Insight: Utility Battery Energy Storage Systems

Recognizing the Risk

With the push for more renewable energy and the need for battery energy storage systems (BESS), the number of installations has been significantly increasing globally. While the use of batteries is nothing new to the electric generation industry, the use of batteries within the electrical grid to support large electrical loads is. This quick expansion has led to added risk and questions about proper fire protection.

There are different types of battery cells available that can be found in a wide range of consumer product applications from mobile phones to electric vehicles. Lithium-ion batteries (LIBs) are currently the most common type used at large-scale power generation facilities to support electrical grid loads. And BESS is still a relatively new application. LIBs have many advantages including efficiency, long life expectancy, and relatively low maintenance. But disadvantages with this technology include significantly increased fire risk with difficulty in fire control and extinguishment once a fire has started.

Like all batteries, LIBs are chemical energy storage units that release their stored charge in the form of electrical energy through an electrochemical reaction. However, the design of the LIB is the reason fire hazards are extremely difficult to extinguish.

Thermal Runaway is the term used when a battery experiences a quickly escalating overheating event. This can lead to a catastrophic fire or explosion which then often quickly cascades to adjacent cells. These types of fires are difficult to put out and are extremely hazardous, producing toxic fumes along with the fire and the associated electrical hazards. This type of failure has been witnessed at multiple BESS facilities across the world with large associated property damage and business interruption costs.

As a result of a significant failure, in 2019, the National Fire Protection Association (NFPA) developed Standard 855 to address the fire protection of these systems. In this standard, the BESS test standard UL 9540A is recognized.

Controlling the Hazard

As these large BESS facilities continue to be built to support the growth of renewable energy, focus has increased on making safer and more reliable systems. The electrical industry knows that batteries are necessary and will play a key role in the future of the electrical grid.

There are many fire protection methods that include fire suppression systems, monitoring and control systems, and spacing between units. While both fire suppression and monitoring and control systems are useful mitigation measures, it has been proven that the only truly effective method is adequate spacing to prevent spread to adjacent units and containment to a single unit. While industry experience has shown that water-based fire suppression systems have even been the cause of thermal runaway due to inadvertent operations or leaks, gaseous fire suppression systems have proven to be ineffective for this type of chemical reaction fire.

Physical Layout

When designing a BESS, one of the most important aspects is the physical layout of the batteries. BESS can be installed in either both newly fabricated buildings designed specifically for this application or retrofitted buildings that before served other purposes. In either case indoor facilities have shown to be a significant risk and mitigating the spread of damage from a fire event extremely difficult. Industry experience has also shown that indoor facilities are not the best option when designing a large scale BESS.

Outdoor facilities are the prefered option when building a large scale BESS as there is usually adequate room to provide the required spacing, typically in rural locations. Where outdoor spacing cannot be extended, electrical capacity of the facility may need to be decreased (fewer batteries) which may make the project economically less attractive.

Adequate spacing of battery racks or containers won't prevent a fire, but will keep losses to a minimum. There is currently no industry standard for the correct spacing, but based on industry experience AIG has adopted a minimum of 10 ft (3.0 m) between units to minimize fire spread.

The UL9540A test method was established for evaluating thermal runaway propagation and is widely recognized thoughout the industry. The results of a UL9540A test will help the manufacturer develop installation guidelines, ventilation requirements, appropriate fire protection methods, and strategies for fire department. There is some confusion too as some test results used during UL9540A testing showed that in some cases adequate spacing can be less than 1 ft (0.3 m) for certain manufacturers. Industry experience has shown that this is not always the case. The UL9540A utilizes certain criteria such as wind speed. The reasoning behind this is that a higher wind speed would help to cool adjacent battery containers and will limit overall damage to these containers which is correct, but higher wind speeds in some cases will also aid the fire in jumping to adjacent containers. Therefore UL9540A is a very useful testing method to evaluate thermal runaway propagation but it does not guarantee that a fire will not spread when certain environmental conditions are present. Only adequate spacing will do this.

In outdoor facilities once a fire has begun at one container it can be assumed that this one container will be a complete loss and if adequate spacing between containers is used no other containers will be heavily damaged. The idea is to keep the damage contained to a single container.

The design of containerized units also needs to take into acount the location of explosion vents or other penetrations to ensure they are placed in a way that directs any hot gases away from surrounding equipment or buildings.

Battery Management Systems

Although not all fires can be mitigated it is still important to incorporate measures into the design that will help mitigate an event before a failure leads to a fire. Battery management systems play an important role in monitoring and controlling the BESS to make sure it is operating within the correct limits.

Battery management systems should monitor cell temperature, capacity, state of charge, voltage, and current while charging and discharging, and provide alarms and trip functions. Just like any other maintenance program or monitoring system the idea is to identify a concern in enough time to take action. Advanced battery monitor systems are able to collect and process a large amount of data that provides valuable information and determines the overall health of each cell.

Recommendations

Large-scale BESS facilities are being built at a fast pace with no signs of slowing down. As the industry continues to gain experience and technology advances mitigation strategies will also need to evolve. When designing BESS the most important consideration needs to be the physical layout and specifically the spacing of equipment. Spacing is the recommended way to limit the overall damage during a fire event. While battery monitoring systems and fire suppression systems are important, a battery fire is like no other fire the electrical industry has seen. Based on industry experience and past BESS failures, it is recommended to only design outdoor facilities with a minium of 10 ft. (3m) between containers.Spacing, Spacing, Spacing!

Resources / Standards

NFPA 855 Standard for the Installation of Stationary Energy Storage Systems

UL 9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

For more information, contact your local AIG Property Risk Engineer.

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