The high environmental performance solution for power supply to high-availability data centers

STATIC UPS

Uninterruptible Power Supplies

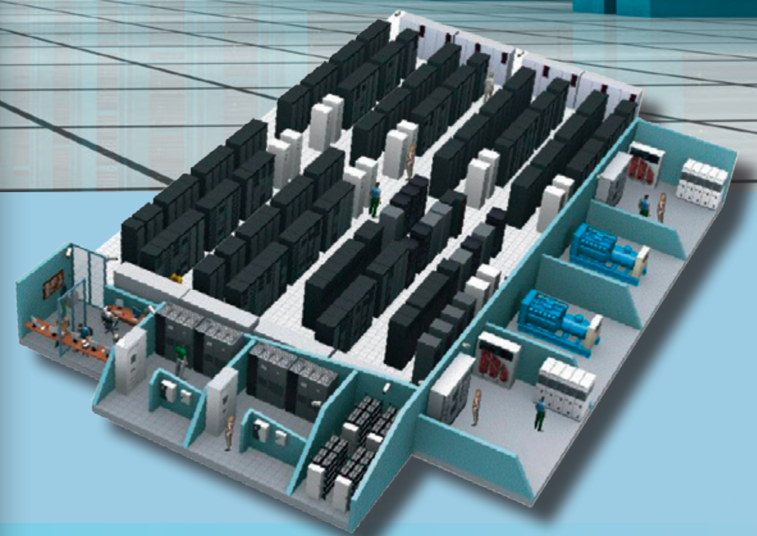
STATIC

Exchanges of information and communication needs are growing at an exponential rate. That growth is more than just a trend; it is a real groundswell that naturally implies concomitant growth in needs for data center computing capacity.

Extremely high demands are made on data centers, and they must be able to guarantee a very high level of availability. A data center's availability depends largely on the supply of electrical power. Power supplies must therefore be highly secure.

The different uninterruptible power supply (UPS) technologies provide solutions to these demands. This document demonstrates the advantages and the attractiveness of adopting a static technology using the concrete case of a large data center:

- Functional robustness
- Availability and scalability
- Control over total cost of operation
- Contributes to a high environmental performance approach



Just what is meant by a "large data center"?

A large data center comprises one or several dedicated rooms with an area of some 1,000 sq. m. per room. The electrical power levels used are generally between 500 kW and 3,000 kW.

A data center's availability performance is expressed by the Tier Standard, a classification established by the USA's Uptime Institute. For a large data center, the Tier classification is III or IV the highest levels in the Standard. Tier III corresponds to an availability of 99.982%, or a potential unavailability of 1 hour and 36 minutes of downtime per year. With Tier IV, the availability level is 99.995%, or 24 minutes of potential unavailability per year.

In terms of electrical power supply, Tier III implies the existence of at least one redundant production source, and Tier IV a double source.

UPS

The effective, reliable, scalable solution for data center operation

Driven by the progress made in the field of power semiconductors, large-capacity UPS technology has evolved quickly over the past twenty years (see Fig.1). The resulting functional improvements are significant both in terms of robustness and performance.

New technologies for high energy efficiency

The increase in the switching frequency of Pulse Width Modulation (PWM) inverters has resulted in a significant reduction in the size of the output filter, whose role is to supply clean sinusoidal voltage to the critical load.

There are multiple benefits:

- Inverters using IGBT (insulated gate bipolar transistor) technology are capable of powering the new capacitive IT loads **without active power downgrading**;
- thanks to the very low impedance of the output filter, the static UPS can supply non-linear loads that generate large harmonics **while maintaining a very high voltage quality** (measured by the rate of harmonic distortion as voltage, typically under 5%);
- Static UPS offer **excellent dynamic response** to sudden load variations: the instantaneous voltage is returned to its ideal value in less than 20 ms, in conformity with the EN 62040-3 standard.

