FIRETRACE™ International

Halma

HOW TO REDUCE BATTERY STORAGE FIRE RISK

Why fire suppression systems are crucial in a climate of growing public concern

Summary

Worldwide deployment of battery storage is soaring. In the US, the Inflation Reduction Act, which includes federal tax credits for standalone storage, has boosted the competitiveness of grid-scale installations with the result that storage capacity is expected to quadruple to 100GW by 2030. Meanwhile, countries around the world are ramping up storage deployment – China plans to install more than 30GW of storage by 2025, which would be an eight-fold increase on its current level of capacity. Elsewhere, 'innovation auctions' in Germany, for example, are rewarding the pairing of renewables with storage – the auctions in 2021 and 2022 accounted for more than 1GW of new battery storage added to the grid.[1]

Why is energy storage deployment increasing? Nations around the world are taking steps to boost their renewable energy supplies in order to play their role in the fight against climate change.

1 https://www.energymonitor.ai/tech/energy-storage/weekly-data-booming-battery-pipeline-heralds-era-of-renewables-dominated-grids/#:~:text=By%20the%20end%20of%202023,storage%20will%20have%20hit%20354GW.

Efforts to use more renewable energy are partly in response to the requirements of the Paris Agreement, a legally binding international treaty on climate change that was adopted by 196 parties (including countries and blocs) at the UN Climate Change Conference in Paris, France in 2015.[2] However, given the need to dramatically expand the use of sources of renewable power like wind and solar – in order to ensure that increases in global temperatures are kept to a minimum (as per the Paris Agreement) – a corresponding rise in energy storage deployment is vital due to the intermittent nature of wind and solar power.

However, despite the tangible 'feel good' factor in the energy storage sector – engendered by the rapid increase in its deployment – fears about fire risk threaten to jeopardise plans for the wider deployment of much-needed batteries. Fire chiefs in the US have said that the risks facing first responders are increasing as more battery storage is installed. Elsewhere, insurers have warned that the use of lithium-ion batteries is causing "new fire protection challenges". In addition, insurance brokers say that high-profile fire incidents in the energy storage sector have resulted in insurers becoming more reluctant to provide energy storage cover.

2 https://unfccc.int/process-and-meetings/the-paris-agreement

This report:

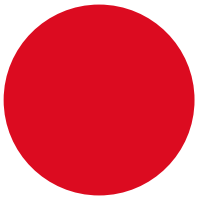
- Outlines the dramatic growth of the energy storage sector
- Highlights growing stakeholder concern about battery storage-related fire risk
- Explains how the energy storage market is currently attempting to mitigate fire risk
- Explores how energy storage fire risk regulations in the US are developing haphazardly on a state-by-state basis, a scenario that is creating considerable confusion and forcing energy storage owners to retrofit fire suppression systems in order to comply with evolving regulatory frameworks
- Shows how community concern about fire risk is resulting in the cancellation of energy storage projects
- Explains the different types of fire hazards facing energy storage projects, and
- Shows what steps should be taken to effectively tackle fire risk

Battery storage market growing rapidly

Battery storage deployment has grown rapidly in recent years and is expected to soar between now and the end of the decade as the sector rapidly grows in tandem with the widespread deployment of wind and solar energy. Data from BloombergNEF shows that energy storage installations around the world are projected to reach a cumulative 411GW (or 1,194GWh) by the end of 2030. This represents a 15-fold increase on the 27GW/56GWh of storage that was online at the end of 2021. In the US alone, cumulative energy storage installations are expected to total 25GW in 2023 before quadrupling to more than 100GW in 2030.[3]

The number of players operating in the energy storage market is also growing dramatically – research has shown that the global energy storage systems market size was valued at US$ 210.92 billion in 2021 and is expected to hit US$ 435.32 billion by 2030. Indeed, the US market is poised to grow at a CAGR [compound annual growth rate] of 8.4% from 2022 to 2030.[4]

Global energy storage systems market value



$210.92 billion in 2021

$435.32 billion
by 2030

3 https://about.bnef.com/blog/global-energy-storage-market-to-grow-15-fold-by-2030/

4 https://www.precedenceresearch.com/energy-storage-systems-market

Increasing emphasis on addressing storage fire risk

As the global deployment of energy storage increases, in an effort to make the use of renewable energy - such as wind and solar - more efficient, the focus on energy storage fire risk is sharpening. This is not necessarily because incidents of energy storage fires are increasing. There is a lack of comprehensive data detailing occurrences of energy storage fires around the world. A database compiled by the California-headquartered Electric Power Research Institute (which includes information about utility and C&I-scale energy storage failure events for which information is publicly available), shows that, as of the end of July 2023, there had been six 'energy storage failure events' in 2023, twelve in 2022, ten in 2021, four in 2020, eight in 2019, and sixteen in 2018.[5] This dataset, while not comprehensive, suggests that energy storage fire incidents have actually decreased in recent years. The problem for the energy storage sector is that when a fire incident does

5 https://storagewiki.epri.com/index.php/BESS_Failure_Event_Database

occur it tends to attract a significant amount of negative media publicity.

It is for this reason that concern about energy storage fire risk is rising. Earlier this year, the US-based International Association of Fire Chiefs said that, as the use of lithium-ion batteries continues to grow, so does the potential risk for first responders who are "called upon to mitigate associated fire incidents and hazards".[6] Consequently, the association ran a campaign in June this year, which focussed on five key areas: recognition of hazards; firefighting operations; firefighter safety; post-incident considerations; and public education.

Meanwhile, insurer FM Global has highlighted how lithium-ion batteries used in energy storage systems are vulnerable to thermal runaway, which leads to a "venting of flammable gases and subsequent combustion, creating new fire protection challenges".[7] As a result, FM Global issued fire safety recommendations based on fire tests conducted on energy storage systems used for commercial applications, such as manufacturing, office buildings, power generation and utility use.

FM Global concluded that energy storage systems could be made safer by introducing fire protection measures. The FM Global tests compared the fire risks associated with energy storage systems composed of either lithium iron phosphate (LFP) or nickel manganese cobalt oxide (NMC) batteries. FM Global concluded that energy storage systems composed of LFP batteries were found to have a lower overall fire hazard.

Elsewhere, DNV has also carried out investigations into energy storage fire safety. The safety testing specialist said that, with regard to energy storage permitting, it has worked closely with the New York City Fire and Building Departments, who, it says, are "at the forefront" of developing energy storage safety and permitting requirements. DNV, drawing on its experience in the oil & gas industry has developed "explosion, fire and plume models" to assess the impact of an uncontrolled failure event and support the design of mitigation systems.

Concern for energy storage fire risk is rising

6 https://www.iafc.org/blogs/blog/iafc/2023/03/16/lithium-ion-batteries-are-you-ready-is-announced-as-theme-for-safety-stand-down-june-18-24-2023

7 https://www.fmglobal.com/insights-and-impacts/2020/energy-storage-systems

The importance of fire suppression systems

The FM Global fire tests proved that sprinklers could delay or prevent the spread of fire to adjacent racks. They also showed that sprinklers coupled with “adequate separation from nearby combustibles”, and the addition of thermal barriers between racks, could reduce fire hazards even more. However, crucially, FM Global stated that without a protection system that can suppress fire in the early stages, a “prolonged burn, high water demand and damage to surroundings are likely”.

FM Global has also warned that fires involving lithium-ion batteries are known to reignite at any time – ranging from minutes to days after the initial event – and, as a result, there should be a ‘fire watch’ until all potentially damaged ESS equipment containing lithium-ion batteries is removed from the area.[8] FM Global has also warned that adequate cooling of the batteries is necessary in order to prevent reignition.

8 file:///Users/bencook/Downloads/Fire%20Magazinelithiumion%20energy%20storage%20systemsMStuckings.pdf

Insurance broker Marsh has warned that high-profile fire incidents in the energy storage sector have affected insurers' appetite for providing energy storage coverage. It has also said that the risks have resulted in some insurers exiting the market or having a "very narrow underwriting footprint".[9] Marsh said this has led to "increased premiums, higher policy excesses and sometimes difficulties with obtaining 100% cover for larger projects."

