

WHITE PAPER

Optimizing operations with low-voltage switchgear combined with modular UPS systems



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Data centers are increasing in number and are growing larger and more complex.

The way to keep control of costs, availability and reliability, while maintaining flexibility, is to take full advantage of standardization and modularity.

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LV switchgear combined with modular UPS systems to reduce equipment footprint, Capex and installation time

Critical power applications – how to keep them running 24/7 without any power interruption

Mission critical electrical equipment, such as servers, programmable logic controllers, industrial and automation components, need power protection and conditioning supply. It means electrical infrastructure must be able to secure electrical energy continuity at the input terminals, at the right power quality level, and at the same time guaranteeing the electrical infrastructure selectivity.

Despite all the precautions taken during both the design and operation of such facilities, situations can arise in which external power is compromised, either in terms of quality or availability. Such events could result in power or data loss, non-availability of essential services, risk to hardware and, potentially, financial losses of millions of dollars. Uninterrupted power supply (UPS) or uninterruptible power sources must be used to guarantee service continuity.

A UPS is an electrical apparatus that provides emergency power to a load when the input power source or mains power fails. A UPS differs from an auxiliary or emergency power system or standby generator in that it will provide near-instantaneous protection from input power interruptions, by supplying energy stored in batteries, supercapacitors, or flywheels. The on-battery run-time of most UPS systems is relatively short, supporting the load only for a few minutes, but that is sufficient to start a stand-by power source or to properly shut down the protected equipment.

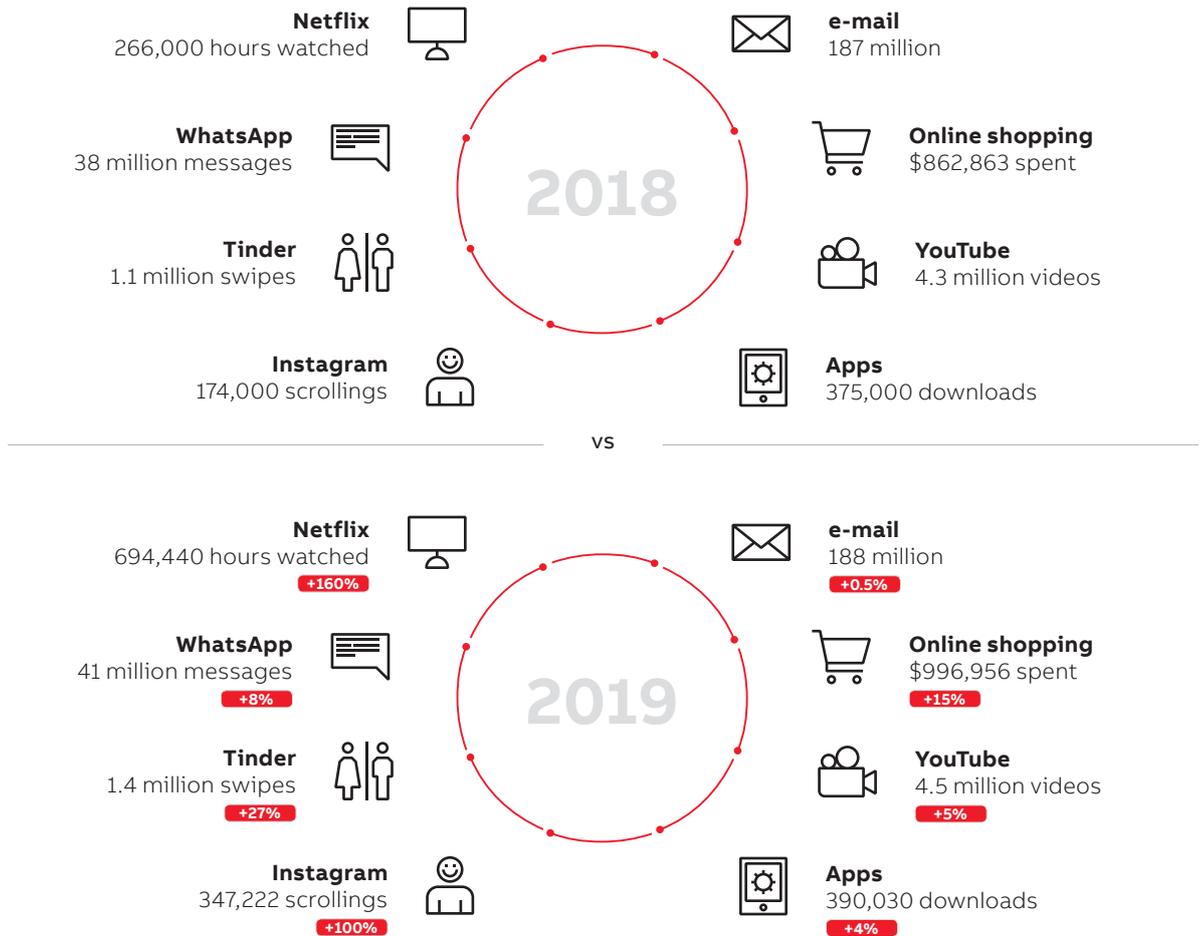
A UPS is typically used to protect hardware such as computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. UPS units range in size from units designed to protect a single computer without a video monitor (around 200-volt-ampere rating) to large units powering entire data centers or buildings.



