



Critical Power - Trends, Technologies, and Best Practices in Healthcare

Kansas City Area Healthcare Engineers

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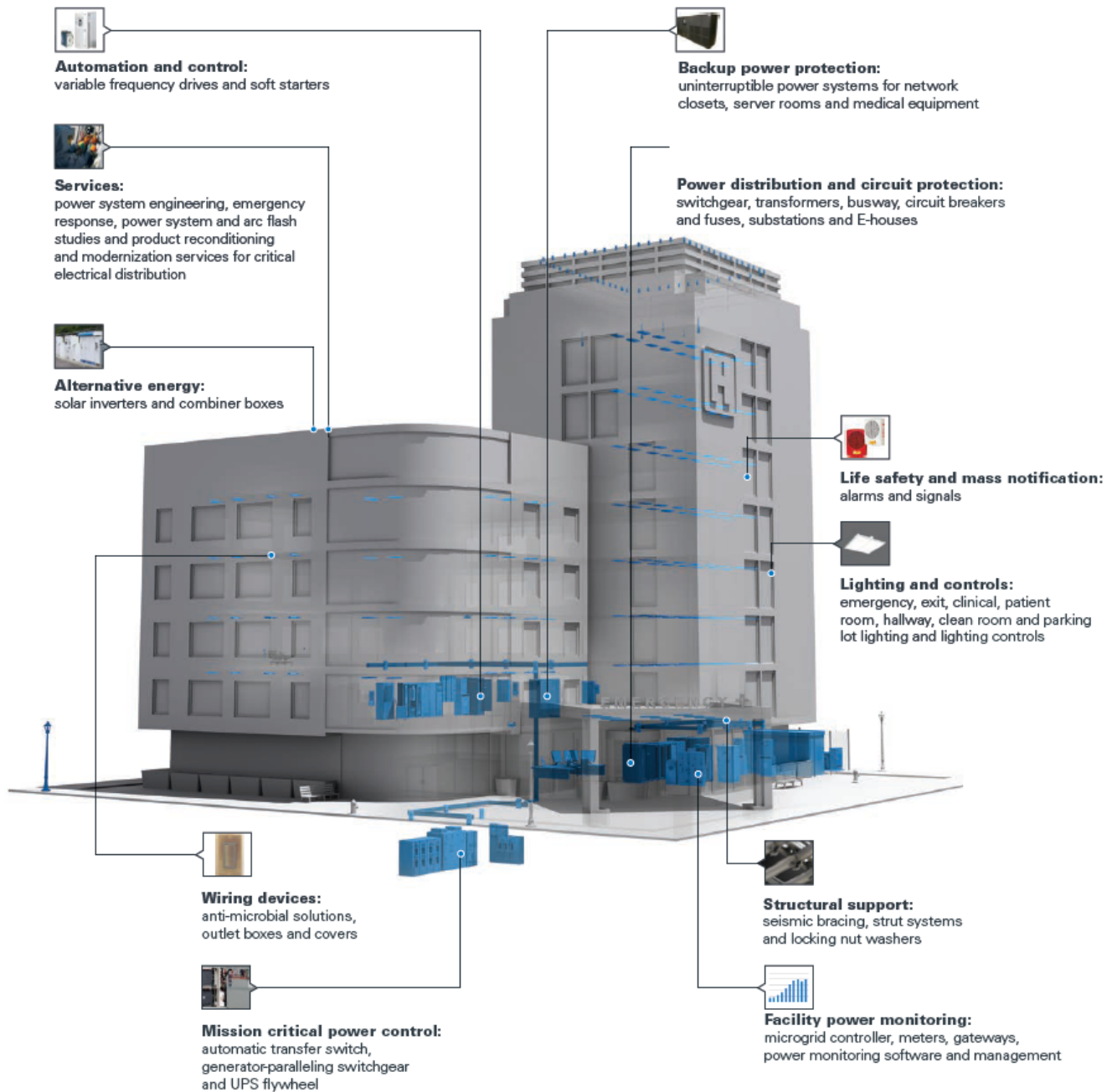
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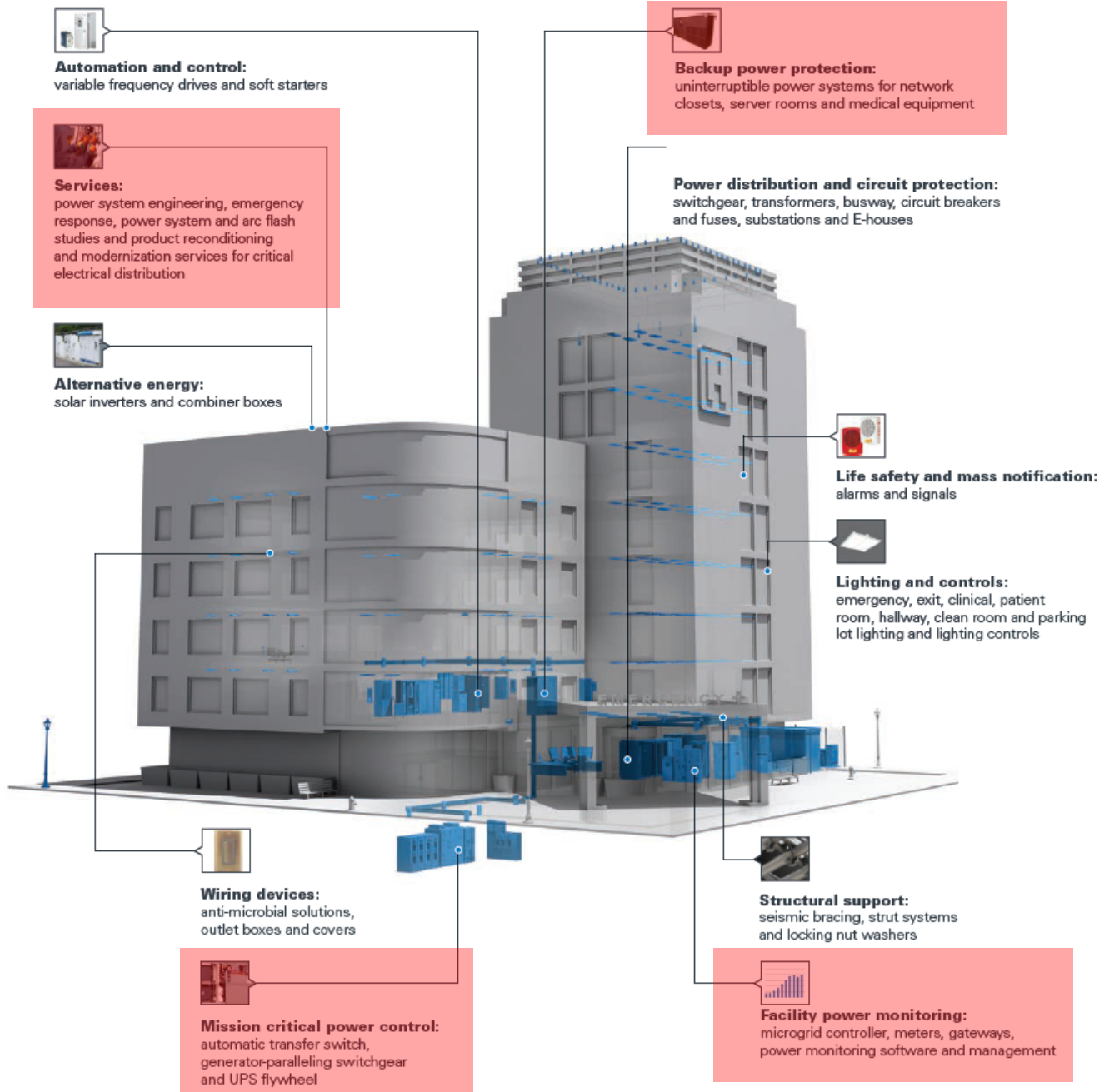
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Backup power protection

Maximizes reliability and continuous uptime to prevent business interruptions



Examples

Uninterruptible power systems

Power distribution units (PDUs)

Paralleling switchgear

Transfer Switches

Surge protection & power factor correction

Backup Power Solutions

- Single Phase UPS
 - Typical size range 0.5-30kVA
 - Online or Line interactive
 - Rack mount or tower format
- Three-Phase UPS
 - Size range 10kW to 2MW
 - Can be paralleled to >5MW
 - Modular or monolithic
 - Multi-mode
 - Online
 - Line interactive
 - Eco mode
 - Auto-selecting of mode
- Data Center Solutions
 - Enclosure PDU/power strips
 - Three Phase freestanding PDU
 - Remote Power Panels RPP
 - Remote Power Modules
 - Rack mounted
 - UPS designed for the white space; in-rack or line and match to IT equipment racks

What is a UPS?

