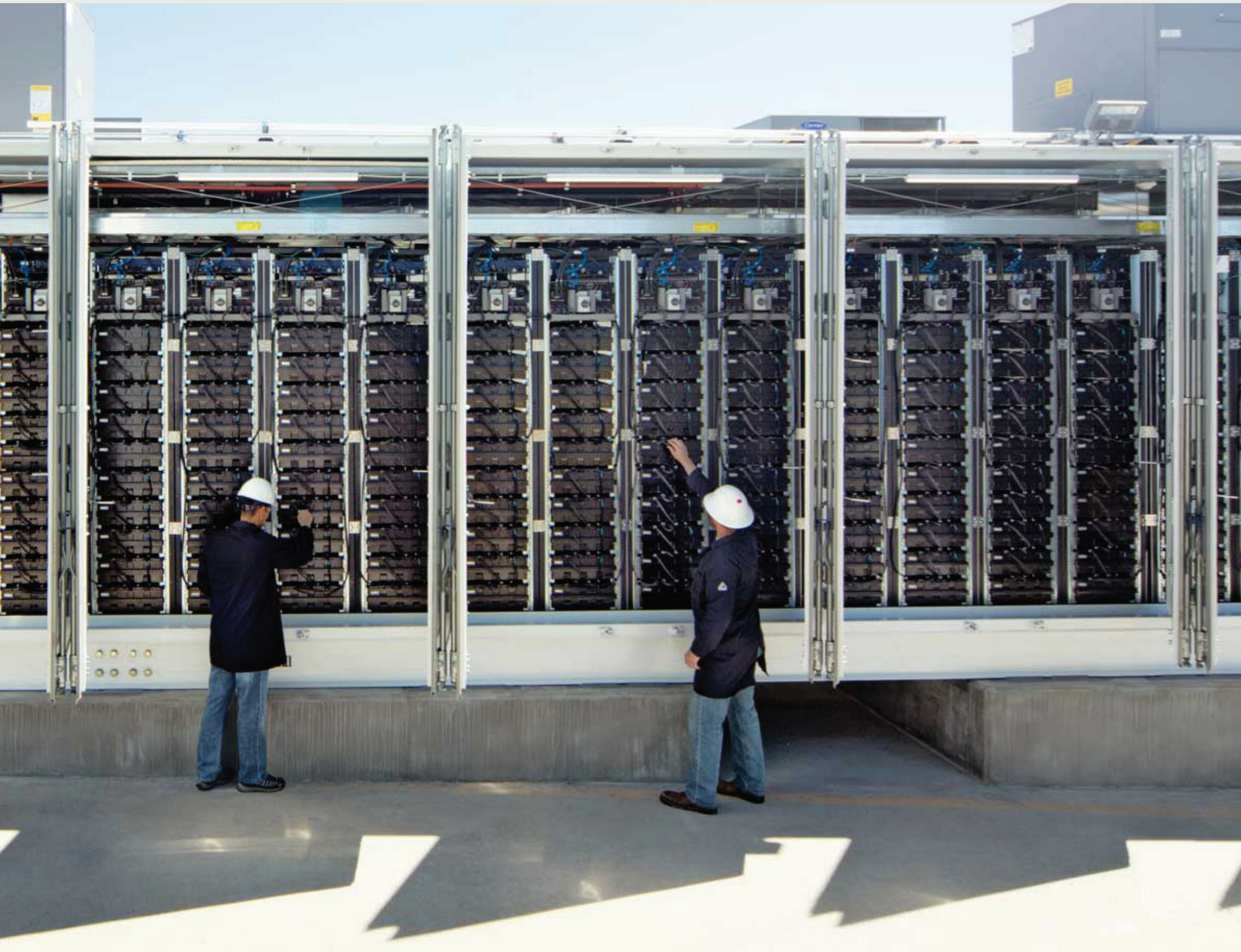
THE PROS AND CONS OF MEDIUM-VOLTAGE

Battery Energy Storage Systems

To serve large, mission critical facilities



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Battery Energy Storage Systems (BESS)

Problem statement
Multiple, decentralized, double-conversion, low-voltage (LV) 480 V n+1 uninterruptable power systems (UPS) with flooded cell, lead-acid, battery strings are a proven solution for uninterrupted power to large facilities with critical loads; however, the protection they provide against utility power interruptions also creates a host of ongoing operation and maintenance (O&M) issues with very real cost impacts.

