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301 – 31 Lakeshore Road East
Port Credit, ON L5G 4V5
Canada
T +1 905.271.7800

Amp Solar Development, Inc. – Energy Storage System Risk Mitigation Strategy

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Introduction

Amp Solar Development, Inc. ("Amp") is committed to meeting or exceeding all local, state, and federal fire requirements for energy storage systems. Amp's energy storage equipment is chosen based on safety, quality, and efficiency standards and will be installed in a way that minimizes the risk of fire and subsequent damages. This document explains potential safety concerns and their mitigation strategies. A key focus for Amp is to collaborate with the local fire department to ensure the system design and operation is acceptable and well understood by first responders.

Technology

Amp's Energy Storage Systems ("ESS") utilize state-of-the-art lithium-ion battery technology contained in secure, controlled enclosures. The ESS solution employs factory-built LFP energy storage solution that includes explosion prevention and fire safety features.

These ESS enclosures include the following equipment:

- Battery cells – solid-state lithium-ion cells from a tier-one battery cell supplier,
- Battery Management System ("BMS") – used to monitor battery cell state of charge, cell health, and is capable of shutting off any battery cell experiencing unusual conditions,
- Power conversion equipment – used to regulate the power supplied by the battery modules for optimum operation,
- Security system – used to deter unauthorized access and theft,
- Heating Ventilation and Air Conditioning ("HVAC") system – used to control the temperature inside the enclosures for optimum battery performance and safety,
- Fire suppression system – actively monitors the temperature and automatically deploys fire suppression agents in the event of a fire.

Amp uses battery cells from leading cell manufactures and collaborates with leading battery system integrators to build safe and reliable ESS installations that comply with all relevant electrical and mechanical engineering standards, including Underwriters Laboratories ("UL") battery cell certifications. During the procurement and detailed design of the ESS, Amp consults with the local fire department in order to incorporate

specific local requirements for fire safety. Once the system is installed, Amp can facilitate site visits by the fire department to inspect the system and better understand the safety systems and operation. Amp can provide additional information as required and involve the ESS equipment supplier as needed.

Siting of Energy Storage Systems

The objective of Amp ESS installations is to harvest the maximum amount of clean solar energy. The ESS will be co-located with the solar energy inverters in safe sites with sufficient separation from other buildings. Following the National Fire Code (NFPA 1), International Fire Code (ICC IFC-2018), National Electrical Code (NFPA 70) and Standard for the Installation of Stationary Energy Storage Systems (NFPA 855), Amp ESS sites will maintain safe distances (more than 5 ft) from lot lines, public ways, buildings, and other combustibles as well as the necessary 2-hour fire barriers required by NFPA Codes.

Possibility of Thermal Runaway

Thermal runaway is an infrequent situation when the battery cell temperatures rise so high that the cells become unstable. This situation only occurs when the cells are operated outside of their normal temperature range without being cooled by an HVAC system. Runaway temperatures of typical battery chemistries vary from 302°F to 518°F [1]. Given that all these battery chemistries have high thermal runaway temperatures, Lithium-ion cells are thermally stable in the range of normal ambient temperature variations.

Mitigation of Thermal Runaway

Battery packs are fitted with separation walls to stop the failing cell from spreading to neighbouring cells. The BMS monitors and controls the batteries to ensure they remain in acceptable performance and safe operating conditions. The BMS monitors abnormal conditions of each battery cell and takes active preventive measures. Each Amp ESS is also equipped with a dedicated HVAC system, which operates automatically at abnormal temperatures. Amp projects are developed with advanced Energy Management Systems ("EMS") to optimize the energy dispatch between the ESS and the PV system. The EMS ensures battery cells are not stressed or abused during normal operation, which could lead to thermal runaway.

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Possibility of Fire:

The chance of a fire caused by the ESS is very low. Lithium-ion battery electrolytes contain different solvents, which may be flammable [2]. However, flashpoints (burn temperature) of these electrolytes are very high, and they have been sealed in air-tight cell pouches. Since all the batteries are also contained in a NEMA-rated enclosure, the possibility of cell damage due to impact and exposure of flammable solvents to catch fire is very low.

