

Conducting an Accurate Utility Cost Analysis Based on UPS Efficiency

Introduction

Efficiency ratings of Uninterruptible Power Supplies (UPS) play an increasingly central role in the decisions of data center managers looking to cut energy costs. However, while these ratings remain an important factor for cost analysis, side-by-side comparisons often do not take into consideration the potential capacity effects on efficiency, that can mask the net efficiency of a UPS system.

What UPS Efficiency Ratings Mean

The efficiency rating of a UPS — represented in percentage form — shows how much of the original incoming utility power is used to power your critical load and how much utility power is simply lost in the operation of the UPS. For example, a UPS that is 98 percent efficient passes 98 percent of the utility power onto the load, while a 94 percent efficient UPS only passes along 94 percent. This also means that two or six percent of the utility, respectively, represents wasted OPEX.

However, while a side-by-side comparison indicates that a 98 percent efficient UPS would yield greater energy savings, it is often overlooked that these “nameplate” ratings only represent full-load efficiency.

How Capacity Utilization Impacts Efficiency

A UPS’s efficiency rating is not static. Rather, it follows a curve dictated primarily by power capacity utilization. When the UPS is not running at full load, its efficiency will be lower. For example, when a 200 kVA UPS rated at 98 percent efficiency is operating at 20 percent capacity (40 kVA), only 85 percent of the utility will be passed along to the load. However, at full load under optimal operating conditions, the same UPS will achieve its full efficiency potential, leaving only two percent of the utility as unusable OPEX.

This emphasizes the notion that electronic equipment achieves maximum efficiency as it approaches full capacity. A UPS’s efficiency ultimately is calculated by the UPS’s potential less fixed and proportional losses. While proportional losses — in the forms of heat-dissipation (“I²R” losses), transistor switching and increased capacitor resistance — are tied directly to increases in load, a UPS’s fixed losses (or “no-load” losses) remain constant independent of the amount of current running through the UPS. This means that fixed losses — power used to maintain the UPS itself — have a more significant impact on efficiency when a UPS is evaluated at partial load.

To illustrate, consider the efficiency curves of two very different UPS systems (Fig. 1). UPS A is rated at 98 percent efficiency and UPS B is rated at 94 percent efficiency.

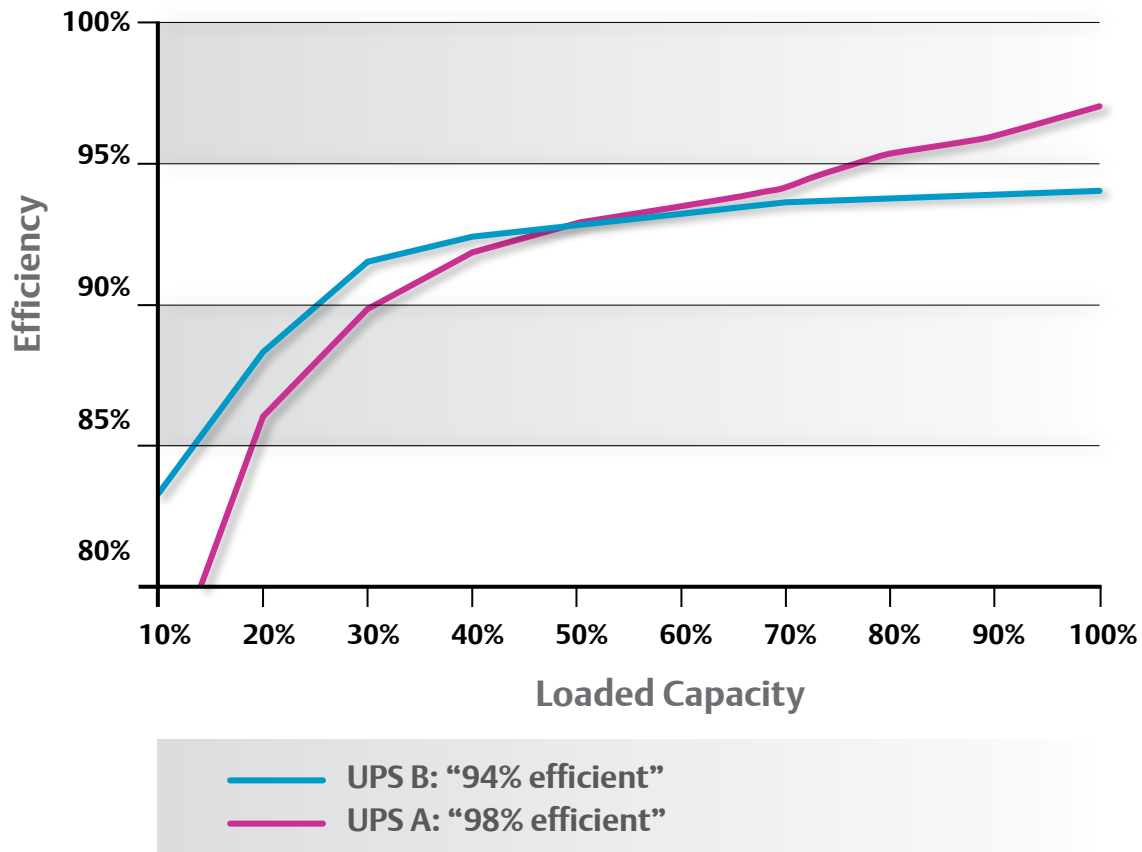


Figure 1. Efficiency curves for two UPS systems are derived by measuring the difference between utility and IT loads from zero to 100 percent capacity.