- Large quantities of flooded cell, lead-acid batteries require near-constant attention with additional distilled water, internal resistance testing, and regular preventative maintenance to ensure that the OEM warranty is not voided by the battery manufacturer.
- The performance of this ongoing maintenance involves not just the risk of electrical discharge to the technicians, but it also compounds the risks with large volumes of battery acid and hydrogen gas. Safety systems are required, such as hydrogen detection systems and emergency shower stations, which create their own open-ended O&M requirements.
- Different redundant schemes can be utilized to increase the reliability of the overall system, such as: n+1 UPS modules, n+2 UPS modules, or 2n UPS modules. n+1 UPS modules offer a reasonable compromise between reliability and cost and are one of the more commonly used strategies for mission critical facilities.

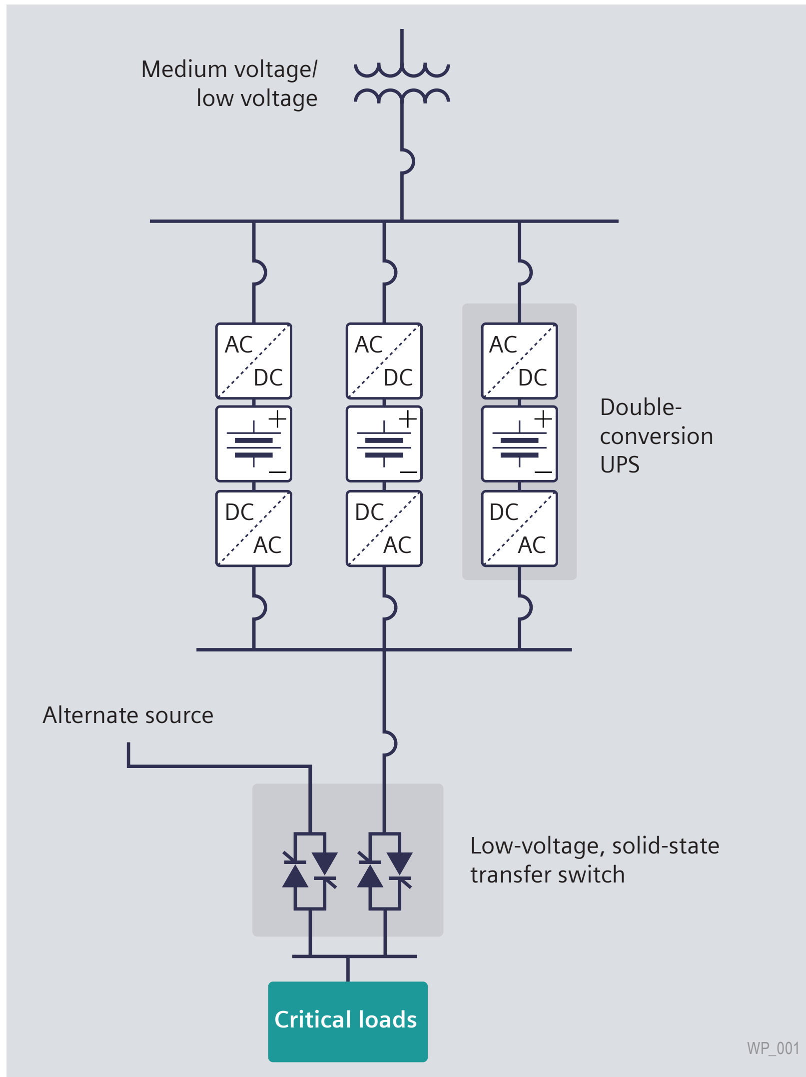


Figure 1: Typical system with double-conversion LV UPS

- n+1 UPS modules and their associated battery strings require very large amounts of space with substantial cooling capabilities to keep both the modules and batteries within their narrow temperature parameters.
- n+1 UPS modules typically balance the load across the n+1 units causing their efficiencies to be lowered well below their optimal level; which in-turn causes additional wear on the components and heat losses (electricity waste) that then requires additional cooling to ensure that the modules do not overheat (additional electricity waste).
- The UPS modules and connected battery strings typically require dedicated space within the facility that escalate cost in an already very costly (per square foot) environment.

