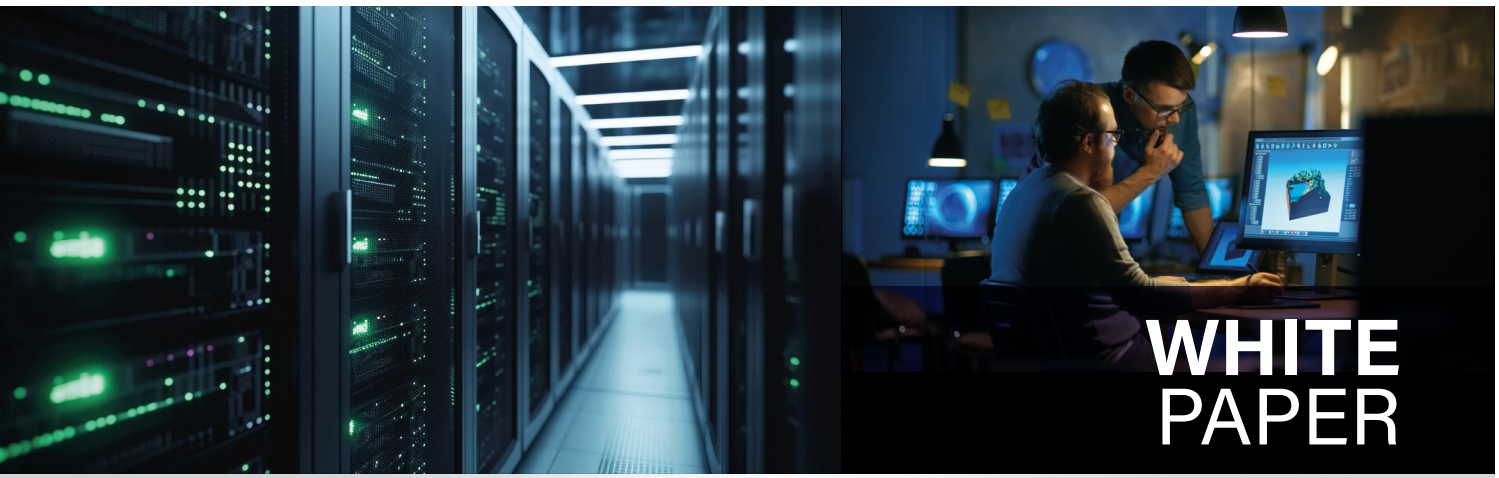


WHITE PAPER



Optimizing UPS Total Cost of Ownership in Data Centers

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The pressures of the ever-expanding digital world, alongside the recent and ongoing AI explosion, combined with the continuing focus on sustainability and Net Zero objectives, means that data center energy efficiency and operations and maintenance optimization is under scrutiny as never before. Here we examine the significant, critical role that UPS systems play within the data center in terms of guaranteeing the reliability, resilience, agility, scalability, and sustainability required to meet both these digital and environmental objectives. The white paper's main objective is to illustrate the importance of choosing the right UPS for your data center environment to ensure that the Total Cost of Ownership (TCO) is as low as possible, without compromising on the mission-criticality of the selected solution.

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WHAT YOU'LL FIND IN THIS WHITE PAPER

This white paper examines the key aspects of a UPS system which can impact the Total Cost of Ownership (TCO), covering:

- Energy Consumption,
- Failures/Downtimes,
- Maintenance,
- Infrastructure Evolution,
- Battery Management Costs,
- Grid Costs and End of Life.

In doing so, it demonstrates the importance of choosing a modular, scalable UPS system that offers the very best metrics when it comes to a variety of operating parameters and performance characteristics, where even a single percentage point difference in energy efficiency, for example, can translate into $100,000s of extra costs/savings over the lifetime of the system, depending on the solution selected.

In selecting a truly optimized modular and scalable UPS system–one which will deliver the best possible, energy-efficient performance over many years–data center owners/operators should prioritize the following attributes:

- high efficiency in VFI OnLine double conversion mode thanks to new SiC Technology to minimize the energy consumption;
- robustness and resiliency against failures and anomalous events in the infrastructure;
- front access and compactness for easy maintenance and repair and optimizing space utilization;
- remote control and predictive self-diagnostics to optimize the maintenance plan and operative lifetime;
- granular, modular architecture for easy and fast service and adaptability to load evolution; configurability to be adapted to existing infrastructures;
- advanced battery management and monitoring with the capability to interact with BMS of the battery system;
- smart grid function with FFR and peak shaving to optimize the interaction with renewable energy source;
- a high percentage of recyclable components and materials to optimize the end-of-life stage of the system.