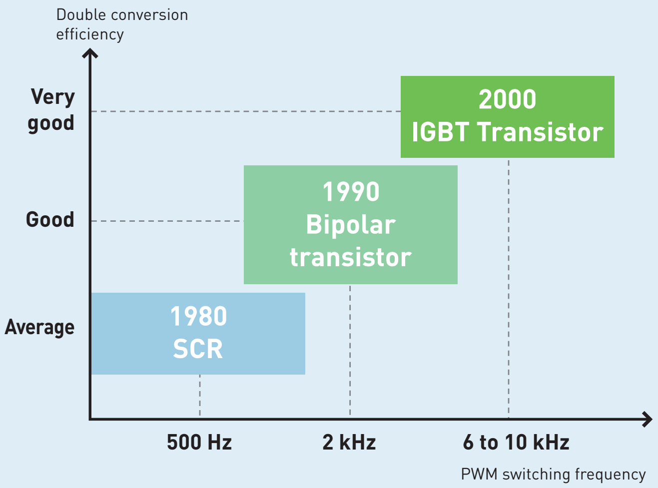


Fig. 1: UPS technology evolution since 1980

Secure electrical distribution

To meet the availability criteria for data centers, the power supply must eliminate a failure on one of the load-side connections on the high-quality distribution board in less than 20 ms and thus preserve power to the loads supplied by the other connections.

99.9% of the time, the backup network is present and instantaneous switching to the UPS by-pass circuit is enough to eliminate the short-circuit. Typically the UPS delivers 20 x In during 100 ms – a level which is amply sufficient to instantaneously trip a load-side branch circuit breaker.

In the rare cases where the backup network is not available, the UPS's inverter delivers a current of, typically, 3 x In during 100 ms to eliminate the short-circuit. Taking the example of a load-side fault in a branch circuit breaker calibrated at In / 5, the inverter will supply a short-circuit current equal to 15 times its nominal calibration. Here again that level is sufficient to ensure instantaneous tripping.

In all cases, the UPS has the capacity to supply a sufficient short-circuit current to quickly eliminate a load-side fault while preserving the continuity of power to the other connections (Fig.2).

The association of new regulation techniques using IGBT technology in UPS guarantees highly robust short-circuit current generation, even in the case of a short-circuit directly on the high-quality distribution board (in particular, electrodynamic effects and thermal constraints are limited via electronic controls) (Fig. 2)

Less-frequent system use for greater reliability

In ensuring availability of electrical power, the storage capacity of the battery used to compensate for brief outages is a key characteristic. An autonomy of 5 to 10 min. can cover most disturbances in the electrical grid without requiring the systematic start-up of the generating set, which reduces both the constraints on the GS and the costs of operation. Also, in the case of brief, closely-spaced outages, that level of autonomy enables repetitive coverage without negative effects. Current battery charging methods and monitoring systems limit battery ageing and prevent failures. Batteries, used within a controlled environment, can therefore guarantee a high level of availability.

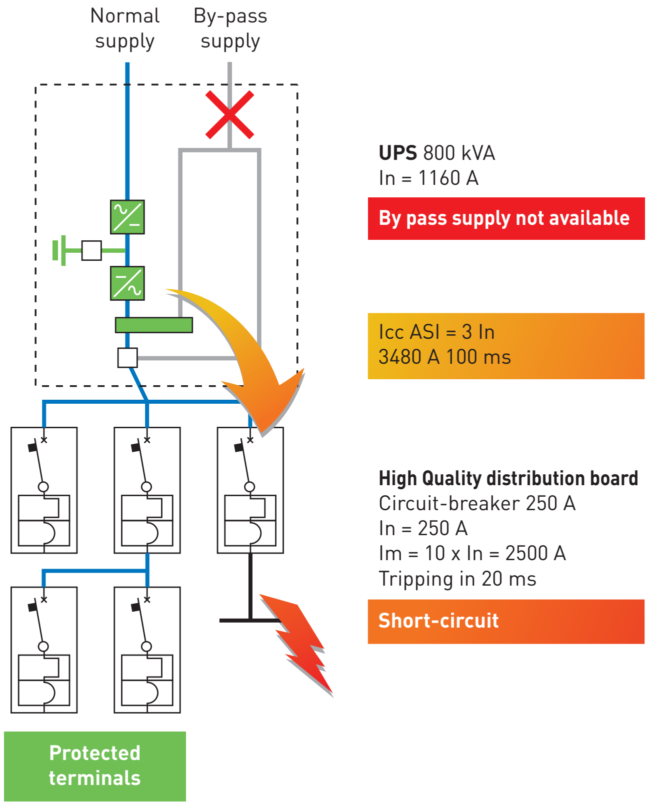
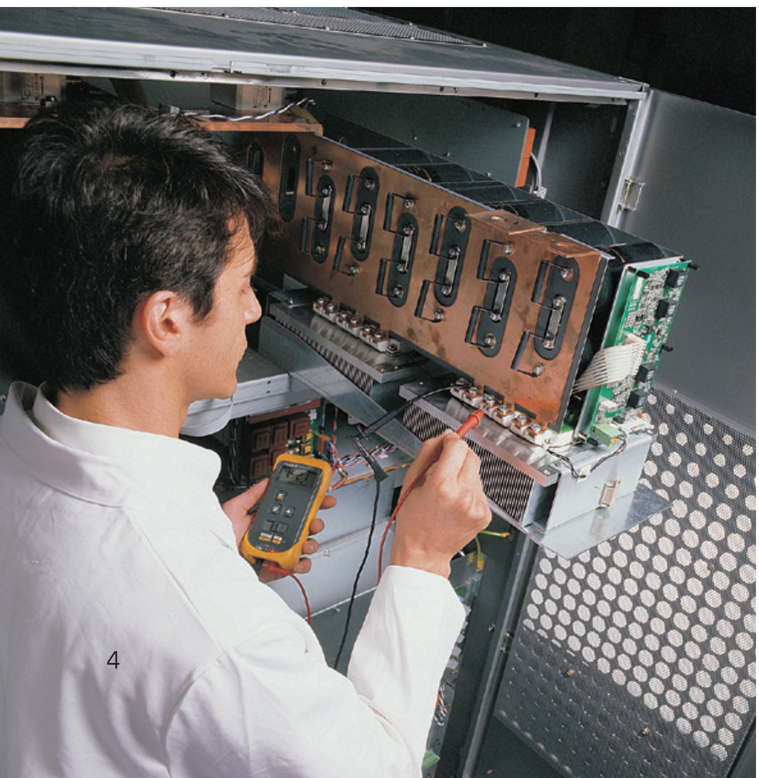


Fig. 2: Clearing fault by inverter

Availability and reliability – the major advantages of a **static UPS**



Small footprint

Static UPS deliver real advantages from the point of view of deployment and time spent on preventive or corrective maintenance. Their small footprint and light weight compared to the power they supply (Fig.3) reduce constraints and facilitate installation.

Easy maintenance, protected loads

In addition, adding a UPS in parallel to increase power to meet demand can be done easily, quickly and without down time for the critical load. By design, the time needed for preventive/corrective

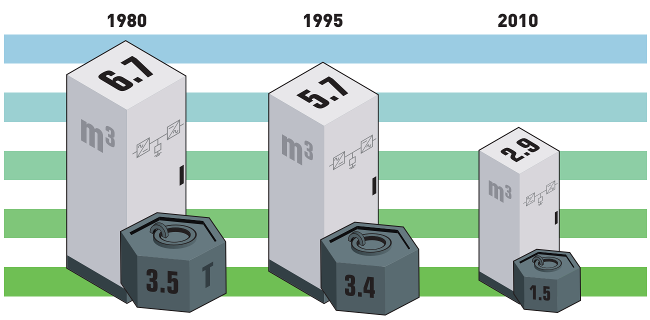


Fig. 3: Volume and weight evolution for a 500 kVA UPS without batteries

maintenance is optimised (typically less than 4 hrs.) and the operation can be performed by a single person. Certain UPS models are equipped with lightweight, hot-swappable drawer systems. Static UPS have another major advantage – the presence of an effective bypass. Reliable and fast, the onboard static switch can move the critical load to the bypass network without disturbing the latter. Its ability to switch to a backup circuit without interruption and its dimensioning result in a significant increase in the MTBF* of a UPS – up to some 400,000 hrs. If you add to that very short MTTR* (in the tens of minutes with modular systems), the availability rate of static UPS can be said to be among the highest.

For example, an MTTR of 15 min. (0.25 hrs.) with an MTBF of 400,000 hrs. works out to a system availability of:

$$\frac{400\,000}{400\,000 + 0{,}25} = 0{,}9999993 \text{ (or six nines)}$$

*MTBF Mean Time Before Failure
*MTTR Mean Time To Repair

Scalability – a more and more pressing need

Faced with the growing needs stemming from IT applications, the need for server power is constantly increasing. What is more, the arrival of new technologies such as high density, virtualisation, and Cloud Computing require rapid reconfiguration of data center infrastructures, cooling and power supply.

Major research and development resources have been brought to bear on static UPS technology and have been shared on a global scale, resulting in reductions in footprint, weight, and acquisition and operating costs, and also in increased availability modular design results in a simplification of corrective procedures.

Static UPS enable each client to build a tailor-made architecture that is scalable to suit the pace of increasing needs.

The scalability of solutions based on the deployment of static UPS stems not only from the latter's technical design, but also from their ease of deployment and the modest technical resources necessary for maintaining them.

The criticality of the applications and the financial considerations at stake can create tense situations during which even the slightest interruption of service can result in dramatic consequences for a company's business activities and for its image.

The scalability of UPS enable operators to avoid such situations while anticipating their needs with accuracy.

Controlled and predictable overall installation costs

A gradual investment

Due to their modularity, static UPS adapt perfectly to data centers' need for scalability. A static UPS provides effective, secure protection which, due to its ease of deployment, enables close control over the total cost of ownership (TCO) of the data center.

The TCO is the sum of two categories of expenditures: CAPEX and OPEX.

CAPEX (Capital expenditure) represents the investment expenditures and OPEX (Operational expenditure) represents operational costs such as energy and operating costs.

Low operating cost

The TCO graph (Fig. 4) compares the differences in costs depending on whether a fixed architecture that is, dimensioned for the target power level at the outset or a scalable architecture is adopted. The figures illustrate the total cost of ownership, over 10 years, of a 500-kW data center scaled up to 3,000 kW after 5 years.

Figures 5 and 6 show that static UPS (scalable architecture) adapt perfectly to the anticipated load profile. Energy is delivered with the optimum PUE (Power Usage Effectiveness).

$$\text{PUE} = \frac{\text{Total energy consumed by the data center}}{\text{Energy consumed by the IT applications alone}}$$

In addition, the flexibility of the installation will enable PUE to be optimised over the entire operating cycle.

Widely distributed around the world (95% of all UPS installations), the static UPS solution offers the best TCO, in large measure thanks to its installation in stages, which avoids a heavy initial financing outlay (see Fig. 7).