“An uninterruptible power supply [or system] is defined as a back-up power system used to ensure uninterrupted power for various electronic devices.”¹

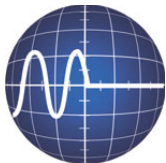
Uninterrupted power may be achieved in the following ways:

- Provides back-up power when utility power fails
 - Either long enough for critical equipment to shut down sequentially, ensuring no data is lost, *or*
 - Long enough to operate required loads before a generator comes on-line
- Provides clean and regulated power to electronic devices

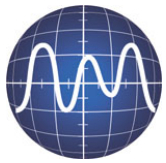


Examples

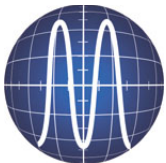
9 Common Power Problems



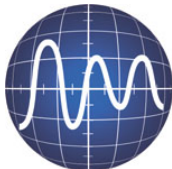
Power Failure



Power Sag



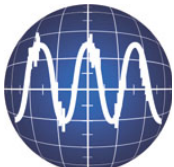
Power Surge



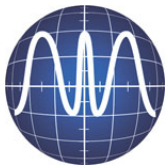
Undervoltage



Overvoltage



Line Noise



Frequency Variation



Switching Transients



Harmonic Distortion

“The Nines” of reliability

The power grid typically provides three 9’s, or 99.9% reliability. This equates to almost 9 hours of downtime per year. ‘High 9’s’ are generally considered to mean five 9’s and above.

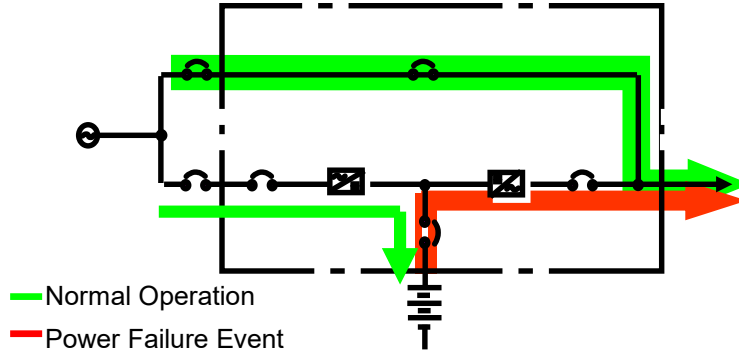
<u>9’s</u>	<u>Downtime per Year</u>	<u>Availability</u>
3	8 hr, 45 min, 36 sec	99.9%
4	52 min, 33.6 sec	99.99%
5	5 min, 15.36 sec	99.999%
6	31.5 sec	99.9999%
7	3.15 sec	99.99999%



UPS Types

Standby

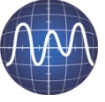
- “Off Line”



Power protection from 3 most common power problems that threaten your equipment and data



Power failure

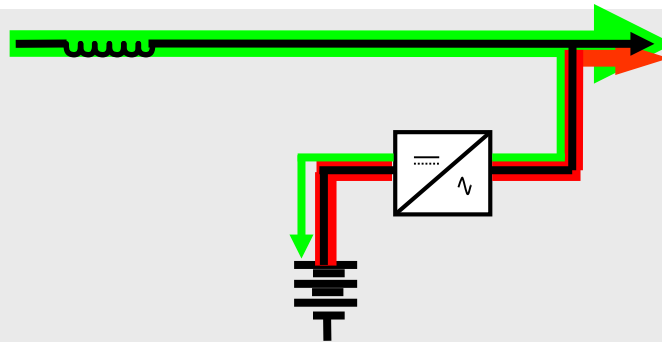


Power sag

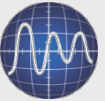


Power surge

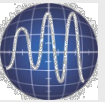
Line Interactive



Power protection from 5 of the most common power problems



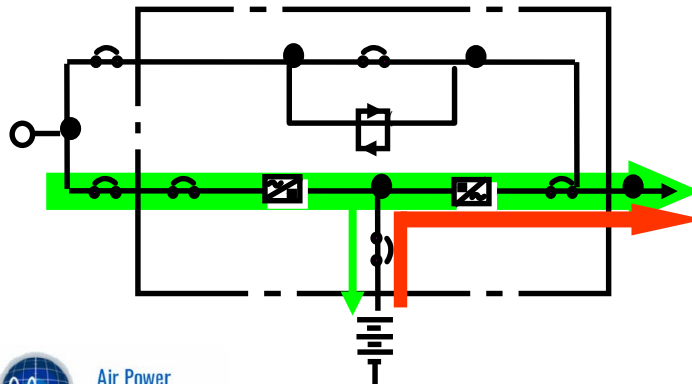
Undervoltage



Overvoltage

On Line

- “Double Conversion”



