Energy Storage System Safety Working Group Activities, Achievements and Next Steps

Sandia National Laboratories and Pacific Northwest National Laboratory

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Overview

**Purpose** – to provide an overview of the status and accomplishments associated with the DOE ESS Safety Working Group activities that can serve as a foundation for future work to meet the stated goal

“Facilitating the timely development and deployment of safe ESS by implementing the DOE ESS Safety Plan through collaboration of all interested parties and key stakeholders”

**Expected Outcomes**

- Recognize key collaborative relationships
- Understand needs and what has been done to address those needs
- Identify and address ongoing challenges to meeting the above goal and how to best organize the collaboration needed to be successful
Energy Storage Safety Working Group Organizational Structure

1) Validation & Risk Assessment (R&D)
   - POC: Summer Ferreira, SNL
   1A) R&D Subcommittee on Technical Priorities

2) Codes & Standards (CSR)
   - POC: Dave Conover, PNNL
   - TF – Compliance Guide Development
   - TF – ESS Installation
   - TF – Mechanical Safety Criteria

3) Outreach & Incident Response (O&IR)
   - POC: David Rosewater, SNL

Energy Storage System Safety Working Group
Collaboration

- All interested and affected parties are encouraged to participate
- Communication is directly with stakeholders as well as key organizations representing specific types of stakeholders
- The makeup of the participants of each group span the industry:
  - Safety Validation and Risk Assessment
    - 110 on the distribution list, 30 average meeting attendance
    - 25 on the Priorities and Gap Assessment subcommittee
  - Codes and Standards
    - 108 on the distribution list, 35 average meeting attendance
    - 6 on the mechanical safety task force (drafted input to UL 9540)
    - 18 on the ESS Compliance Guide task force
    - 11 on the ESS Installation Pre-standard task force
  - Safety Outreach and Incident Response
    - 100 People on the distribution list, 30 average meeting attendance
Working Groups Address Safety Across the Board

ESS Safety Topology

Research

- Organize annual ESS Safety R&D Forum and in person meeting of the working groups
- Identify top R&D priorities and CSR gaps and conduct R&D to address:
  - Fire suppression testing and analysis
  - Thermal runaway research
  - System scale burn test
  - Commodity classification development
  - Fire and vent gas modeling and analysis

Codes and Standards

- Components
  - UL 489 (Circuit Breakers)
  - UL 810A (Electrochemical Capacitors)
  - UL 1642 (Lithium Batteries)
  - UL 1973 (Batteries for Stationary Applications)
  - UL 1974 (Second Use Batteries-DRAFT)
  - NFPA 791 (Recommended Practice and Procedures for Unlabeled Electrical Equipment)

- Systems Layout
  - IBC (Building Code)
  - NFPA 5000 (Building Code)
  - NFPA 70 (Electrical Code)
  - NFPA 1 (Fire Code)

- Safety Systems
  - NFPA 850 (Electrical Generation)
  - NFPA 70 (Electrical Code)
  - NFPA 1 (Fire Code)

- Entire Energy Storage System
  - UL 9540 (Safety for ESS DRAFT)
  - UL 3001 (Safety for Distributed Energy Generation and ESS)
  - ASMETES 1 (Molten Salt Thermal Energy Storage Systems)
  - NFPA 791 (Recommended Practice and Procedures for Unlabeled Electrical Equipment)

Operations Sequence

- NFPA 70 (Article 706)
- IFC (Fire Code)
- NFPA 1 (Fire Code)

Educational Outreach

- Development and dissemination of educational materials
- Cultivating partnerships with key stakeholder groups
Key Highlights

- **DOE OE Workshop for Grid Energy Storage Safety**
- **Energy Storage Technology Advancement Partnership (ESTAP) ESS Safety Webinar**
- **Energy Storage System Guide for Compliance with Safety Codes and Standards**
- **Energy Storage System Workshop on Safety of ESS**
- **Inventory of Safety Related Codes and Standards Published**
- **Formed Working Groups**
- **Overview of Development and Deployment of Codes, Standards, and Regulations Affecting ESS Safety Published**
- **Grid Energy Storage Safety Strategic Plan Published**
- **Energy Storage Safety Strategy Development**

