UPS Replacement

Considerations for Optimal Performance While Minimizing Risk”

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How Many 3 PH UPS in North America

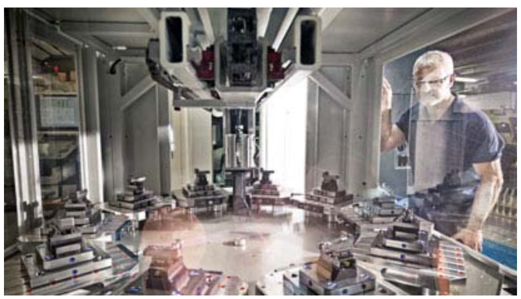
Conservative estimates: ~ 25,000 will EoL w/in the next 12 months

Where Will UPSs Be Replaced?

IT/Data Center Space

Healthcare

Buildings

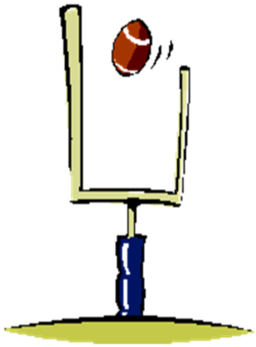


Machine Automation

Food and Beverage

Water & Wastewater

The Goal



1. Use as much existing infrastructure,
2. Optimize capacity, efficiency and footprint
3. Improve redundancy and reliability while
4. Minimizing the impact to operations as well as outage duration.

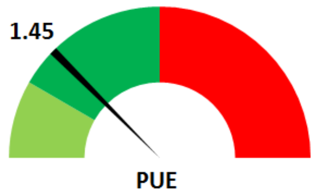
Preserve Capital
&
Manage Risk

5 Pillars of Mission Critical System

1. Capacity
"Revenue Generation"

kW & Ft^2

2. Efficiency
"Cost Avoidance"



3. Reliability
"Risk Avoidance"

4. Finance

CapEx

OpEx

Focus on enhancing and or improving one or more of these 5 Pillars without detrimental impact to the remaining Pillars.

5. Sustainability

Balancing Act

What Determines UPS EoL?

Conditions likely indicating the UPS (3 Phase) is End of Life (EoL) and should be replaced :

Condition	Description
OEM support has ended	Typically occurs 10 years after model is phased out from production. Lack of support makes routine maintenance & recovery from failure impractical, if not, impossible.
Spare parts are unavailable	Once spare parts become unavailable from both the OEM and 3rd party sources, there is basically no option for maintaining/servicing the UPS.
Excessive maintenance	As equipment ages, the need for maintenance increases. It is possible for the maintenance costs and risks to exceed the costs and benefits (capacity, efficiency, and reliability) of installing a new UPS.
Cannot meet critical performance requirements	If the UPS cannot be made to meet the organization's present or future mission critical performance requirements (e.g., supporting the entire IT load at the required redundancy and runtime levels), then it is at "end of life", at least, for that application.

Table 1, SE WP 214 "Guidance on What to Do with an Older UPS"

Most obvious condition that the UPS is EoL:

The UPS ceases to function and replacement parts are not available!!

Summary of 1 Phase UPS components most likely to experience failure

Component	Function	Life expectancy	Factors affecting life
Battery	Provides power when utility power is not available	3 – 5 Years	• UPS Placement • Ambient Temperature • Cycling Frequency • Maintenance • Battery Chemistry • Battery Storage
Fans	Provides cooling to the unit	Up to 10 Years	• Load on the unit • Ambient Temperature • Frequency of Use • Duration of Use
Electrolytic Capacitors	Smoothes out and filters fluctuations in voltage	Up to 10 Years	• Ambient Temperature • Humidity
Metal Oxide Varistors (MOV)	Protects circuits against excessive transient voltages	Variable	• Dependent on the number and severity of surge events
Relays	Electrically operated switch that helps UPS transfer modes	Variable	• Abnormal cycling

Table 2 from SE White Paper 210 "Single Phase UPS Management, Maintenance, and Lifecycle"

Legacy 3 Phase UPS Component Service Life

Table 4, SE WP 214 "Guidance on What to Do with an Older UPS"

Table 4
A list of common parts and sub-assemblies that can be replaced with new without replacing the whole UPS

Replaceable parts & sub-systems	Typical service life
Battery strings	3 to 5 yrs
DC Capacitors	5 yrs
Fan assemblies	5-7 yrs
AC Capacitors	7 yrs
Power Supply Units (PSUs)	10 yrs
Intelligence modules & controller boards	10 - 15 yrs
Inverter assemblies	10 - 15 yrs
Static Switch	10 - 15 yrs
Rectifier SCR	10 - 15 yrs
IGBTs	10 - 15 yrs

At the 10 year mark component replacement costs coupled with capacity and efficiency considerations may favor replacement of the legacy UPS.

