BATTERY ENERGY STORAGE

THERMAL RUNAWAY AND FIRE RISK

CANADA | JULY 2023

A report by BBA

Commissioned by Energy Storage Canada

ENERGY STORAGE CANADA

To whom it may concern

As part of Energy Storage Canada's effort to inform the public and relevant stakeholders about battery energy storage systems (BESS), our organization is pleased to provide this comprehensive report by an independent third-party, which explores the safeguards of this technology against potential hazards. Along with the report itself, we have also included an executive summary and in the appendices, a brief Q and A of its findings, including the critically important measures that BESS manufacturers use to meet industry standards and prevent potential hazards, as well as recommendations for any future BESS applications.

As Canada continues its path towards a more decarbonized future, energy storage is one of the key methods towards a greener energy grid. This year in Ontario alone, the Independent Electricity System Operator has announced over 900 MW of new storage capacity will come online across over a dozen projects in the province in the next few years. While this is welcome news, we do understand there are outstanding concerns about these projects, such as fire and explosion.

With this in mind, ESC retained BBA, an engineering consulting firm with over 40 years of experience, as an independent, third-party expert to not only compile background information on BESS, but also survey four BESS vendors on their safety records, environmental safeguards and recommendations for what these projects should include. Key findings include:

- **No incidents of thermal runaway (the chemical reaction which leads to potential fire) occurred in systems using the latest battery technology;**
- **Mitigation tools and strategies used by operators, leading to the very low risk of thermal runaway;**
- **Recommendations for not only developers and manufacturers, but all stakeholders, such as municipalities and system operators, involved in a potential BESS project;**

This report helps in answering the questions of what's working to keep these projects safe and what stakeholders and decision-makers should look for in assessing projects once they're proposed.

We would be happy to provide any additional information or answer any questions in further detail.

Justin W. Rangooni
Executive Director | Energy Storage Canada

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EXECUTIVE SUMMARY

BACKGROUND

The report includes technical background information about BESS, including the chemistry involved, the codes and standards which apply to projects, the components that make up an energy storage system, and the mitigation strategies to protect against potential hazards.

As part of BBA's survey work, four leading original equipment manufacturers (OEMs) of BESS working in Canada and the rest of North America were engaged to provide information on its safety procedures and mitigation strategies against what's known as thermal runaway.

Thermal runaway is a chemical chain reaction which can lead to increased heat inside BESS, which if not properly mitigated, can spread. For example, this can happen when there's a manufacturing defect or when there's some sort of accident, such as a fluids leak, something from the outside crashing into the infrastructure or a failure of an internal management system. A thermal runaway event is what can lead to hazards: the primary risk being fire.

SURVEY QUESTIONS

The four OEMs were asked a series of initial questions, such as what specific chemistry is used in their products, what codes and standards their products must comply with, as well as what they do to mitigate the risk of thermal runaway and therefore, potential fire. Following those questions, they were asked to provide any incidents of thermal runaway, how they would describe the risk of thermal runaway in their products, and what are the most common questions they receive about BESS.

KEY FINDINGS

- Of the four OEMs, only one encountered any incidents of thermal runaway, which were related to an older product. The OEM involved notes there have been no thermal runaway events for the current product.
- All four OEMs described the risk of thermal runaway as "extremely low."
- Along with the very low risk of thermal runaway initially, the additional mitigation measures to prevent a resulting fire means the potential consequences are "easily outweighed" by the benefits to the public.
- Potential fire is the most frequently asked question regarding BESS risks.

A significant reason for these results is OEMs using more modern chemistry systems, specifically using lithium-irExecution-phosphate (LFP), which is significantly more stable and has a lower likelihood of thermal runaway.

Canada's energy storage industry has a strong foundation of building safe and reliable systems. However, it is equally important for industry to engage with outside partners. This means projects having proper communications protocols, pre-planning for emergency response and making sure first responders are properly trained on an ongoing basis in the rare case of a thermal runaway event.

BEST PRACTICES AND RECOMMENDATIONS

It should be noted that BESS are regulated by several categories of safety standards, including equipment, installation, and its thermal runaway safeguards – all of which are detailed in the full report. To meet these requirements, OEMs have tested strategies and tools to ensure safe operations, including 24/7 system monitoring, battery management, ventilation, site design, heat/smoke/gas/fire detection and advanced shutdown systems, battery management, fire suppression walls, thermal imaging and more. Based on these best practices and proven modern technologies used by these operators, the report makes several key recommendations for not only BESS developers, but for stakeholders exploring potential projects.

