Understanding Thermal Runaway in Large-Scale Lithium Grid-Scale Batteries from Monitoring, Prevention, and Extinguishing Fires

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Discover the risks of thermal runaway in large-scale lithium battery systems, its impact on grid stability and safety, and effective strategies for monitoring, prevention, and extinguishing lithium fires. Learn how to mitigate hazards while supporting renewable energy storage.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Understanding Thermal Runaway in Large-Scale Lithium Grid-Scale Batteries: Monitoring, Prevention, and Extinguishing Fires

Large-scale lithium battery systems are essential for supporting renewable energy storage, ensuring grid stability, and meeting growing energy demands. However, these systems come with inherent risks, with thermal runaway being one of the most serious. Thermal runaway can lead to catastrophic fires, posing risks to infrastructure, the environment, and human safety. This article examines what thermal runaway is, how it can be monitored and prevented, and what steps are needed to extinguish a lithium fire once it has started.

What is Thermal Runaway?

Thermal runaway is a self-perpetuating chemical reaction that occurs in lithium-ion batteries when excessive heat is generated within a battery cell. This heat triggers a chain reaction that spreads to other cells in the system, resulting in fire, explosions, and the release of toxic gases.

How Thermal Runaway Occurs
1. Initial Trigger:
• Overheating: Can occur due to external heat sources, high ambient temperatures, or internal heat buildup.
• Overcharging/Overdischarging: Leads to voltage instability, causing excessive heat.
• Physical Damage: Punctures or impacts to battery cells can result in short circuits and heat generation.
• Manufacturing Defects: Impurities or poor-quality components increase the risk of failure.

2. Chain Reaction:
• Once a cell exceeds its thermal threshold, its internal electrolyte decomposes, releasing flammable gases and more heat.
• The heat and gases spread to adjacent cells, triggering a cascading failure.

3. Outcome:
• Fires, explosions, and the release of harmful gases like hydrogen fluoride (HF), carbon monoxide, and other volatile organic compounds (VOCs).

Monitoring Thermal Runaway in Lithium Batteries

Early detection is crucial for preventing thermal runaway from escalating. Monitoring systems provide real-time data and alerts to identify potential risks before they become critical.

Key Monitoring Technologies
1. Battery Management Systems (BMS):
• Continuously monitor temperature, voltage, and current at the cell, module, and system levels.
• Trigger alarms and shut down the system if parameters exceed safe thresholds.

2. Thermal Sensors:
• Thermocouples and Infrared Sensors: Detect hotspots or abnormal temperature fluctuations.
• Fiber Optic Sensors: Provide accurate, real-time temperature readings across large installations.

3. Gas Detection Systems:
• Detect early emissions of flammable or toxic gases (e.g., hydrogen, hydrogen fluoride) that indicate cell degradation.

4. Thermal Imaging Cameras: