Thought Leadership White Paper

Is power protection costing you more than it should?

A simple change in your power system can pay for itself many times over—and return thousands of dollars to your IT budget.

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Executive Summary

In the quest to reduce energy consumption and cooling costs, data center managers have been looking more closely than ever at the energy efficiency of their uninterruptible power systems (UPSs). Legacy UPSs—those five to 10 years old—could be squandering as much as 10 percent of incoming energy in the course of doing their jobs. Since most of the power lost by a UPS is dissipated as heat, an inefficient UPS costs more in cooling as well.

New, groundbreaking UPSs maximize efficiency by operating in multiple modes, changing their operating characteristics to adapt to the electrical conditions of the moment. By engaging internal components only as necessary, these multi-mode UPSs can achieve exceptional efficiency—up to 99 percent across a very broad load range.

However, multi-mode UPSs from different manufacturers vary considerably in how they work, the level of protection they can offer, and their true efficiency under real-world load levels. This white paper looks at five questions you need to ask before selecting a high-efficiency, multi-mode UPS for your data center.

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All the electronics in your organization—from desktop to data center—require continuous, clean power. Anything less puts the business at risk for data corruption, equipment damage and unplanned downtime. For virtually all organizations, this requirement is met by having one or more uninterruptible power systems (UPSs) in the facility—whether that is a central UPS that serves an entire building or data center, distributed UPSs placed closer to the equipment being protected—or both.

If UPS technology in your organization is even five years old, it is costing you more than it should. If it is 10 years old, you could be leaving tens of thousands of dollars on the table.

In a one megawatt data center, a 10-year-old UPS could be wasting 150 kilowatts (kW) or more of utility power and dissipating a *lot* of added heat. Replacing that vintage equipment with new, high-efficiency UPSs can free up about 120 kW of that power to support new IT equipment and reduce the burden on cooling systems.

For example, replacing just one 550 kW UPS from a redundant UPS configuration with a higher-efficiency model could save you more than $40,000 in power and cooling bills each year, while eliminating 190 tons of CO_2 emissions and netting you substantial utility company rebates.

Changing the game in UPS efficiency

Until recently, 96 or 97 percent energy efficiency was the upper limit in a double-conversion UPS. For every dollar spent on utility power, three to seven cents of it was used or dissipated as heat by the UPS. That does not sound like much, but it adds up, as we will see later.

That game has changed. New energy-saving UPSs can deliver up to 99 percent efficiency, providing more usable power for every utility dollar. These UPSs achieve this high efficiency by intelligently adapting to the quality of the utility power and operating in energy-saving mode most of the time. In contrast, traditional *double-conversion* UPSs process utility power through an inverter and rectifier every millisecond of the day, converting it from AC to DC and back to AC again—dissipating heat and wasting power at every stage.

The traditional trade-off with high-efficiency UPSs

Until recently, there were significant trade-offs to increasing energy efficiency. To offer the highest efficiency, the UPS had to expose downstream equipment to potentially harmful surges and could create other problems due to slow reaction times.

New advances in high-efficiency UPSs eliminate these sacrifices.
You can have it all in a single UPS—99 percent efficiency and premium protection.

This is the kind of relief data center managers have been looking for as they face intense pressure to reduce energy consumption and meet environmental regulations—without compromising uptime.

Does a gain of a few percentage points in efficiency really matter that much?

Yes. The less efficient your power protection systems, the more utility power you have to buy to run your facility or data center. Since most of the power lost by a UPS is dissipated as heat, an inefficient UPS adds more costs and unnecessary load on the cooling system.

Even slight gains deliver significant potential savings in power and cooling. The table below shows an example for a UPS supporting loads of various sizes. For a 250 kW load, you save about $4000 per percentage point of efficiency gain, enough to pay for the UPS in three to five years. The reduced carbon footprint is equivalent to pulling 29 cars off the road.