To compound these issues, these traditional 480 V UPS systems also tend to silo their backup capabilities to specific load sizes and physical locations and offer very limited flexibility to reapportion the battery energy stored as mission critical loads evolve over time.

In favor of these systems, 480 V is well understood and commercially available through multiple proven manufacturers including static transfer switches to rapidly transfer from a disrupted utility source to the UPS circuit within 4 ms to aid in the prevention of damage to any downstream equipment during utility voltage anomalies.

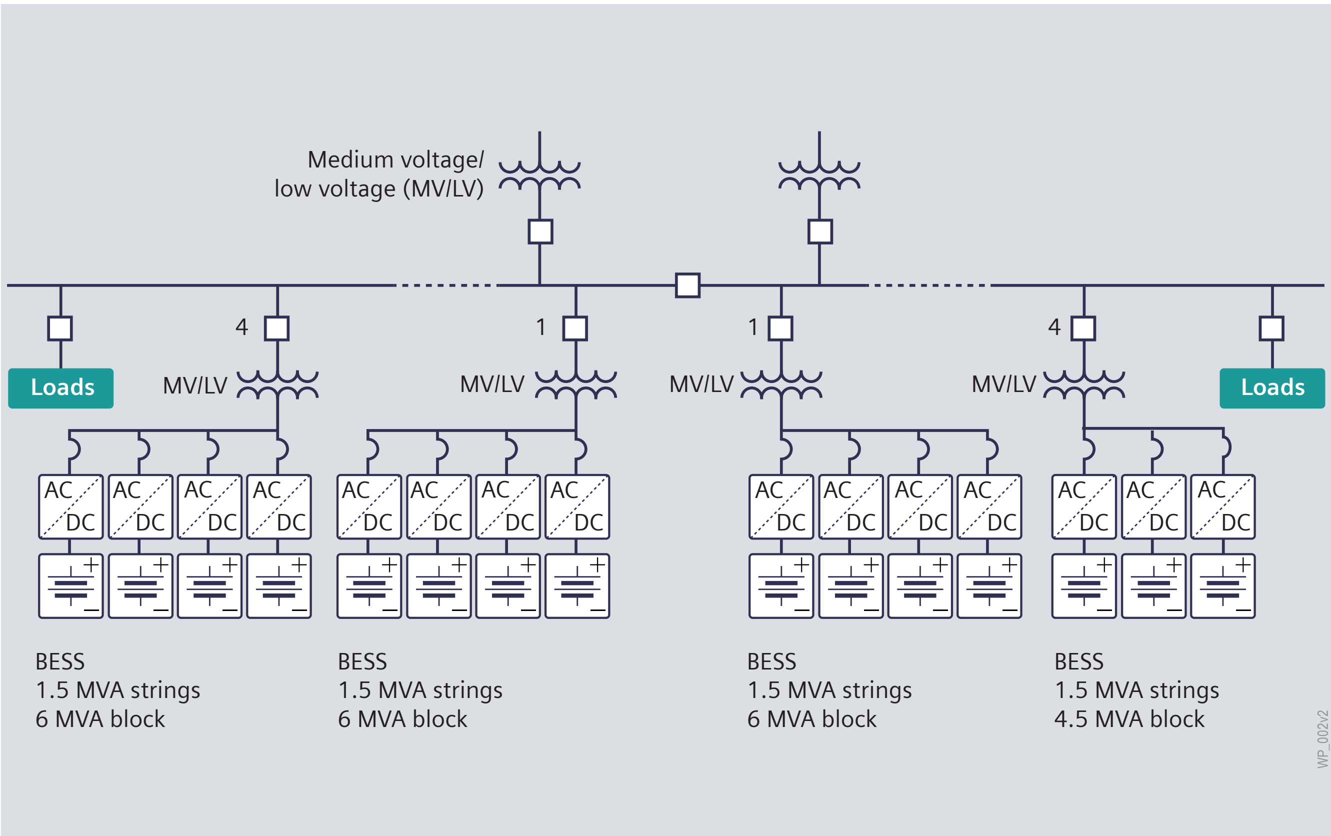


Figure 2: Typical medium-voltage system with BESS system at medium voltage. Each BESS block can be made of up to four 1.5 MVA strings. BESS blocks can be added as needed.

