



Energy Storage Technology Advancement
Partnership (ESTAP) Webinar:

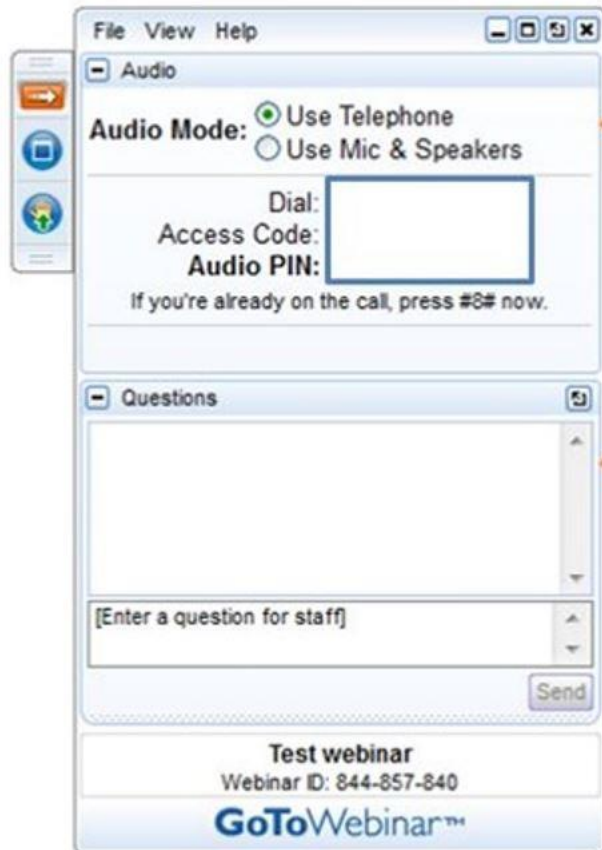
DOE OE Energy Storage Safety Plan

Wednesday, January 14, 2015

**Hosted by Todd Olinsky-Paul
ESTAP Project Director, CESA**



Housekeeping



← All participants are in “Listen-Only” mode. Select “Use Mic & Speakers” to avoid toll charges and use your computer’s VOIP capabilities. Or select “Use Telephone” and enter your PIN onto your phone key pad.

← Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

You will find a recording of this webinar, as well as all previous CESA webcasts, archived on the CESA website at

www.cesa.org/webinars

State & Federal Energy Storage Technology Advancement Partnership (ESTAP)

Todd Olinsky-Paul
Project Director
Clean Energy States Alliance



Thank You:

Dr. Imre Gyuk

U.S. Department of Energy,
Office of Electricity Delivery and
Energy Reliability

Dan Borneo

Sandia National Laboratories



ESTAP is a project of CESA

Clean Energy States Alliance (CESA) is a non-profit organization providing a forum for states to work together to implement effective clean energy policies & programs:

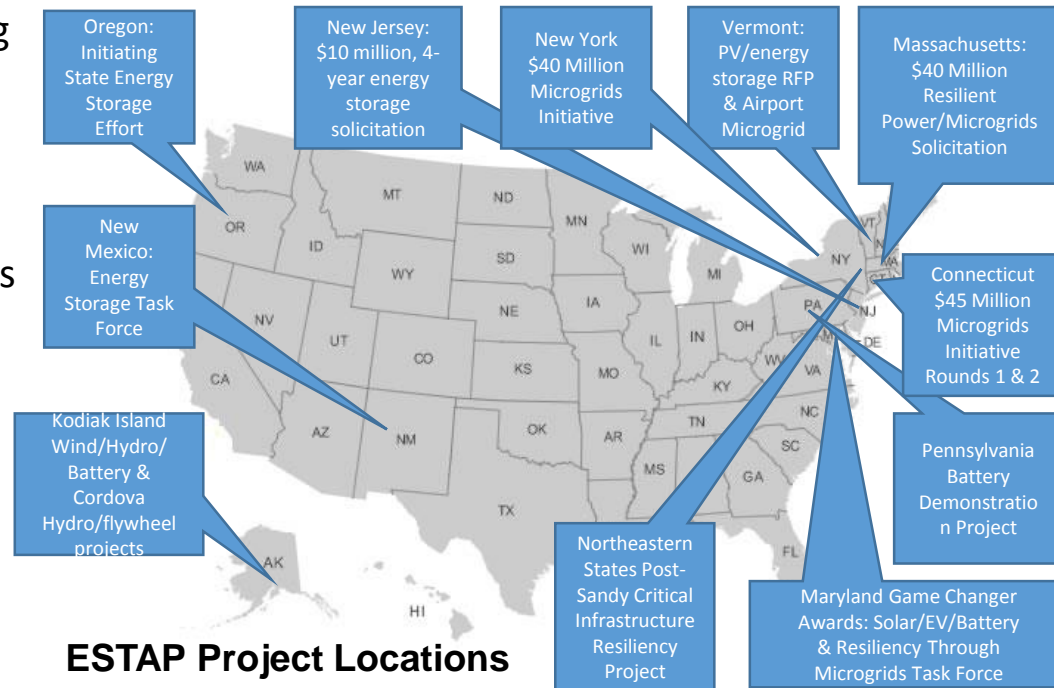
ESTAP is conducted under contract with Sandia National Laboratories, with funding from US DOE.

ESTAP Key Activities:

1. Disseminate information to stakeholders

- ESTAP listserv >500 members
- Webinars, conferences, information updates, surveys.