Introduction

Uninterruptible Power Supply (UPS) systems are crucial for ensuring the reliable operation of data centers.

Within the importance of energy continuity, a modern UPS system can also guarantee a high-quality energy feed for the critical IT loads, protecting them from grid disturbances, harmonics pollution, frequency instability, and the like.

Set against these advantages, an advanced, high-performance UPS system can incur significant costs that need to be managed effectively over the operating lifetime of the data center.

It is important to identify and understand the key technical factors which have an impact on the costs, in order to identify strategies that optimize the Total Cost of Ownership (TCO) of the UPS, without affecting its performance and functions which must guarantee maximum availability, energy continuity and optimum protection against energy problems.

TCO Definition:
TCO is the sum of the initial Capital Expenditures (CapEx), which includes the cost of equipment and installation expenses, and the ongoing and long-term operational expenditure (OpEx).

The CapEx is immediately known at the selection of a UPS suitable for the data center needs. The Capex is mainly related to the UPS typology, technology, performance, and features.

In contrast, the OpEx is not always easy to know at the beginning of UPS ownership, since it depends on the actual (as opposed to planned) usage, working conditions, and ordinary maintenance of the UPS throughout its life. In addition, the OpEx is also strongly impacted by unpredictable events, such as failures, downtime, evolution of the workloads, and modifications of data center infrastructure. OpEx is also affected by changing economic conditions like energy costs, labour costs, and the like.

For all of these reasons, it is important to identify the key factors to consider and a proper strategy to prevent as far as possible any surprises, hence, to minimize the long term OpEx, with consequent optimization of the TCO.

KEY FACTORS IN OPEX

The key factors which can affect UPS operating costs can be summarized in the following macro-categories:

- Energy Consumption ► p. 4
- Failures/Downtimes ► p. 8
- Maintenance ► p. 10
- Infrastructure Evolution ► p. 11
- Battery Management Costs ► p. 12
- Grid Costs ► p. 12
- End of Life ► p. 12



Energy Consumption

The energy consumption in data centers is one of the most important costs: servers and other IT devices need energy, and the bigger the data center, the more IT devices there are, with the associated increased power consumption. A parameter to quantify the energy usage in a data center is the PUE (Power Usage Effectiveness), defined as the ratio of the total power absorbed by a data center and the power absorbed only by the IT loads.

$$PUE = \frac{\text{Total power absorbed by the data center}}{\text{Total power absorbed by the IT loads}}$$

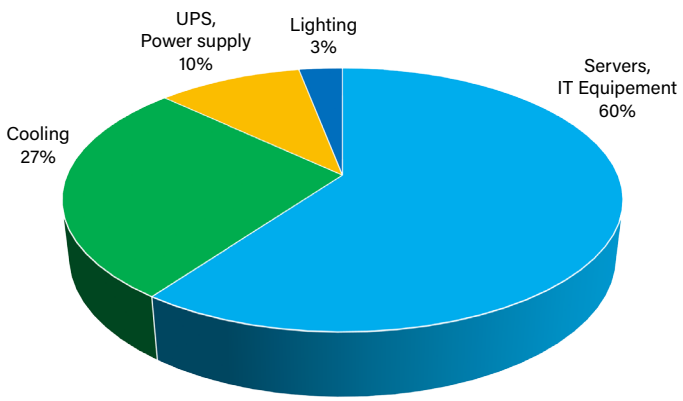
The ideal situation is when the energy absorbed by the data center is totally used for servers and IT devices so PUE = 1. However, with the modern data center increasingly designed to minimize the PUE, for the correct operation of the IT equipment, other technological systems are needed. The typical PUE of data centers is circa 1.67 but there is a great interest and engagement for new design and research to reduce the PUE to values closer to 1.

Analyzing the non-IT load, it appears that the major energy absorption is from the cooling and the UPS.

Typical Data Center Consumption Breakdown

Cooling is needed to keep the temperature of the IT environment at the proper level for the optimum running of the active load

The UPS is needed to guarantee the energy quality and continuity to the IT loads, cooling systems and other critical loads



Different component of the energy used

▪ UPS Energy absorption

UPSs for Data Center applications are an Online Double Conversion topology, in order to guarantee total continuity, full protection from grid problems, and the best quality of the energy provided to the IT loads. In this topology, the input electric energy is continuously converted from AC to DC by a rectifier and then regenerated from DC to AC by an inverter (double conversion). To perform these conversions, including advanced controls and monitoring, a portion of the input energy is required.

