Guidance on What to Do with an Older UPS

White Paper 214

Revision 0

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Executive summary

"When should an older UPS be replaced with a new one?" is a question that virtually all data center owners will have to answer. The answer is not always self evident and depends on several factors. This paper provides data center owners and managers a simple framework for answering the question in the context of their own circumstances and requirements. Three options are explained and compared: run to fail, upgrade, and buy new.

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Introduction

This paper provides guidance for deciding what to do with older three phase, uninterruptable power supplies (UPSs). The answer is not always self-evident and will depend on many factors. The primary factors are:

- Present UPS conditions/capabilities
- Future requirements/constraints

Once a UPS has been in service for 10 years or so, the following three options present themselves to the owner as potential options:

1. **Buy new** – Should the UPS be replaced with a new one?
2. **Upgrade** - Can it be revitalized in some way to extend the life and performance for several more years?
3. **Do nothing** - Or is it better to do nothing beyond the most basic maintenance and just let it, in effect, "run-to-fail"?

Surprisingly, each of these options has a set of circumstances that would make it a rational choice. Each has their own set of advantages and disadvantages. This paper will review these options in the context of the primary factors listed above. A simple step-by-step framework for making the decision is provided along with recommendations to help ensure data center managers make their decision based on a full accounting of their own requirements and constraints.

Evaluate current situation and determine future needs

Before comparing and contrasting the three options described above, the first thing to determine, is whether the existing legacy UPS is (or soon will be) unable to meet its performance requirements ***and cannot be feasibly serviced or upgraded to do so***. **Table 1** shows a list of conditions that would typically indicate the UPS is at or near the end of its useful service life for the given application. **Assuming the data center facility is not being consolidated or outsourced; replacement with a new UPS is the recommended option in this case.**

Table 1

Conditions likely indicating the UPS must be replaced with a new one

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.

Assuming the UPS is meeting the load and runtime requirements, one could choose to leave the old UPS in service and let it run to failure. But this would be a highly risky path to take.

Careful planning, close facilities/IT cooperation, and a well-trained operations team would be necessary to minimize the impact of the UPS's imminent and inevitable failure.

If the UPS is not at the end of its service life for the intended application, the next step is to evaluate the UPS across three factors, all of which guide or outright determine the decision to keep, upgrade, or buy new.

- Outsource strategy
- Energy efficiency
- Future load requirements

Outsource strategy

By the time the UPS has become older, owners may also be considering what to do with their facility's other aging systems. Consideration as to whether or not to upgrade existing equipment, build new, or outsource to the cloud or collocation vendor (or both) is an initial step in the process. For existing data centers with available power, cooling, and space capacity, the decision is often an obvious one, but when a data center is at or near full capacity, a decision must be made as to where to house the IT equipment. White Paper 171, *Considerations for Owning vs. Outsourcing Data Center Physical Infrastructure*, describes the approaches for meeting new IT capacity requirements and discusses the factors that must be considered in making a fully informed decision. While the cost analysis may favor upgrading or building over outsourcing over a 10-year lifetime, sensitivity to cash flow, cash cross-over point, deployment timeframe, life expectancy of the data center, and other strategic factors play important roles in the decision. TradeOff Tool 13, *Data Center Build vs. Colocation TCO Calculator* allows you to input your own facility attributes and costs to determine a 10-year TCO estimation for building vs. collocating your IT in a retail colocation vendor.

These strategic choices about where or whether to house IT can have a large impact on what should be done with the existing UPS system. Obviously a decision to move everything to a retail colocation vendor, where the UPS system is maintained and managed by the vendor, would make this choice clear. It would really only be a matter of when the move would take place. The longer it takes to make the move, the greater the risk that the aging UPS will exhibit problems. Moving only some applications to the cloud might mean the new UPS could be much smaller making replacement with a new one a more affordable option. Mirroring workloads at another site or in the cloud could also reduce the level of redundancy required which might further reduce the investment needed to replace the older system with a new one at the existing facility. The point is, the outsource strategy should be understood when evaluating what to do with the older UPS. It should also be noted that the staff making the decisions about the UPS may not be the same people who determine the larger out-source plan. Therefore, communication and coordination between management & staff, and facilities & IT is important.