Markets trend and drivers

A typical critical power application is a data center, which are used to run essential services, such as home banking, telecommunication, internet, social media and much more. This is an important market increasing year by year to satisfy growing demand of services,

entertainment and social media applications. But how big is that market? How fast is it growing each year? Let's try to understand it looking at what happened in an 'Internet minute' in 2019 compared to in 2018:



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01 What happens in an internet minute? Adapted from the original infographic created by @LoriLewis and @OfficiallyChadd.

All data centers require a minimum level of availability over 99.6 percent according TIER classification of the Uptime Institute. To achieve that they must be able to react to any loss of primary in less than 15 ms (according to CBEMA/ITIC curves). UPS are the only equipment able to meet that requirement.

Data centers are increasing in number and are growing larger and more complex. The way to keep control of costs, availability and reliability, while maintaining flexibility, is to take full advantage of standardization and modularity.

Modular design: the evolution of the UPS to better match data centers' business needs

The main challenges for a UPS are reliability, preventing any single failure point, and scalability to adapt the installed capacity to changes in customer demands, especially considering plants increase required power every year. The solution is a modular UPS, which can grow in response to customer demand.

Modular UPS recently took a big leap forward with the development of decentralized parallel architecture (DPA), which eliminates single points of failure and downtime during maintenance. At the same time, it makes installation significantly easier.

In a modular UPS with DPA each module contains all the hardware and software required for full system operation. The modules share no common components and each UPS module has its own independent static bypass, rectifier, inverter, logic control, control panel, battery charger and batteries. With all the critical components duplicated and distributed between individual units, potential single points of failure are eliminated. In the unlikely event of one UPS module failing, the overall system will continue to operate normally, but with the reduced capacity of one module. The failed module will be completely disconnected and will not impact the operating modules.

Each module is fully independent, and modules can be combined in a similar fashion to building with Lego™ bricks, just as you like. This powerful scalability approach means the UPS can be sized to perfectly fit the prevailing needs and requirements. Modules can simply be added as requirements grow. This means that you only power, cable and cool what you need currently. Power consumption is the topic of greatest concern for data center operators and the energy savings made by this modular approach are substantial during the service life of the UPS.

Modules can be hot swapped too, that is, removed or inserted, without posing a risk to the critical load and without the need to power down or transfer to raw mains supply. This unique aspect of modularity directly addresses continuous uptime requirements, significantly reduces mean time to repair (MTTR), reduces inventory levels of specialist spare parts, and simplifies system upgrades. This approach pays off when it comes to serviceability and availability, too. Online swapping of modules means you do not have to switch off the equipment resulting in no downtime and the service personnel does not need any special electrical training.