Another part of the input energy is also used to recharge batteries if they were previously used for some reason (e.g. blackouts or tests), but fortunately, in most parts of the life of the UPS, the grid is present, and the batteries are charged. In modern UPSs, there are advanced algorithms which optimize the recharge and stop it when batteries reach full charge.

▪ Effect of UPS losses on the cooling

The energy used by the UPS to keep running the double conversion is released in the environment as heat, which must be removed, along with the heat generated by the IT load, by the cooling system.

This means that the efficiency of the UPS has an indirect impact also on the consumption of the cooling system.

▪ New technology opportunities

Is evident that the higher the efficiency of the UPS, the lower will be the overall energy consumption of the data center. For this reason, in recent years there has been a strong effort in technological research to increase the efficiency of the electronic power converters of the UPS, and now, with new Silicon Carbide (SiC) technology, it is possible to reach impressive energy performance levels which brings the efficiency to over 98%.

Nevertheless, the performance of the electronic conversion alone is not enough to maximize the overall efficiency of the UPS system. In fact, to go beyond 98% at a whole system level, it is necessary to minimize all possible losses in internal connections and the electrical distribution inside the UPS.



Energy Consumption *(continued)*

▪ Impact on the environment

The EU Energy Efficiency Directive makes significant demands on data centers in terms of transparency (reporting KPIs etc.), and, one imagines that, over time, data centers will be required to demonstrate a commitment to new designs and efficiency developments which can not only reduce energy and water consumption, for example, but also promote renewable energy use, increased grid efficiency and even waste heat reuse. The UPS has a potentially increasingly important role to play in such an environment.

In terms of broader ESG and compliance goals, the UPS system's efficiency level is important, especially at partial loads–less energy waste means lower carbon emissions. Higher efficiency also translates into lower heat output, hence a reduced cooling requirement.

In terms of lowering electronic waste, consideration has to be given to discarding an entire UPS system, compared to replacing an individual module (which may also have recyclability designed-in).

A UPS system's ability to integrate with renewable energy sources and battery energy storage systems (BESS) also needs to be considered in terms of the environmental impact.

When it comes to governance and compliance, efficient power infrastructure (including a UPS) helps meet energy performance regulations like the EU Code of Conduct for Data Centers, ISO 50001, Energy Star for Data Centers, and Greenhouse Gas Protocol Scope 2 reporting. The UPS systems can also contribute to achieving certifications like Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), or the Uptime Institute's Sustainable Data Center Certification.

With reference to ESG, it is also worth considering whether a UPS is equipped with smart monitoring tools, which can aid compliance with real-time energy audits and sustainability reporting.

Obviously, UPS energy consumption also has a direct impact on the environment. Saving energy with a high-efficiency UPS allows for the reduction of the CO_2 emissions caused by the generation of electric energy in power plants.

In data centers, in particular for colocation or hyperscale, the amount of energy required can reach several megawatts, and even a few percentage points gained in efficiency can bring considerable energy and cost savings and, consequently, a reduction of CO_2 emissions.



EXAMPLE

- Consider only the energy consumption of two UPSs of 1MW, one with 98.3% efficiency and the other one with 97% efficiency, the result of the comparison is as follows:

	UPS 1	UPS 2
Energy efficiency	98.3%	97%
Power Out [kW]	1.000	1.000
Power in [kW]	1.017	1.031
Power losses [kW]	17	31
Energy lost 1st Year [kWh]	151.495	270.928
Energy lost 10th Year [kWh]	1.514.954	2.709.278

Assuming a cost of electricity of 0,207€/kWh (close to the average cost of electricity in Europe), the average energy mix used in Europe to produce electricity, and the average CO_2 absorption of a typical urban tree in Europe, we have the following result after 10 years of operating life:

After 10 years of operating life

Energy Savings	-1.194.324 kWh
Cost Savings	-247.225 €
Ton of CO_2 not emitted	-584 Ton
Equivalent No. of Urban Trees Plant	29.205 Trees

For a 1MW UPS, an increase of only 1.3% in the efficiency determines a ten-year saving of 247 k€ and a significant reduction of environmental impact.
The difference is even bigger when also considering the consumption of the cooling to dissipate the power lost by the UPS as heat.