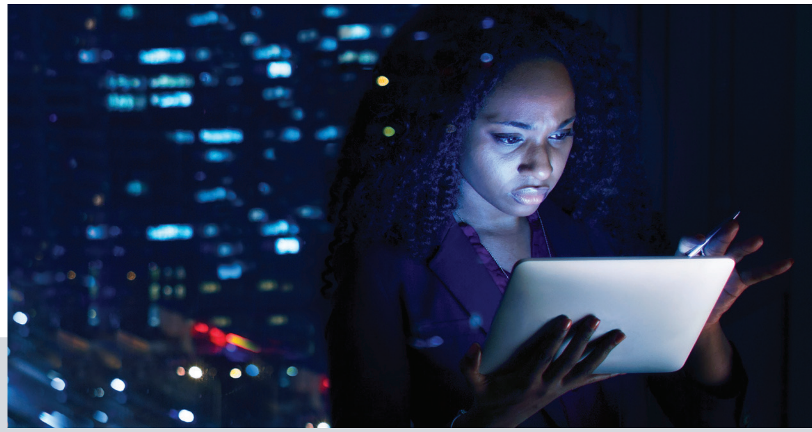
Medium-voltage battery energy storage system (BESS) solution statement

Industry has shown a recent interest in moving towards large scale and centralized medium-voltage (MV) battery energy storage system (BESS) to replace a LV 480 V UPS.

A transition from LV UPS to MV BESS offers several pros and cons that must be carefully evaluated for each possible use case before a user commits to a final solution.

Pros

Large scale, MV, centralized Li-Ion battery energy storage systems (MV BESS) can meet the backup power requirements to critical loads while minimizing the ongoing risks and costs associated with a decentralized n+1 UPS modules with flooded cell-battery strings.



- While Li-Ion batteries still require preventative maintenance, they are nowhere near the ongoing maintenance or O&M hazard of lead-acid batteries, and utility scale Li-Ion BESS is now widely adopted and implemented around the world by both utility and private industry.
- Centralized, large MV BESS can be installed in prefabricated enclosures with packaged HVAC units that are located exterior to a facility saving construction costs.
- Modular, highly configurable, grid-scale energy storage system are commercially available and designed to support the most demanding applications. These modular systems can also provide utility-scale BESS through multiple smaller blocks that can fed through multiple parallel static-transfer switches to feed critical loads with a minimal transfer time.
- A centralized and large MV BESS system provides greater flexibility for the utilization of battery-energy storage through its ability to convert non-critical loads to critical loads (and vice versa) when mission requirements change.
- A MV BESS system could also be utilized to address peak demand or reduce backup power requirements provided by the utility or other non-renewable energy resources as backup diesel-generation, besides providing power to critical loads.

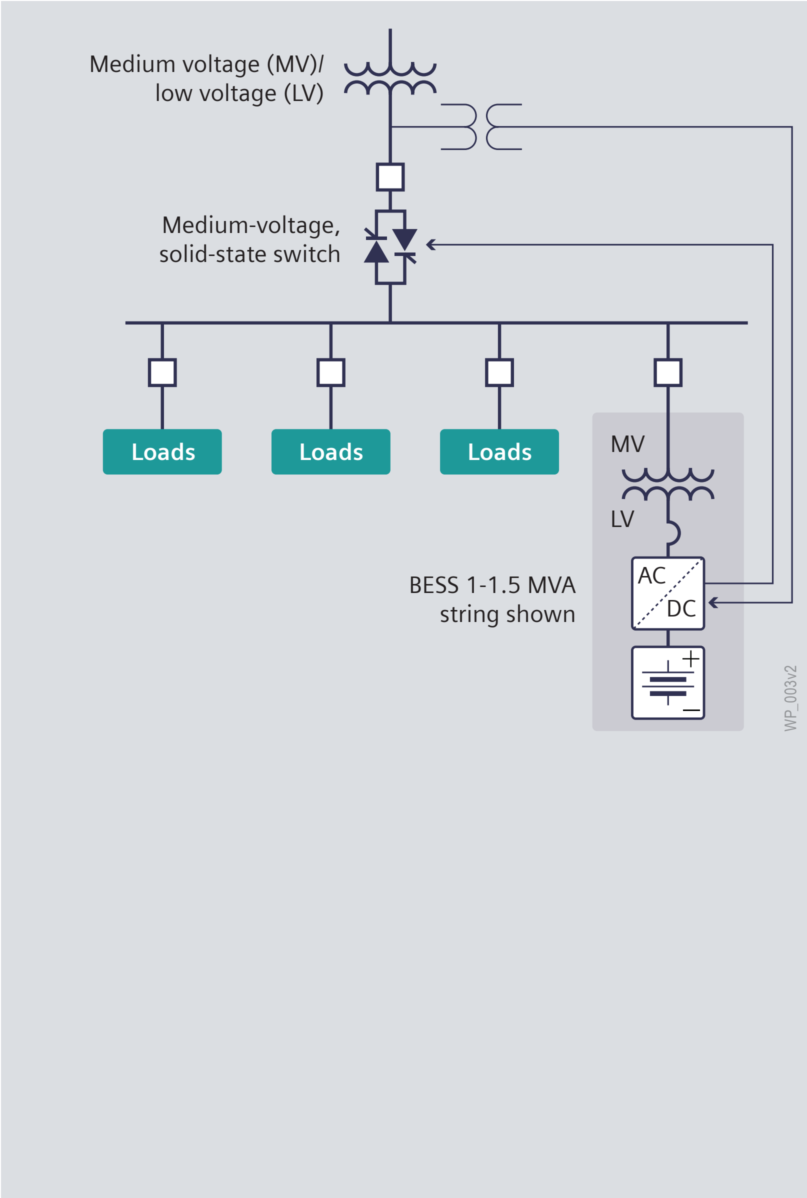


Figure 3: Typical BESS system with MV solid-state switch and direct voltage connection to inverter at the BESS system to be able to achieve betweem 12 ms-15 ms of transfer time.

Cons

Depending upon the size of the blocks of MV BESS incorporated, reacting to a localized anomaly with a small associated load may require more of the infrastructure than needed to transfer over to the BESS; causing additional wear and battery discharge cycles than a LV system.

By having a BESS at the MV level, any failure downstream from where the BESS is located would require the BESS to identify those anomalies. The time needed to identify and communicate localized anomalies to the central MV BESS system may be beyond the transfer time required for some applications.

Due to the applicable codes and standards required for MV equipment and installations, static-transfer switches will typically be much larger and more robust than at the LV threshold. However, this is somewhat offset by the reduced need for as many components at the MV level.

Integration of a BESS system at the MV level would require the BESS system to detect any anomaly directly, without the need of an external protective relay, and the use of MV static switches adequately rated to guarantee operation times of the electrical system within 12 ms to 15 ms. While MV transfer switches can transfer loads as fast as 4 ms, the overall time required to transfer the system including the detection and inverter time to the battery energy storage bus is between 12 ms to15 ms. Also, proper sizing and interruptive ratings of the MV static switch need to be considered.

This timeframe is still within the Computer and Business Equipment Manufacturers Association (CBEMA) curve, but it may not meet specific needs of the end user. This switching time is very likely to improve as the technology evolves and becomes more commercially available.

Alternative hybrid design

A possible alternative solution for a battery storage system with a transition time requirement of 4 ms or less could be a hybrid approach, which combines both a MV BESS and LV UPS where the size of the LV UPS would be reduced to address only the critical loads until the MV BESS system is brought online. This alternative has the advantage of reducing both the maintenance required for the LV UPS and eliminating any MV, solid-state switching devices.

