The Li-ion Tamer Battery Rack Monitor is a safety product specifically designed to detect the potential thermal runaway of lithium-ion batteries. The key to Li-ion Tamer’s value proposition is the distributed gas sensing network that provides the earliest warning of battery failure by detecting single cell off-gas events which precede thermal runaway. (Please see our blog post on stages of the battery failure here for more information). If Li-ion Tamer off-gas monitoring is paired with proper mitigating actions, thermal runaway can be entirely avoided.

Market Background
The lithium-ion battery energy storage market is growing at an alarming rate and is projected to be a market that exceeds $100BN by 2030. The proliferation of electric vehicles have caused the cost of lithium-ion batteries to decrease to the point that they are now cost-effective for stationary applications. There are many utility and commercial/industrial applications for energy storage (see use cases here), such as renewables intergration, frequency regulation, transmission deferral, back up/uninterruptible power supplies and many more.

There has been a recent increase in lithium-ion battery stationary energy storage system fires in many countries which have highlighted the weaknesses and inherent fragility of lithium-ion batteries. This has caused many end users to be fearful of the battery chemistry and Li-ion Tamer is a great product to help ease their fears and increase the proliferation of lithium-ion batteries.

Key Features
- Earliest warning of lithium-ion battery failures
- Prevents thermal runaway with proper mitigating actions
- Single cell failure detection without electrical or mechanical contact of battery cells
- Calibration-free detectors for long operational life
- High detection reliability with referencing control to avoid false positives
- Compatible with all lithium-ion battery form factors and chemistries
- Auto diagnostic algorithms to optimise response
- Independent and redundant perspective on battery health monitoring
- Simple plug and play for new and retrofit installations
- Low power consumption

Code Compliance
- CE
- ETL (to UL 61010 standard)
- UL 2075 standard (In progress)
Cater your sales message

The lithium-ion battery stationary energy storage market has a similar supply chain to other fire protection technologies and your sales message should be targeted to the respective audience. Depending on the level of knowledge of your audience, you can use a data, value-oriented or education communication strategy to help set the stage for Li-ion Tamer.

Potential audiences:

**Battery/Rack Manufacturer:** Manufacturers li-ion cells, integrates battery modules, integrates battery racks

**Battery Systems Integrator:** Specifies, integrates, installs li-ion battery racks, HVAC, other power equipment, and potentially the fire suppression/detection system

**Fire Engineered Systems Distributor (Fire ESD):** Integrates and installs fire suppression/detection system

**Engineering, Procurement and Construction (EPC)/Project Developers:** Private sector company who undertakes large-scale and complex infrastructure projects.

**End Users:** The entity who is using the energy storage system and utilizing one or many of the different ways the system can be used.

**Authority Having Jurisdiction (AHJ):** Organization, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

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<table>
<thead>
<tr>
<th>Data, Value-Oriented Communication Flow</th>
<th>Facts</th>
<th>Educational Communication Flow</th>
<th>Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro to Product, Development History</td>
<td>Funded by US Navy 10 years of R&amp;D</td>
<td>Intro to Lithium-ion Batteries</td>
<td>The salesperson should do their own research here and highlight the inherent flammability of the electrolyte.</td>
</tr>
<tr>
<td>Codes &amp; Regulations</td>
<td>NFPA 855 UL 9540A</td>
<td>Use Cases of Energy Storage Systems</td>
<td>See use cases here.</td>
</tr>
<tr>
<td><strong>Stages of Battery Failure</strong></td>
<td>Stage 1: Abuse Stage 2: Off-gas Stage 3: Smoke Stage 4: Fire</td>
<td>Korean battery failure data</td>
<td>South Koreans have had 29 lithium-ion battery failures in 2019. South Korean government shutdown 30% of existing energy storage systems and stopped the deployment of all new energy storage systems in early 2019.</td>
</tr>
<tr>
<td>Data (heavy)</td>
<td>Third party data Summarized data What gases does Li-ion Tamer detect?</td>
<td>Codes &amp; Regulations</td>
<td>NFPA 855 UL 9540A</td>
</tr>
<tr>
<td>Applications Engineering (heavy)</td>
<td>Demonstration of capability to detect in different customer conditions</td>
<td>Stages of battery failure</td>
<td>Stage 1: Abuse Stage 2: Off-gas Stage 3: Smoke Stage 4: Fire</td>
</tr>
<tr>
<td>Benefits</td>
<td>Li-ion Tamer applications engineering process</td>
<td>Data (light)</td>
<td>Summarized data What gases does Li-ion Tamer detect?</td>
</tr>
<tr>
<td>------------------------------------</td>
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</tr>
<tr>
<td><strong>Case Studies</strong></td>
<td>See external case studies document</td>
<td>Applications Engineering (light)</td>
<td>Li-ion Tamer applications engineering process</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
<td></td>
<td>Early warning Prevent thermal runaway Easy to install Calibration-free Reliable signal</td>
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</tr>
</tbody>
</table>

**Bolded text indicates points that should be hit during elevator pitches.**

**Value Proposition**

<table>
<thead>
<tr>
<th>Customer Needs</th>
<th>Educational Communication Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early warning of lithium-ion battery failure</td>
<td>• Monitor for cell venting/off gas events to provide earliest indication of failure</td>
</tr>
</tbody>
</table>
| Minimum false alarms, high reliability | • Three layers of defence against false positives  
• Customized Li-ion Tamer solution to ensure maximum compatibility |
| Redundant, independent monitoring | • Provides a physical measurement of the failure  
• Designed to operate outside of the existing battery controls systems |
| Minimize downtime                  | • Use granular sensor network to understand exactly where events have occurred |
| Easy installation                  | • Intuitive, quick and user-friendly installation process |
| Low maintenance                    | • Simple “puff test” to validate sensor operation |
Frequently Asked Questions

Is the Li-ion Tamer system compatible with any lithium-ion battery chemistry?