- In this case, considering a cooling system with a coefficient of performance-COP = 3, the calculation is modified as follows:

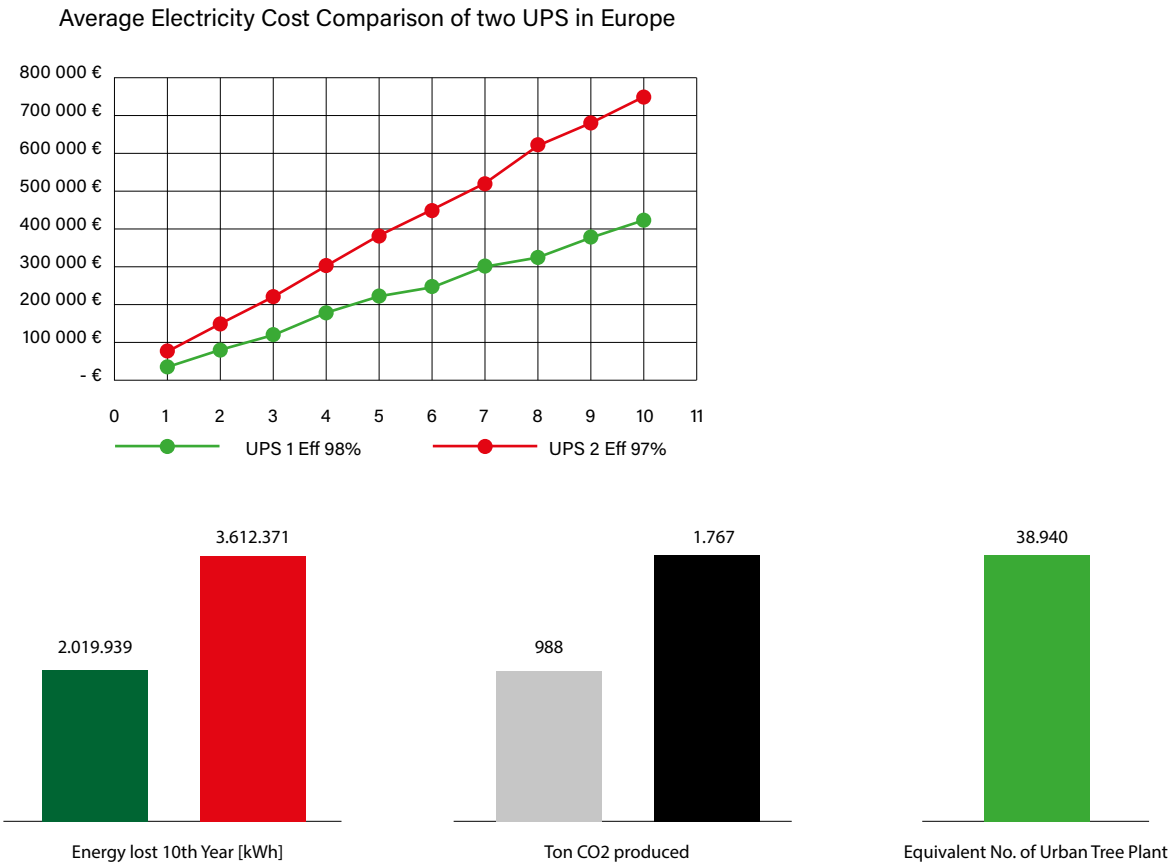
After 10 years of operating life

Energy Savings	-1.592.432 kWh
Cost Savings	-329.633 €
Ton of CO_2 not emitted	-779 Ton
Equivalent No. of Urban Trees Plant	38.940 Trees

	UPS 1	UPS 2
Energy efficiency	98.3%	97%
UPS Power Out [kW]	1.000	1.000
UPSPower in [kW]	1.017	1.031
UPS Power losses [kW]	17	31
Cooling Power to dissipate the UPS losses [kWh]	6	10
Total Power consumption	23	41
Energy lost 1st Year [kWh]	201.994	361.237
Energy lost 10th Year [kWh]	2.019.939	3.612.371

This calculation simply multiplies the yearly savings by the number of years without taking into consideration the inflation rate.

Energy Consumption *(continued)*



Even if the high-efficiency UPS is more expensive than the other UPS, the energy cost savings can more than compensate for the initial price difference over the lifetime of the system.

Failures/Downtime

Together with energy-related costs, which can easily be evaluated and forecasted, there are also other costs which are more complex to predict and evaluate in advance. Failures and downtime can bring important costs over the lifetime of the UPS. In addition to the cost of repair intervention, components replacement, and restart of the system, the downtime itself can bring very high costs, considering that in data center applications, every single second of inactivity corresponds to potentially huge economic losses. As a rule of thumb, the cost of downtime in a data center can range from $100,000/hour (small size) up to > $1 million per hour (financial services).

