WHITE PAPER

Battery energy storage moving to higher DC voltages

For improved efficiency and avoided costs

Today, most utility-scale solar inverters and converters use 1500 VDC input from the solar panels. Matching the energy storage DC voltage with that of the PV eliminates the need to convert battery voltage, resulting in greater space efficiency and avoided equipment costs.

The evolution of battery energy storage systems (BESS) is now pushing higher DC voltages in utility scale applications. The Wood Mackenzie Power & Renewables Report is forecasting phenomenal growth in the industry, with annual revenue projections growing from $1.2B in 2020 to $4.3B in 2025. With this tremendous market expansion, the industry is continually looking for ways to increase system efficiency.

In the beginning, battery technology and sizes were left to traditional voltages such as the familiar 12 VDC used in lead acid battery systems. Over the last few years, we have seen DC voltages advance higher, using lithium-ion battery technology, to 250 VDC, 600 VDC, 1000 VDC and now even 1500 VDC. Higher voltages at the same amperage yield higher power. One of the key drivers of higher-voltage systems is the availability of advanced solar inverters and power converters.

Considering that most utility-scale battery energy storage systems are now being deployed alongside utility scale solar installations, it makes sense that the battery systems match the input DC voltages of the inverters and converters. Today most utility-scale solar inverters and converters use 1500 VDC input from the solar panels.

The single line diagram below illustrates a BESS integrated with utility-scale renewable generation. You will notice the BESS power converter solution is connected to the input side of the inverter and in parallel to the input of the solar PV panels rated 1500 VDC.

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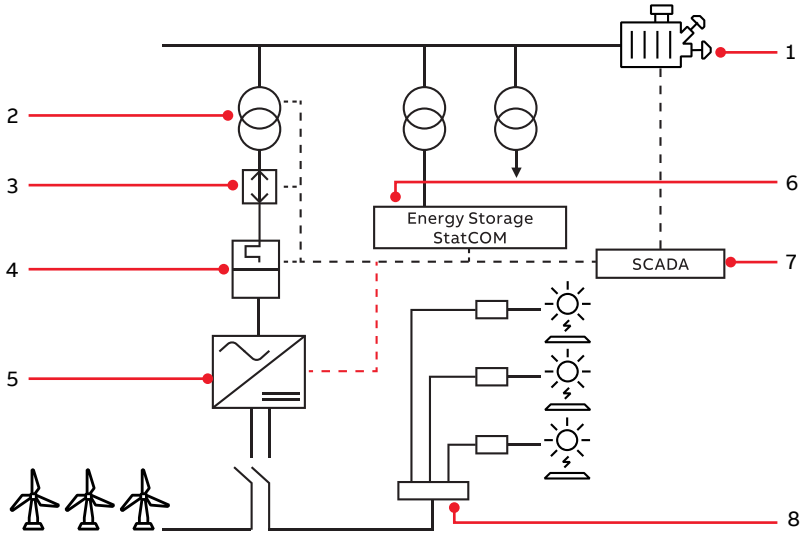
Renewables
integrated one-line



Functions

1. Substation*
2. MV Transformers
3. Metering System*
4. LV AC Protection*
5. DC/AC Inverters
6. Power Converter Solution*
7. Plant Controller (SCADA)*
8. DC Junction Boxes

* ABB offering

The BESS DC voltage is matched with the 1500 VDC from the solar PV panels and the input on the solar inverter. This eliminates the need to convert the battery voltage, resulting in greater energy and space efficiency and avoided equipment costs.

The evolution of higher DC voltages brings some challenges, such as finding components rated at the higher voltage that have embedded protection features. To address these concerns, component manufacturers are developing products rated at 1500 VDC, including:

- Breakers designed to protect against system overloads
- Disconnect switches used to isolate battery racks
- Insulation monitors used to measure leakage currents
- Contactors used to quickly switch battery banks on and off
- Fuses and fuse holders used to help protect against faults
- Ground fault devices used to help protect against system ground faults

With these new devices, a system designer can expect that the system will be as efficient, reliable, and protected as possible. At ABB we offer an extensive line of higher rated DC components from 600 VDC to 1500 VDC, designed to meet today's utility BESS requirements.