The report recommends the following:

- Transitioning to more modern BESS designs, specifically projects which don't require walk-in enclosures.
- Transitioning to LFP chemistry-based projects, which reduce the risk of thermal runaway, which has already been adopted by OEMs.
- Ensuring all test reports and certifications for any BESS product are made available to the impacted jurisdiction, (specific test results and standards are outlined in the report and should be followed even if there aren't explicit requirements by a particular jurisdiction.)
- Reviewing and considering the best practices, strategies and tools highlighted by current OEMs in this report when planning new projects.
- Those constructing the project must follow all design procedures and site design requirements.
- Robust testing and commissioning shall be completed prior to BESS system completion.
- An Emergency Response Plan should be in place, with the OEM responsible for providing emergency procedures, datasheets, manuals, test results, etc.
- The training and educating of first responders about thermal runaway and BESS fire and how it differs from traditional structure fires.

CONCLUSION

Ultimately, modern BESS systems developed by OEMs have a distinguished record of extremely low risk of thermal runaway, which is made possible by industry-standard construction, design, management, and monitoring of these projects. By meeting the extremely high standards to ensure public safety through these mitigation strategies, BESS is a safe, stable, and secure way to stabilize our energy grids on our collective path to decarbonization.

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"We are proud professionals who positively impact society's development by providing practical and technologically advanced solutions in a mindful way. We help companies with their challenges and transformation by relying on our sharp business acumen, extensive practical experience and vast technological curiosity. We use all our teams' ingenuity to develop innovative, scalable and proven engineering strategies and solutions. As catalysts for change, we're committed to supporting the industry in its transition to a sustainable, mutually beneficial future."

For more information, please visit https://www.bba.ca/

1. Background

Energy Storage Canada ("ESC") has engaged BBA, as an independent third-party expert on topics related to Battery Energy Storage System ("BESS") thermal runaway and fire, to prepare this summary report and appendices to summarize key aspects of the topics.

As the number of BESS installations rise globally, thermal runaway and a fire involving a BESS has become increasingly a topic of consideration for industry and public stakeholders. This topic has been raised through regulatory and permitting processes concerning proposed new BESS projects in Canada, such as in Alberta and Ontario. Additionally, it has been a topic of discussion in media and other jurisdictions such as the United States and Australia.

Objectives of this work scope focused on research and compilation of information, distilling down to key communications to educate key stakeholders and provide the industry in Canada with succinct and clear, publicly available reference materials.

1.1. Chemistries

The most common chemistries employed today are lithium-iron-phosphate (LFP) and lithium-nickel-manganese-cobalt-oxide (NMC) and are accordingly the focus of this summary report.

1.2. BESS Terminology

For context, terminology used in this report will commonly refer to the following for a BESS:

- **Cell** – as per UL 1973, a cell is "the basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy". As shown in Figure 1, a Li-ion battery cell can come in one of the three main formats: cylindrical, prismatic, or pouch.
- **Module** – as per UL 1973, a module is "a subassembly consisting of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry."
- **Unit** – a unit consists of one or more battery modules, electrical connections, protection and control circuits, and thermal management system. A BESS consists of one or more units.

Cylindrical Prismatic Pouch

a) Cell (in three main form factors)

b) Module

c) Unit

Figure 1: Battery cells, module, and unit

2. Li-ion BESS thermal runaway

Thermal runaway in a Li-ion BESS is the phenomenon of exothermic chain reactions, which are chain reactions that release heat, [1] during which the rate of heat generation exceeds the BESS' rate of heat dissipation. Thermal runaway results in sharp uncontrolled temperature rise in the cell, up to 1,000^{0}C depending on the BESS chemistry and State of Charge (SOC)[1].

Figure 2 shows the cell temperature behaviours of different Li-ion chemistries during thermal runaway [2]. The graphs are from experimental measurements. During the experiment, the following occurred at different times:

- Different cells were heated until they fail and start thermal runaway.
- The moment when the heating starts is marked as t=0 in the graphs.
- After approximately 2 hours, the cell failure occurs during which the cell's voltage abruptly drops to 0V and the cell won't be able to supply an electric load.

