Understanding UPS efficiency in data centres

In modern data centres, maintaining continuous and reliable power is critical. Uninterruptible Power Supply (UPS) systems ensure power is available without interruption during outages, fluctuations, or other power disturbances. However, beyond providing backup power, the efficiency of a UPS system plays a crucial role in energy consumption, cost management, and overall operational performance. This article will explore UPS efficiency, how it's calculated, the factors influencing it, and the practical benefits for operators managing large data centre facilities.

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UPS EFFICIENCY refers to the ratio of energy delivered to the load compared to the energy absorbed by the UPS from the mains grid or batteries. Simply put, it measures how effectively the UPS system converts input energy into usable power for connected equipment. Efficiency is typically represented as a percentage, with a higher percentage indicating a more efficient system.

For data centres, efficiency is critical. These facilities run large-scale IT operations and require constant energy to support servers, storage systems, and other computing resources. Any inefficiency in power conversion directly results in higher energy costs and increased operational overhead.

Therefore, optimizing UPS efficiency is essential for managing power costs and ensuring the reliable protection of sensitive IT equipment.

How Is UPS efficiency calculated?

Calculating UPS efficiency is straightforward. It's the ratio of output power to input power, expressed as a percentage:

- **Output Power:** The actual power delivered to the connected load.
- **Input Power:** The power drawn by the UPS from the utility source or battery.

This calculation is typically performed using a high precision wattmeter connected to the UPS system's input and output points. It's important to note that UPS efficiency can vary depending on whether the system is drawing power from the mains (utility source) or its batteries. During regular operation (on mains), part of the input energy is used to charge the batteries.

However, manufacturers often exclude this energy from efficiency calculations since the charging phase is temporary, and the system operates most of the time with fully charged batteries, making the energy they absorb negligible.

Key factors influencing UPS efficiency

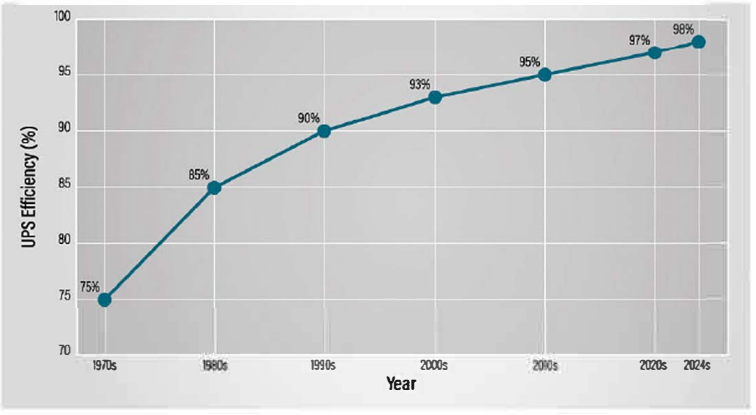
Several factors can affect the efficiency of a UPS system. Understanding these variables can help data centre operators optimize performance:

- **Load Level and Type:** UPS systems typically operate more efficiently at higher loads. Partial or low loads decrease efficiency, resulting in higher power losses.
- **Power Factor:** A higher power factor (near unity) means more of the power drawn is effectively used by the load. Power factor correction technologies in modern UPS systems help improve efficiency.
- **Temperature:** Environmental factors, particularly high temperatures, can degrade internal components like capacitors and fans, reducing overall efficiency.
- **Component Aging:** Over time, key UPS components such as batteries, fans, and capacitors wear down, negatively affecting efficiency. Regular maintenance is essential to replace aging parts before performance significantly declines.

UPS topologies and their efficiency comparisons

UPS systems come in different topologies, each with distinct efficiency characteristics:

- **Off-Line (VFD):** This is the simplest UPS topology, where the load is directly connected to the mains power during normal operation. It provides high efficiency but minimal protection against power disturbances. When mains power fails, the UPS switches to battery mode to provide backup power.
- **Line-Interactive (VI):** This topology adds an automatic voltage regulator (AVR) to stabilize voltage variations. It is more efficient than off-line systems during normal operation and offers better protection against power disturbances, though it doesn't protect against frequency variations.
- **Online Double-Conversion (VFI):** The most advanced UPS topology, continuously converting incoming AC power to DC and back to AC to supply the load. While offering the highest protection, it is less efficient due to the continuous running of two power converters. However, it is ideal for data centres that prioritise power quality and uptime.