Consequently, addressing fire risk has become a crucial consideration for battery energy storage owners, contractors and operators.

High profile fire-incidents in the energy storage sector have resulted in insurers becoming more reluctant to provide energy storage cover.

9 https://www.marshcommercial.co.uk/articles/battery-energy-storage-fire-risks-explained

How the energy storage industry has tackled fire risk

Marsh has said the storage market's efforts to mitigate fire risk can be broken down into four key areas:

1. **Battery storage planning and design**
   This could include the overall design of the site and, in particular, the separation of battery containers and other major equipment, such as transformers, inverters and sub stations. In more recent projects, Marsh has observed "improved clearance distances" between each battery container, thereby reducing the potential for a "series of containers being destroyed" or fire spreading from one container to the next.
2. **Battery storage construction**
   A major consideration should be understanding to what extent EPC contractors are experienced in, and familiar with, battery storage technology. Some battery fires in South Korea have been attributed to "poor workmanship and the EPC contractor's lack of experience in the sector".[10]
3. **Battery storage fire protection systems**
   Battery operators must ensure sufficient water supply is available for firefighters and that the local fire brigade have visited, and familiarised themselves with, the site. The fire brigade will ideally have a plan for preventing reignition and thermal runaway. Remote and continuous online monitoring, early detection sensors, appropriate venting to avoid the build-up of gas, and automatic fire suppression systems to NFPA 855 standard should also be in place.
4. **Battery storage maintenance**
   Every battery storage site should have a dedicated maintenance schedule that incorporates monthly preventive checks, and thermographic testing. Spare parts should be readily available to minimise business interruption losses.

10 https://www.marshcommercial.co.uk/articles/battery-energy-storage-fire-risks-explained

US storage fire regulations vary from state to state

Regulations related to battery fire protection are developing haphazardly, with a state-by-state approach taken to the issue in the US market. This means each state may have a different fire code, which results in an array of different regulations informing the design and installation of energy storage systems in each state. This range of scenarios concerning the approach to battery storage fire risk means that, while some energy storage manufacturers consult with fire suppression specialists at the battery energy storage system (BESS) design stage, other project owners are forced to retrofit fire suppression systems to batteries to keep pace with rapidly evolving regulatory frameworks.

As solar and energy storage design and engineering consultancy Mayfield Renewables has highlighted, some US states adopt the International Fire Code (IFC) for energy storage, while others adhere to the National Fire Protection Association (NFPA) code. The differing approaches to fire risk by state are emphasized by the fact that

NFPA and IFC fire code cycle adoption varies by state. For example, as of April 1, 2021, there were eight states on the 2012 cycle, 23 states (plus the District of Columbia) on the 2015 cycle, 17 states on the 2018 cycle, and two states (California and New York) on the 2021 cycle.[11] While the 2015 versions of the IFC and NFPA 1 fire code do contain some requirements for energy storage systems, they have few when compared to the 2018 and 2021 versions. Meanwhile, the energy storage requirements in the 2018 version, though certainly more restrictive than the 2015 version, are relatively modest. On the other hand, the 2021 codes "build out ESS requirements considerably", Mayfield Renewables has said.

California and New York were the first US states to adopt the 2021 IFC, but the expectation is that other states and cities are likely to adopt the same code in the coming years, with the result that there will be more requirements for energy storage projects across a wider area of the US.[12]

Codes regulating solar and energy storage systems are continuously evolving in the US as systems scale and manufacturers introduce new products into the market. Keeping up-to-date with the relevant codes and standards for energy storage not only helps ensure system safety, but is also "good for business", Mayfield Renewables has said. Systems that adhere to the current code mean happier customers, satisfied inspectors, and smoother installations.

US storage fire regulations vary from state to state resulting in an array of different regulations informing design and installation.