Power protection from **all 9** common power problems



Switching transients



Line noise

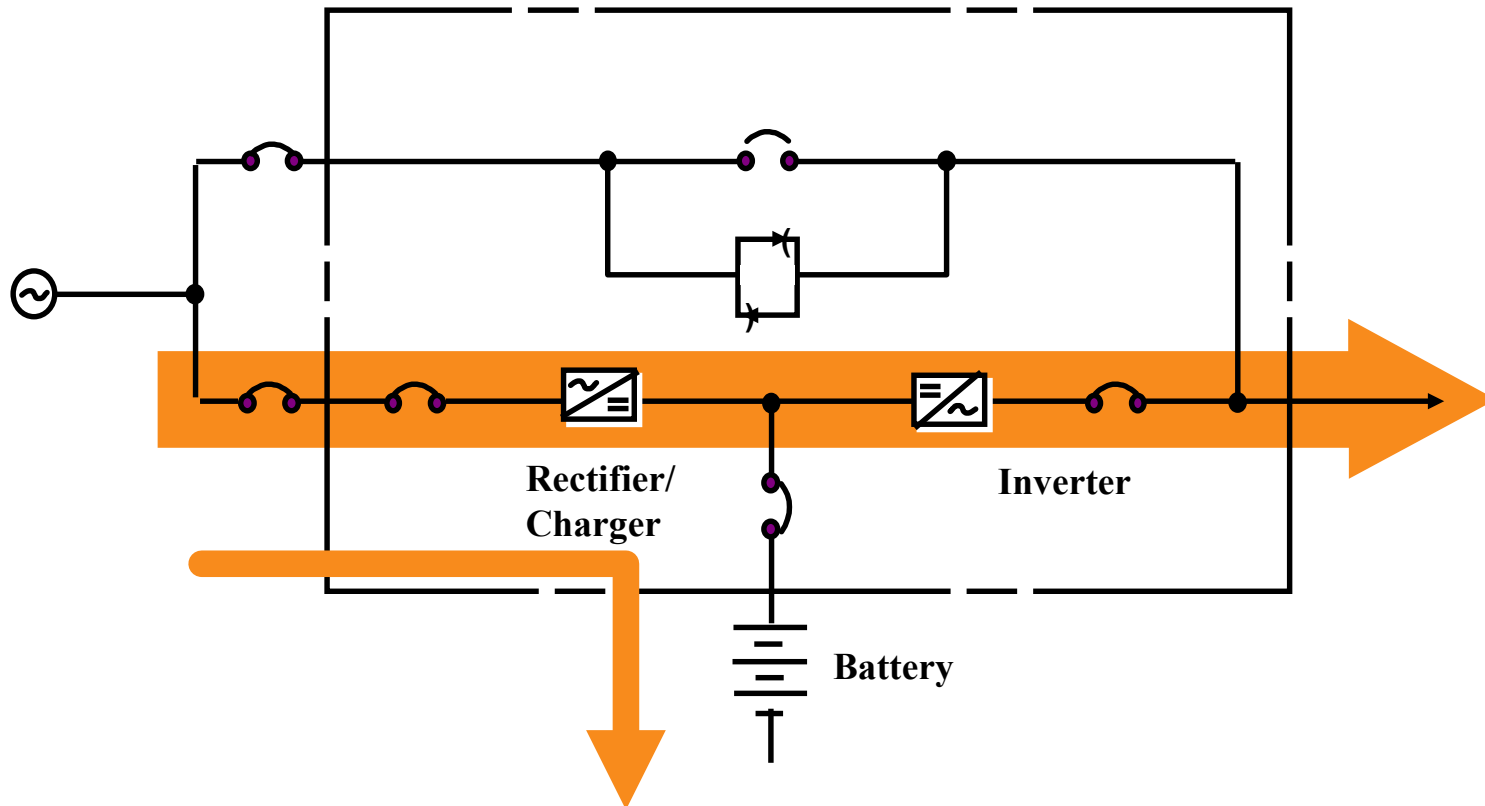


Frequency variation

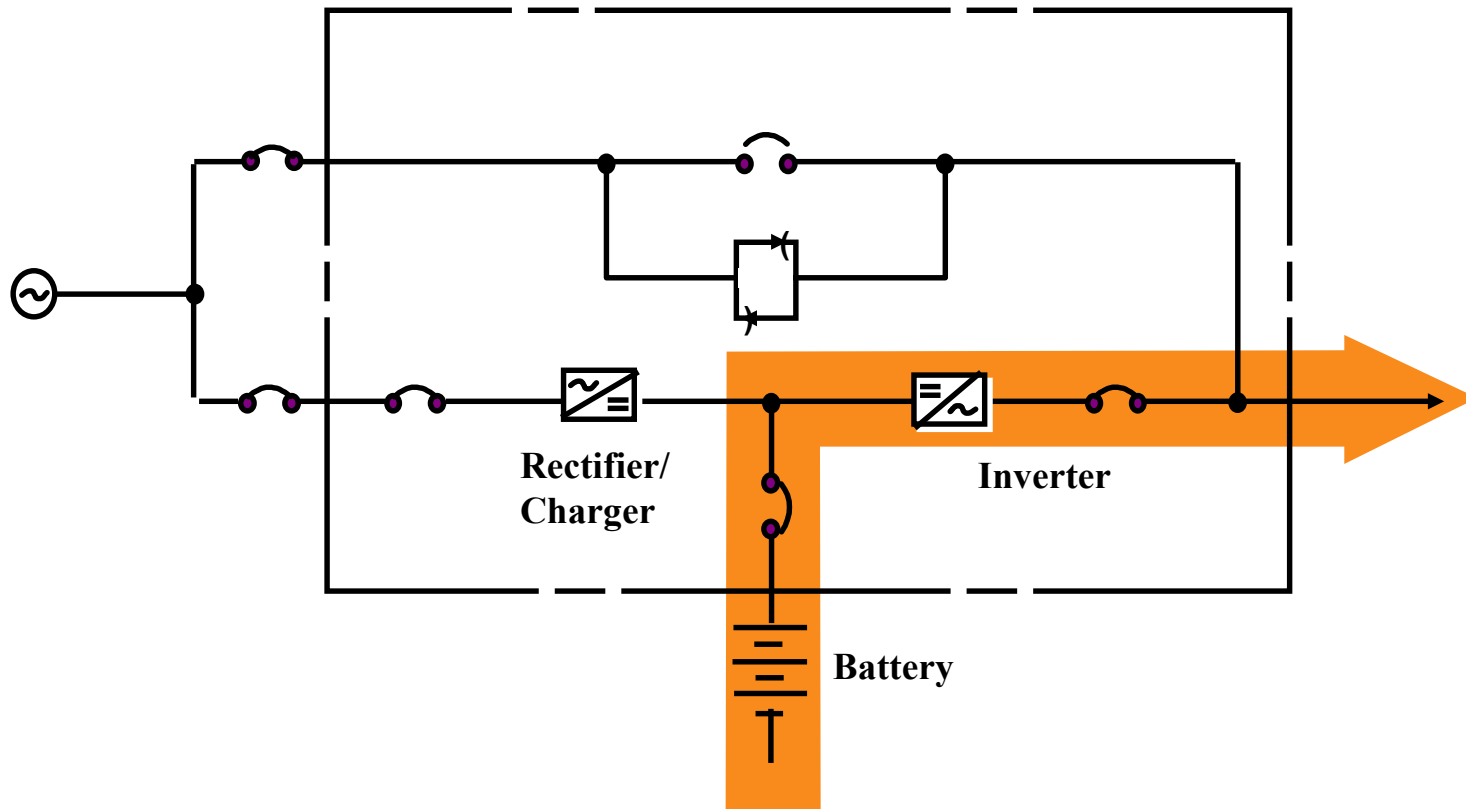


Harmonic distortion

Normal Operation Battery Recharge

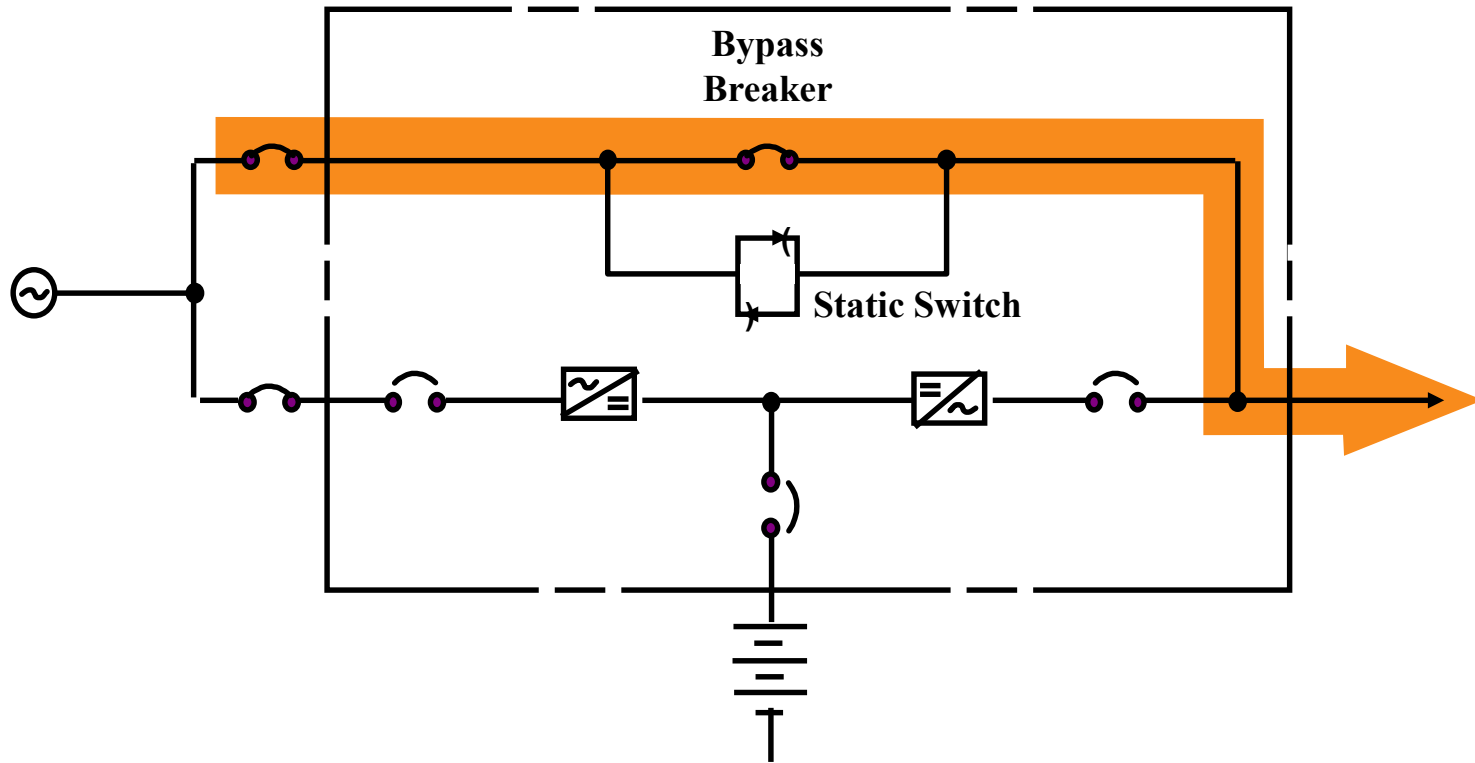


Normal Operation Emergency



Transfer to Bypass

Bypass Breaker Closed



Modular and Scalable UPS Solutions

Vertical

Single Phase



3 to 18kVA (N+1)

Horizontal

Single Phase



8 to 45kVA (N+1)

Vertical + Horizontal

Three-Phase



20 to 800kW (N+1)



400 100 to 400kW

Three-Phase



5 KW to 60 kW (N+1)

Three-Phase



10 to 90 kVA (N+1)



20 to 640 kVA (N+1)



20 to 180 kVA (N+1)

Horizontal 2



225 to 4000kVA+

Which UPS to Select?

- What size UPS? (KVA or Watts or amperage)
- What is the load? (PLC, computer, etc.)
- What voltage in/out? 208/120/240/480
- Single phase or three phase?
- Form Factor? Tower or RM
- What runtime do you want?
- Any clearance or size constraints?
- Bypass requirements?
- Input/output connections? HW or Plug & Outlet
- Does the UPS need to be scalable?
- Do you need redundancy?

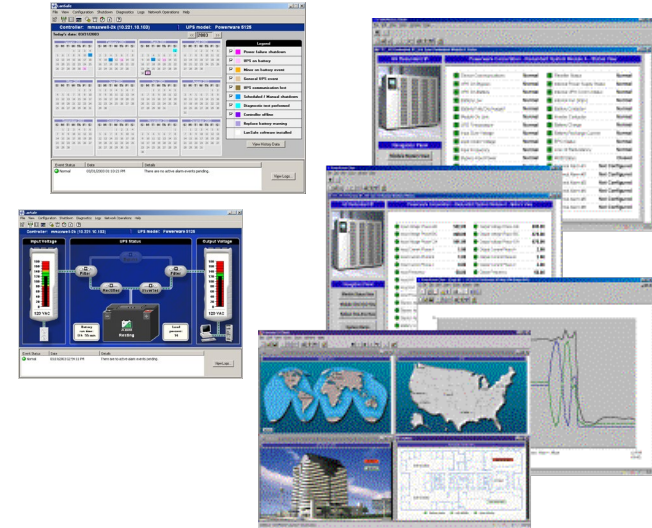
Software and Connectivity

- **Software:**

- Software for network shutdown and power management
- Enterprise-wide UPS monitoring and data analysis
- Comprehensive system for proactive management of power, environmental, and life/safety systems—beyond just UPS.