This hot swappable technology, along with significant reductions in repair time, can help achieve six nines (99.9999 percent) availability which is highly desirable for data centers in pursuit of zero downtime.

A modular UPS can maximize the double conversion efficiency by engaging UPS modules based on load power. When the load is very low compared to the UPS system's rated power, the overcapacity is automatically switched to

stand-by mode, in which modules consume much less power and thus help save energy. The efficiency improvement is especially significant when the load is ≤ 25 percent of the full capacity of the UPS system.

Modular UPSs typically use a single size power module based on the maximum power required by the machine. This makes it easier to swap modules, since they all have the same power and sensible, it reduces the number of spare parts needed in stock.

Electrification of critical power plants

Another key element to required availability is the electrical infrastructure that powers the data center. The data center business has many similarities to other industries, when it comes to electrification. Some industrial customers prefer to be deeply involved in the design of the electrical network and the selection of the relevant components, whereas others prefer to focus on the Information Technology, leaving the power supply network definition and implementation in the hands of consultants, EPCs, or equipment producers. In both cases the role of the suppliers can evolve to business partners, as they can propose and implement innovative solutions to deliver the required availability and reliability of power supply. The most innovative suppliers deliver added value to data center owners with solutions and products specifically designed for the electrification of critical power applications.

The role of low-voltage switchgear in the electrification network of data centers

The UPS, low-voltage (LV) switchgear and the IT server are the key components of any data center network. Depending on the electrical characteristics, the location and the functionality needed, there are different types of LV switchgear that can be used such as power centers, emergency boards and Power Distribution Units (PDU) directly connected to the IT Server.

Also the LV switchgear needs to meet the key requirements set for data centers:

- Safety: zero tolerance of unsafe working conditions for personnel
- Reliability: to guarantee uptime
- Flexibility: to adapt the power supply to the changing requirements such as in a colocation data center

- Optimized footprint to increase space available for core business assets, such as the IT servers
- Reduction of Capex and Opex to maximize competitiveness

What are the characteristics required of switchgear in order to be able to meet those requirements? Let's consider solutions and technologies used for each requirement.

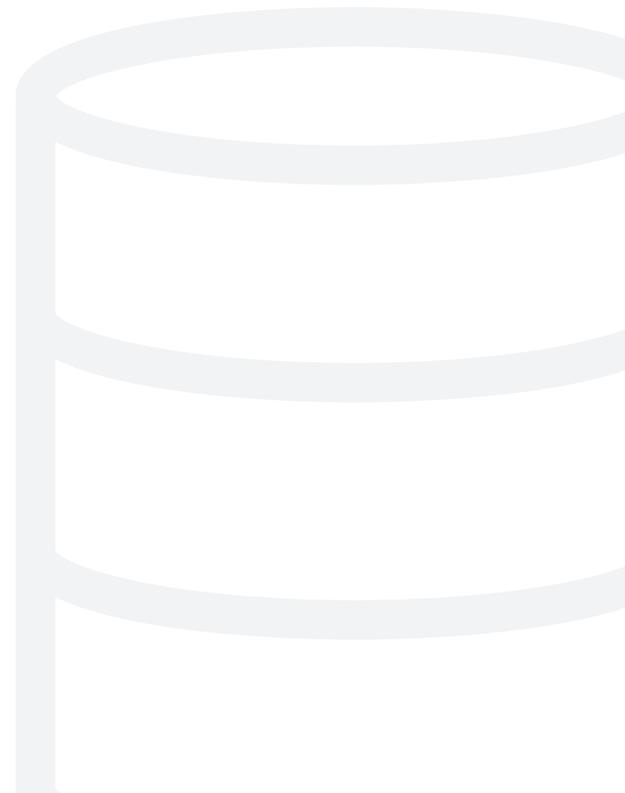
Safety is a must in every data center without exception including rare events like internal arcs; which are mainly generated by human error or poor maintenance. Arc proof tested switchgear with passive and/or active protection according IEC/TR 61641 will protect personnel and minimize damage to the switchgear.