Thermal runaway can occur when the battery cell has a manufacturing defect, such as a defect in the separator that can cause internal short circuit, or when the cell experiences an abuse, which can be classified into one of the following categories:

- Electrical abuse such as cell overcharge or short circuit due to exposure to fluids (e.g., coolant leakage)
- Mechanical abuse such as crash or penetration
- Thermal abuse such as excessive heat due to thermal runaway of adjacent cells or failure of Thermal Management System (TMS)

When a thermal runaway occurs in one cell, if the BESS was not designed properly, the excessive heat released can cause the adjacent cells to fail and start subsequent thermal runaways that propagate within a module and even a unit.

[1] State of Charge (SOC) is the amount of energy available in the battery at a specific point expressed as a percentage of maximum possible energy stored in the battery. In simple terms, SOC shows how full the battery is.

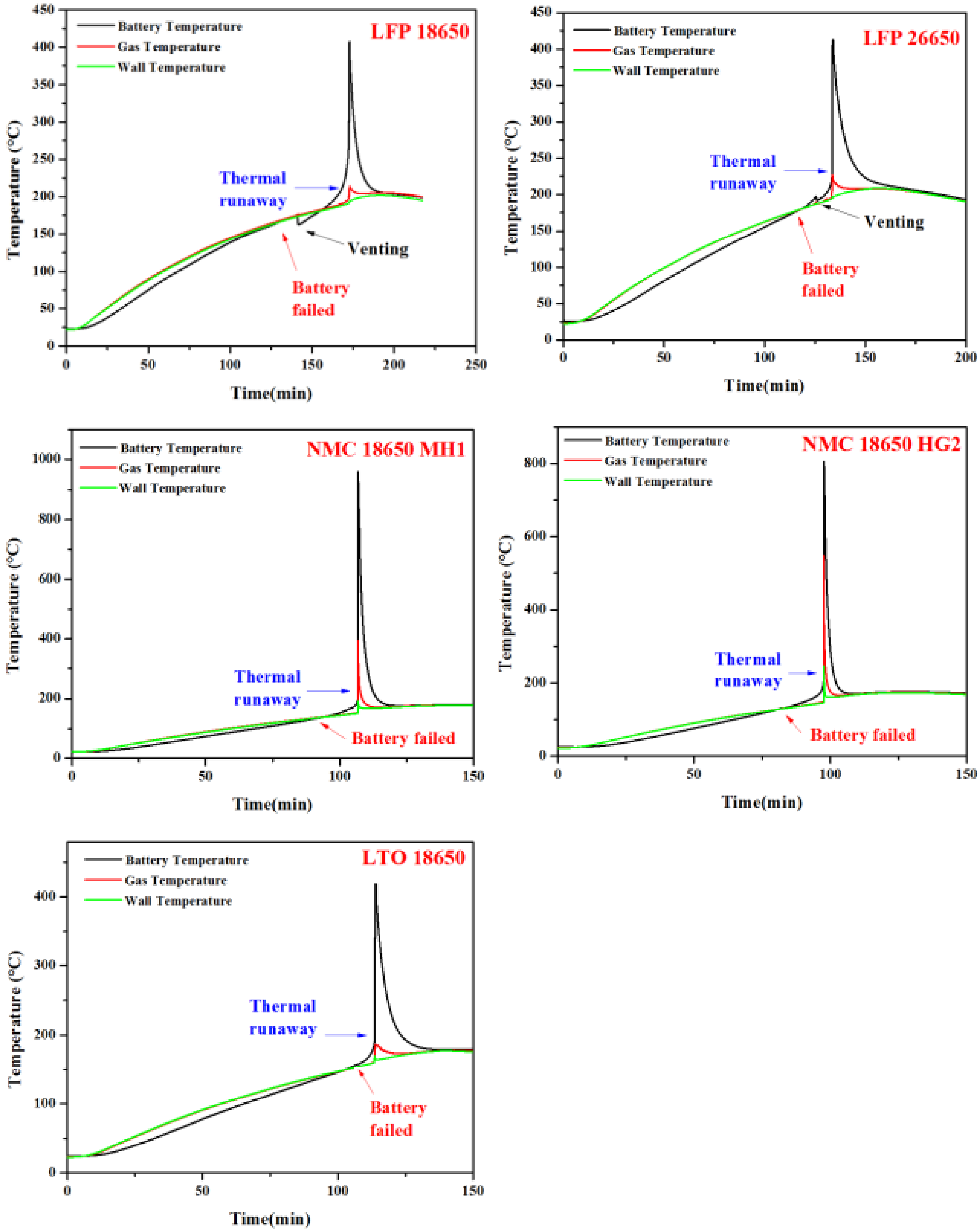

Figure 2: Battery cell temperatures during thermal runaway [2]