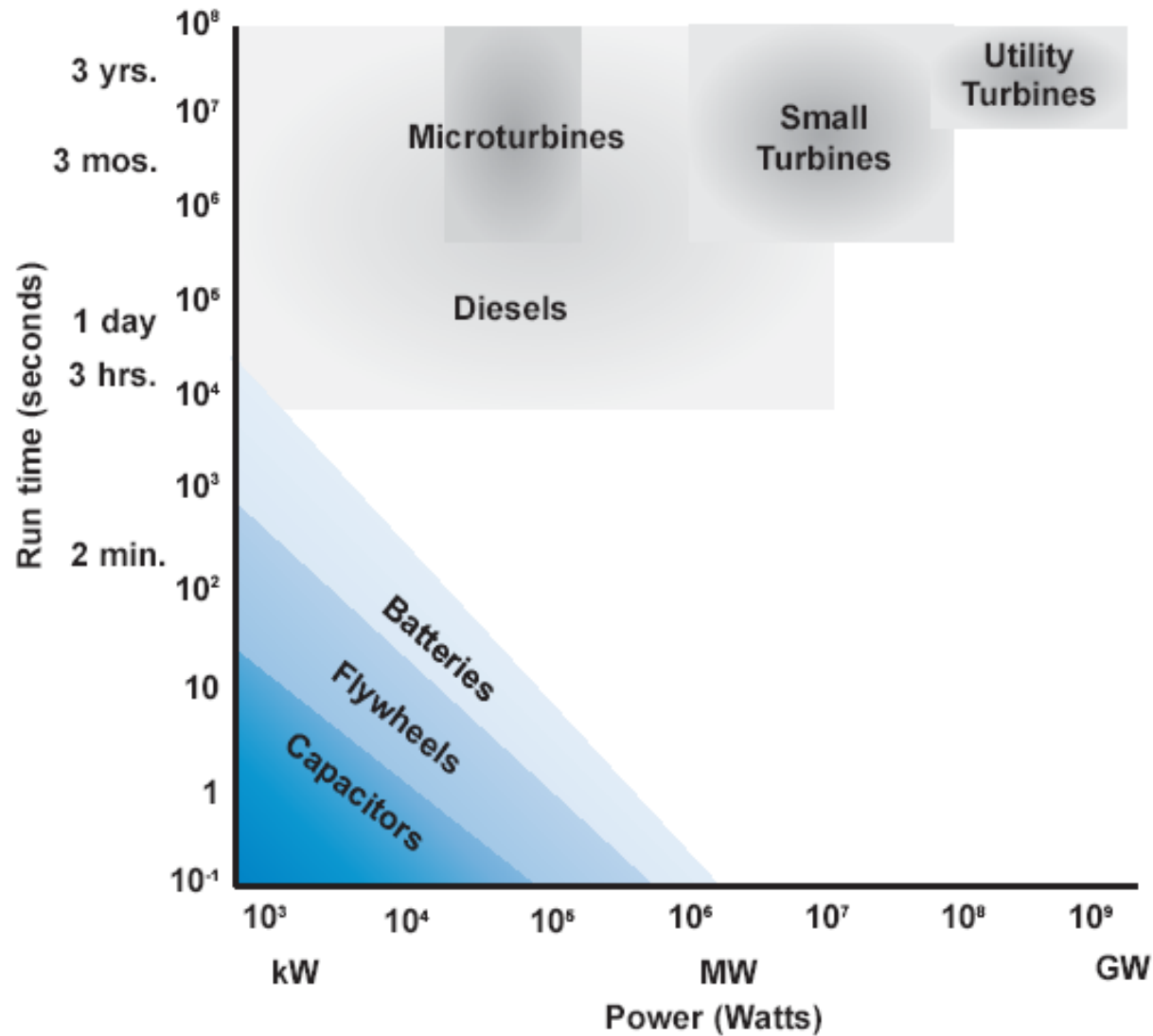
- **Connectivity:**

- Network card for integration into the network, Internet, and SNMP management systems
- Modbus card for integration with building management systems
- Cell modem or MultiServer cards for special applications and out-of-band communications
- USB, and Relay cards for basic and advance computer connections, or building management systems
- Environmental Monitoring Probe



Examples

Backup Power Sources

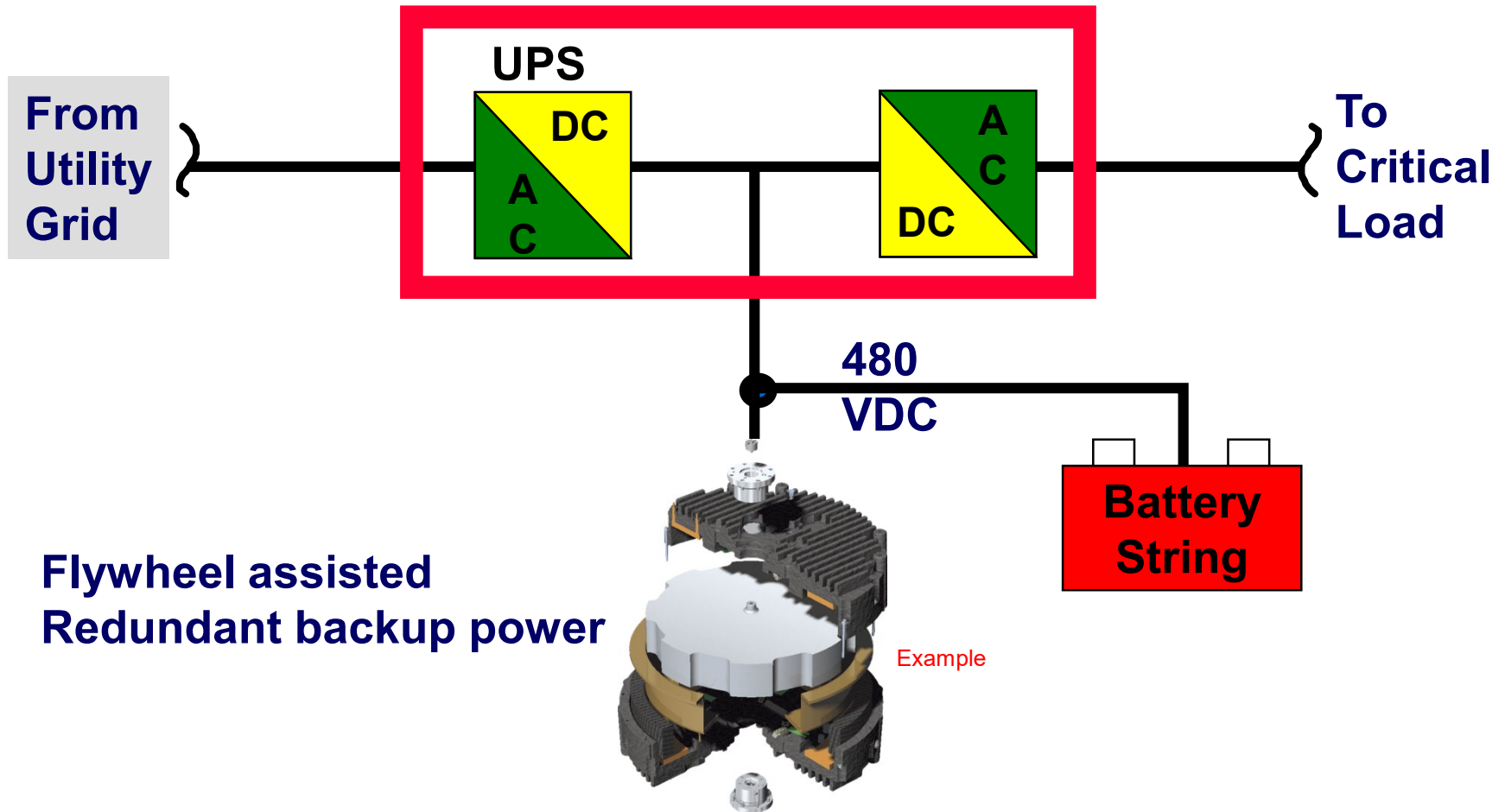


Generator

- ▶ Preferred method to provide long ride-through (5-48 hours)
- ▶ Maintenance is required
- ▶ Noise and exhaust are concerns
- ▶ Be sure to size properly with UPS
- ▶ Vendor should have UPS interface experience