Critical Load	50 kW	125 kW	250 kW	500 kW	700 kW	1 MW
Electric Costs (energy + demand)	$0.11 per kWhr					
Efficiency—Conventional UPS	92.5 percent		93 percent			
Efficiency—Best-in-class, multi-mode UPS	99 percent					
Three-year energy savings (MWhrs)	145	363	670	1340	1876	2680
Three-year CO_2 savings (metric tons)	104	261	481	962	1347	1924
Equivalent number of cars off the road	6	16	29	59	82	118
Three-year utility cost savings	**$15,972**	**$39,929**	**$73,715**	**$147,431**	**$206,403**	**$294,862**

Table 1. Representative savings by upgrading from conventional to high-efficiency, multi-mode UPS

Separating hype from reality about high-efficiency or "eco-mode" UPSs

If you have dealt with UPSs for any length of time—whether as an analyst, specifying engineer or facilities/operations professional—no doubt you have heard plenty of hype about high-efficiency or "eco-mode" UPSs in the past. Those terms generally referred to UPSs that switched between modes to improve efficiency. Some form of multi-mode capability has been available on UPS products for years.

Those conventional multi-mode UPSs have their limitations. They can be ineffective against many types of power problems. They can be slow to respond to transient power conditions. They can be vulnerable to high surges, downstream shorts and other electrical system conditions.

With that history for multi-mode UPSs, you have every right to be skeptical and ask, "What makes new multi-mode UPSs so different? Can I entrust my mission-critical data centers to multi-mode power protection?"

The answer is yes, if you choose wisely and ask the right questions of a UPS vendor. There are vast differences in the way these UPSs achieve their high efficiency—and the degree of protection they afford.

Five questions to ask before selecting a high-efficiency, multi-mode UPS

1. **Does the UPS sacrifice protection to gain high efficiency?**
Some high-efficiency UPSs force a trade-off between power savings and power quality.

Internal design—*topology*—profoundly affects efficiency and protection levels. *Line-interactive* UPSs are efficient, but they only offer limited voltage regulation, surge suppression, and battery backup. Premium, double-conversion UPSs do the most processing to deliver clean power, but at a cost to efficiency.

New multi-mode UPSs offer the best of multiple topologies in one UPS. As mentioned earlier, these UPSs flash between different modes to match the conditions of the moment:

- Under normal conditions, the UPS is in a high-efficiency mode that includes surge suppression and voltage regulation.
- When input power is poor, the UPS uses double-conversion technology to deliver cleanest output power for equipment.
- When power quality is very bad or goes out altogether, the UPS draws on internal or external batteries or a standby generator as needed, just as a typical UPS does.

2. **How does the UPS achieve its high efficiency?**
Models vary in how they switch between operating modes.

Conventional multi-mode or eco-mode UPSs usually operate in one of two ways. They either:

- *Run in standby mode* under normal conditions, powering the load from a utility input source that bypasses the internal circuitry of the UPS. Whenever major power disturbances occur, the UPS has to start up and charge those internal components, synchronize the electrical waveform, and then transfer to double-conversion mode. During short power disturbances, critical loads are left exposed to potentially damaging conditions.
- *Run in line-interactive* mode, with an inverter or some sort of power stage running all the time, to provide some surge suppression and voltage regulation when in high-efficiency mode and enable faster switchovers to double-conversion mode.

The first type of UPS takes too long to respond to power conditions. Damaging surges or transient power problems could still reach your valuable electronics. The second type of UPS is faster to jump into action but consumes more energy. This type of UPS tends to be no better than 96–98 percent efficient.

New multi-mode technology resolves both issues. In this newer type of UPS, the inverter is continuously charged but not processing power. The inverter remains connected, running all controls and synchronized with the input power, so the UPS can transition to double-conversion mode without delay and without compromising efficiency. Inverter filtering components are connected to the load all the time, providing surge conditioning comparable to that present in double-conversion mode.

3. **How efficient is the UPS when lightly loaded?**
Average efficiency in the real world can be quite different from stated efficiency.

