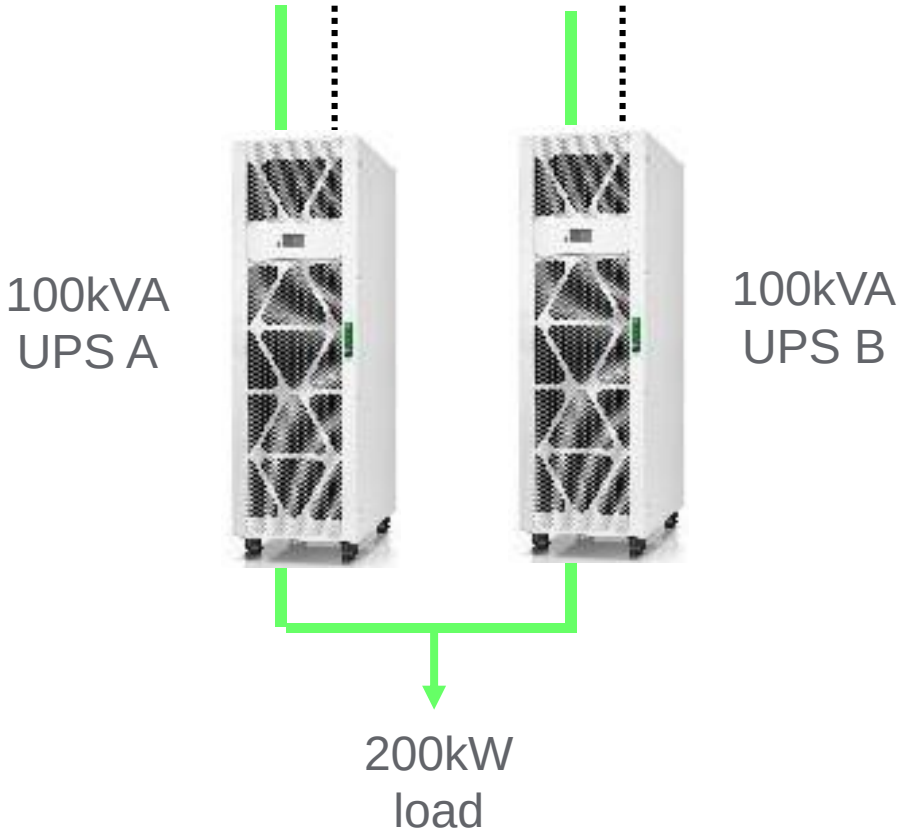
A. 4 hours.
B. TNB-GENSET transition time.
C. UPS battery runtime should last as long as possible.
D. Depends power stability (frequency of blackout).

Quiz

Question 3

An electrical system design has the following design and load level, what is the UPS availability depicted?

A. N.
B. N+1.
C. 2(N+1).
D. N+2.



Quiz

Question 3

A UPS system design has the following design and is connected to **75kW load**, what is the UPS availability depicted?

A. N.
B. N+1.
C. 2(N+1).
D. N+2.

25kW power modules

Load is 100kW

Life Is On | Schneider Electric