Accumulation of Combustible Gases:

A thermal runaway event can produce combustible gasses. Accumulation of such gases should be vented out to mitigate possible explosions. Amp ESS enclosures are equipped with gas detectors. When gas accumulations are detected, the HVAC system vents out such gases. Due to this safety design, the possibility of gas accumulations is considerably low with Amp ESS enclosures.

Fire Suppression:

Each Amp ESS is equipped with a fire suppression system. This includes the use of industry-approved safe fire suppression agents such as FM 200 and aerosol to lower the temperature and oxygen level within the enclosures rapidly. The ESS enclosures are sufficiency sealed to contain the fire and are equipped with smoke detectors to automatically switch off the HVAC system and notify the local fire department. Amp works closely with the local fire department to ensure that they are familiar with the equipment and are provided 24-hour access in the event of a fire to safely prevent the fire from propagating outside of the equipment area. In the unlikely event of a fire, Amp battery cells will burn out inside their enclosures due to fire propagation restrictions in place. Amp ESS installations comply with the following fire regulations:

NFPA 70: National Electrical Code
NFPA 1: Fire Code
NFPA 855: Standard for the Installation of Stationary Energy Storage Systems
ICC IFC-2018: International Fire Code
UL – 1973: Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
UL – 9540: Standard for Energy Storage Systems and Equipment

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Possibility of Electrolyte Spills

Lithium-ion batteries contain electrolytes that are semi-solid or gel, depending on their solvent characteristics [2], and have very high melting points, so the risk of spillage is very low during normal operating conditions. Electrolytes used in Amp cells are nonaqueous materials [3] and do not easily mix with water. With different layers of packaging, the risk of water contamination is very low.

Spill Mitigation

Amp ESS has several layers of packaging. All the cells with electrolytes are packaged in air-tight pouches. Then these cells are packaged as battery modules within battery racks. All the battery racks are contained within a NEMA-rated enclosure. Considering these different layers of packaging, it is very unlikely that a spill will occur outside of the ESS. Given the technology employed by Amp's ESS solution, electrolyte in LFP cells is largely absorbed in the electrodes within the individual cells (which are individually wrapped and contained in trays). In practical terms, in Amp´s ESS solution there is no liquid electrolyte that is freely flowing within each LFP cell that can easily leak out into the environment once the cell is damaged. Furthermore, Amp battery enclosures will be installed on elevated equipment pads for added containment.

Possibility of Gas Emissions

Lithium-ion batteries do not produce measurable gas emissions while they are under normal operation [4]. In an unlikely event of a battery fire, different toxic gases could emit based on the battery cells and packaging materials [5]. However, the possibility of a fire and subsequent gas emission is very low due to the fire prevention and suppression measures described above.

Risk of Lightning:

In Amp ESS projects, batteries are placed in NEMA outdoor rated enclosures, which are electrically grounded using stable grounding grids. Therefore, enclosures could never be electrically energized in any situation. Even though the risk of lightning cannot be mitigated, the damage due to lightning has been mitigated with these actively grounded enclosures. These enclosures act as "Faraday Cage" during lightning events and protect all the contents from electrical damage.