Conclusion

While LV UPS 480 V n+1 have been proven for use supporting mission-critical facilities and loads, their ongoing maintenance and limited ability to re-allocate power across a facility limits the ability of an end user to curtail costs and future proof their facility against changing requirements.

MV Li-Ion BESS offer solutions that can be very attractive to mitigate these ongoing costs, and they offer a greater flexibility to distribute the backup power across a facility as the mission evolves. However, the technology for combined MV static-transfer switches and BESS to replace a LV UPS is still relatively young with limited options. This combination is currently unable to provide the rapid (4 ms) switching capability that an LV system can offer.

The end user is encouraged to weigh all these factors, as well as their true switching-time requirements to ensure they install the correct system for both their current and future mission and budget needs.

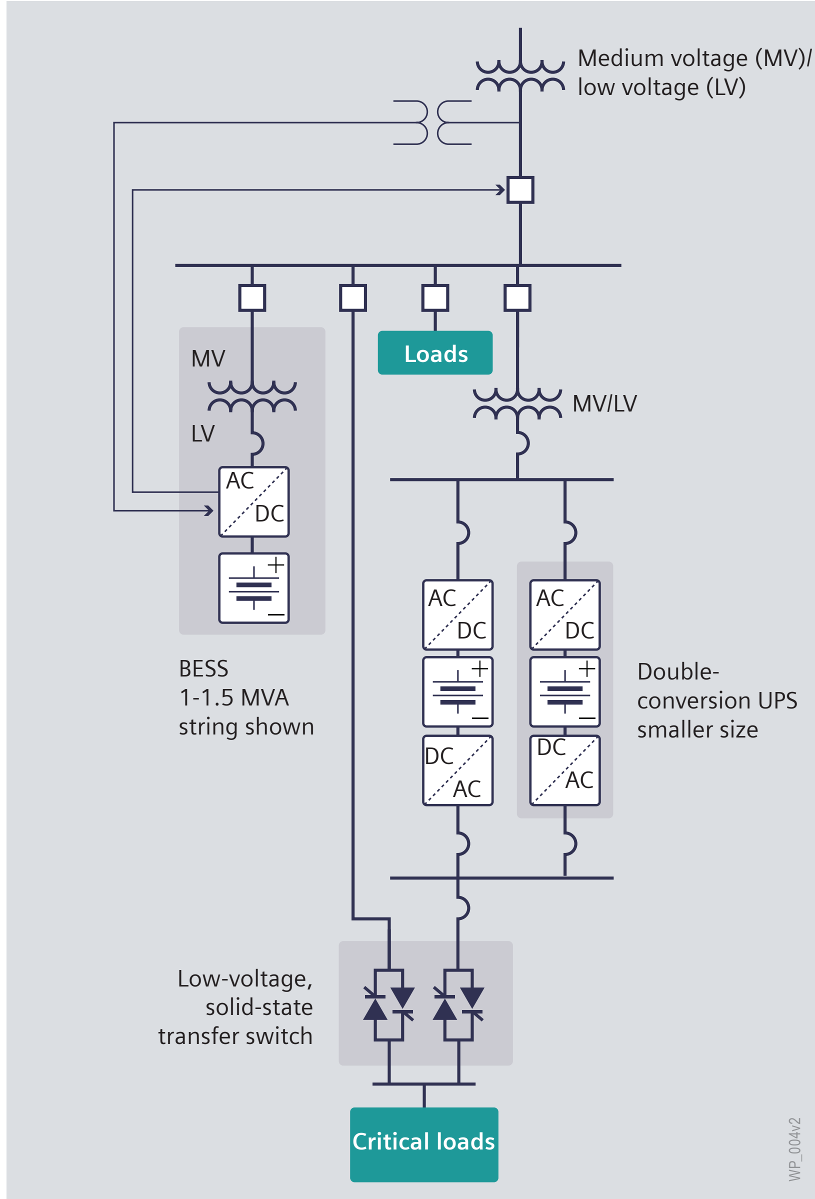


Figure 4: Hybrid scheme integrating MV BESS and reduced-in-size LV UPS.
MV solid-static switches are not required.

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