Energy efficiency

The efficiency of the UPS system, to a large extent, determines the operating cost. So it is important to understand how efficient the UPS system is today and how it can be improved through upgrades, changed load requirements, or by replacing with new UPS(s). These energy savings should be accounted for in the decision process.

The efficiency of the UPS system is largely determined by three things as shown in **Table 2**.

Table 2

Three main drivers of UPS system efficiency

Efficiency Driver	Description
Internal design efficiency	The internal losses of the UPS itself. Modern UPS systems operate in the 94%-99% range while older legacy UPSs are at 85% -92% across the same load range.
Utilization rate	The amount of load on the UPS relative to the UPS's power capacity. The efficiency of a UPS will vary based on the load. Generally speaking, efficiency is better at higher loads than lower. Modern UPSs typically maintain high efficiency levels even at loads as low as 50% or lower.
Redundancy architecture	The facility's design redundancy has a direct impact on the UPS's utilization rate. A 2N design implies that each UPS would not be more than 40-50% loaded. If either UPS failed or went offline, the other "backup" UPS would be capable of carrying the rest of the load. This low utilization rate negatively impacts the facility's power usage effectiveness (PUE). Particularly for an older transformer-based UPS, efficiency is significantly less at half load than at 90%, for example. Older transformer-based UPSs can have efficiencies in the 85% range when loaded at half load.

The following example illustrates the potential for savings based solely on the difference in UPS internal power losses. 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%. **Table 3** shows the ten year cost differences of these two systems. See footnote for assumptions[1].

Table 3

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

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

To understand how efficiency will impact the decision, start with an efficiency curve for the existing UPS that shows the percent efficiency as a function of percent load. Compare that to the new UPS being considered as a replacement. Many newer UPSs offer more advanced control systems that improve efficiencies by one or more methods such as "ECO Mode" operation (bypasses inverter) or hibernation of unloaded power modules. White Paper 157, *Eco-mode: Benefits and Risks of Energy-saving Modes of UPS Operation*, details the energy consumptions savings and limitations of Eco-mode operation. These newer operating schemes reduce power losses and, therefore, reduce OPEX. Find out from the manufacturer if the power modules for the existing UPS can be upgraded with newer more efficient modules.

See White Paper 108, *Making Large UPS Systems More Efficient*, for a detailed explanation of efficiency curves, how to compare them, as well as to see their cost implications quantified.

Note that government and utility-based energy efficiency improvement incentives, where available, can significantly influence the financial UPS replacement business case (see

[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

Other efficiency-related incentives

Data center owners should consult with their local utility, national, state/provincial, and municipal governments to learn what programs and incentives exist for improving the energy efficiency of their facility. These 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

sidebar). There may also be corporate "green" initiatives that would further favor replacement with a new UPS.

Schneider Electric UPS efficiency ratings and their impact on energy costs and carbon footprint can be quickly and easily evaluated using our TradeOff Tool, *UPS Efficiency Comparison Calculator*.

Future load requirements

How the IT load is expected to change over time should also influence the decision to keep, upgrade, or buy new. If the existing UPS system is at or near full load and future load growth is anticipated, options to add capacity must be explored, such as adding more power modules or another UPS unit in a parallel system configuration, assuming the existing UPS system allows for it. Obviously, if the existing UPS capacity cannot be changed to meet the future requirements, then buying new is the only option.

The capacity of the UPS itself is not the only consideration to be made. Handling future load growth also depends on the larger electrical distribution infrastructure network that had been provisioned for the existing UPS. The capacity of the input and output wiring, breakers, panels, switchgear, transfer switches, and the genset all need to be evaluated. This information will determine associated costs and risk exposure in order to reach the UPSs' future capacity requirements.

On the other hand, if the existing units are lightly loaded, then buying new or performing upgrades may not be necessary. However, keep in mind that if the load is expected to continue to be a small percentage of the rated capacity, then it is possible to replace with smaller units. Downsizing the UPS would improve efficiency, reduce the number of batteries needed, and likely lower service costs. These gains should be noted in the financial analysis. The point is to be careful not to simply assume that a new UPS necessarily needs to be a similar size as to what is currently installed.