11 https://www.mayfield.energy/technical-articles/fire-codes-and-nfpa-855-for-energy-storage-systems

12 https://www.mayfield.energy/technical-articles/fire-codes-and-nfpa-855-for-energy-storage-systems/

Addressing community concerns about BESS

Fitting fire suppression systems at BESS projects can do much to alleviate concern among local communities about battery storage fire risk. In October last year, the American Public Power Association (APPA) highlighted how a fire at Pacific Gas & Electric's (PG&E) Moss Landing battery storage facility in California had brought "fresh attention to safety issues tied to energy storage".[13] Following the fire, one newspaper used its editorial column to state that the fire was a "reminder that battery blazes are becoming increasingly common and destructive – and safety measures, including fire drills, for residents around storage facilities will have to be put in place and widely disseminated."[14] The article also raised concerns that "lithium-ion batteries might be releasing toxins into the air". The Moss Landing fire also led the APPA to highlight comments made three years earlier by a commissioner from the Arizona Corporation Commission, who said that the lithium-ion chemistries used in battery storage facilities "create unacceptable risks".[15]

Elsewhere, battery storage projects in the US and Canada have had to be postponed as a result of fire risk concerns raised by local communities. In April 2023, residents in Maryland's Price George's County opposed plans for a lithium-ion battery storage system citing fire and explosion risks.[16] Meanwhile, in the New York borough of Staten Island, plans for 120MWh of battery storage were withdrawn due to the local community's fears about fire risk and potential exposure to toxic chemicals.[17]

In the UK, politicians have sought to highlight the risks associated with battery storage systems and called for them to be subject to checks

13 https://www.publicpower.org/periodical/article/recent-california-energy-storage-battery-fire-draws-renewed-attention-storage-safety-issues

14 https://www.santacruzsentinel.com/2022/09/23/editorial-battery-fire-at-moss-landing-a-stark-reminder-of-new-technology-risks/

15 https://www.publicpower.org/periodical/article/recent-california-energy-storage-battery-fire-draws-renewed-attention-storage-safety-issues

16 https://insideclimatenews.org/news/14042023/lithium-battery-storage-maryland-prince-georges-county/

17 https://www.silive.com/business/2023/01/plans-withdrawn-for-community-opposed-lithium-ion-battery-storage-system-on-staten-island.html

by fire services. One UK Member of Parliament has called for energy storage installations to be classed as 'hazardous', which would mean the UK Environment Agency, Health and Safety Executive, as well as fire services. would be statutory consultees when planning applications are considered.[18]

Meanwhile, one chief fire officer in the UK – which is one of the world's most advanced energy storage markets – has raised concerns about dealing with a potential fire breaking out at a battery storage project. He said that his crews would face an "impossible choice" between protecting the community from a potential toxic or explosive gas plume or applying water that would pollute local waterways for years.

"We remain concerned about the impact of the chosen locations that could have such a detrimental effect on the local environment and important infrastructure should a fire occur," the chief fire officer added.

Fitting fire suppression systems at BESS projects can do much to alleviate concern among local communities about battery storage fire risk.

18 https://www.bbc.co.uk/news/uk-england-hampshire-66097217

What are the types of fire hazard faced by energy storage projects?

The US-based National Fire Protection Association (NFPA) has identified nine key fire-related hazards facing energy storage, they are:

Thermal Runaway

A term describing the rapid uncontrolled release of heat energy from a battery cell. This occurs when a battery creates more heat than it can effectively dissipate. Thermal runaway in a single cell can cause a chain reaction that heats up neighbouring cells. As this process continues, it has the potential to cause a battery fire or explosion. This is frequently the ignition source for larger battery fires.

Stranded Energy

As with most electrical equipment there is a shock hazard present, but energy storage systems are unique in that, even after being involved in a fire, there is still energy within the storage system. This energy is difficult to discharge if terminals have been damaged and therefore poses a risk to those performing overhaul after a fire. Stranded energy can also cause a fire to reignite hours or even days later.