Manufacturers usually state UPS efficiency ratings at full load, but most of today's UPSs are markedly less efficient under lighter loads, which is how they are likely to be used. Since so many IT systems use dual-bus architecture for redundancy, the typical data center loads each power bus (and each corresponding UPS) at less than 50 percent capacity, often as little as 20 to 40 percent.

As a result, it is important to know UPS efficiency across the entire load range, not just under theoretical ideal UPS operating conditions. While many UPSs drop off markedly in their efficiency under light loads, others can perform at 99 percent efficiency even when lightly loaded, as much as 15 percentage points better than a traditional UPS.

4. **Just how quickly does the UPS detect and respond to power events?**
Electronic equipment can only tolerate brief, sub-second interruptions.

Look for a UPS that is very quick to detect and respond to power problems—ideally, within two to four milliseconds (1000ths of a second)—for two key reasons:

- *Minimizing inrush current.* After even a brief disruption in power, IT equipment draws a surge of energy to recharge its capacitors. The longer the interruption, the greater the *inrush current*. Even if the disruption was only 10–15 milliseconds, the surge current could be 10 times higher than normal draw. If hundreds of servers were all drawing inrush current, the UPS could be overloaded or circuits could trip. For this reason, you want a UPS that switches between modes with the least possible interruption in power—ideally, 2 ms or less.
- *Preventing disruption to downstream static switches*. If a data center has A and B side power systems for redundancy, it probably has static switches in the power infrastructure to extend this A/B redundancy to single-corded loads. If an upstream UPS takes too long to change state—either from high-efficiency mode to double-conversion mode or back again—these downstream static switches could mistakenly perceive a disruption in power and switch between A and B power sources. To prevent these unwanted and unnecessary transfers from occurring, the UPS must have a faster detection/transfer time than the static switch.

Look closely at a vendor's claim that a UPS changes modes in a stated number of milliseconds. The stated figure sometimes does not include all the steps involved. Transition time is a function of two factors: (A) How fast the UPS can turn on its inverter, and (B) How fast it can turn off the static switch, which opens the door for power to flow through the UPS internal circuitry. Only when both activities have been accomplished is a UPS truly online in double-conversion mode.

5. **What extras does the UPS offer for maximum protection?**
How does the UPS handle storms, overloads and load faults?

New high-efficiency UPSs have been proven reliable under prolonged and repeated power problems far greater than the typical commercial site would experience. Even so, some data center managers and facilities managers will still feel more comfortable knowing the UPS is fully in double-conversion mode at times, such as during thunderstorms or rolling brownouts. Some multi-mode UPSs offer options for locking in double-conversion mode under user-specified conditions.

Also look for a UPS that knows the difference between an upstream and downstream fault. The UPS should respond differently depending on the origin of the power problem.

Closing thoughts

Utility costs now account for 20–30 percent of data center operating costs. According to IDC, for every dollar spent on new IT hardware, an additional 50 cents is spent on power and cooling, more than double the ratio of five years ago. The cost of electricity is already outpacing the cost of hardware. $1 million worth of servers that was purchased in 2009 will consume $1.2 million in electricity over a three-year operating life—a figure that will only increase with rising utility rates.[1]

The good news is that manufacturers have dramatically improved the efficiency of power protection systems—reducing the costs and environmental impact of powering the business.

With a more efficient allocation of power, you not only reduce utility bills and total operating cost, but also achieve more with available backup power and cooling systems—delaying the point where those systems would have to be upgraded to accommodate expansion. With a lower carbon footprint, high-efficiency UPSs also help advance your corporate sustainability initiatives.

About the author

Pedro Robredo is a three-phase UPS product line manager for Eaton Corporation. Pedro has more than 10 years' experience in the electrical industry, working in product management, strategic planning and marketing for UPS and industrial products. He holds BS and MSc degrees in Engineering and an MBA from the University of Texas, Austin.

Sources

1. Underlying figures from *The Invisible Crisis in the Data Center: The Economic Meltdown of Moore's Law,* Uptime Institute