UST

The Weakness at the Heart of Data Center Power-Backup Systems. And the Fix.

THE ECONOMIC CASE FOR ADDING ELECTRONIC VOLTAGE REGULATION TO THE STANDARD UPS SYSTEM CONFIGURATION

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Executive Summary

We estimate the combined cost of electrical inefficiency plus preventable unplanned outages at a 500kVA data center (used in this paper's calculations) due to legacy UPS system design at **$371,000** over 10 years. At an *average* U.S. data center, that cost will exceed **$1,800,000.**

Uninterruptible Power Supply (UPS) systems in data centers are designed to do double duty – supply backup power in the event of a blackout, and continuously monitor and condition power in the event of other voltage irregularities. This legacy design is electrically inefficient, costing the average data center more than $130,000 in unnecessary utility charges annually.[1] However, efforts to introduce 'green' or 'eco-mode' options, despite the promise of significant cost savings, have been rejected by facility managers who believe they are making a safe choice by sticking to a standard configuration. Unfortunately, the standard configuration contains a basic design weakness that all but guarantees one or more costly unplanned outages over the typical 10-year lifespan of an installation. This white paper examines the costs and the risks of the legacy UPS configuration and recommends consideration of an alternate system design that includes a modern electronic voltage regulator (EVR) as a standard component.

Introduction

Data centers are ravenous, intolerant beasts consuming, according to some reports, up to 2% of the world's electricity production. Power – clean and constant power – is an imperative. Customers dependent upon monster data centers for business-critical applications expect zero downtime. Consequently, the focus of data center facility managers is on reliability.

Data centers deploy large and expensive battery-based Uninterruptible Power Supply (UPS) systems to ensure continuous service to a demanding customer base. To meet expectations for 100% uptime, facility managers trade electrical efficiency for the assurance of knowing that their backup systems will start the millisecond they are needed. Despite calls by investors and the general public to lower utility costs and reduce their carbon footprint, facility managers have largely rejected industry efforts to introduce 'green' or 'eco-mode' solutions, fearful that these complex systems will fail when needed.

However, there is a **significant weakness** in the legacy design of power-backup systems at data centers. Developed before the advent of modern electronic voltage regulators (EVR), data center UPS systems are designed to do double duty – supply backup power in the event of a blackout, and continuously monitor and condition power.

The implied promise of a UPS is uptime. It is ironic, then, that a report sponsored by Emerson Network Power[2] found that one of the leading causes of unplanned power outages was failure of the UPS system itself.

A report sponsored by Emerson Network Power found that up to 16% of unplanned power outages at data centers are due to UPS system failure.[3]

The typical UPS system is called upon 40 to 60 times a year, but only a small handful of those events are in response to a total power loss or deep voltage sag. Up to 90% of the time, the UPS system is responding to events that could be more reliably and economically managed by alternate voltage regulation technologies. This excessive switching stresses UPS systems, and more critically, **exposes data centers to the surprisingly high incidence of UPS failure.**

This white paper explores the costs of lost electrical efficiency and unplanned outages due to UPS failure at data centers, examines why industry efforts to introduce 'green' solutions have been rejected by facility managers, and suggests an alternative system design that promises to deliver increased electrical efficiency and **reduce risk of system failure** by incorporating an EVR into the standard power-backup and power-conditioning configuration.

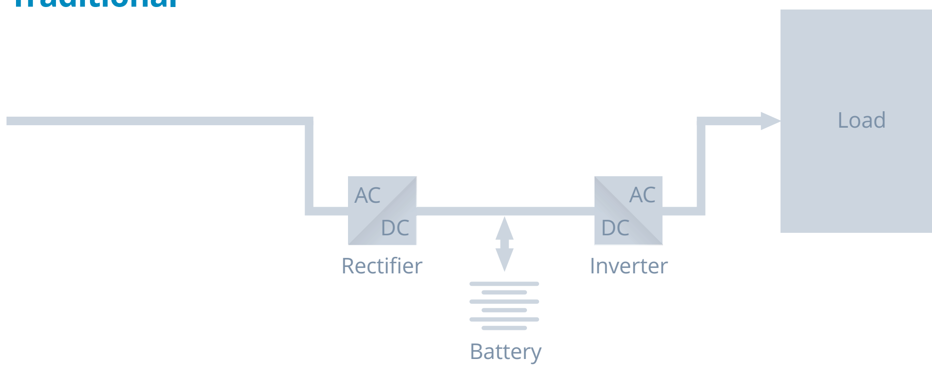
Research Design and Assumptions

In this paper, we evaluate the total owning cost of a UPS system with and without an EVR for a typical 500kVA data center by comparing four typical UPS installation scenarios:

- 500 kVA traditionally configured UPS
- 500 kVA eco-mode equipped UPS (with eco-mode enabled)
- 500 kVA eco-mode equipped UPS (with eco-mode disabled)
- 500 kVA EVR-protected UPS

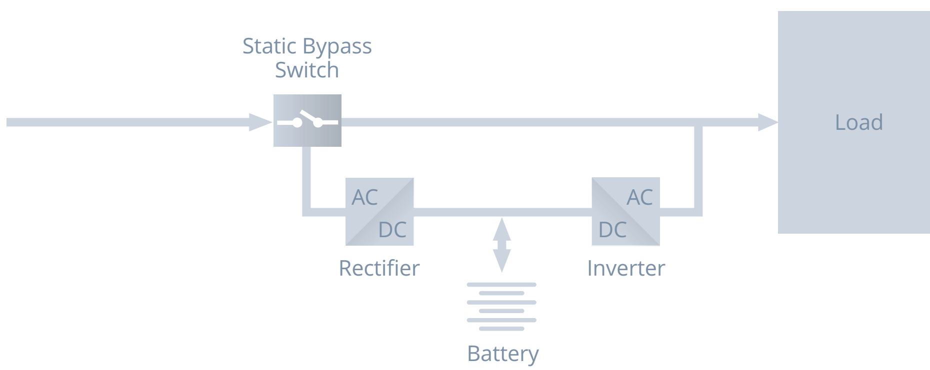
System Configuration Schematics

Traditional



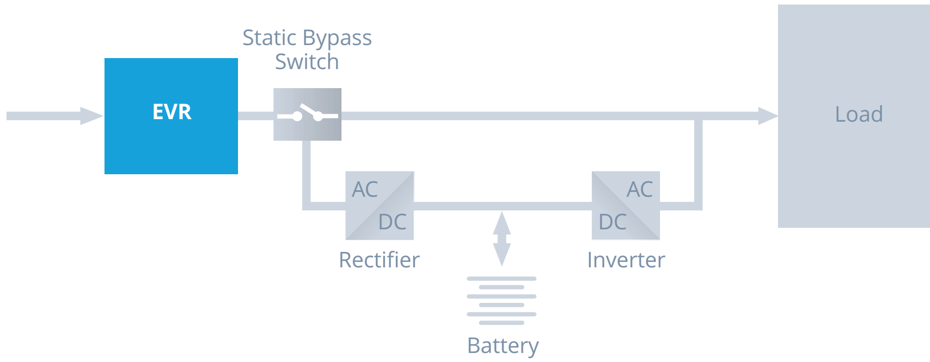
In a **traditional** UPS backup system, all incoming power is routed through the UPS rectifier, which converts power from AC to DC. It is then routed back from DC to AC through the UPS inverter. Through this process, power quality is assured, but electrical efficiency is greatly reduced.

Eco-Mode-Equipped



An **eco-mode-equipped** UPS backup system increases electrical efficiency by enabling a monitored bypass, which must be custom programmed on a per-installation basis for proper sensitivity to electrical 'events,' such as sags, surges, brownouts and blackouts. Due to complex configuration issues and limited reliability data, facility managers rarely enable the eco-mode feature.

EVR-Protected



In an **EVR-protected** UPS backup system, incoming power is monitored by an EVR, which compensates for voltage fluctuations. In this configuration, power anomalies are conditioned within one cycle, and the static switch is rarely triggered. This leaves the UPS in safe standby mode, unstressed. This system offers a level of electrical efficiency identical to an eco-mode-equipped UPS at a much lower risk level. More importantly, the reliability of an EVR-protected system *exceeds* that of a traditionally configured system.