Determining the future UPS load is an essential step in evaluating the options to keep, upgrade, or buy new. Having a reasonable estimation of future needs will determine, in part, whether or not the current UPS system can meet load requirements. White Paper 143, *Data Center Projects: Growth Model* shows a simple and effective way to develop a capacity plan for a data center or network room.

Redundancy requirements may have also changed from the original design. Newer architectures exist that enable higher electrical power utilization rates. For example, so called "catcher" systems use multiple smaller primary UPSs in a "3 to 1" or "4 to1" ratio with only one UPS as a backup versus a "1 to 1" ratio traditionally found in 2N systems The possibility for implementing less UPS redundancy should be considered when evaluating the potential cost of replacing old UPS systems with new. Redundancy considerations can affect both CAPEX and OPEX costs. See White Paper 75, *Comparing UPS System Design Configurations* for more information regarding UPS redundancy options.

Comparison of options

With the current status and future requirements of the UPS system in mind, three options for what to do with the old UPS system should be compared. Each one has its own advantages and disadvantages. The three options are: do nothing ("run to fail"), proactive maintenance (upgrade), and buy new. **Table 5** at the end of this section shows the conditions that tend to favor each of the options.

Do nothing ("run to fail" with minimal maintenance)

"Do nothing" is not meant to mean literally doing nothing to maintain the UPS. Rather, it means to keep the older UPS in service until "end of life" is reached without any significant capital expenditures to maintain or upgrade the UPS to newer condition, such as by replacing batteries or other major sub-systems and parts like capacitors, power modules, fans, etc. Even in a "run-to-fail" mode, UPS systems should still be regularly monitored for health and status changes that might indicate the presence of a problem. Assuming the UPS does not unexpectedly fail or drop the load, it is the lowest cost option with the least amount of disruption to day-to-day operations. However, the risk of sudden failure and impacting the load is higher. As a UPS ages, more reactive maintenance should be expected. Experience has shown that the instances of "time & material" type service more than doubles once the UPS has reached 10 years in service. However, the amount of risk from such a sudden failure can be mitigated by several factors:

- **UPS design redundancy employed**
  - If one UPS fails, will the loads remain powered without interruption?
  - Is concurrent maintenance possible?
- **Maturity of the operations & maintenance program**
  - Is staff trained and available to respond quickly to problems?
  - Are methods of procedures in place detailing steps to mitigate common problems?
  - Are spare parts on hand to deal with common problems?
- **Service contract terms and status**
  - Is break/fix service still provided and are response times within required timeframes
  - Does technical support service meet requirements and operating schedule?
- **Disaster recovery/fail-over scheme**
  - Does the load require 7x24 power without interruption**?**
  - Are workloads mirrored in disaster recovery (DR) site or in other sites?
  - Can workloads be migrated to other sites or other unaffected areas of the facility if one UPS fails? Can this be done with minimal impact to required service levels?

Upgrade

UPS manufacturers and third party service providers often offer services to revitalize or modernize an older UPS which will extend the service life by several years. These services typically come with a warranty (1 year is typical) and service terms that further reduce risk of extending the life of the legacy UPS. What can be upgraded or replaced in a UPS varies depending on the manufacturer and model. **Generally speaking, the more standardized and modular a UPS is in its design, the greater the number of upgrade options that will be available and the easier or less disruptive it will be to implement these improvements**. **Table 3** lists the types of components and sub-systems that can often be replaced or upgraded with new, over the service life of the 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

*Note that some vendors offer bundled upgrade packages that include replacement of some or all of the items in **Table 4** at a significant discount compared to performing the upgrades in a piecemeal, one-at-a-time fashion. Some upgrades (i.e. inverter blocks and fan assemblies) may also offer enhanced power efficiency. Along with the reduction in downtime risk, this benefit, if it exists, should be factored into the decision as well.