At full capacity, UPS A with 98 percent efficiency would be the logical choice when deciding which of the two units is more efficient, but the story is different when compared at different operating capacities (Fig. 2). At capacities under 50 percent, the “less efficient” UPS actually is more efficient than the “98 percent efficient” UPS.

	30% capacity	50% capacity	100% capacity
UPS A “98% efficient”	89.5% efficient	92.0% efficient	98% efficient
UPS B “94% efficient”	91.5% efficient	92.5% efficient	94% efficient

Figure 2. Fixed losses for UPS A are slightly higher than those for UPS B, making UPS B the ideal choice for operating at loads below 50 percent.

When considering that utilization of a UPS at less than half capacity (sometimes as low as 10 percent) is standard procedure when operating redundant UPS systems or when anticipating infrastructure expansion, comparison of these curves emphasizes the need to evaluate the efficiency of the UPS based on real-life operating scenarios. This means developing utility cost models that accurately reflect real-life operations rather than nameplate rating alone.

How to Develop a Basic Utility Cost Model

Step 1: Identify the expected Loaded Capacity of the UPS.

Step 2: Identify the Output Efficiency at the Loaded Capacity.

Step 3: Determine your electricity cost.

Step 4: Calculate the real power in kilowatts of the UPS by taking the kVA rating and multiplying it by the unit's power factor.

Step 5: Calculate using the standard formula:

$$\frac{(\text{Cost Per kWh} \times \text{Annual Operating Hours}) \times (\text{UPS Real Power} \times \text{Load Utilized})}{\text{UPS Efficiency at Load Utilized}}$$

Based on information gathered through the first four steps, a basic efficiency analysis example would look like this:

- Loaded Capacity: 40%
- Output Efficiency at the Loaded Capacity: 92%
- Electricity Cost: 10 cents per kilowatt hour
- The 750 kVA UPS has a power factor of .9 and thus a real power rating of 675 kW (750 x .9)
- 8760 operating hours in a year (24 hours x 365 days)

For this specific example, the operating cost calculation would be:

$$\frac{(\text{10 cents} \times \text{8760 hours}) \times (\text{675 kW} \times \text{40\% capacity})}{(\text{92\% efficiency})} = \text{\$257,086 in utility operating costs for one year.}$$

How UPS design impacts efficiency

Some UPS systems can achieve 99 percent efficiency by running on the UPS bypass. This mode of operation is called many things, including energy-saving mode, high-efficiency mode, eco-mode and sleep mode. It is essential to know if the efficiency rating you've been given is a bypass mode or if it represents your preferred operating mode.

First, ask the UPS manufacturer or representative if the efficiency rating incorporates some type of bypass operation. Then, consider whether or not the efficiency rating reflects your real-life operations and if you are going to run your UPS on the bypass?

- If “No,” get the real efficiency rating described in Step 2 of “How to Develop a Basic Utility Cost Model.”
- If “Yes,” consider how often you will be in this mode. Adjust your model to reflect this by calculating costs with bypass mode in operation (for the expected time duration) and without, then add the costs together to see what a full year's operation would look like.

Running on bypass is a good way to be more efficient, but it should not compromise your data center's availability. Also, it is important to understand how the bypass operation is achieved. For example, you should consider if the static switch is utilized; whether the inverters are off or only idled; or what types of faults will be passed to your critical load.

Besides bypass utilization there are other factors that can improve UPS efficiency, but may severely compromise availability:

- Utilizing capacitors instead of breakers
- Momentary duty static switch instead of continuous duty
- Elimination of the isolation transformers from the UPS

The implications of the final point are especially important to understand. While eliminating transformers from the UPS will improve efficiency, the critical load will be more susceptible to fault currents. Furthermore, it is important to remember that eliminating output transformers from the UPS does not mean they have been eliminated from the power bus altogether. Most likely, the cost savings resulting from the removal of a UPS transformer likely will have been shifted to other cost increases in the data center by placing transformers elsewhere on the bus.

Conclusion

As we have demonstrated, UPS efficiency can fluctuate widely based on capacity utilization. In light of this fact, a thorough understanding of how partial-load configurations impact a UPS system's performance and efficiency is essential to achieving an accurate utility cost model. However, utility costs are only a single component of a Total Cost of Ownership analysis.

Any cost analysis must include maintenance, reliability, monitoring and, especially, the impact of UPS design on IT system availability. It also is critical to understand how a UPS is able to achieve its efficiency rating and what the impact is on availability. The high-efficiency UPS might not be the most fault-tolerant and might not be the best option for extremely critical environments.

By asking some questions and doing the math, you can find the UPS that is ideal for your specific operations.

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