Electrical Efficiency

UPS systems rarely achieve the levels of electrical efficiency manufacturers advertise. An Emerson study[4] notes that 'nameplate' ratings, which are often 96% or better, are based upon full-load efficiency, not typcial use. Emerson suggests using 92% as a standard for calculation. For this comparison, we use 93%, which we believe is a *conservative* calculation standard.

Cost Per Kilowatt Hour

The charts and graphs included in this paper are calculated based upon electricity cost of 10¢ per kwh @ 93% efficiency. Using this figure (which is conservative relative to the 20¢ or more common in urban areas), and comparing a traditional UPS running at 93%

efficiency verses an EVR-protected UPS running at 99% efficiency at a 500kVA data center, the differential cost due to electrical inefficiency is **$26,280 per year, or $262,800 over the expected 10-year lifespan** of a power-backup system.

Cost of Unplanned Outages Due to UPS Failure

- A single unplanned outage costs the average data center $690,204.
- Up to 90% of the so-called 'outages' UPS systems are called upon to manage are actually transient electrical events, better handled by an automatic voltage regulator.

The "2013 Cost of Data Center Outages"[5] study, conducted by the Ponemon Institute on behalf of Emerson Network Power, concluded that **15.8% of unplanned outage costs are due to UPS system failure**, while a complementary survey of data center professionals[6] lists UPS failure as the cause of nearly 25% of unplanned outages.

The same study reports that the average cost per unplanned outage is $690,204 for a data center averaging 12,558 square feet. Normalizing this data for a 500kVA installation (approximately one-fifth the size of the average data center surveyed by Ponemon), we estimate the cost of an unplanned outage at **$137,403**.

UST estimates that **at least half** of these UPS-related outages, and perhaps as many as 90%, could be avoided if these relatively fragile systems were not required to operate as frequently. Using the more conservative 50% figure, over a typical 10-year lifespan, the cost savings from a reduction in unplanned outages at a 500kVA data center equals the cost of a single outage times the number of expected outages (1.58 to 2.5) divided by 2 (the number of UPS-related outages mitigated by an EVR).

Based upon this formula, we compute the cost of unplanned power outages (that could be prevented by the inclusion of an EVR at a 500kVA installation) to be between **$108,548 and $171,754** over 10 years.

Maintenance and Other Potential Cost Factors

To fully compensate for unplanned outages due to UPS failure at data centers, the literature suggests significantly supplementing manufacturer-recommended maintenance schedules, or even installing expensive redundant systems. However, the addition of an EVR, which would reduce wear and tear on the UPS system, should allow facility mangers to confidently implement a less-costly maintenance schedule.

While battery replacement costs remain flat, based upon customer history, UST believes scheduled maintenance costs could be reduced by as much as 17%, or **$2,000 per year**, per 500kVA installation.

EVR and Additional Component Costs

Of course, an EVR (along with a static switch and other hardware required to integrate the system) increases the initial cost of a power-backup and power-management system. However, when the cost of unplanned outages and lifetime maintenance are factored in, the total cost of ownership of an EVR-protected system over 10 years is significantly less than all other options, including a comparably sized eco-mode-equipped and enabled UPS.

UPS Eco-Mode: A Risky and Rarely Enabled Option

Data centers are under increasing pressure, both from customers advocating for greener operations and investors advocating for more profitable operations, to improve energy efficiency. Major UPS manufacturers, including Eaton, General Electric and APC, have introduced proprietary 'eco-modes' on their UPSs, which, when activated, can achieve 98.5% to 99% efficiency.

This is a great selling feature.

Objections to eco-mode:

- Systems require expensive and tricky fine-tuning
- No significant reliability data
- Loss of electrical protection

But a study by Schneider Electric shows that eco-mode is rarely enabled, despite the ensured (and considerable) cost savings. Why? As the study's author states, "the use of eco-mode entails risks." While computers and servers are actually relatively resilient relative to power variations, data centers are more complex and "less predictable in their response to infrequent and unusual power events."[7]

To work as advertised, eco-mode-enabled UPS systems need to be fine-tuned per installation. This fine-tuning is expensive and tricky. If sensitivity triggers are set too high, the system will switch too frequently, causing significant wear and tear; if set too low, damaging surges and sags can transit before the system reacts.

EVR-Protected UPS: Solving for Both Reliability and Efficiency

Within the last decade, EVRs equipped with electronic on-load tap changers have proven capable of reliably and efficiently compensating for variations in incoming voltage.