Flywheels

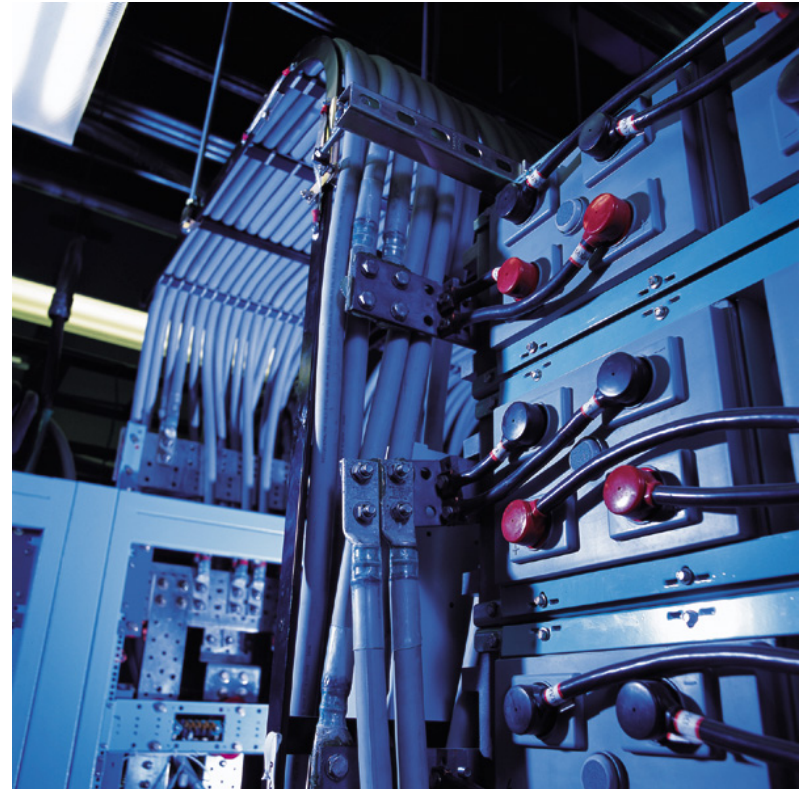


Flywheel assisted
Redundant backup power

Protects batteries from frequent discharges -- prolongs life.

Batteries

- ▶ For now, batteries are the least expensive mid-term solution
- ▶ **They can also be the weakest link**
 - ▶ Service life is always an issue
 - ▶ Hazardous materials disposal is a challenge
 - ▶ Frequent testing and constant monitoring is a requirement
 - ▶ Size and weight are inconvenient in a datacenter



Example

Lithium-ion batteries for UPS applications



Example

Batteries “slow” evolution

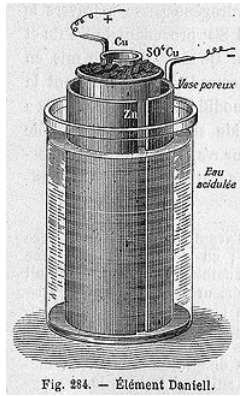


- Battery type “lead acid” hasn’t changed in 158 years (due to cost per kWh)!
- Other battery alternatives have not been proven to be cost effective
- With the best TCO, Lithium is now poised to take over lead-acid

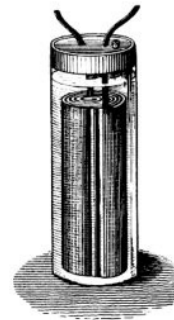
The past.....



1800 Voltaic pile
“First battery”
Alessandro Volta



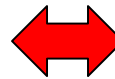
1838 Porous pot cell
Dancer



1859 “original”
lead-acid cell
Gaston Planté



2017 flooded
and VRLA **lead-acid** batteries



Present/future



>= 2017 Lithium

Lithium vs. VRLA Comparison

- Lithium is a viable alternative to traditional VRLA offerings
- Lithium provides longer life (and warranties), higher operating temperatures, higher cycle rates and smaller footprints. These benefits, in turn, provide the lowest total cost of ownership!

VRLA

Lithium

- 58% smaller
- 75% less weight
- BMS included
- >8x # of cycles
- >2.4x life and warranty
- Higher operating temp (0 - 40°C)

N54 VRLA



kWh:	33
Weight (lbs):	4855
In ² :	1436

Samsung



kW:	200
kWh:	33
Weight (lbs):	1213
In ² :	624

LG Chem

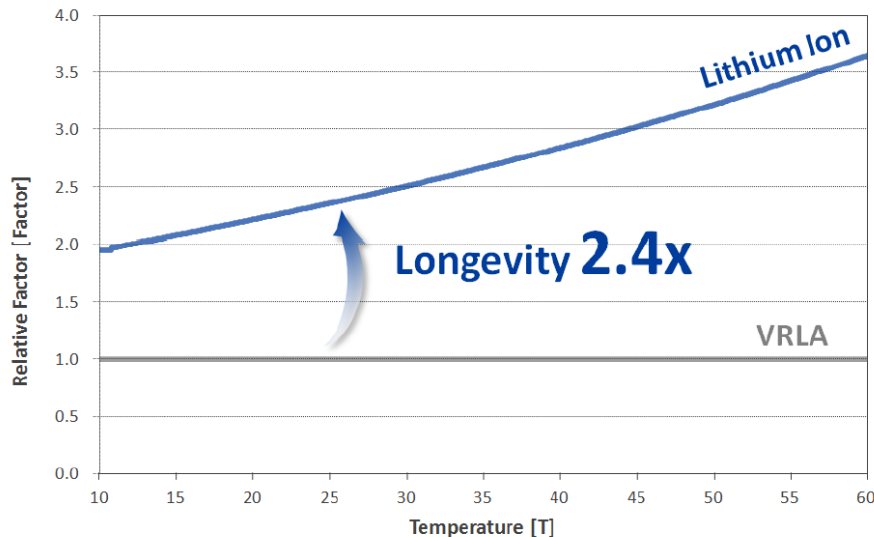


kW:	250
kWh:	28
Weight (lbs):	1100
In ² :	432

Lithium vs. VRLA – Life Comparison

- Lithium provides 2.4x longer life at 25C (vs VLRA) and even longer “x life” at higher temps
- At 25C lithium provides 15 years of life (with a 10 year warranty on the performance of the lithium). Acceptable range 18C – 28C

Calendar Life Comparison



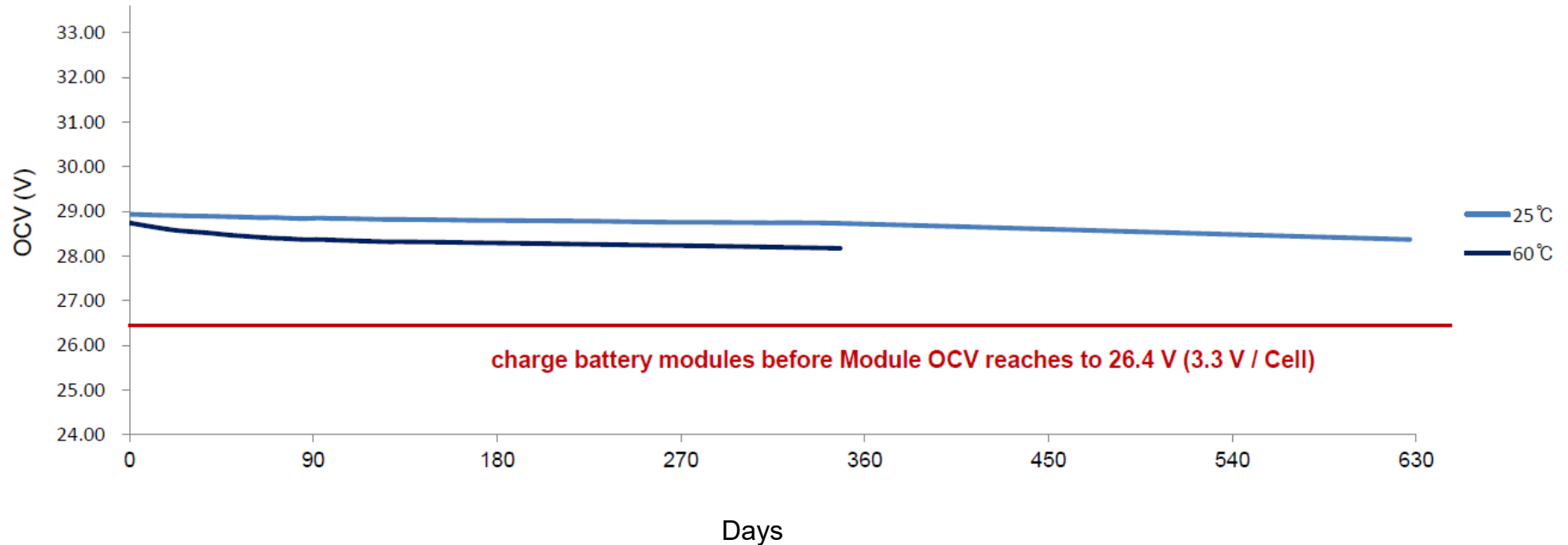
Ambient Temp [°C]	Calendar Life [years]		Ratio
	VRLA (Premium)	LIB	
10	20	33	1.65
15	14	25	1.8
25	7	15	2.15
60	0.6	2	3.8

Expected Life vs Temp:

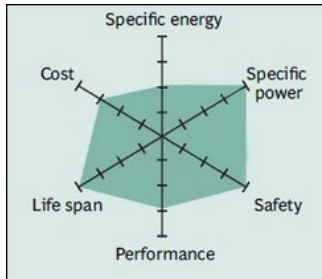
- $\leq 25\text{C}$ - ≥ 15 years
- 30C - 12 years
- 35C – 6 years