3. Safety risks

A BESS thermal runaway event can introduce the following risks to the project site, site personnel, or even to the public if it is not designed, constructed, tested, commissioned, or maintained properly or if the BESS does not comply with applicable codes and standards.

3.1. Fire

The heat generated during thermal runaway can start a fire in a BESS module. Module-to-module propagation can start a fire in a particular BESS unit, and the fire can propagate to the additional units and more broadly on the BESS facility site or even beyond the site boundaries if site design requirements were not followed.

3.2. Explosion

As the temperature increases beyond acceptable levels in a compromised cell, the cell goes through off-gassing or venting due to evaporation of the electrolyte. Some of the gases released, such as hydrogen gas (H_2), are flammable and can explode at a certain concentration during off-gassing unless vented to avoid concentration levels that could risk explosion.

3.3. Toxic fumes

During thermal runaway or BESS fire, depending on the electrolyte composition, toxic fumes such as hydrogen fluoride (HF), phosphorus pentafluoride (PF_5) and phosphoryl fluoride (POF_3) may be released [3]. However, BBA has reviewed the UL 9540A test results for two (2) of the industry leading BESS vendors who both use lithium-iron-phosphate (LFP) cells and in each of those cases, none of those gases were present at a significant level in the measurements. This implies that those toxic fumes are likely not a significant concern based on these examples of actual measured concentrations.

An overview of UL 9540A test is presented in Section 5.2 of this report. Table 1 shows the gas composition in UL 9540A test for a BESS vendor, referred to as vendor “A”, at cell level and expressed as a fraction percentage, and Table 2 shows the gas composition for another BESS vendor, referred to as vendor “B”, at module level and expressed as a measurement peak in parts per million (ppm).

Table 1: Gases released during UL 9540A cell level test for Vendor "A"

Gas		Fraction (%)
Carbon Monoxide	CO	11.1
Carbon Dioxide	CO_2	33.3
Hydrogen	H_2	35.7
Methane	CH_4	10.1
Acetylene	C_2H_2	0.2
Ethylene	C_2H_4	5.3
Ethane	C_2H_6	1.1
Propene	C_3H_6	0.6
Propane	C_3H_8	0.2
Others	-	2.5

Table 2: Gases released during UL 9540A module level test for Vendor "B"

Gas Name	Chemical Structure	Measurement Peak (PPM)
Carbon Monoxide	CO	204.84
Carbon Dioxide	CO2	6720.62
Methane	CH4	67.83
Acetylene	C2H2	Not detected
Ethene	C2H4	Not detected
Ethane	C2H6	Not detected
Propane	C3H8	Not detected
Butane	C3H4	Not detected
Pentane	C3H6	Not detected
Benzene	C6H6	9.01
Hexane	C7H14	Not detected
Hydrofluoric acid	HF	Not detected
Hydrogen Chloride	HCl	Not detected
Hydrogen Cyanide	HCN	Not detected
Hydrogen	H2	446

4. Mitigation tools and strategies

BESS OEMs have implemented several strategies, tools, and mechanisms to minimize the likelihood of thermal runaway occurrence and also to mitigate the safety risks associated with the unlikely scenario of an occurrence of a thermal runaway. The most common tools and strategies are listed below:

- **Battery Management System (BMS)** – BMS continuously monitors the BESS at cell, module and unit level. Voltage and temperature of each cell is monitored to ensure the cell does not experience overcharging/discharging or unacceptable temperatures.
- **Electrical protection** – several electrical protection layers are implemented to a BESS to avoid electrical abuse of the cells such as module overcurrent protection (DC fuses), inverter DC and AC side protection, ground fault monitoring, etc.
- **Thermal Management** – a BESS unit shall be equipped with a TMS to ensure the BESS operates within acceptable temperature range. A TMS can consist of heaters, air or liquid cooling systems, fans, etc.
- **Site design and clearance requirements** – the BESS OEMs provide a site design manual that must be followed by the constructor. The manual determines minimum clearances between the BESS units to each other and to the other elements at site to eliminate the risk of fire propagation.
- **Non-walk-in design** – the non-walk-in design minimizes the risk of fire and toxic fumes to the personnel.
- **Effective ventilation** – in an off-gassing event, fan operation maintains the flammable gases concentrations below their Lower Flammable Limit (LFL) to prevent any explosion.
- **Deflagration panels** – these panels direct the flames away from the personnel or other BESS units (typically towards the sky) to minimize the risk of injury and fire propagation to other BESS units.
- **Pressure release mechanisms** – overpressure vents, blast panels and other pressure release mechanisms are to prevent or control BESS unit explosion.
- **Heat/Smoke/flammable gas/fire detection** – upon operation of these detectors, the BESS unit shuts down while protection and monitoring systems are still active, to avoid further abuse to the cell(s).

- **Sparkers** – some OEMs utilize sparkers to ignite the flammable gases during a thermal runaway to prevent concentration of these gases, and consequently, prevent explosion.
- **Fire suppression systems (aerosol, dry pipe, etc.)** – while these systems are not effective means to suppress lithium battery fire, some OEMs offer these as a part of overall fire safety system to work in conjunction with the rest of the tools listed in this section.
- **Fire resisting walls and shelves for BESS container** – insulating material is being used in BESS container walls and shelves to eliminate the risk of module-to-module and unit-to-unit fire propagation.
- **Continuous thermal imaging at site** – some project owners utilize third-party thermal imaging cameras at sites to continuously monitor the BESS units and detect any hot spots as early as possible.
- **Remote operation/monitoring center by OEM** – some OEMs have 24/7 operation and monitoring centers that continuously receive information from each site and take appropriate actions upon noticing an anomaly in the system.

5. Code and standards

The focus of this section is on the codes and standards related to the safety of Lithium-ion BESS'.

5.1. UL 9540 – Standard for Safety of Energy Storage Systems and Equipment

ANSI/CAN/UL 9540 is a standard for safety of Energy Storage System (ESS) and Equipment. This standard covers different types of ESS such as electrochemical, chemical, mechanical, and thermal. Li-ion BESS falls under electrochemical ESS. UL 9540 covers the following aspects of ESS from a safety perspective:

- Construction
- Performance
- Electrical tests
- Mechanical tests
- Environmental tests
- Manufacturing and production tests
- Markings
- Instructions

UL 9540 requires electrochemical ESS (such as BESS) to be subjected to the large-scale fire testing in accordance with UL 9540A, which will be briefly reviewed in the next subsection.

This standard also requires the BESS to comply with the requirements of UL 1973 which separately will be reviewed in a subsequent section. This standard also has an informative appendix (Appendix B - General Battery Safety Considerations) that covers the design recommendations for BESS. Some recommendations examples are as following:

- BESS should have a two-fault tolerance for all catastrophic failures.
- For a Li-ion BESS, the following should be monitored:
  - voltage should be monitored for every series element
  - temperature should be monitored throughout the battery pack, and
  - battery level currents should be monitored continuously
- Thermal runaway protection should be provided.
- Any off-nominal values should be recorded by the BMS.
- For Li-ion BESS, cells should be spaced and thermally insulated so that cell-to-cell thermal runaway propagation is avoided.

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

UL 9540A is a UL standard that covers the test method for evaluating fire safety hazards associated with propagating thermal runaway within BESS. UL 9540A test does not provide a certificate but rather a test report. The data generated during the test will be used to determine the fire and explosion protection requirements [4]. UL 9540A test is conducted at different BESS levels [4]:

- Cell level test: whether the cell can undergo thermal runaway, thermal runaway characteristics, gas composition, etc.
- Module level test: potential for thermal runaway propagation, rate of release of heat and gas, flaming/deflagration hazards, etc.
- Unit level test: evaluation of module-to-module fire spread, heat and gas release rate, deflagration hazards, re-ignition hazards, etc.

In addition to these three (3) levels, installation level test my be required if any of the unit level performance criteria is not met. Installation refers to a system comprised of multiple BESS units.

Table 3 below summarizes the data generated by UL 9540A testing [5].