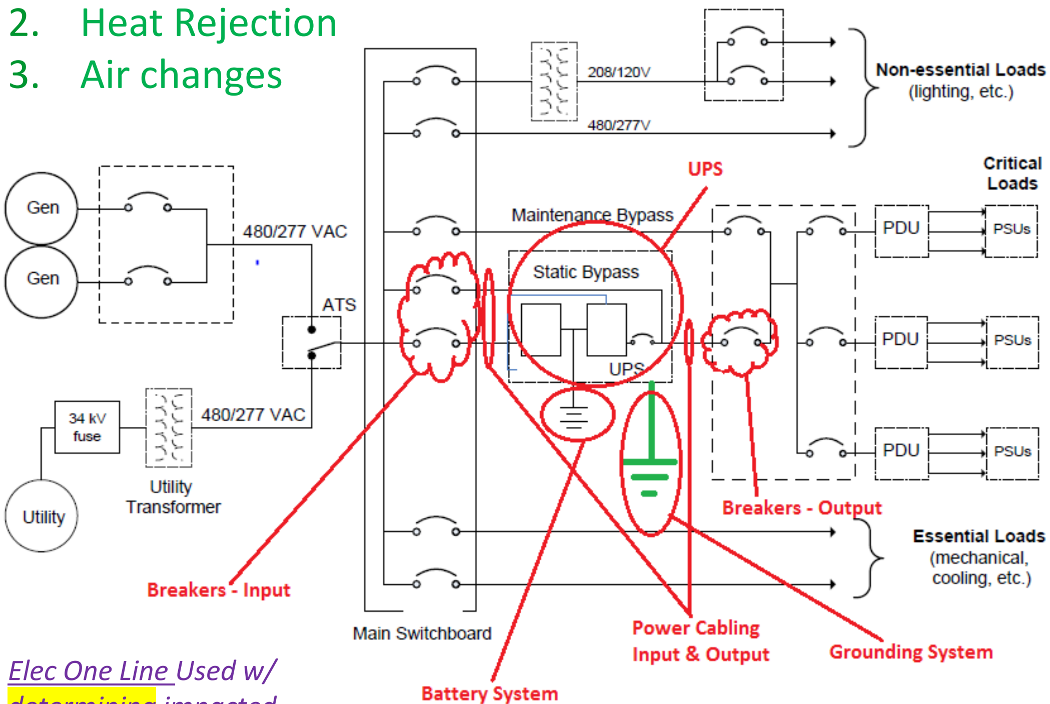
Developing the Project Plan

1. Develop a scope of work (SoW), budget and project schedule w milestones
2. Determine present conditions = Engineering Site Assessment
3. Determine capacity requirements (present & future)
4. Identification of impacted loads
5. Identification of risks and mitigating actions
6. UPS Selection
7. Factory Acceptance Testing (3 Phase)
8. Procedures (Developed and Approved)
9. Training of facility operations teams
10. As-Built Documentation

Present Conditions

Mechanical System

1. Smoke Detection & Fire Suppression
2. Heat Rejection
3. Air changes



Elec One Line Used w/ determining impacted loads

Source: Green Grid WP51 Power Equipment and Data Center Design - Figure III-1

Electrical System (Check Points)

1. Breakers – Input, Output & Maint. Bypass
2. Conductors – Input (single or dual) & Output
3. Elec Raceway – Installation
4. Grounding system – Installation, Fault Detection, Fault Protection
5. DCIM/BMS – Monitored Points
6. Battery System – type, age, BMS
7. UPS – Top or Bottom Feed, Access Requirements
8. EPO