For the electrical network, reliable equipment – tested and certified according IEC 61439 is fundamental and new technologies enable predictive maintenance to reduce maintenance interventions, without affecting safety standards.

Using withdrawable or plug-in execution of the feeders with spare feeders makes switchgear flexible – adding the possibility to quickly and easily reconfigure or upgrade the electrical infrastructure keeping it up and running, while ensuring safety for personnel and preventing damage to the equipment.

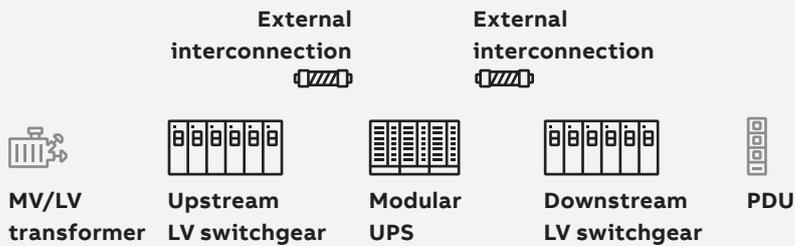
Not all data centers are new constructions. Many are developed inside existing buildings, which makes it crucial that the switchgear can be adapted to the room layout, with space saving solutions like stacked breakers. When the overall footprint of the switchgear is reduced, the amount of space available for IT devices, such as servers, is increased contributing to space efficiency for the data center owner.

As data centers run 24/7 so too does the requirement to reduce costs. Switchgear cost savings are not limited to Capex but can also bring about Capex reduction. Continuous monitoring of the equipment over its lifetime makes it possible to optimize operations by detecting early aging of the equipment and optimize maintenance activities.



Conventional architecture using standalone LV switchgear and modular UPS systems

In the architecture of a conventional data center the LV switchgear and modular UPS are separate components of the electrical network with the following scheme:



The connections are external and made by cable or bus duct, as the components might not even be located inside the same room or area. This is often the case when leveraging existing infrastructure and the available space is limited.

If components are physically separated or located in different rooms, the maintenance of the system becomes more complicated. For example, if maintenance activities are required on components in different rooms, or if the working area needs to be isolated for safety requirement reasons.

External interconnections between UPS and upstream/downstream LV switchgear need to be protected to prevent faults and must be capable of isolation for maintenance. Due to the nominal current of those interconnections air circuit breakers (ACB) are typically required. The presence of a high number of ACBs is increasing the footprint and the cost of the LV switchgear.

To maximize the benefits of the modular UPS, where the power can be increased during the lifetime of the facility, additional upfront investment needs to be made in LV switchgear and interconnections. The future state maximum power rating of the UPS should be defined upfront to properly size the LV switchgear. Using switchgear spare feeder with withdrawable breakers can mitigate the initial cost, but this is not possible for the external interconnections.

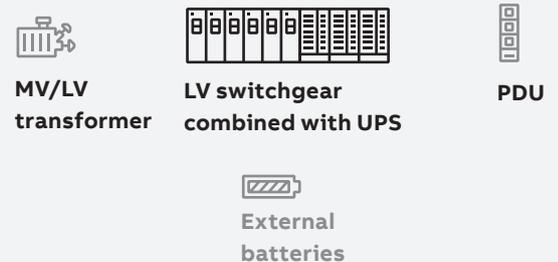
This is a time-consuming solution as all the single components need to be installed and tested separately. In the worst-case scenario, the

installation of the switchgear, UPS and bus duct are not executed by the same technicians, which require increased coordination and authorizations for the personnel inside the data center. Installation time is a critical KPI for all data centers following the “pay as you grow” model.

Selectivity and coordination need to be verified project-by-project, as parameters affecting the calculation, such as the electrical impedance of the interconnections (cable or bus duct) are different case-by-case. Even if we use the same equipment (same switchgear, same UPS, same interconnections) the different asset locations in the facility change the distance between them, impacting on the impedance of the interconnections. In the case of small differences in layout selectivity and coordination modification may not be needed but verification is always recommended.