Lithium – Warehouse Storage

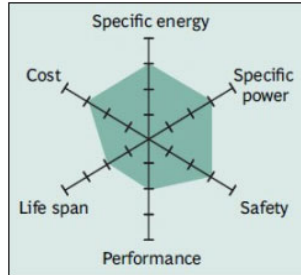
- Lithium modules can be stored for years without recharge at 25C (6 months when connected within a cabinet, due to parasitic losses associated with the BMS)



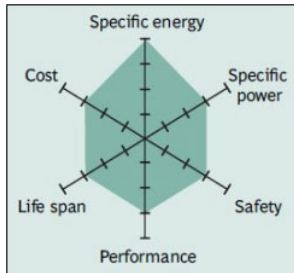
Lithium – Chemistry Types



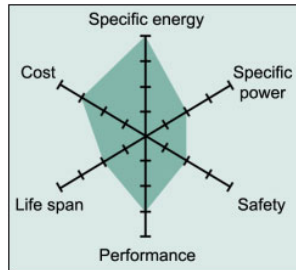
Lithium Iron Phosphate (LFP) – Thermal runaway 270C



Lithium Manganese Oxide (LMO) – Thermal runaway 255C



Lithium Nickel Manganese Cobalt Oxide (NMC) – Thermal Runaway 215C



Lithium Cobalt Oxide (LCO) – Thermal runaway 170C

- *specific energy* - or capacity that relates to runtime
- *specific power* - or the ability to deliver high current
- *performance* - at hot and cold temperatures
- *life span* - reflecting cycle life and longevity

Samsung



Lithium Manganese Oxide (LMO) +

Lithium Nickel Manganese Cobalt Oxide (NMC)

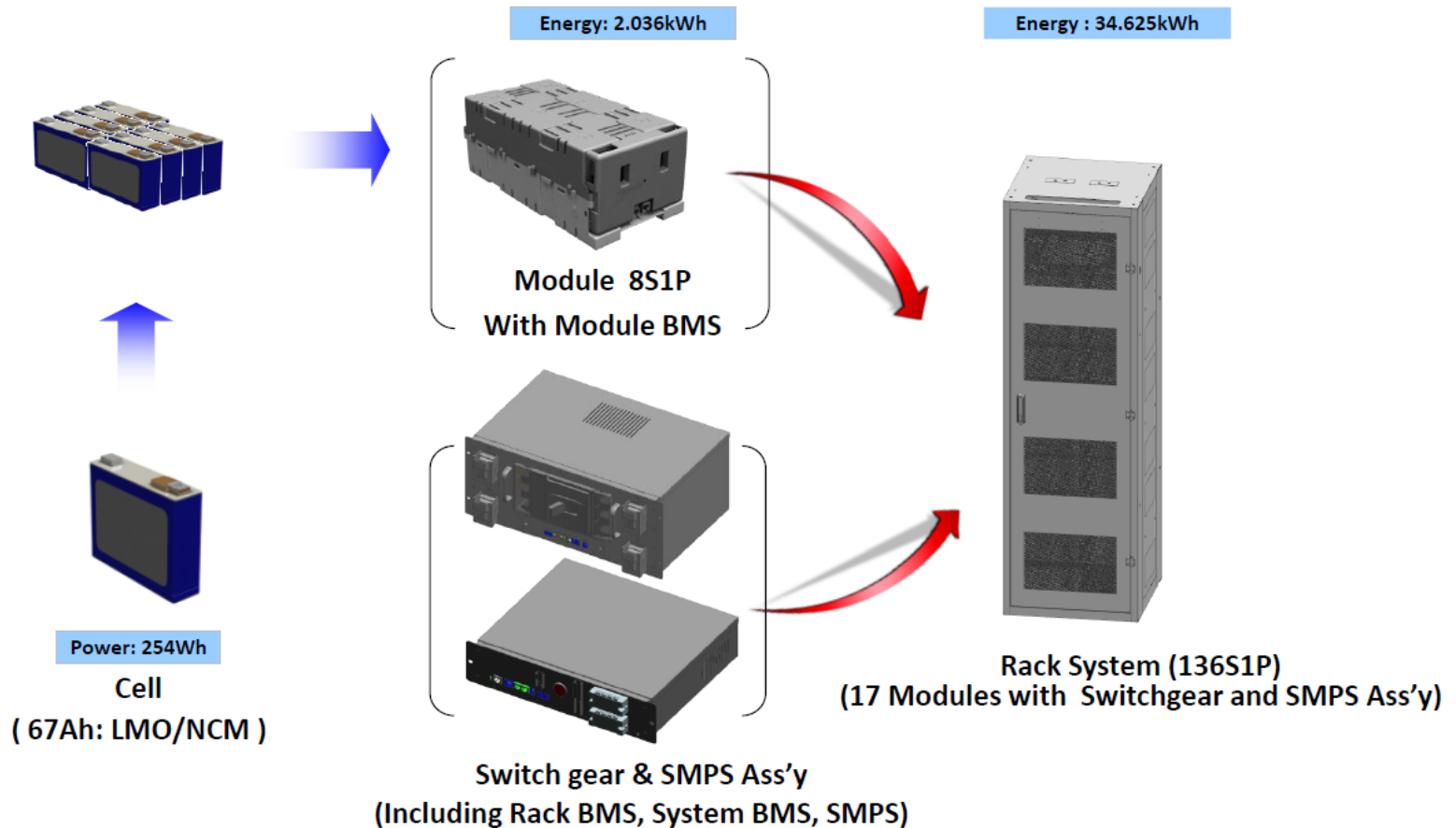
LG Chem



Chem

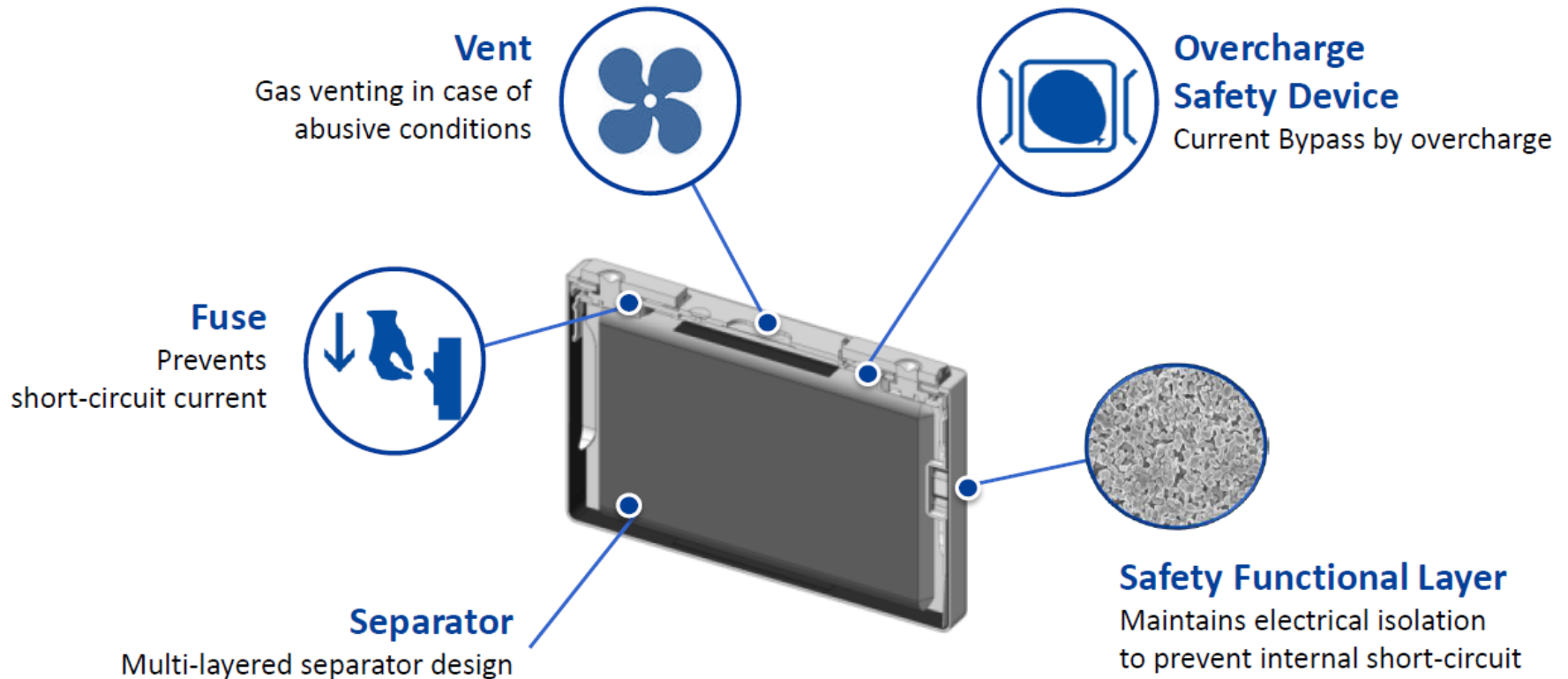
Lithium Nickel Manganese Cobalt Oxide (NMC)

Lithium – Cabinet Design



Lithium – Safety (Samsung)

Safety Cell Design

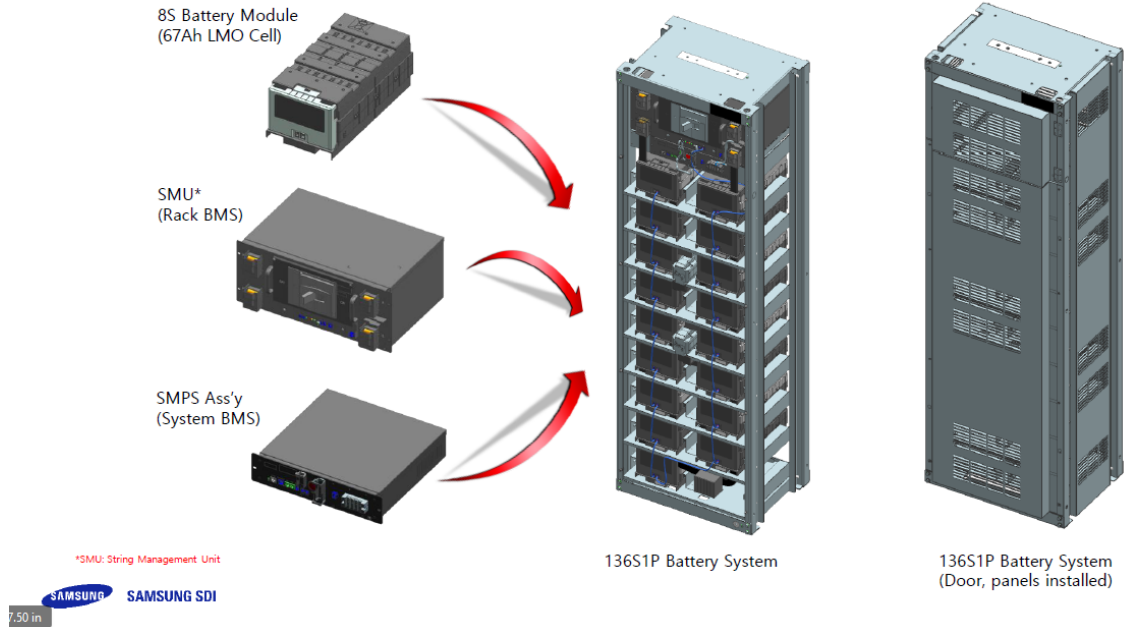


Samsung UL9540A Cabinet

UPS Battery System - Description

Confidential

Battery system for UPS is designed to supply power to the critical load when there is a grid failure or power outage. Key components in the UPS battery system includes the battery module, SMU (string management unit), SMPS assembly, rack frame and accessories (bus bar, wire harness, fuse, etc.) BMS monitors and manages the battery status and protects the battery by tripping the circuit breaker in the SMU.











1

Samsung UL9540A Cabinet

Confidential

UPS Battery System 2019 – Key Changes

Main purpose of the change is to meet the testing criteria of UL9540A

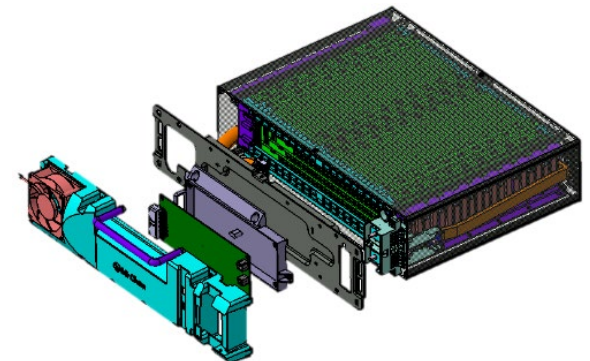
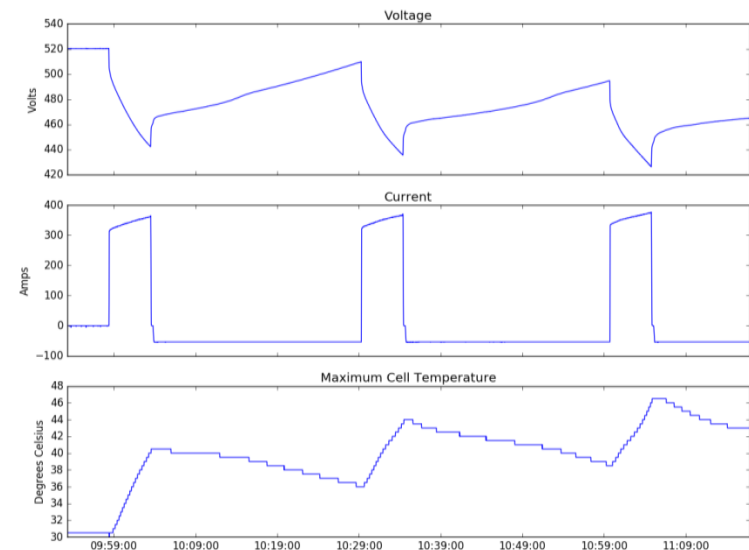
	Current Design (2016 ~ 2019 2Q)	New Design (2019 3Q ~)
Battery Module	 <p>1) Dimension W216 X H163 x D414 2) Weight About 17kg</p>	 <p>1) Dimension W214 X H163 X D404 2) Weight About 16.5kg 3) Designed for UL9540A testing 4) New Module BMS - Not interchangeable with current module BMS. - BMS size is unchanged.</p>
Rack Frame	 <p>1) Dimension W650 X H2055 X D600 2) Design - Front door</p>	 <p>1) Dimension W650 X H2055 X D530 2) Design - Designed for UL9540A testing - Reduced footprint - Front bolted panel for modules, door for SMU and SMPS</p>
SMU	 <p>1) Dimension W583 x H235 x D411 2) Key components MCCB (600A) Fuse (500A) Rack BMS</p>	 <p>1) Dimension: no change 2) No change in key components 3) Rack BMS F/W change - Communication with new Module BMS - Added protective functions</p>
SMPS Assembly	 <p>1) Dimension W397 x H86 x D338 2) Key components - SMPS 3-phase 480VAC</p>	 <p>1) Dimension: no change 2) Key components - Added SMPS option: 1-phase 120~230VAC 3) System BMS F/W change - To match with Rack BMS F/W change (added protective functions)</p>

Other Changes to Note:

- New cabinet is Black (old was white)
- New cabinet is Seismic 4 (old was Seismic 3)

LG Chem Overview

- Cabinet options – Get closer to desired runtimes; 1 string or 2 string (14kWh/string)
 - One half rack (14kWh) paired with <100kW UPS
- Internal contactors
- Forced air cooling
 - Faster re-charge
 - Better cycle performance
- **10 year warranty** – 80% capacity at 8C discharge rate
- **Shipping – no refrigeration required**
- 250kW per cabinet – great for 9395C-1MW or 1.5MW UPS
- Custom warranty at higher temperature



Lithium – Cabinet Design (LG Chem)

Advanced LiB solution is mainly composed of cell, module, BPU, BMS and HMI



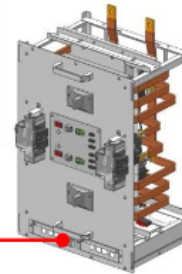
HMI

communication



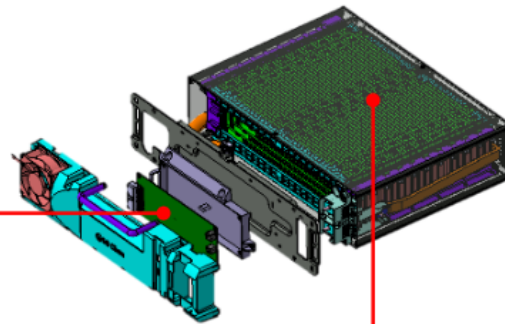
BBMS

communication



RBMS

communication



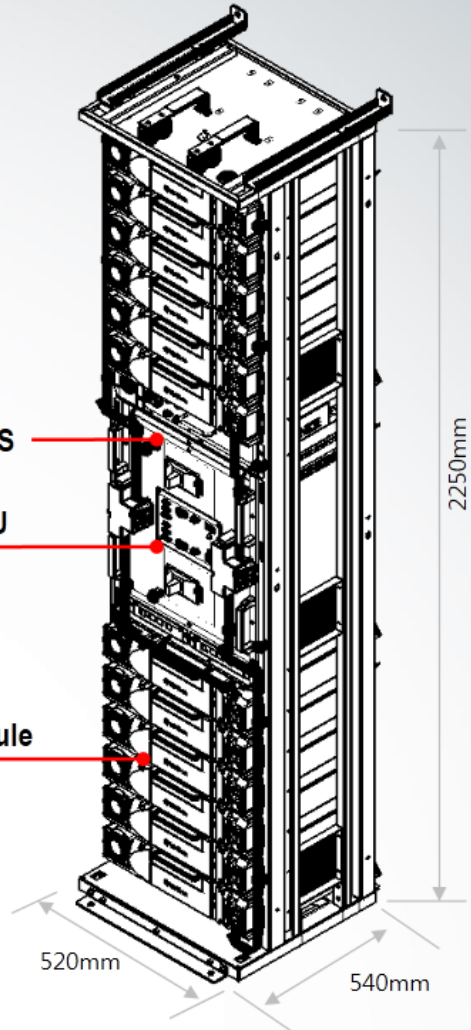
MBMS

Cell(JP4)