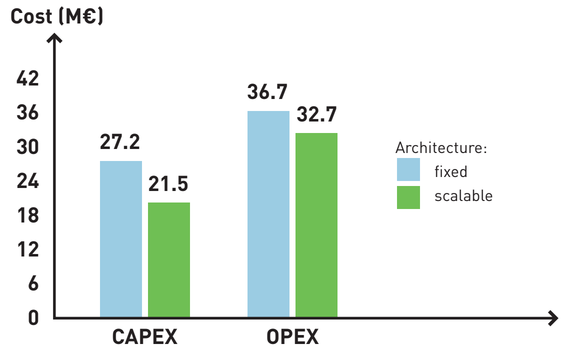


Fig. 4: TCO - Cost breakdown according to architecture type

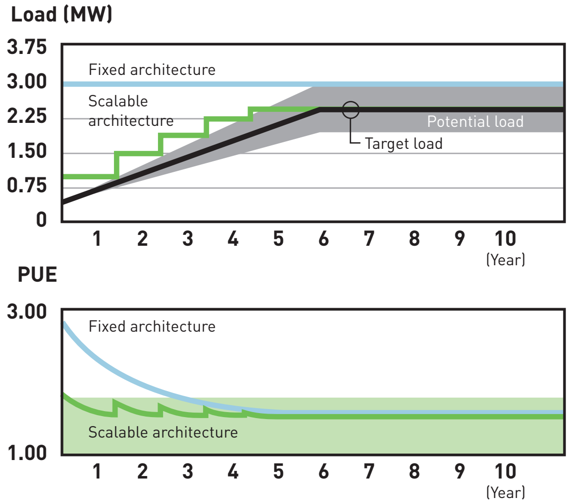


Fig. 5 and 6: Load and PUE evolution over 5 years for a data center growing from 500kW to 3000kW within 5 years.

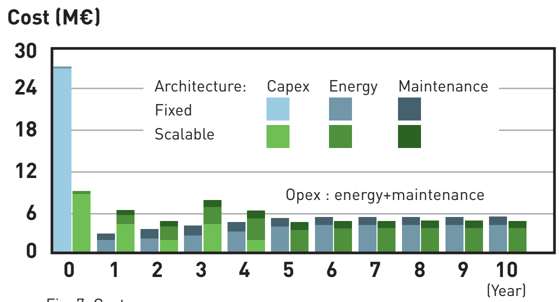


Fig. 7: Cost

An investment to suit operating requirements

A data center is characterised by operating requirements such as power density of the IT rooms per sq. m., the availability and scalability of the data center, the redundancy of the infrastructures, the data center's energy efficiency, and return on investment.

Static UPS offer appropriate solutions for these various requirements. Regarding energy efficiency, static UPS have the advantage of providing a high level of performance over the entire power range (Fig. 8).

Efficiency is above 90% starting at 25% load. That is a significant criterion for optimising the PUE of a data center at the start of its operation, or for Tier IV-type architectures (separate dual paths) that operate with a load rate on the electrical infrastructure of less than 40% (cf. fig. 8).

The concept of high efficiency is now part of the UPS Code of Conduct signed by manufacturers of static UPS. These manufacturers have committed to reducing energy losses, with an obligation of continuous improvement of performance in the years ahead.

An appropriate solution for dimensioning installations

The latest generation of static UPS is fully compatible with generating sets (GS). Energy draw on the supply side of static UPS is gradual and free of harmonics. This means real savings on the distribution infrastructure and the GS.

UPS in close proximity to the application

The functional independence between the GS and the static UPS makes it possible to separate the two installations geographically and place the UPS close to the load – for example, the GS can be located in containers outside the data center building.

Aside from the great freedom it allows in managing facilities, and in particular those dedicated to IT applications, this arrangement reduces constraints related to civil works (loads, vibrations, fire risks, noise).