Table 3: Data generated by UL 9540A testing

Test level	Data developed
Cell	• Methodology required to initiate thermal runaway for testing • Cell surface temperature at onset of gas venting and thermal runaway • Gas composition, volume, and explosibility parameters
Module	• Number of initiating cells required for propagation of thermal runaway • Heat, smoke, and flammable gas release rates and total release quantity • Observations of external flame extension • Observations of deflagration and debris hazards
Unit	• Extent of thermal runaway propagation • Heat, smoke, and flammable gas release rates and total release quantity • Observations of external flame extension, deflagration, and debris hazards, and re-ignition hazards • Thermal exposure (temperature on adjacent walls, and target units; heat flux to adjacent walls, target units, and egress pathways)
Installation	• Evaluation of fire protection method • Fire growth control • Extent of thermal runaway propagation • Design features related to containment of thermal runaway gases and heat that create an explosion hazard • Deflagration protection system • Egress protection • Thermal exposure to adjacent surfaces • Observations of flaming outside the installation • Observations of reignition • Deflagration and debris

5.3. UL 1973 - Standard for Safety of Batteries for Use in Stationary and Motive Auxiliary Power Applications

ANSI/CAN/UL 1973 is Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications. This standard covers the following topics:

- Construction

- Performance
- Electrical tests
- Mechanical tests
- Environmental tests
- Tolerance to internal cell failure tests
- Manufacturing and production line tests
- Markings
- Instructions

Below are some examples of UL 1973 safety requirements:

- The BESS enclosure shall be constructed to maintain the H_2 concentration below 25% of the LFL.
- The BMS shall maintain the cells within their voltage, current, and temperature limits.
- If safe operating limits are exceeded, a protective circuit shall limit or shut down charging or discharging.
- The BESS shall shutdown upon failure of the TMS unless it can be demonstrated that failure of TMS does not create a hazardous situation.
- A minimum of two (2) gas monitors are required which are suitable for detecting 25% of the LFL of the flammable gasses. As an alternative, a minimum of two (2) continuous spark sources (i.e. sparkers) can be utilized.

5.4. NFPA 855 - Standard for the Installation of Stationary Energy Storage Systems

NFPA 855 is a standard by National Fire Protection Association for the Installation of Stationary Energy Storage Systems. NFPA 855 applies to several types of ESS including but not limited to any Li-ion BESS larger than 20kWh, and sets the minimum requirements to mitigate the hazards of ESS. This standard refers to several other standards from NFPA, UL, ANSI, etc. Fig. 3 [6] shows the BESS codes and standards hirearchy. As this figure shows, NFPA 855 is the tip of the pyramid at the application level, while UL 1973 and UL 9540/A are at the product level, and based on many other supporting standards and documents. As an example, NFPA 855 requires that ESS shall be listed in accordance with UL 9540.

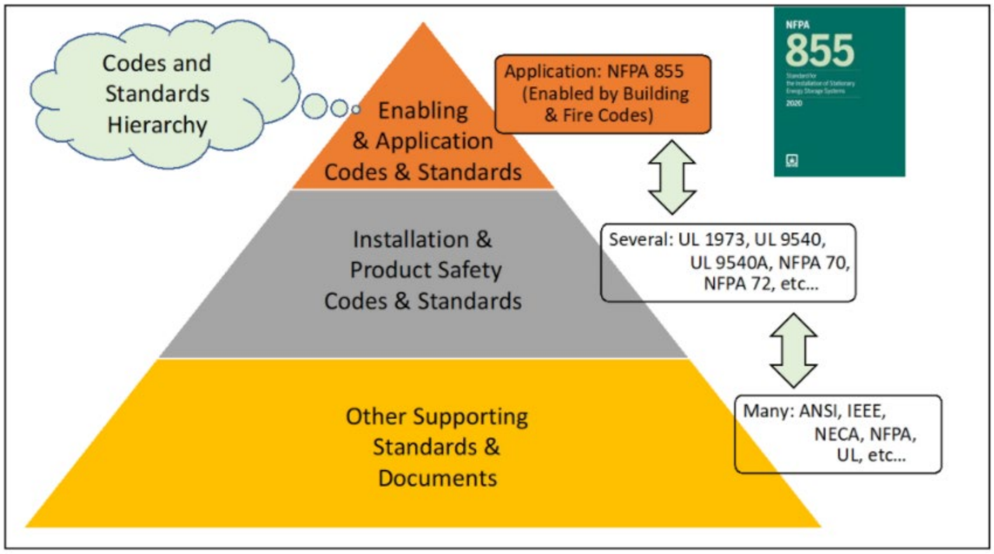

Figure 3: BESS Safety Codes and Standards Hierarchy [6]

