



ENERGY STORAGE SYSTEMS SAFETY FACT SHEET

Because of the growing concerns surrounding the use of fossil fuels and a greater demand for a cleaner, more efficient, and more resilient energy grid, the use of energy storage systems, or ESS, has increased dramatically in the past decade. Renewable sources of energy such as solar and wind power are intermittent, and so storage becomes a key factor in supplying reliable energy. ESS also help meet energy demands during peak times and can supply backup power during natural disasters and other emergencies. However, the rise in the number of ESS installations requires the need for a heightened understanding of the hazards involved and more extensive measures to reduce the risks.

What Is an ESS?

An energy storage system, often abbreviated as ESS, is a device or group of devices assembled together, capable of storing energy in order to supply electrical energy at a later time. Battery ESS are the most common type of new installation and are the focus of this fact sheet.

DID YOU KNOW?

According to the US Department of Energy, in 2019, about 18 percent of electricity generated at utility-scale electricity generation facilities in the United States was from renewable energy sources.

What Are the Advantages?

ESS have many useful applications.

Supplement Renewables

Renewable energies such as solar panels or wind turbines only produce electricity when the sun is out or the wind is blowing. Supplementing these with ESS allows users to take advantage of the electricity that is generated when the renewable energy technologies are not producing electricity.

Peak Shaving

ESS allows a user to shift where their electricity comes from by drawing power from the batteries during the higher-cost daytime hours then recharging during the lower-cost nighttime hours. This practice is referred to as peak shaving.

Load Leveling

When power generation facilities ramp up and ramp down to keep up with the changing demand for electricity, it puts stress on the system. ESS can help flatten out the demand curve by charging when electrical demand is low and discharging when it is high.

Uninterruptible Power Supply

ESS can provide near instantaneous protection from power interruptions and are often used in hospitals, data centers, and homes.

What Are Some of the Hazards?

Thermal Runaway

Thermal runaway is a term used for the rapid uncontrolled release of heat energy from a battery cell; it is a condition when a battery creates more heat than it can effectively dissipate. Thermal runaway in a single cell can result in a chain reaction that heats up neighboring cells. As this process continues, it can result in a battery fire or explosion. This can often be the ignition source for larger battery fires.

Stranded Energy

As with most electrical equipment there is a shock hazard present, but what is unique about ESS is that often, even after being involved in a fire, there is still energy within the ESS. This is difficult to discharge since the terminals are often damaged and presents a hazard to those performing overhaul after a fire. Stranded energy can also cause reignition of the fire hours or even days later.



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Toxic and Flammable Gases Generated

Most batteries create toxic and flammable gases when they undergo thermal runaway. If the gases do not ignite before the lower explosive limit is reached, it can lead to the creation of an explosive atmosphere inside of the ESS room or container.

Deep Seated Fires

ESS are usually comprised of batteries that are housed in a protective metal or plastic casing within larger cabinets. These layers of protection help prevent damage to the system but can also block water from accessing the seat of the fire. This means that it takes large amounts of water to effectively dissipate the heat generated from ESS fires since cooling the hottest part of the fire is often difficult.

Failure Modes

These are ways the batteries can fail, often leading to thermal runaway and subsequent fires or explosions.

Mechanical Abuse

Mechanical abuse is when a battery is physically compromised by either being dropped, crushed, or penetrated.

Thermal Abuse

Thermal abuse can occur when a battery is exposed to external heat sources.

Electrical Abuse

Electrical abuse can happen when the battery is overcharged, charged too rapidly or at high voltage, or discharged too rapidly.

Environmental Impacts

Environmental impacts that can lead to battery failure include seismic activity, rodent damage to wiring, extreme heat, and floods.

How Do We Help Keep People and Property Safe?

For the Designer/Installer:

Explosion Protection/Prevention

If there are enough batteries in a room to create an explosive atmosphere, then explosion prevention systems or deflagration venting should be installed per NFPA 69, *Standard on Explosion Prevention Systems*, and NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

Fire Suppression System

Testing has shown water to be the most effective medium for cooling an ESS fire. A sprinkler system that complies with NFPA 13, *Standard for the Installation of Sprinkler Systems*, should be installed in buildings where an ESS is installed.