Physical Check Points

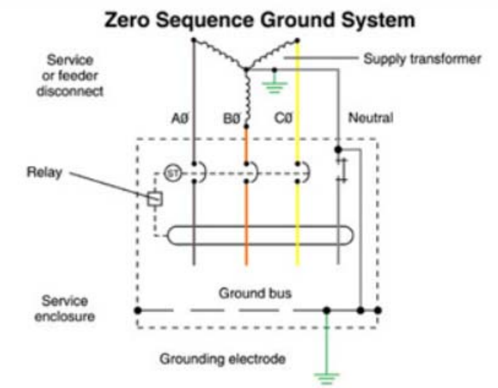
1. UPS & Battery Footprint
    1. Dimensions & Weight
2. Egress & Ingress Routes

Electrical Considerations

Electrical Documentation

Are the electrical one line diagrams accurate including but not limited to:

1. Size and length of conductors (input, output, battery and grounding)
2. Over Current Protection device data
3. Ground fault protection (NFPA 70 2017 Art. 215.10)
4. Communications and control wiring



Source: IAEA Performance Testing Requirements for Ground Fault Protection Equipment By M. Johnston, March 16, 2001

Maintenance records

Has equipment been maintained in accordance with recommendations and requirements of NFPA 70B, NETA and or OEM criteria?

Electrical Considerations Cont.

Over Current Protection (OCP)

1. Has an electrical system study been performed within the last 3 years?
2. Will the present OCP devices accommodate new equipment and be in compliance with applicable codes (NFPA 70 in USA.)
3. Breaker age and availability of parts

Cable Routes, Terminations & General Conditions

1. Are cables run in or below the concrete or overhead?
2. What type of terminations are used?
3. What is the condition of each conductor?
4. What is the condition of the raceway system?
5. Heat calculations on conduit runs (overhead, underground in gravel vs concrete encased)

Electrical Considerations Cont.

Critical Operations Power Systems

NFPA 70 2017, Art. 708 - Critical Operations Power Systems (COPS)

"708.1 Scope. The provisions of this article apply to the installation, operation, monitoring, control, and maintenance of the portions of the premises wiring system intended to supply, distribute, and control electricity to ***designated critical operations areas (DCOA)*** in the event of disruption to elements of the normal system.

Critical operations power systems are those systems so classed by municipal, state, federal, or other codes by any governmental agency having jurisdiction or by facility engineering documentation establishing the necessity for such a system. These systems include but are not limited to power systems, HVAC, fire alarm, security, communications, and signaling for designated critical operations areas."

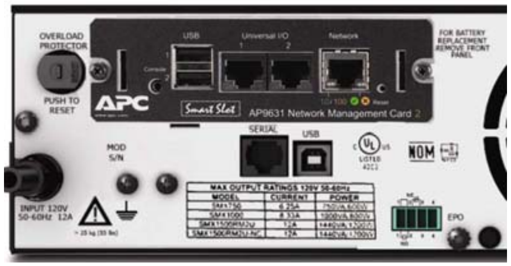
Bold, underlined and highlighted emphasis added

Electrical Considerations Cont.