6. OEM Survey

As part of this project, BBA developed and issued a questionnaire related to BESS thermal runaway and fire safety. The questionnaire was sent to a select group of BESS OEMs that are most active and with an operating history in Canada (or North America). The goal was to expand upon a review of the applicable codes and standards, publicly available information and our industry knowledge, and gain insights directly from the most active and established original equipment manufacturers and vendors in the BESS market regarding thermal runaway and fire risks, the mitigation measures they apply in their products, and collect operational statistics regarding BESS fire occurrences.

7. Conclusion

BESS chemistries being used in modern stationary Li-ion systems are increasingly employing chemistries that are more stable and have a lower likelihood of thermal runaway and fire.

While the chemical nature of a BESS does present some degree of risk in of thermal runaway and fire, robust standards exist outlining the necessary detailed requirements for system design, configuration, construction, performance, and monitoring.

There are also specific standards requiring testing of each BESS and gathering of empirical data prior to any on-site installation. The existence and widespread adoption of these standards provides the energy storage industry with a strong foundation from which to safely develop, plan and execute BESS projects and operating the facilities.

BESS OEMs employ numerous strategies, methods and tools to mitigate the risk of thermal runaway and fire, through a combination of prevention, detection, containment and reduced propagation, and which is supplemented by any measures applied by project developers and facility operators.

Additionally, it is strongly recommended for each BESS project and facility to ensure a high degree of diligence in pre-planning for emergency response, developing procedures and communications protocols, and ensuring operational personnel and first responders are adequately and periodically trained.

The likelihood of a BESS thermal runaway event is low, and with the additional mitigations and fire safety measures applied, the potential consequences of a BESS are easily outweighed by the numerous unique advantages it offers to the electricity grid, and consequently, to the public, which must be considered by the public stakeholders.

8. Recommendations

BBA's recommendations to Li-ion BESS project developers, constructors, and other stakeholders involved in a Li-ion BESS project is the following:

- The current technology trend is moving away from indoor or walk-in utility scale BESS to non-walk-in outdoor enclosures, which is recommended.
- Transitioning from Nickel-based chemistries such as lithium-nickel-manganese-cobalt-oxides (NMC) to LFP to reduce the risk of thermal runaway is recommended and is also an industry trend that has been adopted by several BESS original equipment manufacturers.
- The BESS product shall have all the test reports and certifications required by the Authority Having Jurisdiction (AHJ) – at minimum, UL 9540A test results shall be provided, and the BESS shall be compliant with UL 9540, UL 1973, and NFPA 855.
    - The aforementioned standards represent current industry best practice and should be followed where possible, even if these are not explicit requirements in a particular jurisdiction.

- The strategies, methods and tools that are offered by BESS OEMs should be considered and reviewed when planning a BESS development project and procuring a BESS.
- The constructor shall follow the design procedures and meet the site design requirements outlined by the BESS OEM.
- Robust testing and commissioning shall be completed prior to BESS system completion. All HVAC, protection, control, alarm, SCADA and communication schemes shall be in place and tested with acceptable results before undertaking commissioning of the BESS.
- An Emergency Response Plan (ERP) shall be in place and shall include the Emergency Response Procedure, datasheet, manuals, test results, etc. by the OEM.
- Training and educating local first responders about Li-ion BESS thermal runaway and fire in general, safety considerations and actions to take, specific to each project is crucial.
    - Firefighters shall be familiar with the nature of Li-ion BESS fire, prolonged fire with chance of reignition, and shall be trained how to respond to such a fire, taking actions in consulting the ERP and BESS OEM operating manual and safety instructions.
    - For example, actions could include: Allow the unit safely burn and extinguish itself while monitoring from a safe distance, and urgently taking other steps to ensure the fire does not propagate to other units

9. References

[1] S. Shahid et M. Agelin-Chaab, «A review of thermal runaway prevention and mitigation strategies for lithium-ion batteries,» *Energy Conversion and Management: X,* vol. 16, 2022.

[2] W. Tang, W. C. Tam, L. Yuan, T. Dubaniewicz et J. Soles, «Estimation of the critical external heat leading to the failure of litium-ion batteries,» *Applied Thermal Engineering,* vol. 179, 2020.