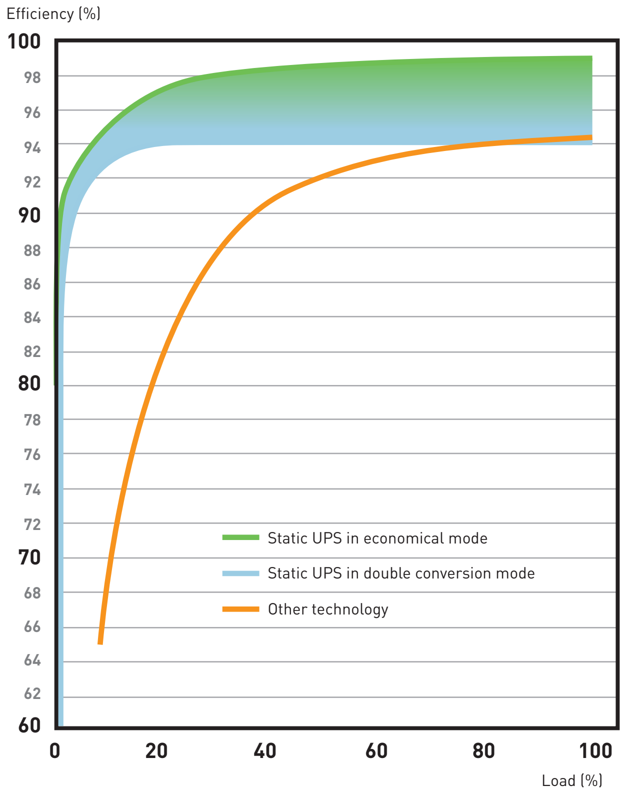


Fig. 8: Efficiency zone

Battery recycling is under complete control

UPS manufacturers are organised to properly handle end-of-life of batteries

Specific environmental regulations apply to Electrical and Electronic Equipment (EEE) to guarantee that the use of hazardous substances is limited and that handling of end-of-life products and packaging is under strict control.

A low carbon footprint

Thanks to their autonomy of several minutes, static UPS reduce the carbon footprint related to operating on a generating set. During a brief power outage, the bank of lead-acid batteries provides current, eliminating the need to start the generating set. This means fewer GS start-ups per year and a reduction in fuel consumption. This mode also improves PUE on the installation as a whole by avoiding the necessary permanent warm-up as well as cool-down time (20 to 30 minutes) after each use of the GS during a micro-outage.

Battery: when waste becomes raw material

A battery's life cycle is under control from the design phase through to recycling. Production plants (ISO 14001) work to minimise their impact on the environment in terms of CO_2 emissions and use of primary raw materials. The majority of high-capacity battery manufacturers are located in Europe. Recycling of the various battery components (lead, electrolyte, case, etc.) is fully monitored and regulated. This is an essential point since 100% of the batteries under consideration are usefully reprocessed. Lead, even in recycled form, has a high market value.

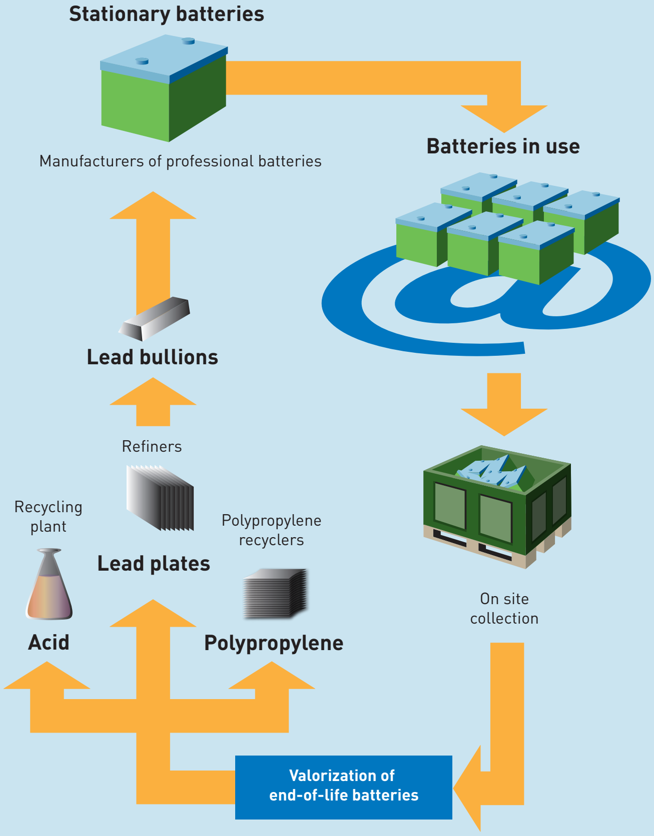


Fig. 9: Recycling of the various battery components

CEMEP UPS
European Committee of Manufacturers of Electrical Machines and Power Electronics