A recent study by the Ponemon Institute found the average cost of a data center outage to be around $9,000 per minute, including lost revenue, productivity, and recovery expenses. More serious outages can cost over $100,000, with some even exceeding $1 million. According to the Uptime Institute's Annual Outages Analysis 2023, 70 percent of data center outage incidents cost $100,000 or more, with 25 percent costing more than $1 million. The proportion of outages costing more than $100,000 has increased steadily, largely due to the growing business dependence on data center availability. The report highlights that power failures accounted for 36% of the biggest global public service outages tracked by Uptime Institute since January 2016.

So, there's a significant financial cost to downtime, but there's also the reputational damage to consider. Increasingly, IT-related incidents attract news headlines, and the organizations impacted suffer not just the actual disruption of the outage itself, but having to manage the fallout in terms of restoring their reputation with their customers.

▪ Reliability

The mitigation of the risk of failure and downtime limitation can be achieved with a combination of several factors. For example, the high quality of the product in terms of both materials and design can offer a higher level of reliability, robustness, and resiliency against failures and ageing, offering a high level of MTBF (Mean Time Between Failure).

▪ Robustness

Strong electrical distribution and bypass lines with a high short circuit current capability also make the UPS resilient against failures and anomalies in the surrounding electrical system (in particular, downstream in the output connected loads). In the case of short circuits or anomalous overloads, this high current capability allows the intervention of overcurrent protection devices without affecting the integrity of the UPS and its bypass line.

▪ Availability

In reality, the robustness and reliability of the UPS may not be enough to mitigate the risk of downtime. Failures in the UPS can happen and it is important to fix them as quickly as possible. In this scenario, the architecture of the system can bring several advantages; for example, a modular design with small modules (granular modularity) and hot serviceability can significantly shorten the repair time, providing a short MTTR (Mean Time to Repair) and limiting the service cost associated with the downtime. Combining MTBF and MTTR makes it possible to calculate the availability of the UPS system, which indicates the percentage of the operational time in respect to the total lifetime.

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

Today, a cutting-edge technology UPS can reach availability up to 99.9999...% (6-nines) in its operating life.

EXAMPLE

Consider two premium high-power UPS systems (for instance, 1MW)

- UPS 1 with MTBF = 1000000h; MTBF = 0,5h (for example, modular with small modules)
- UPS 2 with MTBF = 2000000h; MTTR = 10h (for example, monolithic)

the two availabilities will be:

$$A_{UPS\,1} = \frac{1000000}{(1000000 + 0.5)} = 99{,}99992\% = \text{6-nines}$$

$$A_{UPS\,2} = \frac{2000000}{(2000000 + 10)} = 99{,}99950\% = \text{5-nines}$$

So, even if the UPS 2 has double the MTBF of UPS 1, its long time to repair makes its availability less than the UPS 1, which is very fast to repair.
One “nine” more means the availability of UPS 1 is ten times bigger than UPS 2, so the downtime is 10 times shorter, and the downtime cost is 10 times less.

▪ Preventive maintenance

Another good strategy to mitigate failure risks is preventive maintenance, which can achieve maximum effectiveness if the UPS system has its own logic and self-predictive diagnostics. With a combination of internal monitoring and sensor systems and advanced algorithms, the UPS can monitor the real-time status of internal components and of the running conditions and give recommendations for preventive actions to replace consumables parts or to fine-tune the system parameters to increase its lifetime.

Maintenance

As previously stated, a proper maintenance plan is a valid approach to mitigate the risks of failures and downtime, and their associated costs. On the other hand, maintenance has its own costs.

The number of technicians required, the duration of intervention, the quantity and type of tools needed, as well as the space needed around the UPS, or the need to move the UPS, are some of the many factors which determine maintenance costs.

▪ Serviceability

The architecture and design of the UPS can help to reduce the cost of space and positioning, and to reduce the intervention time; for instance, total front access of the UPS, the modularity, and comfortable replacement of consumable components bring big savings in maintenance costs.

▪ Predictive self-diagnostics

Additionally, an advanced self-diagnostic system will optimize the maintenance plan, rationalizing the service interventions.

▪ Remote control and monitoring

Another key feature which can help to minimize the maintenance costs is a well-designed remote control and monitoring system, which allows checking of the working status of the UPS in real-time (without the need for any physical intervention in front of the equipment) and, as necessary, can apply remote fine-tuning or plan corrective actions.

If the remote monitoring is integrated with the embedded predictive diagnostics the cost reduction advantage will be even higher.

▪ Space cost

The effective occupied space of the UPS system not only determines the cost for maintenance and service, but it is, itself, a cost. In fact, the bigger the space required for the UPS, the smaller is the space available for active data center devices (server racks, data storage, etc.). On a big infrastructure project, this could mean a significant additional space requirement which could have a far from negligible impact on the overall site costs.