[3] F. Larsson, P. Andersson, P. Blomqvist et B.-E. Mellander, «Toxic fluoride gas emissions from lithium-ion battery fires,» *Scientific Reports,* vol. 7, 2017.

[4] UL Solutions, «Test Methods for Evaluating Thermal Runaway Propagation in Battery Energy Storage Systems Webinar,» 2023.

[5] A. Barowy, A. Klieger, J. Regan et M. Mckinnon, «UL 9540A - Installation Level Tests with Outdoor Lithium-ion Energy Storage System Mockups,» UL Solutions, 2021.

[6] Energy Safety Response Group (ESRG), «Battery Safety 101 Webinar,» 2023.

BESS Thermal Runaway & Fire Risk

Q & A

Report Q & As

What can I learn from this report?

A: This report explains what original equipment managers (OEMs) of battery energy storage systems (BESS) are doing to prevent mechanical hazards in their projects and ensure public safety. It also includes recommendations for other BESS constructors and developers and outside stakeholders that may be involved in a BESS project.

Who did BBA consult for this report?

A: BBA received information from a select group of four OEMs with an active and operating history in Canada (or North America).

What information did you get from them?

A: We received information ranging from the type of chemistry they use for their products and the codes and standards they follow, to their safety features and fire prevention and suppression systems to protect what's known in the industry as thermal runaway.

How likely is thermal runaway – the chain reaction which can lead to hazards like fire – in BESS?

A: Thanks to advanced technology and modern chemistry adoption of lithium-based systems, the risk of is considered 'extremely low.'

Have the OEMs you consulted ever encountered incidents of thermal runaway with its products?

A: Three of the four have never had a thermal runaway incident. In the case of the one that did, those incidents involved an older generation of systems, with no thermal events for its current lithium-based product. These also occurred at the commissioning and testing stage, with the only damaged property being a block in the BESS itself.

What sorts of codes and standards must these projects meet?

A: Codes, standards and testing range from the construction and installation of the projects themselves, to their hazard prevention, mitigation and suppression systems. A full list is included in the report.

What are OEMs doing to keep these projects safe?

A: There are safeguards at every stage of a BESS project. When it comes to design and construction, OEMs include ventilation, special panels, fire resisting walls, detectors, and non-walk-in structures to minimize the risk of fire and fumes to personnel. There are also clear instructions on the installation of these facilities and afterwards, ongoing monitoring systems of its batteries, temperature, and thermal imaging. A more detailed list is available in the report.

What have been the key recent trends of ensuring safer BESS?

A: Current technology trends include moving away from indoor or walk-in facilities to outdoor enclosures, as well as adopting lithium-based projects vs. nickel-based.

What happens if a particular jurisdiction doesn't have explicit requirements for certain parts of a BESS?

A: Any standards outlined in the report should be followed even if they are not explicit requirements for a particular jurisdiction.

What other responsibilities do OEMs have?

A: Robust testing including HVAC, protection, control, alarm and other measures shall be completed, as well as having an Emergency Response Plan before BESS system completion.

What role do other staff that might come into contact with a BESS (constructors, emergency staff) have?

A: Any constructor must follow design procedures and meet site requirements outlined by a BESS OEM. Training and educating local first responders about BESS thermal runaway and fire is also crucial, including how they differ from more conventional structure fires.

ABOUT ENERGY STORAGE CANADA

Energy Storage Canada is the only national voice for energy storage in Canada today. We focus exclusively on energy storage and represent the full value chain of energy storage opportunities in our own markets and internationally. Energy Storage Canada is your direct channel to influence, knowledge and critical industry insights.

Ontario is in the midst of one of the largest procurements for energy storage in North America, and Energy Storage Canada is supporting that process by sharing clear, accessible, information about these projects, such as:

- **Energy storage is a critical lever to provide a sustainable, reliable, flexible energy grid for Ontario as the province looks to accelerate its transition to a low-carbon electricity.**
- **Energy storage technology is dependable and affordable.**
- **Canada is on an express path to decarbonization, and energy storage solutions are critical to ensuring we can achieve our objectives as a country.**

Energy Storage Canada is engaged with governments and companies across Canada, and with counterparts in the US & globally, providing a depth & breadth of information & expertise.