Risk Considerations for Battery Energy Storage Systems

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The U.S. power grid is comprised of several energy sources from fossil fuels to nuclear energy to renewable energy sources. Battery Energy Storage Systems (BESS) balance the various power sources to keep energy flowing seamlessly to customers. We'll explore battery energy storage systems, how they are used within a commercial environment and risk factors to consider.

What is Battery Energy Storage?

A battery is a device that can store energy in a chemical form and convert it into electrical energy when needed. There are two fundamental types of chemical storage batteries: (1) the rechargeable, or secondary cell; and (2) the nonrechargeable, or primary cell. They both discharge energy in a similar fashion, but only one of them permits multiple charging and discharging.

Battery energy storage systems are typically configured in one of two ways: (a) a power configuration or (b) an energy configuration, depending on their intended application.

In a power configuration, the batteries are used to inject a large amount of power into the grid in a relatively short period of time, which requires a high inverter-to-battery ratio. A typical application would be to simulate a gas turbine ramp-up for frequency regulation, spinning reserve, or black-start capacity.

In an energy configuration, the batteries are used to inject a steady amount of power into the grid for an extended amount of time. This application has a low inverter-to-battery ratio and would typically be used for addressing such issues as the California "Duck Curve," in which power demand changes occur over a period of up to several hours; or shifting curtailed PV production to later in the day. BESS projects are increasing in popularity due to the fluctuating power supply from renewable energy power sources.

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BESS mainly performs one or more of these specific tasks:

- Provide voltage support for the transmission grid (e.g., when the actual grid voltage differs from the stated voltage).
- Provide stability in response to grid power oscillations (e.g., system faults).
- Help control the turbine 'ramp rate' (e.g., response to sudden change in wind speed or electrical demand).

Rechargeable batteries and BESS

A rechargeable battery comprises one or more electrochemical cells. It is known as a 'secondary cell' because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging from button cells to megawatt grid systems.

The batteries alternately store and discharge direct current (DC) electrical energy. The convertors change it to AC power, the Converter Transformer 'steps up' the alternating current (AC) voltage to match the desired output, the Control System coordinates the numerous processes taking place and the cooling system removes the intense heat generated by the DC/AC conversion.

One of the distinctive characteristics of the electric power sector is that the amount of electricity that can be generated is relatively fixed over short periods of time, although demand for electricity fluctuates throughout the day. Developing technology to store electrical energy so it can be available to meet demand whenever needed would represent a major breakthrough in electricity distribution. Helping to meet this goal, electricity storage devices can manage the amount of power required to supply customers at times when need is greatest, which is during peak load (demand). These devices can also help make renewable energy, whose power output cannot be controlled by grid operators, smoother and more easily dispatched.

BESS projects can also balance microgrids to achieve a match between generation and load. Storage devices can provide frequency regulation to maintain the balance between the network's load and power generated, and they can achieve a more reliable power supply for high-tech industrial facilities.

The power grids of today and tomorrow are characterized by a high share of renewable energy sources. This leads to a massive fluctuating power injection, which needs to be balanced by battery energy storage systems.

Common types of rechargeable batteries

Lead acid battery: Holds the largest market share of electric storage products. A single cell produces about 2V when charged. In the charged state, the metallic lead negative electrode and the lead sulfate positive electrode are immersed in a dilute sulfuric acid electrolyte. In the discharge process, electrons are pushed out of the cell as lead sulfate is formed at the negative electrode, while the electrolyte is reduced to water.

Nickel Cadmium battery (NiCd): Uses nickel oxide hydroxide and metallic cadmium as electrodes. Cadmium is a toxic element, and was banned for most uses by the European Union in 2004. Nickel–cadmium batteries have been almost completely replaced by nickel–metal hydride (NiMH) batteries.

Nickel Metal Hydride battery (NiMH): These are now a common consumer and industrial type. The battery has a hydrogen-absorbing alloy for the negative electrode, instead of cadmium.

Lithium-ion battery: The choice in many consumer electronics. They have one of the best energy-to-mass ratios and a very slow self-discharge when not in use.

Lithium-ion polymer battery: These batteries are light in weight and can be made in any shape desired.

Why are BESS used?

The power grids of today and tomorrow are characterized by a high share of renewable energy sources. This leads to a massive fluctuating power injection, which needs to be balanced by battery energy storage systems.

In its simplest form, BESS is a technique for energy storage and reinjection back into the grid, or as backup power to a connected load. Enhanced energy storage can provide multiple benefits to both the power industry and its customers.

Among these benefits are:

- improved power quality and the reliable delivery of electricity to customers;
- improved stability and reliability of transmission and distribution systems;
- increased use of existing equipment, thereby deferring or eliminating costly upgrades;

- improved availability and increased market value of distributed generation sources;
- improved value of renewable energy generation; and
- cost reductions through capacity and transmission payment deferral.

The energy storage program also seeks to improve energy storage density by conducting research into advanced electrolytes for flow batteries, development of low temperature Na batteries and nano-structured electrodes with improved electrochemical properties. In power electronics, research into new high-voltage, high-power, high frequency, wide-band-gap materials such as silicon-carbide and gallium-nitride is underway. In addition, advanced power conversion systems using advanced magnetics, high-voltage capacitors, packaging and advanced controls to significantly increase power density and performance is ongoing.