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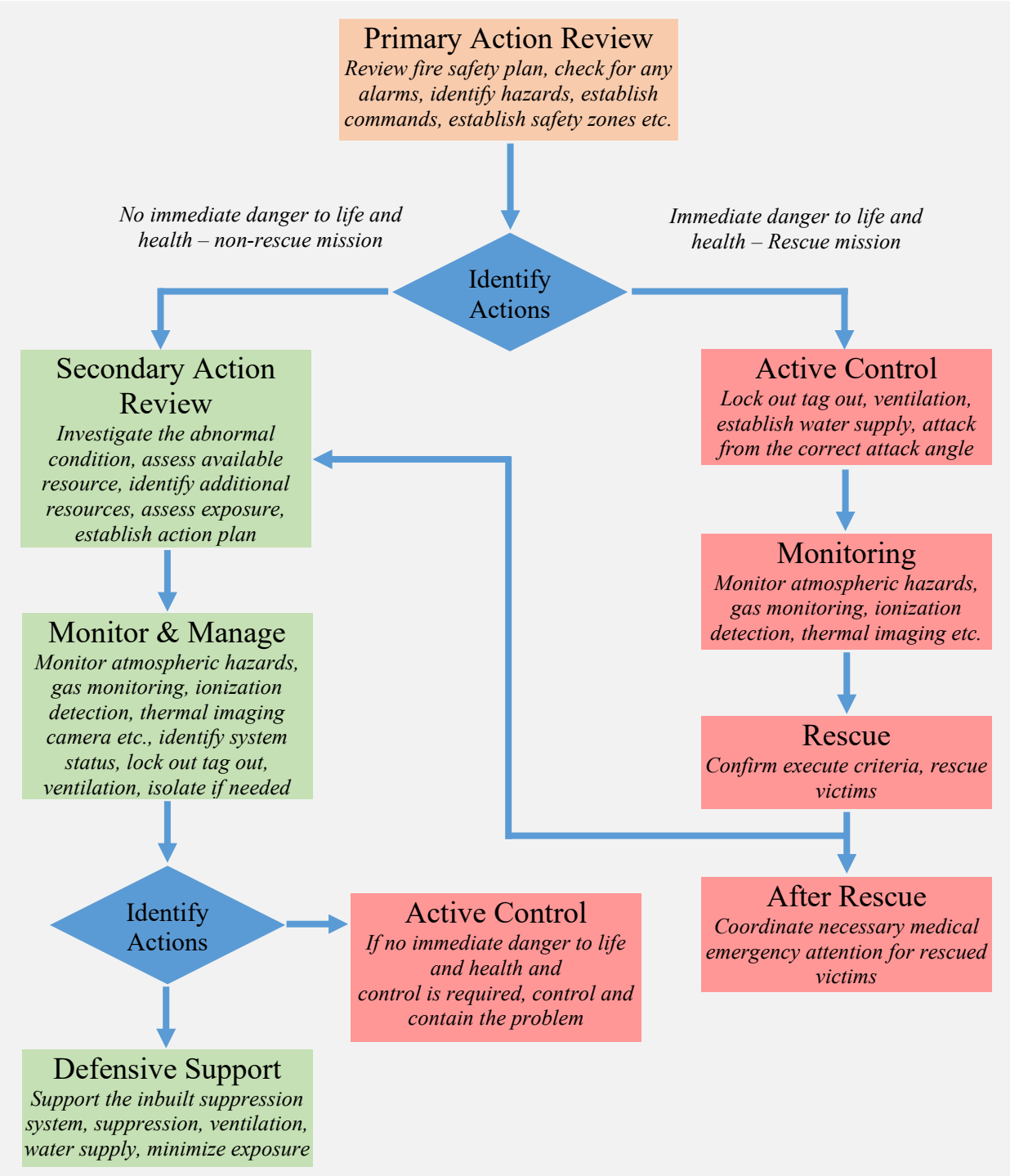
Fire Safety Plan

Amp selects battery cell technology for each project based on the battery operation requirements. The chemical compositions of these cell technologies vary from project to project. Each battery comes with an appropriate fire suppression system designed to trigger automatically in the event of a fire. The following fire safety procedure forms the basis for initial discussions with the local fire department and can be updated for each project based on additional requirements.



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Scientific References

[1] Understanding Lithium-ion.
https://batteryuniversity.com/learn/archive/understanding_lithium_ion

[2] Qi Li, Juner Chen, Lei Fan, Xueqian Kong, Yingying Lu, Progress in electrolytes for rechargeable Li-based batteries and beyond, Green Energy & Environment 1 (2016) 18 – 42.
https://www.sciencedirect.com/science/article/pii/S2468025716300218

[3] Makoto Ue, Yukio Sasaki, Yasutaka Tanaka, Masayuki Morita Nonaqueous Electrolytes with Advances in Solvents.
https://link.springer.com/chapter/10.1007/978-1-4939-0302-3_2

[4] Mia Romare and Lisbeth Dahllöf, The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries, IVL Swedish Environmental Research Institute, S-100 31 Stockholm, Sweden.
http://www.energimyndigheten.se/globalassets/forskning--innovation/transporter/c243-the-life-cycle-energy-consumption-and-co2-emissions-from-lithium-ion-batteries-.pdf

[5] Final Report Considerations for ESS Fire Safety. Consolidated Edison and NYSERDA New York, NY, DNV.GL, Report No.: OAPUS301WIKO(PP151894), Rev. 4 February 9th, 2017.
https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Energy-Storage/20170118-ConEd-NYSERDA-Battery-Testing-Report.pdf