Infrastructure Evolution

Other costs not easy to predict are related to the evolution, modification, and upgrade of the infrastructure around the UPS. Modern data centers are continuously evolving to meet the trend of new technologies such as AI servers, liquid cooling systems, and the like. This means that over the operating life of the UPS the surrounding electrical system could change its architecture, topology or power size according to the new needs of the data center.

▪ Modular Scalability

In particular, the amount of active IT load may increase, and consequently, the energy demand could increase. In this case, a UPS with modular and scalable architecture can help to minimize the upgrade costs by adding only the required modules and avoiding replacement of the entire UPS with a bigger one or using an oversized UPS from the start.

In addition to eliminating high upfront capital expenditure on oversized systems, on-demand scalability and supporting the pay-as-you-grow model offer a number of other potential benefits. Modular UPS systems allow operators to maintain the UPS at optimal load levels – typically between 40-80% - and since modules can be added or removed based on load requirements, data centers can avoid the inefficiencies which occur when a monolithic UPS system operates at low loads. Many modular UPS systems also come with eco-mode and/or dynamic capacity management options, which automatically adjust power module usage to further reduce energy consumption.

Modular UPS systems are often smaller and more compact than traditional systems, offering a space optimization advantage and potentially freeing-up room for revenue-generating IT equipment.

Other modular scalability advantages include simplified maintenance and higher availability, faster deployment and easy integration, and, important in today's fast-moving data center environment, futureproofing and technological agility. Modular UPS systems by design support futureproofing by enabling flexible, on-the-fly adjustments to changing power requirements. And, as newer and more efficient modules become available, they can often be integrated into existing set-ups without the need to replace an entire UPS system.

▪ Configurability

The capability of the UPS to be easily configured to fit with the existing electrical system (type of connection, grounding system, etc.) brings cost savings - avoiding local adaptations or modifications of the electrical system and avoiding the need for additional equipment like power panels, transformers, busbar mechanical adaptors, etc.

Battery management costs

Batteries are a fundamental part of the UPS, essential to guarantee energy continuity, but they can have a significant impact on the TCO of the data center. Let us examine them in more detail.

The first impact is in the CapEx - due to the high-power demand of data center applications, even for short autonomy of a few minutes, the amount of battery capacity can be very high. Additionally, a critical application like the data center requires batteries of very high quality, reliability, and expected lifetime. This makes the initial cost of batteries far from negligible in respect to the overall UPS system's cost - very often their cost can be similar to the cost of the UPS itself.

Batteries consume energy to be recharged after a blackout and to be kept at proper charge level ready to cover a future energy outage, and as with any other electrical device, they have energy losses during the recharge stage.

Batteries are consumables, with natural aging factors depending on their technology and operating conditions. A good maintenance plan must consider the replacement of the batteries before they reach the end of their life to avoid the risk of losing them when a blackout or other grid issue occurs. This means that batteries bring associated costs for monitoring, periodic checking, replacement, and disposal.

In addition, there is also the cost of occupied space since, like the UPS, batteries need space which cannot be used for the active IT load.

A good choice of UPS can help to reduce all these costs. In fact, a UPS which has advanced battery management and control can optimize the energy consumption and the required capacity (reducing the number of battery blocks and consequent footprint).

Proper monitoring and diagnostics systems embedded in the UPS logic and able to communicate with the Battery Management System (BMS) included with the batteries (as with Li-Ion battery cabinets), will help to reduce the maintenance cost, prevent battery failures and increase battery operating life.

Grid costs

One of the grid costs related to UPSs (and in general with electronics power converters) is the impact of reactive power absorption (due to non-unity power factors, harmonics current pollution, etc.), but these costs are mitigated in modern UPS thanks to the advanced input controls with active PFC (Power Factor Control). Nonetheless, it is always a good practice to check these features when selecting UPS.

▪ Smart grid

In modern data centers, there may also occur other risks and costs which are not directly related to the UPS, but which the UPS itself can help to mitigate and/or minimize.

In particular, if the data center is connected to a grid which includes renewable energy sources (like photovoltaic or wind), there could be costs and downtimes related to the grid frequency instability or peak load absorptions. In these cases, a UPS with smart grid functions, able to implement fast frequency regulations or peak shaving, can provide useful support to help reduce these indirect costs from the grid.

End of life

Finally, we come to the management of the end of life of the UPS, which has its costs, which are mainly related to material disposal and recycling. A product containing a great amount of recyclable materials and a high percentage of materials coming from the circular economy will have less cost at the end of its life.

The guarantee of a proper study of the recyclability rate of the UPS can be assured by official documents like the PEP (Product Eco Passport), which includes data and information about the life cycle of the product, in accordance with the major international standards and directives.