The Li-ion Tamer system has been proven to work with all lithium-ion battery chemistries, form factors, and system designs. The sensors are tuned to gases that are released by the electrolyte solvents, which are made up of the same basic volatile, flammable organic compounds.

Shouldn’t battery management systems provide early warnings of failures?

- Battery management systems typically provide electrical and temperature monitoring only and do not address physical damage nor do they specifically monitor for off-gas events; a reliable early indication of battery failure.
- Li-ion Tamer is an independent monitoring system and provides redundancy from BMS.
- BMS often have limitations (e.g. measuring voltage across parallel strings, not very many temperature sensors).
- The energy storage industry recognizes that large scale fires are possible even with the existence of battery management systems, hence the creation of NFPA 855 and UL 9540A. The Li-ion Tamer product can be used to prevent large scale fires by detecting off-gas events, which preclude thermal runaway.

How does the Li-ion Tamer product work with the fire panel?

The Li-ion Tamer system works best by initiating electrical isolation of the battery systems to help prevent thermal runaway. It is most important that the batteries are no longer being charged or discharged when an off-gas event happens. Electrical isolation can be initiated through the fire panel or through the battery controls systems, whatever is necessary for performing the correct mitigating action.

The controller natively has digital outputs which can drive relays. The digital outputs are addressable (i.e. there is a unique output for every sensor) and there is also a dedicated digital output for an aggregated alarm. These relays create dry contacts and can directly communicate with fire panels.

Additionally, used in conjunction with smoke detection, the Li-ion Tamer product is a great method for informing the initiating of fire suppression.

Is the Li-ion Tamer required by codes and standards?

NFPA 855 2020 4.2.9.2 “The Energy Storage Management System (ESMS) shall electrically isolate the components of the Energy Storage System or place it in a safe condition if potentially hazardous temperatures or other hazardous conditions are detected.”. Li-ion Tamer is a monitoring system for detecting hazardous conditions.

NFPA 855 2020 4.1.4.1 states “A hazard mitigation analysis (HMA) shall be provided to the AHJ for review and approval…”. Li-ion Tamer is a great barrier to failure that can be documented in an HMA.

How does the cost of Li-ion Tamer compare to a Lithium-ion Installation?

Total battery system costs* (NREL 2018 Report).
<table>
<thead>
<tr>
<th>Capacity</th>
<th>60 MW, 30 MWhr</th>
<th>60 MW, 60 MWhr</th>
<th>60 MW, 120 MWhr</th>
<th>60 MW, 240 MWhr</th>
</tr>
</thead>
<tbody>
<tr>
<td>System cost</td>
<td>$27M</td>
<td>$36M</td>
<td>$54M</td>
<td>$91M</td>
</tr>
<tr>
<td># of Racks</td>
<td>325</td>
<td>475</td>
<td>875</td>
<td>1700</td>
</tr>
<tr>
<td># Li-ion Tamer sensors*</td>
<td>266</td>
<td>375</td>
<td>652</td>
<td>1282</td>
</tr>
<tr>
<td># Li-ion Tamer controllers</td>
<td>20</td>
<td>27</td>
<td>47</td>
<td>92</td>
</tr>
<tr>
<td>Li-ion Tamer cost</td>
<td>$385K</td>
<td>$539K</td>
<td>$1.2M</td>
<td>$1.8M</td>
</tr>
<tr>
<td>Li-ion Tamer cost as % of system cost</td>
<td>1.4%</td>
<td>1.4%</td>
<td>2.2%</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

* Racks, sensors, and controllers are all estimates.

Competitors Key Facts & Overview

The threat of thermal runaway is very real and becoming more understood in the fire engineering community. With the amount of stored energy in lithium-ion facilities the subsequent fires are intense and devastating. Customers with lithium-ion batteries are keen to avoid that impact to their facility and their reputation.

Look at these YouTube videos to appreciate a thermal runaway event:

https://www.youtube.com/watch?v=BpNLoznxwqY

https://www.youtube.com/watch?v=Cx03a8GvrXA

Often standard fixed gas systems are deployed and may be combined with early warning smoke detection systems in battery installations. Smoke is generated later in the battery failure cycle and while important for fire response measures does not provide the earliest possible warning of potential battery failure. Some gas systems are being marketed but they do not have the tuned gas monitoring capability of Li-ion Tamer and do not provide the rack level protection required for very early warning of off gas events.

If a customer does not deploy early warning measure they may lose their battery facility which costs ~$1M per MW.

The key competition is the lack of understanding of how a lithium-ion battery fails and why/how the Li-ion Tamer system is able to detect an off-gas event. If a potential customer understands this then the Li-ion Tamer product sells itself. It is critical this is addressed during customer communication.