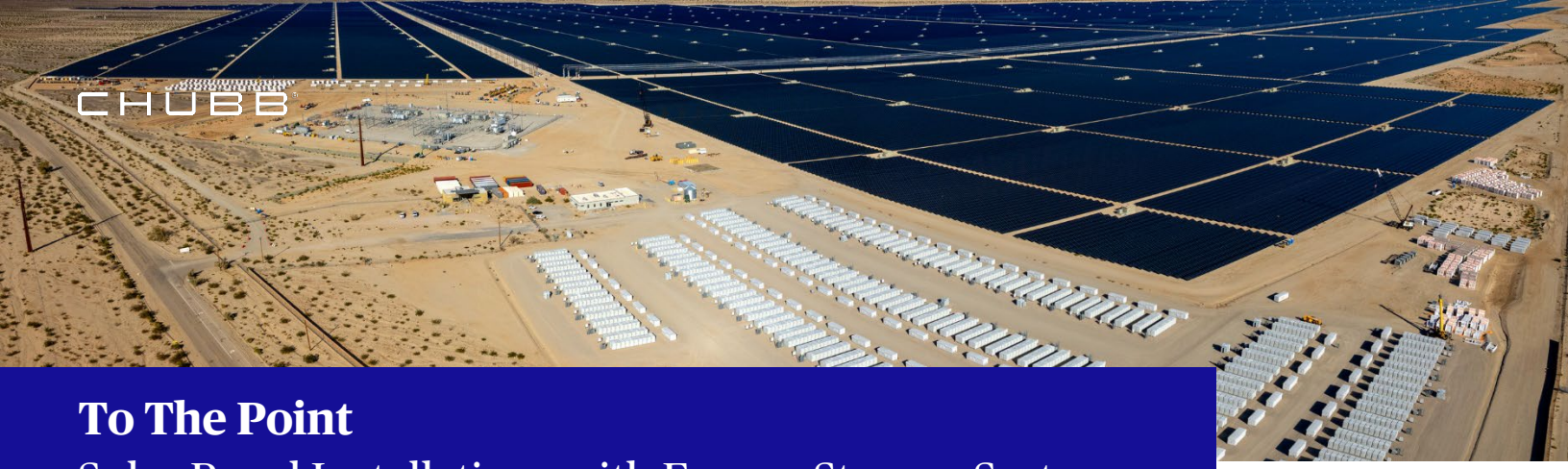


# To The Point
## Solar Panel Installations with Energy Storage Systems

Solar farm installations produce electricity every day independent of demand. Combining solar with Energy Storage Systems (ESS) allows the systems to adapt in a flexible manner. ESS are emerging as an integral component to a resilient and efficient electrical grid. ESSS are primarily being driven by Renewable Portfolio Standards (RPS) and for the purposes of grid regulation and stability.

### Importance of Energy Storage Systems (ESS)

Peak shaving helps with reducing carbon / Green House Gas (GHG) emission by curtailing fossil power generation when the electrical grid is taxed with high demand. Load balancing helps smooth the intermittent nature of renewable energy sources, such as solar, making the grid more stable, reliable, and resilient. As more renewables get installed, grid stability becomes an increasing concern.

### Safety Considerations

While the concept of ESS is not new, there has been a marked increase in the deployment of larger-scale and higher energy density Li-ion batteries used in modern Energy Storage Systems and these ESSs can be collocated in a wide variety of occupancies.

The primary safety focus in these installations has centered on the fire hazards associated with Li-ion batteries, and the potential for a condition known as ‘thermal runaway’. Thermal runaway results from internal shorts inside a battery cell that can occur due to a variety of reasons that ultimately can lead to fire.

### Components and Design

Solar farm installations combined with ESSs are, at their most basic level, a set of batteries that get charged and discharged as needed. They can be used to supply utility grids, local microgrids (e.g., campuses and neighborhoods), and/or the host building the ESS supports.

The anatomy of ESSs revolves around a system of interconnected components, hardware, and software and can include batteries, battery chargers, battery management systems (BMS), thermal management systems (HVAC), and associated enclosures. BMS systems control the operation and safety of the system to prevent thermal runaway and other abnormal parameters.

Li-Ion battery-based systems are a common ESS design due to the inherent power density advantages of lithium chemistries. However, it should be noted that ESS and Li-Ion batteries should not be considered synonymous. Traditional lead acid batteries can be used, such as in colder climates where they might offer a preferred alternative. Other battery technologies include “flow” ESS which uses materials such as vanadium.

### Installation

ESSs are typically installed in a building, outside a building within a smaller NEMA rated enclosure, or within larger intermodal containers. The Battery Management System (BMS) is the brains behind the ESS. It is crucial to have a proven BMS used in the ESS. Ultimately, it is the lifeblood of the system. It also serves as an early warning system to alarm and shut the system down in a short or other situation. Furthermore, BMS's are crucial for the ESSSs ongoing Operations and Maintenance (O&M) efforts.