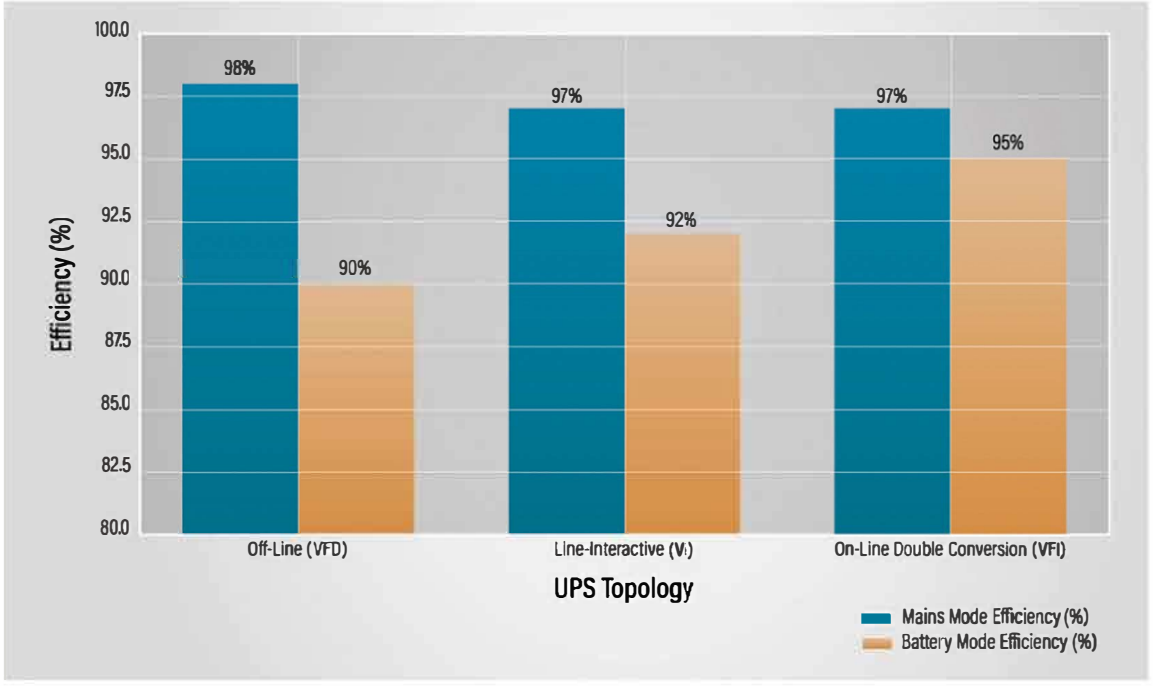
Historical improvement of UPS efficiency (1970s-2020s)

Advances in UPS technology: Silicon carbide and modular designs

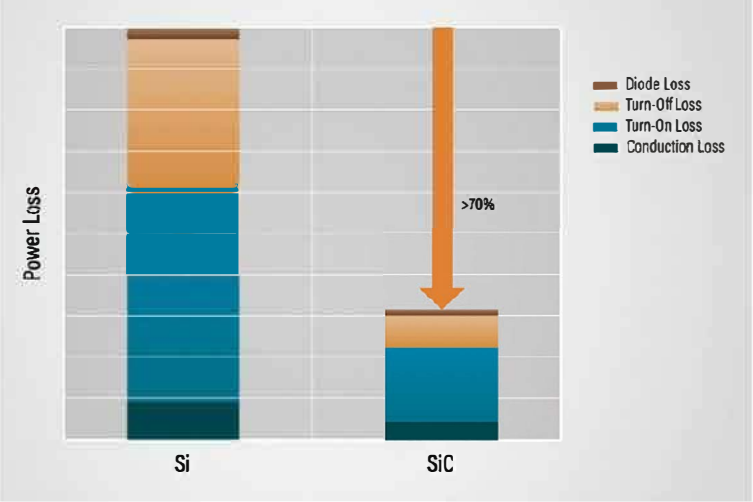
Recent advancements in UPS design have driven efficiency improvements. One significant innovation is the use of Silicon Carbide (SiC) components in power converters.

Compared to traditional Silicon (Si) components, SiC offers superior efficiency, faster switching speeds, and better thermal conductivity. This allows UPS systems to operate at higher power densities with lower losses, resulting in smaller, more efficient systems capable of delivering the same or higher performance levels.