UPS and Battery Connectivity

1. Identify/annotate existing connectivity:
    1. UPS
    2. Battery

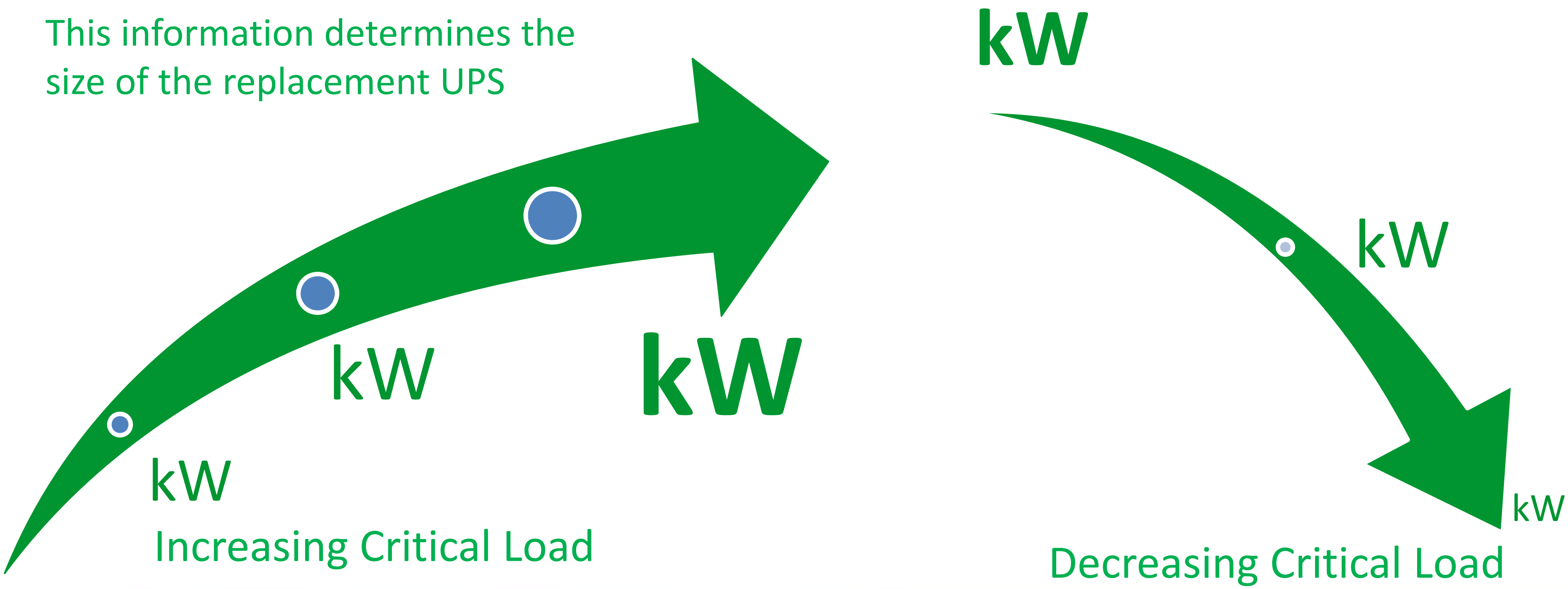
2. Evaluate if this existing connectivity is:
    1. Adequate
    2. Requires modernization



Capacity Requirements

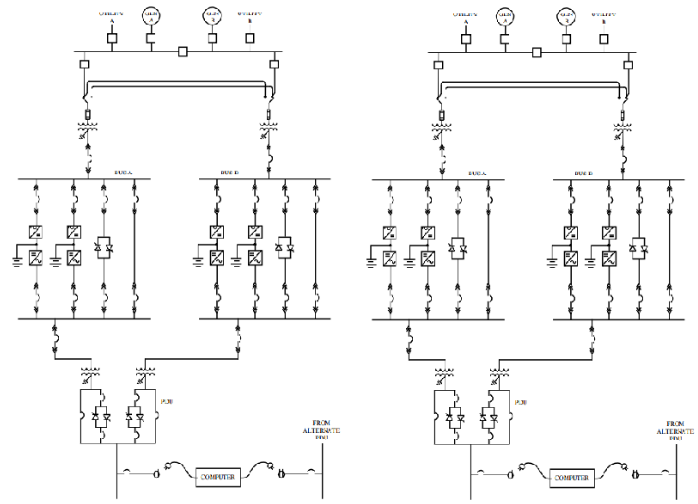
Present & Future

This information determines the size of the replacement UPS



Impacted Loads

1. Which critical loads will be impacted by the project
2. Which critical loads could be impacted
3. Who owns the process associated with the impacted critical loads
4. Communicate regularly with every team that has a device that will be impacted