Timeline:
- **2014**
  - April
  - July
  - Oct
  - **DOE OE Workshop for Grid Energy Storage Safety**
  - **Inventory of Safety Related Codes and Standards Published**
- **2015**
  - April
  - July
  - Oct
  - **Energy Storage Technology Advancement Partnership (ESTAP) ESS Safety Webinar**
  - **Formed Working Groups**
  - **Grid Energy Storage Safety Strategic Plan Published**
  - **Energy Storage Safety Strategy Development**
- **2016**
  - April
  - July
  - Oct
  - **Energy Storage System Guide for Compliance with Safety Codes and Standards**
  - **ESA Workshop on Safety of ESS**
Development and publication of 2 articles and 7 documents

- Articles on ESS published in IAEI magazine and the NIBS Journal
- Codes 101 document that provides an overview of CSR development and deployment and background on why CSR are important to timely deployment of safe ESS
- Inventory of CSR applicable to ESS
- Compliance Guide to documenting and validating ESS safety under current CSR
- National stakeholders list white paper for outreach coordination
- Updated section on safety in the utility integration of energy storage for Sandia/EPRI ESS Handbook team
- ESS safety informational fact sheet for Code Officials
- ESS safety informational fact sheet for the Fire Service
R&D Prioritized List

Key need – Identify R&D efforts that will have the largest impact on the industry.

➢ Work to date
  ▪ Ongoing work in labs, industry and academia address safety in an ad hoc manner.
  ▪ Focused largely on performance and failure of single cells

➢ Short term priorities identified:
  ▪ Fire Suppression testing and analysis
  ▪ Thermal runaway research
  ▪ System scale burn test
  ▪ Commodity classification development
  ▪ Fire and vent gas modeling and analysis

➢ Subcommittee formed and discussed topics individually to create basis for white paper on priorities.
Involvement in the development of 7 standards/model codes

- Participation on a working group that developed a new Article 706 on ESS safety that will appear in the 2017 NEC
- Active participation in development of a new Chapter on ESS for the ICC International Fire Code
- Ongoing participation in development of a new UL standard 9540 on ESS safety
- Active participation in development of ASME TES-1 on molten salt thermal storage system safety
- Development of a pre-standard addressing ESS installation safety that will be used by a new NFPA committee charged with development of an NFPA 855 on ESS installation safety
- Ongoing participation in IEC TC 120 activities developing ESS safety related standards
- Ongoing participation in EPRI ESIC activities developing ESS safety guidelines for utilities
- Continued monitoring and reporting on activities associated with CSR impacting ESS
Presentations

- **NFPA/FDNY workshop** *November 2015* – Energy storage safety assessment and design and CSR
- **Energy Storage Safety Working Group Webinar** *July 2015* – Safety plan implementation kickoff
- **EESAT/Peer Review** *Sept 2015* –
  - ESS Working Groups Update
  - ESS safety CSR activities
- **Webinar** *October 2015* – NFPA energy storage fire service members
- **Webinar** *March 2016* – Boston City Fire and inspectors
- **CO Code Official Training Institute Workshop** *March 2015 and 2016* – ESS technology, safety and CSR
- **Materials Research Society (MRS) Conference** *March 2016* –
  - ESS operational safety and thermal management
  - R&D needs and efforts to address those needs
- **ESA annual conference** *May 2015* – Moderated a safety panel
- **ESA annual conference** *May 2016* – Lead ESS safety panel (4 – presentations)
- **International Association of Electrical Inspectors (IAEI) SW regional conference** *August 2016* – Overview of ESS technology, installations and safety
ESS Working Group Meetings

- Web conferences held in the past year:
  - 10 Codes and Standards
  - 9 Safety Validation and Risk Assessment
  - 6 Safety Outreach and Incident Response
- R&D met every 2-3 months for reviews, with targeted subgroup meetings in the spring to discuss technical topics
- CSR met monthly over the past year; task forces under CSR worked on specific projects
- SOIR met every 2 months to discuss work products, distribution planning, and the outreach opportunities calendar
What’s Next for Activities

- Continued work on **ongoing CSR activities** and identification of **new CSR opportunities**
- Facilitate **R&D on identified top priorities**
- **Update published documents** as warranted due to changes in ESS technology, availability of research results, stakeholder needs and/or updates to CSR including the **2014 safety strategy** document
- Publish a document containing **case studies of ESS safety compliance documentation and validation**
- Develop and implement a **more effective approach to identifying needs**, securing stakeholder participation and fostering activities to address those needs
- Creating an **improved web presence** that is easy to navigate and provides useful information to the public
- **Increase stakeholder participation**
- Conduct of a second national **ESS Safety Forum – February 22-24, 2017**
Call for papers is open! Submit your work in an area related to energy storage safety.