EVRs minimize and balance variations in voltage to protect equipment that draws electricity from a poor power source, ensuring consistent voltage. EVRs "sense" even the smallest voltage fluctuation within a single cycle and adjust electrical output by transforming the voltage coming in from the grid before passing it through to the loads they serve. When an EVR is placed between the source and the load, up to 90% of the electrical events that cause traditional backup systems to engage can be safely bridged.

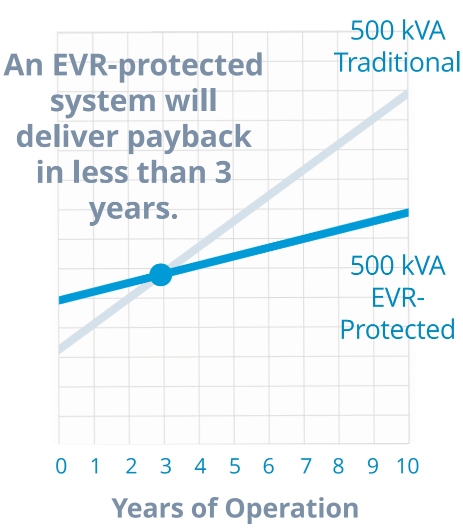
Placing an EVR equipped with a static switch ahead of the battery-based UPS system would allow a data center to remain safely connected to the local grid while reducing stress on the UPS. The EVR is a fully electronic device, with no moving parts, no significant maintenance requirements, and a solid, field-tested record of reliability. It is literally "enabled" upon installation. It is important to note that an EVR does not supply power and cannot compensate during periods of total power loss or blackout. Rather, it compensates for voltage sags, swells and brownouts.

10-Year Total Cost of Ownership Comparison

Based upon the above data, the inclusion of an EVR in the power-backup and power-conditioning system at data centers will lead to a clear and significant reduction in data center operating costs when measured over 10 years (the typical lifespan of a UPS backup system).

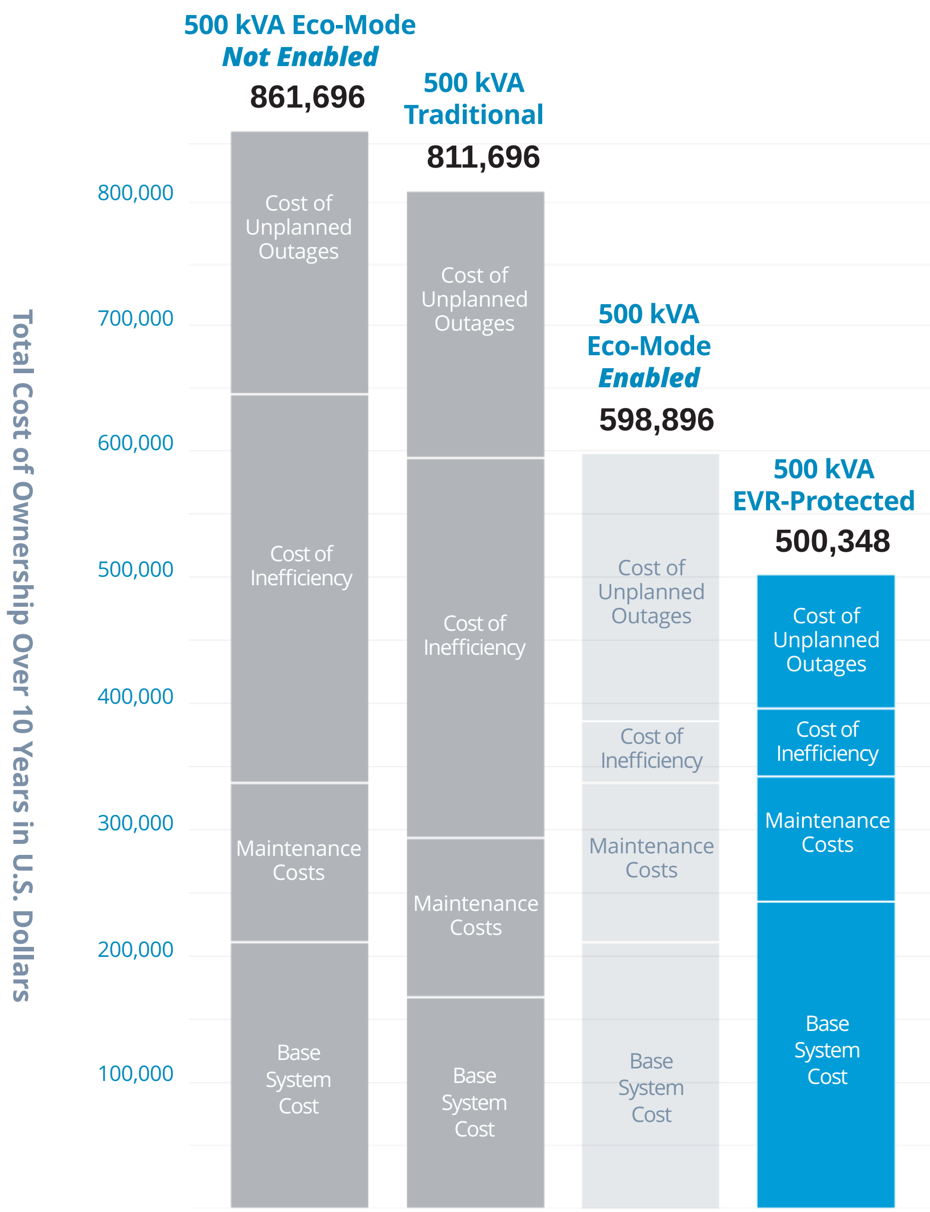
	Risk	Base System Cost	EVR and Static Switch Cost	Maintenance Cost	Cost of Electrical Inefficiency (.10/kwh)	Cost of Unplanned Outage(s)	TOTAL COST OF OWNERSHIP
500 kVA Eco-Mode *Not Enabled*		218,000	0	120,000	306,600	217,096	**861,696**
500 kVA Traditional		168,000	0	120,000	306,600	217,096	**811,696**
500 kVA Eco-Mode *Enabled*		218,000	0	120,000	43,800	217,096	**598,896**
500 kVA EVR-Protected		168,000	80,000	100,000	43,800	108,548	**500,348**