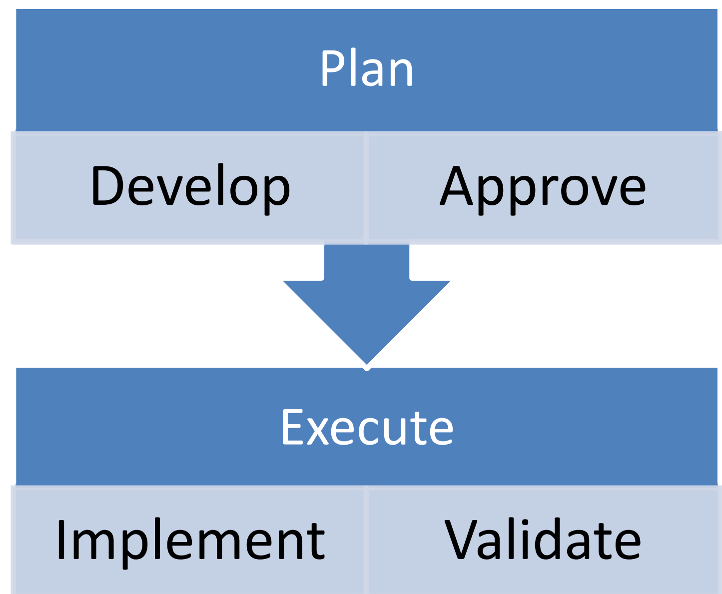


- Use the one line diagram as a starting point.
- Determine all connected loads that will and could be impacted by this work.
- Identify:
  - single corded devices
  - single points of failure

Identify Risks & Develop Mitigation In Advance

- Storm forecast – NO WORK IN STORMS
- Generator
  - Generator Maintenance Successfully Performed
  - Fuel for Generator
  - Generator service crews on standby
- Alt UPS (UPS B) Maintenance Successfully Performed
- Single corded devices addressed
- Single points of failure addressed
- Supplemental lighting if required
- All material and tools on site before Rip & Replace start
- Shutdown, start up and back out procedures vetted and approved

<u>Thou Shalt Pay Attention to Detail!!</u>



UPS Selection

Optimizing Value

- Transformer-less
- Scalable
- No rear access requirements
- Top and/or bottom feed
- Small footprint [ft^2(m^2) & lbs (kg)]
- Easy to move in and position
- Simple to assemble
- Multiple high efficiency operating modes (3Ph)
- Load Shaving Capabilities

- Meets Capacity Requirements
- Reliable
- Low maintenance
- Lithium Ion Battery Compatible
- Favorable TCO

Finding the Fit

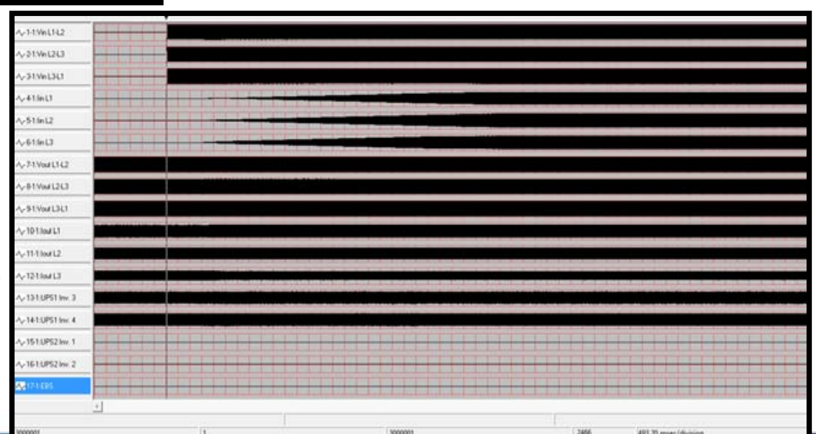
- Electrical
- Mechanical
- Physical

Factory Acceptance Testing

Loss of Utility

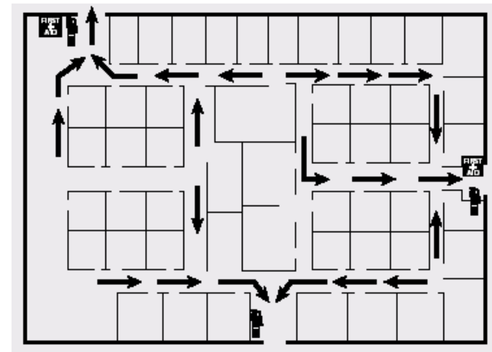
- Efficiency
- Power Factor
- Harmonic content
  - Ithd, Vthd
- Transfers
  - (Inv to Byp, Byp to Inv)
- Load Steps

Restoration of Utility



Procedures
Created & Approved

- General safety
  - Job safety plan
  - Points of emergency egress
  - Emergency contact info
- Electrical safety
  - Lock Out Tag Out (LOTO)
- EoL UPS Removal
  - Demolition drawings and instructions
- New UPS Installation
  - Drawings, installation manuals, start-up and commissioning plans & procedures
- Back-out
  - Back-out procedures in the event that the work must be stopped and made safe.