The deadline for submission is **Friday November 4th, 2016**.

**Topics of interest include, but are not limited to**,  
- Battery failure modes and propagation,  
- Battery safety through inherently safe design,  
- Battery chemistry,  
- State of health monitoring,  
- Fail-gracefully technologies,  
- Hardware, designs, and devices for safer systems,  
- Power electronics,  
- Risk assessment and management,  
- Codes, Standards and Regulations,  
- Safety system integration, commissioning, and/or validation, and  
- Software design and/or optimization.

**2017 ESS Safety Forum website at:**  
How to Accomplish our 2017 Goals

Consolidating into one working groups ‘ESS Safety Working Group’ because the silo approach to our goals puts up artificial boundaries

• Organize annual ESS Safety R&D Forum and in person meeting of the working groups
• Identify top R&D priorities and CSR gaps and conduct R&D to address:
  - Fire suppression testing and analysis
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Research

Codes and Standards

Educational Outreach

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Components
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UL 810A (Electrochemical Capacitors)
UL 1642 (Lithium Batteries)
UL 1973 (Batteries for Stationary Applications)
UL 1974 (Second Use Batteries- DRAFT)
NFPA 791 (Recommended Practice and Procedures for Unlabeled Electrical Equipment)

Systems Layout
IBC (Building Code)
NFPA 5000 (Building Code)
NECA 416 (IES Installation)
NFPA 855 (IES Installation)
IFC (Fire Code)
NFPA 1 (Fire Code)

Operations Sequence
NFPA 70 (Article 706)
IFC (Fire Code)
NFPA 1 (Fire Code)

Safety Systems
NFPA 850 (Electrical Generation)
NFPA 70 (Electrical Code)
IFC (Fire Code)
NFPA 1 (Fire Code)

Entire Energy Storage System
UL 9540 (Safety for ESS- DRAFT)
UL 3001 (Safety for Distributed Energy Generation and BES)
ASMETES-1 (Motran Salt Thermal Energy Storage Systems)
NFPA 791 (Recommended Practice and Procedures for Unlabeled Electrical Equipment)

Incident Response
NFPA 921 (Fire Investigations)
IEEE979 (Guide for Substation FP)
How to Accomplish our 2017 Goals

Consolidating into one working groups ‘ESS Safety Working Group’ because the silo approach to our goals puts up artificial boundaries

- ESS Safety WG will meet bimonthly
- Task forces (TF) will form around specific goals and challenges, and dissolve when concluded. i.e.
  - R&D priority list TF will form each spring to update the list over a couple of months
  - CSR TF groups will form as documents come up that need comments
  - TF groups will be convened to develop outreach documents, guides or other materials as there is need and interest
  - TF will be formed to update the Safety Strategy document
- We brought on additional staff in the national laboratories to support activities—*However,* we need strong participation from all stakeholders to be able to engage in a range of activities
  - Alice Muna (Sandia) – Fire Protection Engineer with 5 year experience (MS Fire Protection Eng., BS EE)
  - Dr. Chris LaFleur, PE (Sandia) – Fire Protection Engineer with 25 years experience in fire codes and risk analyses
  - Pam Cole (PNNL) -- 16 years involved in codes and standards for residential and commercial construction

This activity is intended to support the timely development and deployment of safe ESS technology – all those with a stake in this goal would logically be interested in active participation as we move forward.
New ESS Safety WG Organizational Structure

Energy Storage System Safety Working Group

POC: energystorage@sandia.gov

TF – Ad Hoc task forces will be created as needs arise

POC: Stakeholder Volunteers

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Resources
Acknowledgement

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For more information on DOE OE ESS safety activities
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