[See graph on following page]



The graph to the left compares ownership costs of a 500kVA traditional system vs. a 500kVA EVR-protected system based on base system costs (+ EVR), maintenance costs and the cost of electrical inefficiency (.10/kwh) over 10 years. It does not factor in the cost of unplanned outages.

As the graph indicates, payback is *guaranteed* in **less than 3 years**. However, factoring in the likelihood of at least one prevented UPS outage during the 10-year lifespan of a system, **total savings will be greater**, and payback could be realized even sooner.



Note: While the total cost of ownership over 10 years of an **eco-mode-enabled UPS** backup-power and power-conditioning system is lower than traditional systems, these savings are only *theoretical*, as facility managers rarely enable the power-saving bypass feature due to risk concerns.

Conclusion

The basic configuration of UPS power-backup systems at data centers should be updated to include the EVR as a standard component.

- By separating the power-conditioning function from the power-backup function, an EVR-protected UPS system can achieve the electrical efficiency promised by manufacturers of eco-mode-enabled UPS systems while simultaneously and significantly reducing the risk of UPS-caused outages. Although EVRs are a relatively new technology, their simple design and established record of reliability should allow facility managers to welcome their introduction.

- The savings over the 10-year lifespan of the UPS system at a typical data center more than justify the additional initial costs of an EVR equipped with a static switch.

- For a 500kVA facility, savings will total at least $371,000 over 10 years—and that number will scale directly relative to facility size.

- Beyond these easily calculable savings, including an EVR in the basic backup-power and power-management system design at data centers has the potential to alter the risk formulas used to determine levels of redundancy required at the UPS and data center levels. If this proves true, adoption of this design could dramatically reduce infrastructure costs.

References

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[3] Ponemon Institute. 2013.

[4] Emerson Network Power. 2011. "Conducting an Accurate Utility Cost Analysis Based on UPS Efficiency." Source on 5/15/14 at www.emersonnetworkpower.com/documentation/en-us/brands/liebert/documents/white papers/conducting an accurate utility cost analysis based on ups efficiency.pdf.

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About the Authors

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