JOB SITE SAFETY PLAN

Project Name:

Address of this location:

GPS location

Your Name:

Your Site:

Your Supervisor:

Your First Aid Attendant:

Your MSDS Binder Location:

EMERGENCY PHONE NUMBERS - CALL 9-1-1 or

Fire:

Police:

Ambulance:

Hospital:

UTILITIES (Call before you dig!)

Gas:

Other Prerequisites

Be Prepared

Plan

1. Notifications to impacted parties sent
   – Conveying what is happening, which systems are impacted, starting time, anticipated duration and communications protocols

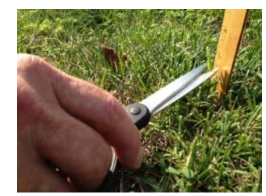
3. All supporting systems operational (recently maintained & operational)
   – Generators, Fuel, UPS-B ….

4. Manpower, materials and tools (and tool inventory) onsite

5. Engineering drawings and documents prepared, reviewed, approved
   – Including removal of EoL systems and installation of New UPS & systems

6. Communicate, Rehearse, Review, Revise

Meticulous



Attention to Detail

Rip Out the Old – Replace w/ the New

Work the Plan

- Safety Briefing
- Shutdown of EoL UPS & associated systems
    - via approved procedures
- **LOTO**
- Inventory of tools
- Out with the Old
- In with the New
- Inventory of tools
- Start up
- Testing
    - UPS, Controls, Interfaces
- Commissioning
- Red line drawings

On your mark

Get set

GO!!!

Facility Operations Team Training

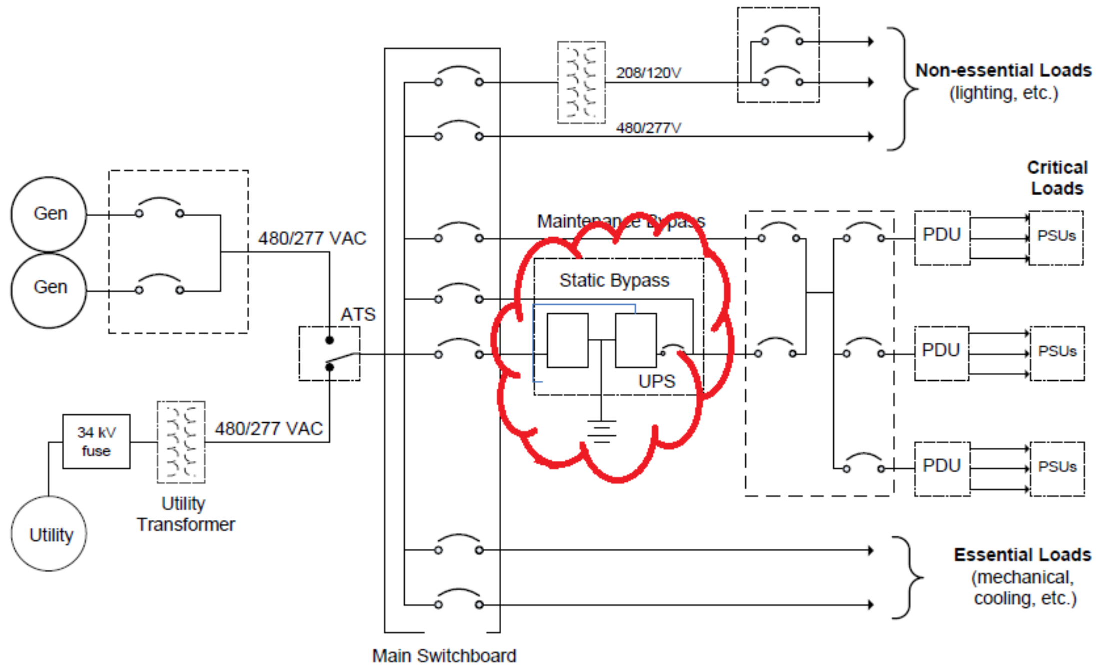
Optimal facility operations team training includes but is not limited to:

1. Participation in the entire project, if only at the informational level, promoting system familiarization in:
   - Electrical protection system
   - Cabling
   - Controls
   - Physical Rip and Replacement
   - Startup and Commissioning
2. Operation
3. Export of logs to tech support

As-Built Documentation

As-Built documentation can include but is not limited to:

1. Installation manual
2. Operations manual
3. Spare Parts Lists
4. As-Built One Line Electrical Diagrams
5. Baseline performance test results
6. Startup/Commissioning report



Source: Green Grid WP51 Power Equipment and Data Center Modified with red cloud to show typical As-Built annotation.

Economic Considerations

Economic Considerations

Source: Schneider Electric WP #214 "Guidance on What to Do with an Older UPS"

Example:

A modern 500 kW UPS is supporting 400 kW of IT load 7x24 with an efficiency rating of 96%. A legacy UPS is used in exactly the same scenario except that its efficiency rating is 88%. See footnote for assumptions[1].

UPS system	Annual internal UPS loss cost	Annual cooling cost for losses	Total 10yr cost of losses
Modern UPS at 96% efficiency	$14, 016	$5,606	$196,220
Legacy UPS at 88% efficiency	$42,048	$16,819	$588,670
OPEX savings of modern UPS	$28,032	$11,213	$392,450

Table 3 Comparison of two UPSs' cost of electrical losses over 10 years

[1] 8,760 hours per year for "7x24" operation, $0.10 per kW/hr cost of energy, energy to remove 1kW of heat is 0.4kW

Economic incentives:

- Local utility
- Governmental (national, state/provincial, and municipal)

Incentives come in several forms including:

- Corporate & property tax rate reduction
- Utility & govt. rebates
- Utility & govt. funded grants /loans for CAPEX projects
- Government bonds

For U.S. located facilities, http://www.dsireusa.org/ offers a free comprehensive source of information on both utility and government-based incentives and programs related to energy efficiency

Economic Considerations Cont.

Source: “UPS Replacement for Improved Efficiency, Reliability & Capacity”

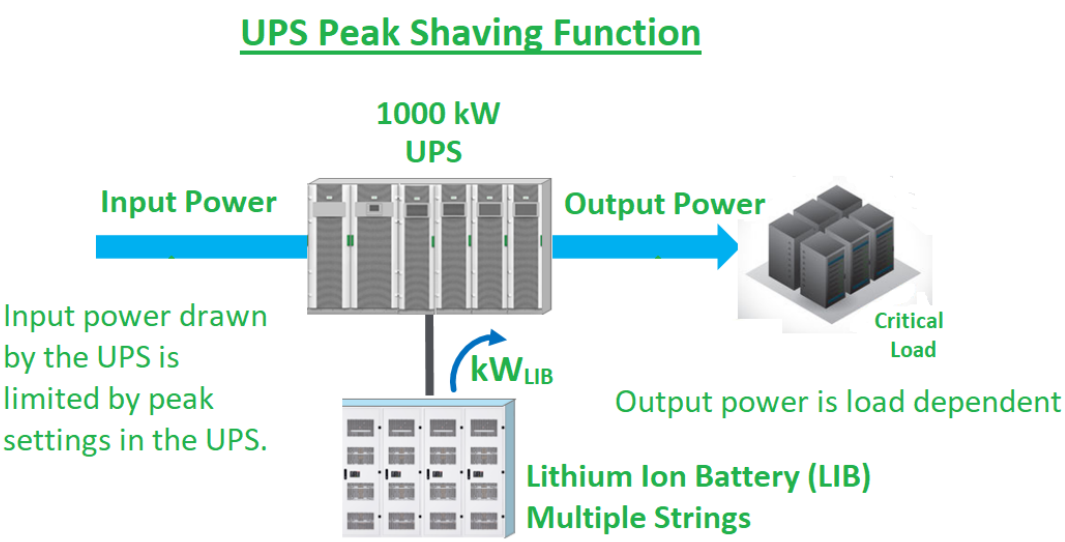
If the EoL UPS had excessive maintenance being performed then an additional savings will be reduced maintenance.