Toxic and Flammable Gases Generated

During thermal runaway, most batteries generate toxic and flammable gases. “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 energy storage system room or container,” the NFPA says.[19]

Deep Seated Fires

Energy storage systems often comprise batteries housed in a protective metal or plastic casing within larger cabinets. While these layers of protection help prevent damage to the system, they can also block water from reaching the seat of the fire. This means it takes significant quantities of water to effectively dissipate the heat generated from energy storage fires since cooling the hottest part of the fire is often difficult.

19 https://www.nfpa.org/~/media/Files/Code%20or%20topic%20fact%20sheets/ESSFactSheet.ashx

Failure Modes
These are the various ways batteries can fail, which often lead to thermal runaway and subsequent fires or explosions.

Mechanical Abuse
This term relates to instances where a battery is physically compromised by either being “dropped, crushed, or penetrated”, according to the NFPA.

Thermal Abuse
Instances in which a battery has been exposed to external heat sources.

Electrical Abuse
Instances where a battery is overcharged, charged too rapidly or at high voltage, or discharged too rapidly.

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

Fire suppression systems should form a key element of any strategy tackling energy storage fire risk.

What steps should be taken to tackle fire risk?

Fire suppression systems should form a key element of any strategy for tackling energy storage fire risk. The NFPA has highlighted water-based suppression systems as among the most effective methods of cooling a fire in an energy storage system. The association recommends that a sprinkler system that complies with 'NFPA 13, Standard for the Installation of Sprinkler System,' should be installed in buildings which house energy storage systems.

The NFPA has also said that, if there are enough batteries in a confined space 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.

Consideration should also be given to the inclusion of a battery management system, which monitors, controls, and optimises performance of an individual or multiple battery modules and can control the disconnection of the modules from the system in the event of abnormal conditions.

Meanwhile, it is also recommended that energy storage units are grouped into small segments limited to certain amounts of kilowatt hours and spaced from other segments and walls to prevent horizontal propagation. Depending on the energy storage type and capacity, as well as whether sprinklers are present, systems should be spaced between 0.9 metres and 4 metres apart.[20]

20 https://www.nfpa.org/~/media/Files/Code%20or%20topic%20fact%20sheets/ESSFactSheet.ashx

Conclusion

Worries about battery storage fire risk among communities and local planning authorities are resulting in the cancellation of energy storage projects, which have a vital role to play in the world's transition to a low carbon economy. Fire chiefs, insurance companies and politicians have expressed fears about the potential risk to human life – as well as the significant financial risks – posed by battery fires.

There is a very real danger that public opposition to energy storage projects could grow significantly given that media reports are describing battery storage fires as increasingly common and increasingly destructive, as well as highlighting the potential for the release of toxins into the air.

Consequently, it is important that battery storage developers and owners are aware of the full extent of the fire risks posed by this technology if they are to successfully win and maintain public support for projects.

To alleviate concerns, it is crucial that energy storage systems incorporate fire suppression systems that eliminate risk to the public, as well as minimizing the potential financial impacts of battery storage fires. Energy storage developers and owners should consult with fire suppression experts to gain an understanding of the extent of the fire risks they face. Failing to do so could make it increasingly difficult to promote energy storage projects – which have a crucial role to play in a low-carbon economy – in a climate of growing public opposition.

Would you like to talk about the risks in this report? How about your approach to fire risk in your portfolio?

Get in touch with the Firetrace team today.

www.firetrace.com/contact

FIRETRACE™ International

firetrace.com/cleanenergy

World Headquarters

Firetrace International
8435 N. 90th St. Suite 2
Scottsdale AZ 85258,
United States of America
+1 480 535 4189

Middle East Office

Firetrace USA LLC (Middle East)
2117 Building 7WB,
Dubai Airport Free Zone,
Dubai, United Arab Emirates
+971 4 295 0167

India Office

Firetrace International
B-149, Ansal Pioneer
Industrial Area, Bilaspur
Guragon Haryana 122413,
India

China Office

Lane 1165 JinDu Road
Floor 3 Block 1 No. 123
Min Hang District,
Shanghai, 201108,
China