Energy Storage Hazard Analysis and Risk Management

09/24/2015 - David Rosewater, Adam Williams, Don Bender, Josh Lamb, Summer Ferreira
Project Overview: Scope

Advance the State of the Art in Energy Storage Safety Analysis

Ensure Impact Through Publication and Collaboration with Industry Stakeholders

Leveraged by Sandia’s Expertise in:
- Battery Safety Testing
- Hydrogen Safety
- Nuclear Power Plant Safety
- Cyber Security
Impacts

Publications


- D. Bender “Recommended Practices for the Safe Design and Operation of Flywheels” Undergoing external expert review before Sandia publication
Impacts

Industry Engagement


- Served on Standards Technical Panel for UL 9540 Outline of Investigation for Energy Storage Systems and Equipment

- Assisted in the formation of the ESSWG and now lead of the Safety Outreach and Incident Response group
Conference Papers and Presentations on ESS Safety

Engineering Systems Theory Applied to Stationary Energy Storage Safety
- Battery Safety, Washington DC, November 2014

Safety Validation in Grid Energy Storage
- EASE Global, Paris France, November 2014

System’s Safety in Grid Energy Storage: Challenges and Solutions through the Application of STAMP
- STAMP Workshop, Boston MA, March 2015

Hazard Analyses in Complex Energy Storage Systems
- Next Generation Batteries, San Diego CA, April 2015

Intro to FMEA and SSA in Energy Storage
- ESA Annual Meeting, Dallas TX, June 2015

Guide to Safety in Utility Integration of Energy Storage Systems
- California PUC Hearing, San Francisco CA, August 2015
Advancing the State of the Art in Energy Storage Safety Analysis
Probability Risk Assessment (PRA)

Analysis answers three questions:

1. **What** can go wrong?
2. How **likely** is that?
3. How **bad** would that be?

PRA Consists of a combination of Event trees and Fault trees

Example Fault Tree: If...

Example Event Tree: tracks deterministic events and outcomes
“With systemic thinking, we recognize that "the cause" frequently lies in the very structure and organization of the system.” (Senge 1990)
“Safety is an emergent property that arises when system components interact with each other within a larger environment.”

(Leveson 2012)

If safety is an emergent property, why/how do accidents happen?
Accidents occur when interactions violate safety constraints.

The system enforces these constraints using control.

Being evaluated for use by:
- Boeing
- EPRI
- NRC
- VOLPE
- Etc.

[Leveson, 12, 13, 14]
System’s Theoretic Process Analysis (STPA) is an effective hazard analysis technique that provides unique incite into battery system safety

Safety Constraints can be rigorously assessed using a combination of analysis and testing.

There is much more to safety then making batteries inert under abuse conditions
Conclusion

Impacts
• The state of the art in energy storage safety has been improved
• Impact has been assured through publication and collaboration
• Advanced hazard analysis techniques are now more accessible to the energy storage industry

FY 16
• Lead the Safety Outreach and Incident Response group as part of the ESSWG
• Publish analysis and testing protocol for safety validation based on advanced hazard analysis techniques
This work was funded by the US DOE OE. Special thanks to Dr. Imre Gyuk for working to develop the ES industry and supporting Sandia’s ES Program.

Questions?

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