Even for highly modular UPS systems, there are still components that are generally not serviceable or replaceable from a cost effectiveness perspective at least. For example, the UPS backplane and bus bars that the modular inverter assemblies and control boards connect to inside the UPS fall into this category. So while these types of revitalization services can dramatically reduce reactive maintenance, they do not necessarily reduce it as much as replacing with a new UPS.

Ease of implementation is another factor to consider when evaluating the option of upgrading an existing UPS. Performing these upgrades is certainly more interruptive and/or risky to on-going operations compared to the first option of "do nothing" or "run-to-fail". But compared to replacing with a completely new system, an upgrade would take much less time and be less risky to the load. Upgrade tasks can typically be performed in a few hours within an approved maintenance window with the UPS in maintenance bypass while the critical load is powered by a generator and or redundant power source. How easy or difficult implementing the upgrade is depends mainly on two factors:

- The degree of modularity that is designed into the UPS
- The expertise and training of the team performing the service

Buy new

Compared to the first two options above, replacing an older legacy UPS with new offers high short duration risk during the changeover, but the lowest long-term risk profile as associated new equipment. Initial capital expenditures will be higher than performing an upgrade, but this needs to be balanced against the lower operating expenses that are due to many possible reasons summarized below and described in previous sections:

- Reduced power losses
- Smaller UPS due to smaller load
- Modular, pay-as-you-grow design (right-sized)
- More efficient system or UPS internal redundancy employed
- Reduced redundancy requirements
- Lower service costs vs. old UPS

- Rebates, tax relief, grants, etc due to improved efficiency

Replacing an older UPS system with a new one may be more complex and time consuming than upgrading especially if the UPS to be upgraded is already modular in design. Careful planning and execution are required in order to minimize UPS downtime during the swap. Some vendors offer a service to do this work as a turnkey project. If the owner's operations team does not have the availability or expertise, ask the UPS OEM vendor if they can perform every task associated with this effort including remove/dispose the old system, install the new, startup and commission the system, as well as transition an existing service contract (if one exists) all under one order.

Table 5 lists typical conditions that make a given option a sound choice.

Table 5

General "rules of thumb" that tend to favor each of the three options

Option	Conditions that favor option
Run-to-fail	• No budget • Moving everything soon to cloud/colo or consolidating into another facility • High degree of redundancy installed with mature operations & maintenance program (spare parts available, well-trained, established methods and procedures) • Existing service contract to handle sudden failures • UPS meets current and near term future requirements (capacity, runtime, redundancy, and efficiency)
Upgrade	• UPS is modular allowing for replacement of key parts prone to failure (batteries, capacitors, fans, PSUs, etc) • UPS is modular with batteries that are >5 yrs old; power modules >10 yrs old • Non-modular UPS where future requirements are stable and match current UPS capabilities and UPS is <15 yrs old
Buy new	• Vendor no longer supports UPS & spare parts are unavailable • Non-modular UPS that is 15 yrs old or older • Capacity and efficiency ratings do not meet current or future needs • Strong Utility rate or govt. tax discounts exists for efficiency improvements that can be taken advantage of with a new UPS • Unserviceable parts have failed or are likely to fail.

Additional key considerations for replacing with a new UPS

If the conditions are such that replacement with a new UPS appears to be the best option, several other key items which could impact the decision making process should be evaluated. These items will also affect the suitability of a given UPS, as well as, the UPS replacement project's scope of work (SoW).

White Paper 61, *Electrical Distribution Equipment in Data Center Environments* describes in general the subsystems that comprise the electrical distribution system for a data center.

At the electrical input of the UPS, verification that the feeder breakers and conductors powering the UPS will support a specific replacement UPS is essential. This verification should be performed by a professional engineer with expertise in electrical distribution system studies and knowledge of applicable code requirements. Verification at a minimum includes: visual inspection of breakers and conductors, confirmation of breaker maintenance, as well as a review of electrical system studies (load flow, short circuit analysis, protection coordination, and arc flash) using electrical characteristics of the replacement UPS as a basis for the study. Operational interaction of the replacement UPS with standby generator(s) should also be included in this analysis.