New electrification architecture: low-voltage switchgear combined with modular UPS

Merging the incoming and outgoing switchgear together with the UPS into a single equivalent device that we will refer to as “low-voltage switchgear combined with UPS” improves the electrification equipment layout with several advantages.



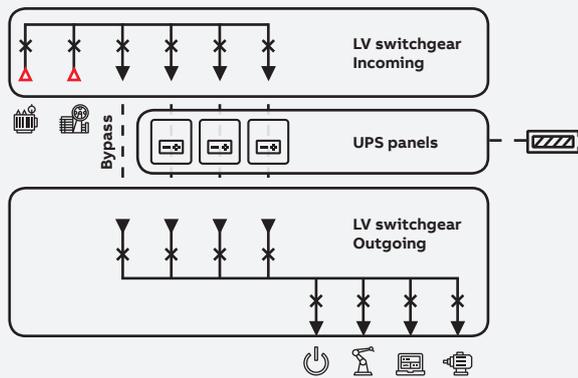
To maximize benefit and quality of the solution the UPS modules must be integrated into the LV switchgear with a direct connection to the switchboard’s busbar system, just as any other component of the LV switchgear, such as energy distribution feeders or motor starters. A simple side-by-side design, which still use external cables or busduct for the interconnection between UPS and switchboard, cannot be considered equivalent to the combined solution.

Advantages of this solution start even before the delivery and installation of the equipment, as a single RFQ (request for quotation) saves engineering time, and a single factory acceptance test (FAT) that covers both the LV switchgear and the UPS according to the relevant testing procedures.

Having a single combined FAT that cover both LV switchgear and a modular UPS reduces the

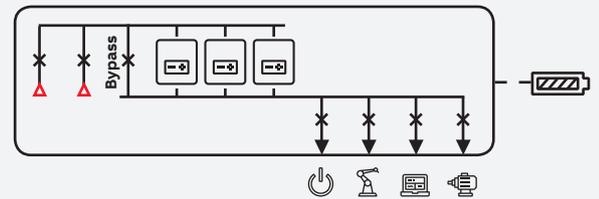
on-site testing activities too. Certain tests such as insulation resistance to verify interconnections, do not need to be repeated on site. This reduces installation time by up to 20 percent.

The switchgear combined with UPS significantly reduces components and external connections. The associated breakers to protect those interconnections can thus be removed without impacting on safety or availability.



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03 Conventional solution



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04 Low-voltage switch-gear combined with modular UPS

As we know the electrical infrastructure footprint is important in the design of data centers. The low-voltage switchgear combined with modular UPS reduces the footprint up to 30 percent compare to a conventional layout. This space saving solution can achieve the desired IT power within the space limitations.

Selecting electric components that also have reduced dimensions such as lithium-ion batteries, and high efficiency transformers make it possible to integrate the equipment into 'ready to install' containers. These smaller containers are not only reducing the space required but also simplify the logistics as delivery and installation are easier, faster and more cost effective.

The LV switchgear combined with UPS solution also reduces the Opex over the solution's entire lifetime. The lifetime of switchgear is about 25–30 years, if the manufacturer's maintenance instructions are followed; while the UPS has a lifetime of 12–15 years. In a conventional layout, when the UPS needs to be replaced, it is recommended that relevant interconnections with upstream and downstream LV switchgear are verified. With the combined solution, the interconnections are part of the electrical switchgear, which is guaranteed for 25-30 years,

so no other activities or verifications are required, when it is time to replace the UPS. If all the modules of the UPS are of plug-in or withdrawable types, and allow for hot swapping, then the replacement time needed is further minimized.

Final considerations are about the cost efficiency advantages of this solution:

- Reduction of purchasing cost issuing a single tender and attending one FAT fully equivalent to switchgear and UPS standalone testing
- Direct cost reduction of (up to 10 percent) removing cable/bus duct external interconnection and associated protection breakers
- Reduction of indirect infrastructure cost due to reduction of required footprint
- Removing installation cost for external interconnections
- Reduction of Opex cost for end of life UPS replacement



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