Battery Management System

A system that monitors, controls, and optimizes performance of an individual or multiple battery modules in an ESS and can control the disconnection of the module(s) from the system in the event of abnormal conditions.

Spacing

ESS units should be grouped into small segments limited to certain kilo-watt hours (kWh) and spaced from other segments and walls to prevent horizontal propagation. The table below, which summarizes information from a Fire Protection Research Foundation (FPRF) report, "Sprinkler Protection Guidance for Lithium-Ion Based Energy Storage Systems" (2019), demonstrates the recommended spacing for the testing for specific chemistries and arrangements.

Recommended Separation of Lithium-Ion Battery Energy Storage Systems

ESS Type & Capacity	Object Combustibility	Sprinklered	Nonsprinklered
LFP 83 kWh	Combustible	–	1.8 m (6 ft)
	Noncombustible	–	1.2 m (4 ft)
NMC 47 kWh	Combustible	2.7 m (9 ft)	4.0 m (13 ft)
	Noncombustible	1.8 m (6 ft)	2.4 m (8 ft)
NMC 125 kWh	Combustible	–	1.2 m (4 ft)
	Noncombustible	–	< 0.9 m (< 3 ft)
LFP 31 kWh	Combustible	1.5 m (5 ft)	1.8 m (6 ft)
	Noncombustible	0.9 m (3 ft)	1.2 m (4 ft)

For the AHJ:

Permitting Checklist

Permits should be issued by and in accordance with the procedures of all authorities having jurisdiction and should bear the name and signature of each authority having jurisdiction or their designated representative(s). In addition, the permit should indicate the following:

1. Purpose of the ESS for which the permit is issued

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2. Type of ESS, size, weight broken down by subcomponents or subsystems, type, and amount of any hazardous materials, general arrangement of the system, and extent of work to be performed
3. Address where the ESS is to be installed and operated
4. Name and address of the permittee
5. Permit number and date of issuance
6. Period of validity of the permit
7. Inspection requirements

**For the Fire Service:****Pre-Incident Planning**

The fire department should develop a pre-incident plan for responding to fires, explosions, and other emergency conditions associated with the ESS installation, and the pre-incident plan should include the following elements:

1. Understanding the procedures included in the facility operation and emergency response plan described
2. Identifying the types of ESS technologies present, the potential hazards associated with the systems, and methods for responding to fires and incidents associated with the particular ESS
3. Identifying the location of all electrical disconnects in the building and understanding that electrical energy stored in ESS equipment cannot always be removed or isolated
4. Understanding the procedures for shutting down and de-energizing or isolating equipment to reduce the risk of fire, electric shock, and personal injury hazards
5. Understanding the procedures for dealing with damaged ESS equipment in a post-fire incident, including the following:
 - a. Recognizing that stranded electrical energy in fire-damaged storage batteries and other ESS has the potential for reignition long after initial extinguishment
 - b. Contacting personnel qualified to safely remove damaged ESS equipment from the facility (This contact information is included in the facility operation and emergency response plan.)

Emergency Operations Planning

An emergency operations plan should be created and contain elements such as procedures to safely shut down the

system, procedures for the removal of damaged ESS, general emergency procedures, and annual staff training.

CASE STUDY: Kahuku Wind Farm Fire

A fire broke out at the Kahuku wind farm in the north shore of Oahu, Hawaii in the summer of 2012. This was a 10,000 ft² battery warehouse where a 15 mega-watt system containing approximately 12,000 lead acid batteries was located. The fire was a challenge to extinguish, burning for over 13 hours and smoldering for over 36 hours. Extensive damage was caused to the system. This event demonstrated the need for first responders to have more education in this area.

Frequently Asked Questions About Battery ESS

Q: Which NFPA standard covers the installation of ESS?

A: If you are installing ESS for either new construction or a renovation, you should review the requirements of NFPA 855, *Standard for the Installation of Energy Storage Systems*.

Q: What is the best extinguishing agent for a fire in a battery ESS?