When located within a building, the ESS is usually installed in cabinets within mechanical and electrical rooms, and will rely on the base building support systems. When installed outside a building, the enclosures usually contain thermal management systems (HVAC), supporting electrical and fire protection equipment.

### Best Practices

To ensure optimal performance and safety, consider the following best practices when dealing with Energy Storage Systems (ESS).

- Results from recent free burn tests, coupled with ongoing R&D for ESS safety from leading experts, have reinforced the following best practices for safety and property protection. Lithium-ion and lithium metal polymer battery systems should be provided with a listed device or other approved method to preclude, detect, and control thermal runaway (generally found within the Battery Management System (BMS)). The best-

known way to help mitigate this exposure is to use UL 1973-certified battery systems.

- ESSs should utilize/incorporate UL 1741 certified inverters/inverter systems. An inverter is the hardware (and potentially embedded software) that converts DC battery electricity to AC electricity.
- New ESSs must be UL 9540 listed. This standard was created specifically for ESS and is intended to address a comprehensive risk assessment and subsequent controls methodology. UL will certify these approved systems, and ESS manufacturers/integrators will receive a label to affix on the ESS, as well as receive the listing on UL's website proving the ESS is, in fact, 9540 listed.
- Most ESSs will be remotely configurable and, as such, connected to the Internet. To prevent an intentional or inadvertent cyber-induced failure to the ESS, electrical grid, etc., robust cybersecurity controls must be incorporated within the BMS and related firmware and software. Security cannot be an afterthought and needs to be "baked into" the system design. Furthermore, cyber risk assessments need to be conducted, and vulnerabilities routinely patched/updated as threats evolve. A good standard to reference is the International Society of Automation (ISA) 99.
- Indoor battery systems should be housed in a noncombustible, locked cabinet, or other enclosure to prevent access by unauthorized personnel unless located in a dedicated and properly protected equipment room accessible only to authorized personnel and is externally accessible for manual firefighting operations.
- In other than assembly, educational, detention and correction facilities, health care, ambulatory health care, day care centers, residential board and care, and residential occupancies, battery systems should be located in a room separated from other portions of the building by a minimum of a 1-hour fire barrier.
- In assembly, educational, detention and correction facilities, health care, ambulatory health care, day care centers, residential board and care, and residential occupancies, battery systems should be located in a room separated from other portions of the building by a minimum of a 2-hour fire barrier.
- Locate ESS outside and away from critical buildings or equipment. Install physical barriers, such as concrete bollards, walls, or fencing, if near high-traffic areas.
- For exterior enclosed ESS containers designed to be outside the building, keep a clear distance of at least 20 feet from the building for firefighter access around the unit(s). Keep batteries protected in a noncombustible enclosure.
- ESSs may utilize ventilation as a risk reduction technology, e.g., reducing a flammable atmosphere to less than 25% of LEL. To provide consistent assessment, evaluation, and guidance, refer to NFPA 70, Article 706.
- For rooms that contain Lithium-Ion or Lithium Metal Polymer batteries, signs should be posted that state the following:
  - Stationary storage battery systems
  - Energized electrical circuits
- An approved automatic smoke detection system should be installed in Li-Ion ESS areas and supervised by an approved central, proprietary, or remote station service.
- Sprinkler protection within the room or enclosure should be designed to extra hazard group 1 for new installations.
- For container-style ESS and remote locations with no water source, the installation of a modern clean-agent gas fire suppression system that is engineered to control a fire is recommended. If incorporating ventilation as part of an HVAC system, it will need to be interlocked to maintain necessary gas concentration.
- Provide portable fire extinguishers in the room or enclosure in accordance with NFPA 10 Standard for Portable Fire Extinguishers.
- Provide temperature monitoring with a high alarm for the battery room and container, tied to a constantly attended station.
- In seismically active areas, battery systems should be seismically braced in accordance with the building code.
- All larger, custom, and/or utility-scale ESSs should be commissioned by a qualified commissioning agent per the project requirements and basis of design (BoD).
- Operation and maintenance programs are key to ensuring all monitoring and protective devices are in good working order. Regular inspection is necessary to ensure the battery systems are not overheating or showing signs of malfunction. Annual (IR) scanning can help ensure the ESS system is operating within normal parameters.
- All ESS systems should have online condition monitoring systems for battery room temperature, and battery modules for charging, temperature, state of charge, state of health, resistance, capacitance, and alarm.
- Installations should have emergency power disconnects to ensure manual, remote, and local disconnect is possible adjacent to the unit.
- ESS should be installed in accordance with the most recent version of NFPA 855 - Standard on the Installation of Stationary Energy Storage Systems.

Solar farms and ESS installations are rapidly expanding and are considered vital for a clean energy future. They connect conventional and renewable energy sources, easing grid burdens and reducing carbon footprints. Employing top technology and smart designs is crucial to prevent potential issues and ensure optimal performance.

## Resources

**UL 9540:** Standard for Energy Storage Systems and Equipment

**UL 1973:** Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail

**UL 1741:** Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

**NFPA 855:** Standard on the Installation of Stationary Energy Storage Systems

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