Several characteristics of the existing power distribution system can significantly impact the replacement UPS selection. These include:

- Input & distribution voltages
- Generator compatibility
- Synchronization requirements if static transfer switches (STSs) are deployed
- Existing feeder breakers and conductors
- Physical footprint and floor loading

Each of these factors is briefly explained below:

Input & distribution voltages
Input voltages may constrain the number of replacement UPS options with 400 VAC being the most prevalent IEC voltage and 480 VAC being the most common used in North America. Other North American voltages include 208 VAC, 415 VAC, 575 VAC and 600 VAC. To minimize site work, the new UPS should match what has already been provisioned for the existing legacy UPS, if possible. **White Paper 129**, *Comparing Data Center Power Distribution Architectures* provides more information about common distribution approaches to IT equipment in the white space.

Generator compatibility
Although most of the latest generation of UPS units are designed and built to be highly compatible with standby generators; if the replacement UPS has more capacity, it is extremely important to validate that the existing generator can support this increased kW capacity in concert with all other generator loads. In addition, the generator's starting load profile/load sequencing should be carefully evaluated to ensure continuity of power delivery throughout the facility when standby generator power is required. When an IGBT-based UPS is replacing a SCR-based UPS (6 pulse or 12 pulse) the overall generator load profile is improved assuming no other changes to the load.

Several White Papers on generators for IT and Data Center service are available including: **White Paper 52**, *Four Steps to Determining When a Standby Generator is Needed for Small Data Centers*, **White Paper 90**, *Essential Standby Generator System Requirements for next Generation Data Centers*, **White Paper 93**, *Fundamental Principles of Generators for Information Technology* and **White Paper 200**, *Impact of Leading Power Factor on Data Center Generator Systems*.

Synchronization with static transfer switches (STSs)
If STSs are part of the conditioned power distribution system, ensure that UPS-STS synchronization criteria meet operating intent.

Existing feeder breaker(s) and conductors
The existing feeder breaker and conductors must be inspected (electrically and mechanically) for suitability of reuse with a replacement UPS and compliance with all applicable codes. The feeder breaker(s) should have been properly maintained and in good operating condition. Verification that the feeder breaker provides proper electrical protection is a requirement. The length of conductors and whether or not the UPS cable entry point is top or bottom will determine I/O cabinetry and suitability for re-use. The best scenario is that the existing breakers and conductors are a perfect fit. However, it is likely that some customization of the replacement UPS input and output bus is required, which is typically easily accommodated for such projects.

Physical footprint and floor loading
The footprint of a new generation UPS is most likely going to have a smaller footprint than a legacy UPS of the same capacity. Even though a replacement UPS may have a smaller

footprint on a square footage basis, there should be verification that all physical clearances are in compliance with applicable electrical and building codes. Typically most legacy UPSs will also weigh more than the latest generation UPS; but weight loading should still be evaluated in every case.

Conclusion

What to do with an aging UPS is not always obvious and there are more options today than many might expect. There is no one right answer, but rather a range of right answers depending upon various factors including what the current and future capacity, redundancy and efficiency requirements are, what the outsourcing strategy is, and what has already been provisioned for in the electrical and physical infrastructure supporting the existing UPS. Understanding the current situation and future requirements will largely determine whether it makes more sense to "run to fail", upgrade, or buy new.

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Resources

Considerations for Owning vs. Outsourcing Data Center Physical Infrastructure
White Paper 171

Eco-mode: Benefits and Risks of Energy-saving Modes of UPS Operation
White Paper 157

Making Large UPS Systems More Efficient
White Paper 108

Data Center Projects: Growth Model
White Paper 143

Comparing UPS System Design Configurations
White Paper 75

Electrical Distribution Equipment in Data Center Environments
White Paper 61

Comparing Data Center Power Distribution Architectures
White Paper 129

Four Steps to Determining When a Standby Generator is Needed for Small Data Centers
White Paper 52

Essential Standby Generator System Requirements for next Generation Data Centers
White Paper 90

Impact of Leading Power Factor on Data Center Generator Systems
White Paper 200

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