Increase in revenue potential if a unity power factor (pf) UPS replaces a 0.8 pf or 0.9 pf UPS of the same kVA rating.

Calculations may also include:

- Payback period calculations
  - How long is capital at risk
- Internal Rate of Return (IRR) calculations
  - How much does this project pay me
- Net Present Value (NPV) calculations
  - What is the value, in today’s dollars, of this project

Peak Shaving



Input Power Limit	UPS Load	LIB Load
500 kW	400 kW	0 kW
500 kW	500 kW	0 kW
500 kW	600 kW	100 kW
500 kW	700 kW	200 kW

NOTE: Peak Shaving duration is limited by the size of the LIB system

Benefits:

1. Savings from reduced power utilization associated with variable loads during peak power pricing periods.
    1. Immediate – using less power during peak pricing
    2. Long term – lower peak demand charges (1 to 12 month impact)
2. Opportunities to participate in Smart Grid and/or Demand Response Programs

Lithium Ion Batteries

Lithium Ion Batteries (LIB)

Being used in both 3 Phase UPS and 1 Phase UPS Applications

Benefits compared to VRLA

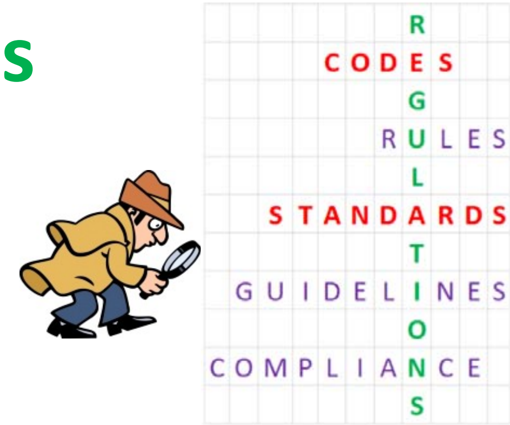
1. Smaller footprint
   - Ft^2 (m^2)
   - Weight lbs. (kg)

2. Higher energy density
3. Greater cycle rate = longer life
4. Faster recharge time
5. Larger temperature operating window
6. Lower Total Cost of Ownership (TCO)

Safety

1. All LIB systems should be certified by the UPS OEM for use in each specific UPS
2. LIB management and protection measures at a minimum should be predicated on a combination of active and passive measures including:
   1. Voltage
   2. Current
   3. Temperature
   4. Pressure

LIB Key Codes & Standards



NFPA 1 2015 Fire Code®

Chapter 52 Stationary Storage Battery Systems

International Fire Code® (IFC®) 2018

ANSI/CAN UL 1973, Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

NFPA 70 2017 National Electrical Code®

Article 706, Energy Storage Systems

Future:

NFPA 855 "Standard for the Installation of Stationary Energy Storage Systems"

Projected Issue Date: Q2 or Q3 2019

References

Bicsi Presentations

- **“What to Do With an Aging UPS”,** by John Gray, PE RCDD, Schneider Electric
  - https://www.bicsi.org/uploadedfiles/BICSI_Conferences/Winter/2016/presentations/what_to_do.pdf
- **“Introduction to Lithium Ion Solutions for Data Center 3 Phase UPS”,** Presented by John Gray, PE, RCDD
  - https://www.bicsi.org/uploadedfiles/bicsi_conferences/winter/2017/presentations/CONCSES_1A.pdf

White Papers

- Schneider Electric WP #214 **“Guidance on What t o Do with an Older UPS”,** by John Gray, PE RCDD & Patrick Donovan
- Schneider Electric WP #210 **“Single by Phase UPS Management, Maintenance, and Lifecycle”** by Justin Solis
- Schneider Electric WP #266 **“Battery Technology for Single Phase UPS Systems: VRLA vs. Li-ion”,** by Victor Avelar & Martin Zacho
- “UPS Replacement for Improved Efficiency, Reliability & Capacity” by Christian Brewer, John Gray, Mike DeCarli, Anthony Montgomery, Alan Lachapelle, Greg Blankenbeckler & Ryan Hustek

Questions