A: Testing has shown that water is the most effective agent for cooling for a battery ESS. For this reason, a sprinkler system designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, is required by NFPA 855, *Standard for the Installation of Energy Storage Systems*.

Q: I've heard that an ESS can reignite several days after a fire has been extinguished, is this true?

A: Lithium-ion batteries have shown they can ignite, or reignite, long after they have been damaged or involved in a fire—hours, days, or even weeks later.

Q: Is it OK to use a fire hose to extinguish a lithium-ion battery fire?

A: The UL study "Firefighter Safety and Photovoltaic Installations Research Project" (2011) showed that for voltages up to 1000 volts dc, water can be safely applied given the right conditions. This study demonstrated that using an adjustable nozzle at a minimum of a 10 degree fog pattern allowed for the safe application of water at a distance of 5 ft from the 1000 volts dc electrical source; however, due to the potential conductivity of pooling water, contact with it may expose you to shock.



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NEXT STEPS

- ✓ Visit nfpa.org/ess to learn more and to access the latest research and reports.
- ✓ Take [Energy Storage and Solar Systems Safety Online Training](#) for fire service personnel.

RESOURCES

US Department of Energy

[Energy Storage System Safety: Plan Review and Inspection Checklist](#) (2017)

Underwriters Laboratories Inc.

[Firefighter Safety and Photovoltaic Installations Research Project](#) (2011)

FPRF Reports

Projects currently underway:

[Stranded Energy within Lithium-Ion Batteries](#)

[Firefighter Safety in Battery Energy Storage System Fires](#) (advisory project with the University of Texas)

Report: [Energy Storage System Research and Design Challenge](#) (2019)

Report: [Sprinkler Protection Guidance for Lithium-Ion Based Energy Storage Systems](#) (2019)

Reports: [Lithium ion batteries hazard and use assessment](#) Phase I (2011), Phase II (2013), Phase III (2016).

Report: [Hazard Assessment of Lithium Ion Battery Energy Storage Systems](#) (February 2016)

Report: [Development of Fire Mitigation Solutions for Photovoltaic \(PV\) Systems Installed on Building Roofs](#) (2016)

Report: [Commercial Roof-Mounted Photovoltaic System Installation Best Practices Review and All Hazard Assessment](#) (2014)

Report: [Property Insurance Research Group Forum on PV Panel Fire Risk](#) (2014)

Workshop: [Energy Storage Systems and the Built Environment](#) (November 2015)

Report: [Emergency Response to Incident Involving Electric Vehicle Battery Hazards](#) (July 2013)

NFPA Information Sheets

[Energy Storage Systems: Is Your Community Ready?](#)

[Lithium Ion Battery Safety for Consumers](#)

Relevant NFPA Standards

Get free access to NFPA codes and standards at nfpa.org.

- ▶ NFPA 1, *Fire Code*, 2018 edition
- ▶ NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition
- ▶ NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition
- ▶ NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition
- ▶ NFPA 70®, *National Electrical Code®*, 2020 edition
- ▶ NFPA 110, *Standard for Emergency and Standby Power Systems*, 2019 edition
- ▶ NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, 2019 edition
- ▶ NFPA 855, *Standard for the Installation of Energy Storage Systems*, 2020 edition
- ▶ NFPA 1620, *Standard for Pre-Incident Planning*, 2020 edition



IT'S A BIG WORLD.
LET'S PROTECT IT TOGETHER.®

This material contains some basic information about energy storage systems (ESS). It identifies some of the requirements in NFPA 855, *Standard for the Installation of Energy Storage Systems*, 2020 edition as of the date of publication. This material is not the official position of any NFPA® technical committee on any referenced topic, which is represented solely by the NFPA documents on such topic in their entirety. For free access to the complete and most current version of all NFPA documents, please go to nfpa.org/docinfo. References to "Related Regulations" is not intended to be a comprehensive list. NFPA makes no warranty or guaranty of the completeness of the information in this material and disclaims liability for personal injury, property, and other damages of any nature whatsoever, from the use of or reliance on this information. In using this information, you should rely on your independent judgment and, when appropriate, consult a competent professional.