SMPS

BPU

Module

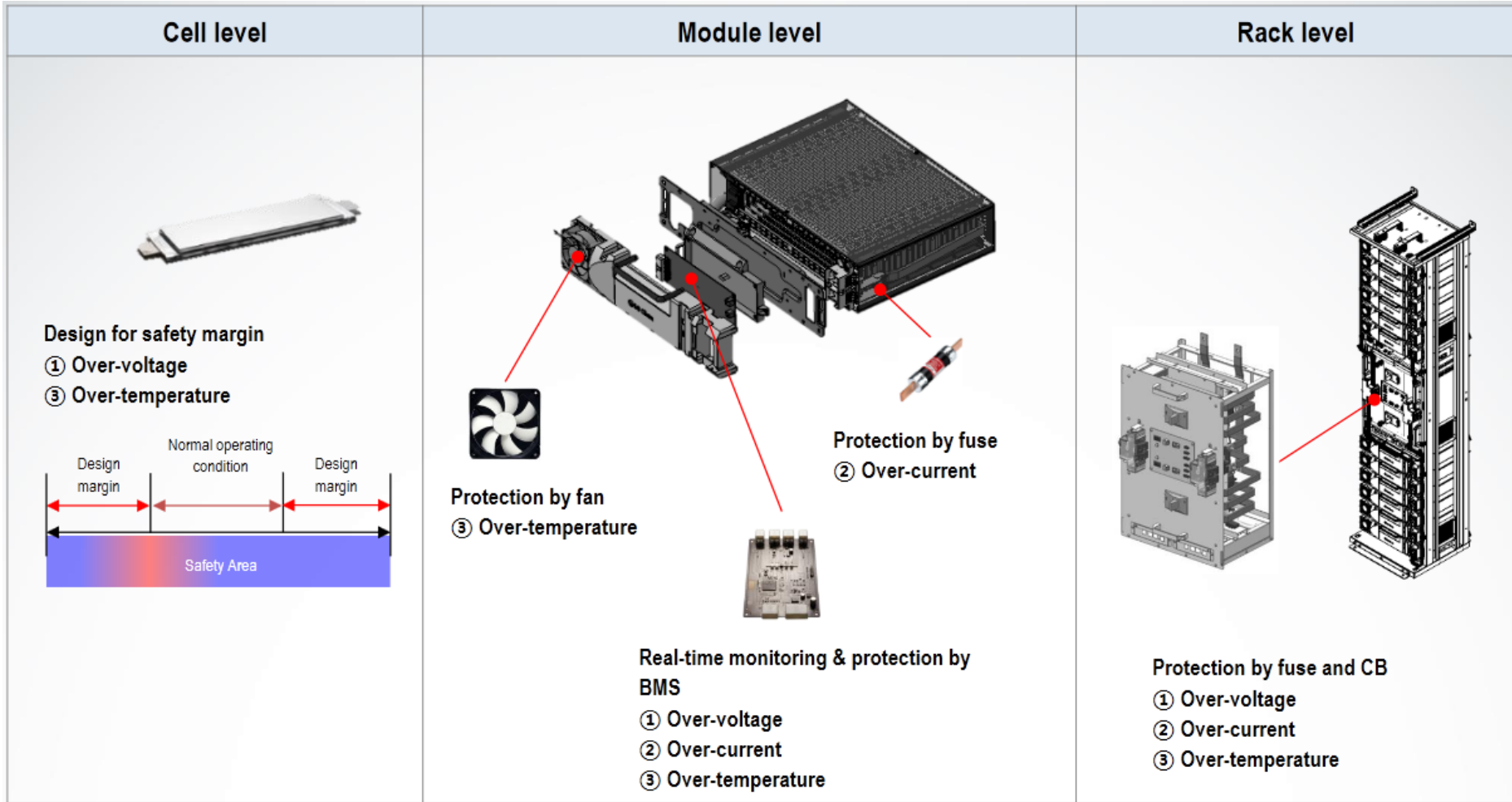


2250mm

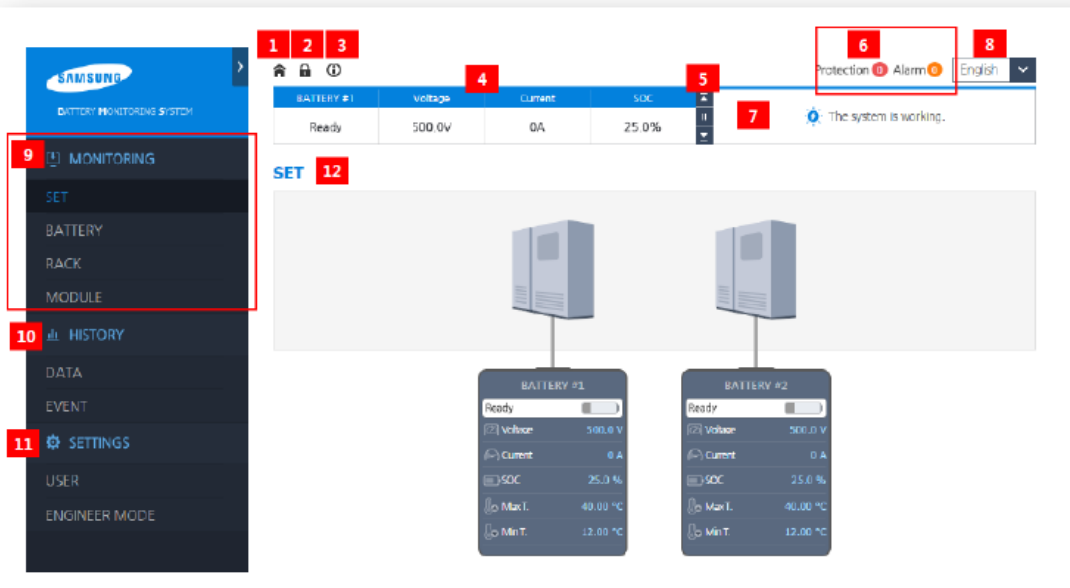
520mm

540mm

Lithium – Safety (LG Chem)



Lithium – BMS included



Cell / Pack Voltage

Over-Under voltage detection



Cell Balancing

Maximize system capacity



Temperature

Over-Under temperature detection



Capacity

State of Charge · State of Health Diagnosis



Warning / Alarm Function

User alarm, report

Lithium – Safety

Why do we consider lithium UPS batteries ‘safe’?

Three main reasons:

1. Battery Management System (BMS) is included on every cabinet and every system
2. Choice of safest lithium ion chemistries for UPS application
3. Systems always designed to release heat faster than it can build up, thus no possibility of thermal runaway

Most lithium solutions comply with the below

UL 1642 – Standard for lithium ion batteries

UL 1973 – Batteries for use in stationary applications

UL 1998 – Standard for software in programmable components

UL 991 – Standard for tests for safety-related controls employing solid state devices

In Process.....UL 9540/9540A – Standard for Energy Storage Systems and Equipment

UN 38.3 – Lithium battery transportation safety

Lithium – Heat Rejection

Heat rejection - Samsung 128 battery cabinet, 16 modules

Assume full power (150kWb/rack) discharge and 10 minutes backup.

Battery configuration (150kWb, 10mins)				Heat Generation Analysis			
Configuration		Average Current (A)	Discharging time (min)	Heat generation		Total Energy (kWh)	1000 BTU
				Module (kW/module)	System (kW/System)		
S	P						
128	1	326	10.0	1.0	15.8	2.6	8.9

Charging at 22A does not generate heat external to the system



Note on Lithium Recycling

“The lithium itself is not currently recycled. When it gets to the smelter, it rises to the top in the form of foam and is sheared off and disposed of. The other elements of the battery fall to the bottom and are recycled in the traditional fashion. There is only about 1-2% of lithium actually in a Li-ion battery.”



Lithium – “GPS Delivers State of the Art Mobile UPS Trailer for Super Bowl”

Mobile UPS Trailer with 1200kW UPS and Lithium-Ion batteries



Example

“GPS's leading-edge technology rental trailer was on site at [Super Bowl LII \(52\)](#) in Minneapolis, Minnesota February 2018 in support of an epic 10-day fan festival. GPS's 1200kW UPS trailer provided backup power to NBC facilities in the compound, in the stadium, and at nearby Nicollet Mall and was integrated with three redundant 1,500-kVA generators.”

[Video & full article here](#)

Q&A

Thank You!!!





Air Power
Consultants, Inc