UL-rated 480 VAC to 1000 VAC and 600 VDC to 1500 VDC components are used in the following BESS system components:

Battery Management System (BMS)

- DC disconnect switches to isolate the battery banks
- DC circuit breakers to help protect the system in case of an overcurrent or short-circuit condition
- DC contactors used to remotely switch battery banks on and off, including isolation
- DC surge protection devices (SPDs) used to protect against voltage spikes and lighting strikes
- DC insulation monitors for identification of leakage current events
- Current Monitoring Systems (CMS) to monitor battery operating conditions, including amperage and voltage levels. Power quality can also be monitored

Power Conditioning System (PCS) or inverter/converter

- AC circuit breakers to help protect the AC side of the system in case of overcurrent or short circuit condition (480 VAC to 1000 VAC)
- AC surge protection devices for protection against voltage spikes and lighting strikes on the AC side of the system
- DC contactors to remotely switch on and off and isolate the DC side of the system
- DC surge protection devices to help protect against voltage spikes and lighting strikes on the DC side of the system

Energy Management System (EMS)

- Ground fault protection devices to help protect against ground faults
- Miniature circuit breakers to help protect auxiliary components
- Disconnect switches to isolate the EMS from other system components

Energy Storage Module (ESM)

- Ground fault protection devices to help protect against ground faults
- DC disconnect switches to isolate the system
- Miniature circuit breakers to help protect auxiliary components

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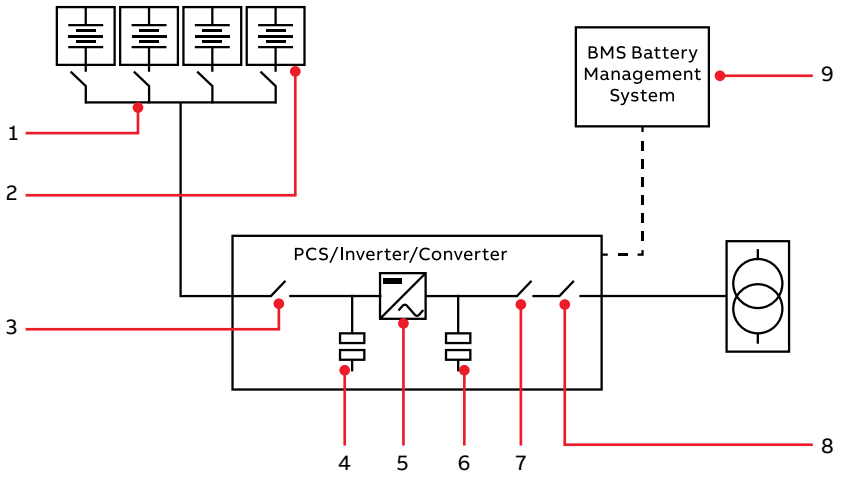
ESS component selection



Functions

1. DC breaker, contactor and/or switch disconnector
2. CMS battery monitoring
3. Main DC breaker, contactor and/or switch disconnector [iii]
4. DC SPD
5. Power supplies monitoring relay
6. AC SPD
7. AC main breaker and RCD
8. AC contactor [iii]
9. Insulation monitor

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Selection parameters

Battery side (DC)[i]

- **Voltage system:** up to 1500 VDC
- **Protection device:** semiconductor fuse or MCB/MCCB[ii]
- **Duty:** load break and short-circuit fault level/withstand rating
- **Short-circuit:** fault level or withstand rating required
- **CMS:** Insulation monitoring, voltage and current
- **Battery state monitoring**

DC main disconnect/isolation

- **Voltage:** up to 1500 VDC
- **Isolation:** Disconnect switch or breaker disconnect[ii]
- **Duty:** load break/no load break
- **Short-circuit:** fault level or withstand rating required

AC side

- **Voltage:** up to 800 VAC
- **Protection device:** MCCB/ACB/Fusible switches[ii]
- **Duty:** load break
- **Short-circuit:** fault level or withstand rating required
- **Residual Current Device (RCD)**

Today's utility-scale battery energy storage systems have made huge advancements in technology. In addition to increasing voltage levels up to 1500 VDC, systems are also being fully integrated with cloud-based measuring and monitoring systems such as the ABB Ability™ platform. Including these latest advancements as part of system design will help provide even greater efficiency and cost savings.

[i] Subject to high fault currents on battery type and withstand rating required (Flow: 2-5xIn, Lead-acid: >100xIn, Li-ion: 45-55xIn)

[ii] MCB: miniature circuit breaker | MCCB: molded case circuit breaker
ACB: air circuit breaker
Breaker disconnect: breaker working as a disconnect switch without protection

[iii] Can be accomplished with motorized devices or contactors

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