Commercial Battery Energy Storage Applications

Peak Shaving

In a commercial setting, the most important application of energy storage is peak shaving. For businesses on demand charge utility tariffs, between 30% and 70% of the utility bill may be made up of demand charges. Solar arrays alone are not always a sufficient solution for these businesses. Battery energy storage systems, however, can guarantee that no power above a predetermined threshold will be drawn from the grid during peak times.

Load Shifting

Battery energy storage systems allow businesses to shift energy usage by charging batteries with solar energy or when electricity is cheapest and discharging batteries when it's more expensive. This is particularly useful for businesses on rural electric cooperatives (RECs) or other utilities that don't offer net metering on an annualized basis.

Emergency Backup

Like the uninterruptible power supply (UPS) under your desk or in your server room, battery energy storage systems can keep operations running during power outages.

Microgrids

Energy storage opens up the possibility of building microgrids in conjunction with renewable energy. The scalability and turnkey simplicity of battery energy storage make these systems economically viable. Islandable microgrids can be used in certain large commercial facilities—or even entire communities. The American Samoa island Ta'u, who switched from diesel generation to solar + storage, is a good example of this application.

Renewable Integration

Energy storage can smooth the output of renewable power generation sources. Solar produces cyclically—day vs. night, summer vs. winter. Energy storage allows solar energy production to mimic the consistency of fossil fuel energy sources.

Grid Services

For utility-scale customers, battery energy storage can provide a host of valuable applications, including reserve capacity, frequency regulation and voltage control to the grid.

Battery Energy Storage System Performance Risk Factors

Many common factors influence how well a BESS will perform, but there are several that are specific to a given project. Things to consider or question when looking at a risk:

Wind Regime

The wind speed volatility determines how often the battery system cycles between charging and discharging. More cycles = more heat generated. Given the vast land area and large number of turbines installed at many North American sites, this factor significantly magnifies the risk. It might not be intuitive, but the wind force can vary significantly at each turbine location. Imagine 100 turbines randomly reacting to wind gusts and lulls at different times—with voltage and power output continually fluctuating out of synch. Chaos = stress on the system.

Local grid conditions

Grid conditions can vary greatly—even across small distances, such as the Island of Oahu for example. Voltage levels can sag momentarily, risking turbine trips. Reactive power levels can also vary, which present a different electrical challenge. The interconnection to the grid is another important factor. For example, a project might be connected via a radial transmission line—meaning a single path in/out. The effects of electrical disturbances tend to be amplified along a radial line, making the BESS, DVAR or STATCOM work much harder and operate more frequently.

Turbine OEM and Model

Some turbines have greater capabilities to handle grid voltage fluctuations and other disturbances. The common features desired by utility operators are "fault ride through" and "low-voltage ride through," which enables the turbine to take on some of this work. Unfortunately, turbine selection is often decided well in advance of the utility interconnection study required for each project.

The current electric grid is an inefficient system that wastes significant amounts of the electricity it produces, because there is a disconnect between the amount of energy consumers require and the amount of energy produced from generation sources.

Insurance Factors for Battery Energy Storage Systems

Below we've highlighted key questions around construction, safety and maintenance of the battery storage systems.

Construction

How is the BESS building constructed? Is it a tin shed or masonry block? Is the space conditioned to provide cooling in summer? Is the connected electrical apparatus installed in its own conditioned and protected enclosure, or in close proximity to the batteries? Is the battery area adequately ventilated to remove potentially explosive gases that are generated from charging cycles?

Safety Protection System Design

Is the BESS building protected by fire and smoke detection systems? Do those systems provide remote alert and annunciation to offsite personnel and a fire brigade? Is the BESS building and/or battery banks protected by a fire suppression system? Does the system design allow for continuing operation of the facility, at full or reduced capacity, if the BESS becomes inoperative?

Maintenance

What is the procedure and frequency for battery maintenance and testing? Are records maintained and available for review? Are spares readily available, if the individual cells fail?

Conclusion

Battery Energy Storage Systems are essential within the commercial power landscape. With the number of energy sources increasing, the use of these systems is key to balancing energy load. Understanding the risks of end-to-end battery energy storage systems is our specialty.

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About the author.

Al Caceres is an Executive Director within Gallagher's Energy Practice. Based in Houston Texas, Al joined Gallagher from GCube, where he was responsible for leading GCube's underwriting and account management teams in the US. While at GCube, he was responsible for establishing the renewable energy advisory council which included members from major utility companies.

Previously, he was with AEGIS Insurance Services as a Senior Property Underwriter, responsible for underwriting operational and construction projects for power and utility, oil/gas, petrochemical companies and renewable energy projects including wind, solar and ethanol plants. Mr. Caceres also worked at AIG – World Source Property as Assistant Regional Manager and at Starr Technical Risks Agency Inc. as Senior Property Underwriter. Al began his insurance career at Marsh as a Risk Analyst in the Power and Utilities Division.

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