Strategies

To mitigate the impact of operating costs of the UPS in a data center, there are several recommended strategies and actions, such as a clear plan of the infrastructure life cycle, a detailed study and scheduling of preventive maintenance, and a good after-sales service contract, but the initial choice of the UPS plays a fundamental role in the future life of the application.

Selecting a UPS by only considering the power, autonomy, and low price, ignoring other characteristics and features, may result in high operating costs.

In contrast, choosing a UPS with high energy efficiency, high quality material and design, high availability, and smart architecture oriented to adaptability and serviceability, is a good strategy to minimize the operating costs.

It is probable that a UPS with high premium features will be more expensive than a lower performance one, but the initial price difference will be compensated for by the savings during the operating life. In other words, the CapEx can be considered as an investment to reduce the OpEx, with consequent optimization of the TCO.

The recommended strategy to optimize the TCO through the choice of the UPS can be summarized in the following table:

UPS OPERATING COSTS	MITIGATION STRATEGY
Energy Consumption	High VFI Efficiency Level at every load condition from 20 to 100% load (Good choice is the last generation SiC Technology)
Failures, Repairs, and Downtimes	High Availability (6-nines) guaranteed by the combination of high Quality, Robustness and Resilient UPS (high MTBF) and fast and easy Serviceability (Low MTTR), (Good choice is the granular modularity architecture)
Maintenance	Easy and fast Maintainability, proper Ordinary Maintenance Program, predictive Self Diagnostics and Remote monitoring and Control, compact footprint, total Front Access Service to minimize the needed space
Infrastructure Evolution	Modular Power & Autonomy Scalability, configurability for existing Infrastructures, compatibility with Electric Up/Down stream Panels
Battery Management	Advanced Battery management embedded in the UPS logic, advanced Battery Monitoring and Diagnostics, compatibility with BMS of Battery Set
Indirect Grid Costs	UPS with input PFC, absorption Power Factor close to unity, low input harmonic distortion (low THDi%), UPS with Smart Grind functions like Fast Frequency Regulation (FFR) and Peak Shaving
End Of Life	Circular Economy and Recyclable material useful at the End of Life. PEP documents, provided with the UPS, assure reliable official information about its recyclability rate and overall Life Cycle Environmental impact.

Case Study

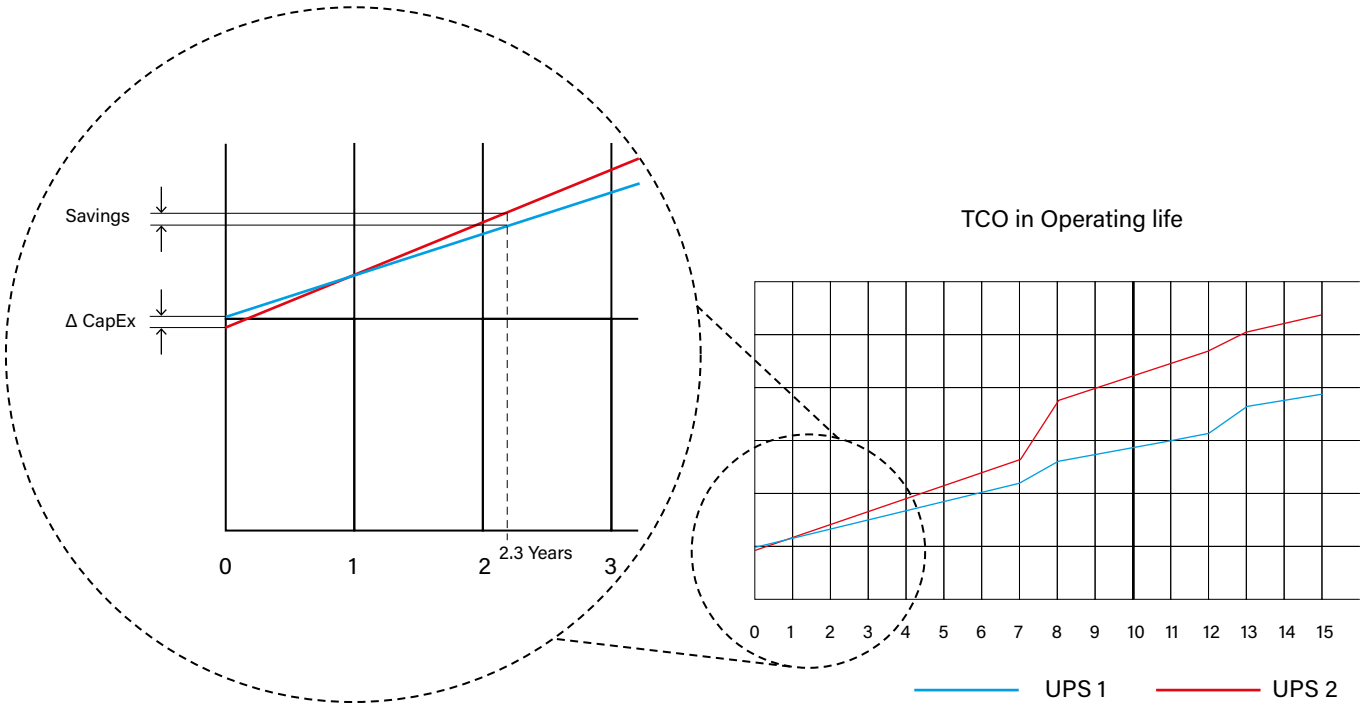
Consider a comparison of two premium UPSs of 1MW with exactly the same battery Set, in a small data center in Europe running at 60% load rate, with a lifetime of 15 years.