Modular designs are also gaining popularity, enabling operators to scale power capacity more effectively and improve system redundancy.



Comparison of UPS efficiency levels in main and battery modes



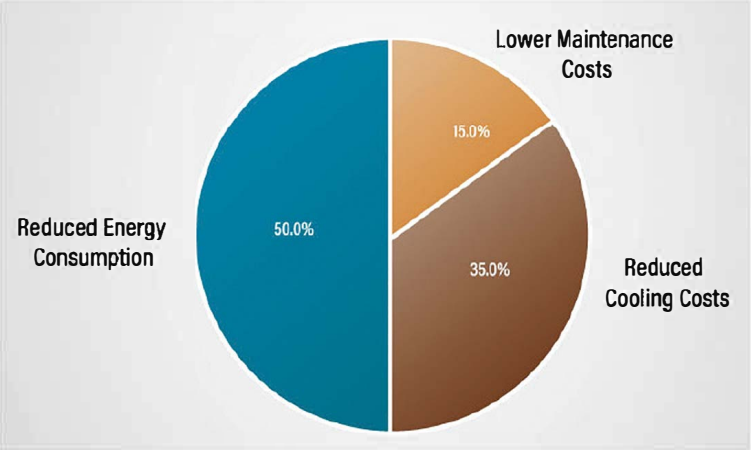
➤ Scheme power loss

Modular UPS systems can be optimized for varying load conditions, ensuring peak efficiency regardless of load levels.

Practical benefits of high-efficiency UPS systems

The efficiency of a UPS system has significant practical implications for data centres, particularly in terms of operational costs and environmental impact:

- **Energy Cost Savings:** Data centres are energy-intensive, and even small improvements in UPS efficiency can lead to substantial cost savings. A 1-1.5% increase in efficiency can significantly reduce energy consumption over time, especially in large-scale facilities where UPS systems may be rated in megawatts.
- **Reduced Cooling Requirements:** Inefficient UPS systems generate excess heat, which must be dissipated using additional cooling systems. Improving efficiency not only saves on direct energy costs but also reduces the cooling load, driving down operational expenses further.
- **Lower Carbon Footprint:** Improving UPS efficiency helps meet sustainability goals by reducing overall energy consumption. This, in turn, lowers the facility's carbon footprint, as less electricity is drawn from the grid, reducing greenhouse gas emissions.



➤ Cost savings breakdown due to high-efficiency UPS systems in data centres

UPS efficiency and data centre reliability

An often-overlooked benefit of higher UPS efficiency is its contribution to reliability. Efficient systems generate less heat, reducing stress on internal components and minimizing the risk of overheating. This extends the lifespan of critical equipment, lowers the risk of thermal shutdowns, and improves overall system stability.

Additionally, UPS systems with advanced monitoring and diagnostic capabilities can detect potential issues before they lead to failures, enhancing uptime.

Future trends in UPS technology and efficiency

Looking ahead, UPS technology will likely place greater emphasis on efficiency and longer lifespans through the integration of advanced battery technologies, such as lithium-ion and solid-state batteries. Additionally, advancements in AI and machine learning are expected to play a major role in optimizing energy usage, predictive maintenance, and system diagnostics. These technologies will enable UPS systems to self-optimize based on real-time load conditions and environmental factors, consistently ensuring peak efficiency.

Furthermore, the growing demand for high-performance computing (HPC) and artificial intelligence (AI) workloads is pushing the boundaries of UPS design. Data centres will increasingly seek UPS systems offering superior power quality, scalability, and reliability to support these advanced applications.

Conclusion: Choosing the right UPS for your data centre

For data centre operators, selecting the right UPS system is a critical decision that impacts both operational costs and reliability. Prioritizing high-efficiency systems with advanced features like AI-driven power management and modular scalability can help operators achieve their performance and sustainability goals.

As UPS technology continues to evolve, data centres will need to adopt the latest innovations to ensure long-term efficiency and reliability. By investing in high-efficiency UPS systems, data centre operators can reduce energy consumption, lower their carbon footprint, and ensure continuous power protection for critical IT infrastructure.

Legrand, a global specialist in electrical and digital building infrastructures, offers a comprehensive range of UPS solutions, from compact single-phase units to modular three-phase systems designed to meet the diverse needs of modern data centre environments.