With the following data:

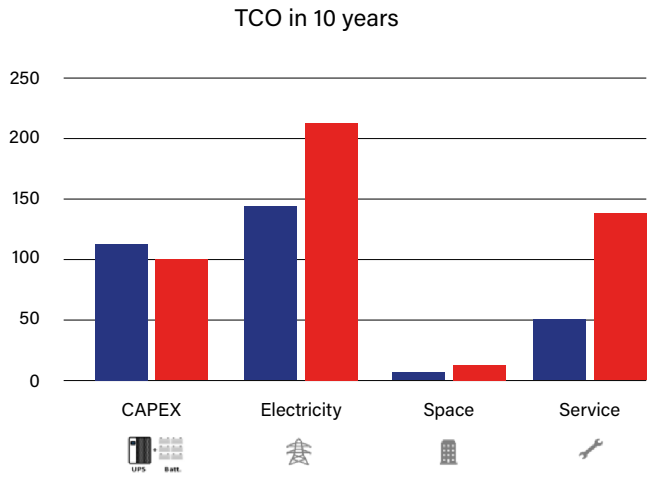
	UPS 1	UPS 2
Efficiency	98,2%	97,3%
Footprint m^2 UPS + Batt + clearance for use/service	5	6
Availability	6-nines	5-nines
Capex (indicative "a dimensional" level)	110	100

Consider a typical maintenance plan with consumable replacement, with additional hypothesis of a power upgrade of one module at year 6 and an important failure, with critical downtime, at year 8.

The TCO analysis at Year 10 is represented in the following graphics:



In circa 2-3 years the overall cost of Capex of 10% of the UPS 1 is compensated by the savings in OpEx.



Data are referred to assuming an indicative (a dimensional) price level of 100 for UPS 2.

CONCLUSION

The UPS guarantees energy continuity and is an essential component in critical applications like data centers. For this reason, it is vital that the UPS will be able to give the best possible protection to the critical IT loads. This means that the data center manager must consider the capital cost (CapEx) of this equipment.

Together with the cooling system, the UPS absorbs an important quantity of energy which cannot be used for active IT loads, and this brings an additional Operating Cost (OpEx) for the electrical energy over the life of the equipment.

The UPS system itself also has other operating costs, less evident and predictable in respect of energy consumption, (maintenance, downtime, repairs, upgrades, batteries).

The data center manager has to implement a comprehensive approach and plan to minimize and mitigate these OpEx and to optimize the TCO.

In any TCO optimizing strategy, the choice of the UPS is crucial because with its features and functions, it could bring several advantages and savings to OpEx, which can even compensate the initial Capex.

In conclusion, a UPS which can mitigate all the OpEx we have considered will offer:

- High efficiency in VFI OnLine Double Conversion mode thanks to new SiC technology to minimize energy consumption
- Robustness and resiliency against failures and anomalous events in the infrastructure (overload, short circuits, etc.)
- Front access and compactness for easy maintenance and repair and optimizing space utilization
- Remote control and predictive self-diagnostics to optimize the maintenance plan and operational lifetime
- Granular modular architecture for easy and fast service and adaptability to load evolution
- Configurability to be adapted to existing Infrastructures
- Advanced battery management and monitoring with the capability to interact with the BMS of the battery system, for optimum usage of batteries, and minimum energy losses
- Smart Grid Function with FFR and peak shaving to optimize interaction with renewable energy sources in the supply grid - minimizing indirect costs and energy issues
- High rate of recyclable components and materials to optimize the end-of-life stage of the system









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