2. Facilitate public/private partnerships at state level to support energy storage demonstration project development



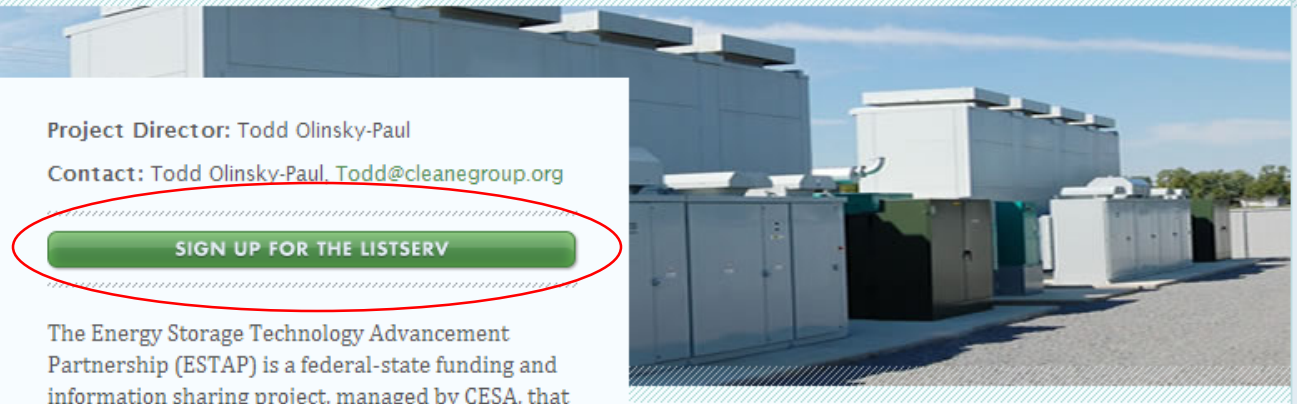


Energy Storage Technology Advancement Partnership

More CESA Projects

Overview

- Energy Storage Events
- Energy Storage News
- Energy Storage Links
- Energy Storage Listserv Signup
- Energy Storage Resources and Webinar Archives



Project Director: Todd Olinsky-Paul
Contact: Todd Olinsky-Paul, Todd@cleanegroup.org

[SIGN UP FOR THE LISTSERV](#)

The Energy Storage Technology Advancement Partnership (ESTAP) is a federal-state funding and information sharing project, managed by CESA, that aims to accelerate the deployment of electrical energy storage technologies in the U.S.

Project Objective

The project's objective is to accelerate the pace of deployment of energy storage technologies in the United States through the creation of technical assistance and co-funding partnerships between states and the U.S. Department of Energy.

ESTAP conducts two key activities:

- 1) Disseminate information to stakeholders through:

NEW RESOURCES

May 1, 2014
The Economics of Grid Defection
 By Rocky Mountain Institute

April 4, 2014
ESTAP Webinar Slides: Microgrid Technologies
 By ESTAP

April 4, 2014
ESTAP Webinar Recording: Microgrid

UPCOMING EVENTS

May 20, 2014
ESTAP Webinar: Commissioning Energy Storage,

[More Events](#)

LATEST NEWS

April 30, 2014
NYSERDA Announces Opening of Battery and

Today's Guest Speakers

Imre Gyuk, Energy Storage Program Manager, US DOE
Office of Electricity Delivery and Energy Reliability

Sean Hearne, Manager, Electrical Energy Storage Group,
Sandia National Labs

Kenneth Willette, Division Manager, Public Fire Protection
Division, National Fire Protection Association (NFPA)

Vincent Sprenkle, Chief Engineer, Electrochemical Energy
Storage and Conversion, Pacific Northwestern National
Laboratory



Towards Safety in Energy Storage Systems

The OE Energy Storage Safety Strategic Plan

**IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE**

Why Energy Storage Safety?

To reach full acceptance as a component of the electric grid, Energy Storage must demonstrate:

- Technical Feasibility
- Competitive Cost
- A Regulatory Framework
- **Safety!!**



The Lack of Safety:

- Endangers Life
- Leads to Loss of Property
- Damages the Provider's Reputation
- Leads to Costly Litigation
- Decreases Confidence in Storage



Actions Towards Energy Storage Safety

Safety is an overarching concern that needs to involve diverse partners.

- **DOE Office of Electricity Safety Meeting, February 2014**
 - **Representatives from:**
 - National Laboratories: Sandia, PNNL
 - Utility Organizations: EPRI, NRECA
 - Fire Departments, Fire Fighters
 - Building Commissions
 - Insurance Industry
 - Testing Laboratories
- **Energy Storage Safety Strategic Plan**
 - **Science-based Safety Validation Techniques**
 - **Incident Preparedness**
 - **Safety Documentation**

Challenge Area:

Science-Based Safety Validation Techniques

Motivation

- Science-based safety validation techniques for an entire energy storage system are critical as the deployments of energy storage systems expand.

Challenges

- Growing number of diverse systems
- No precedent for techniques that span the breadth of grid storage technology
- Science-based methods to validate system safety need to be developed.
- Validation techniques must span micro to macro and enable prediction of safe performance.

Proposed Solutions

- Focus R&D effort in:
 - Materials Science
 - Engineering controls and system design
 - Modeling
 - System testing and analysis
 - Commissioning and field system safety research

Challenge Area: Incident Preparedness

Motivation

- As with any large-scale deployed technology, there are risks that unintended events could result in a safety incident, exposing life, the environment and critical infrastructure at risk. Therefore, it is critical to develop an understanding of the possible failure modes of the systems and create plans to mitigate the potential for and the risk of these events as much as possible.

Gap Areas

- Fire suppression and protection systems
- Commodity classification
- Verification and control of stored energy
- Post-incident response and recovery
- First responder awareness and response practices

Proposed Solutions

- Establish ESS requirements for ensuring the safety of first and second responders

Challenge Area: Safety Documentation

Motivation

- To be effective, safety determination, documentation and verification must be standardized and specific to each chemistry, component, module, and deployment environment of each type of system.

Challenges

- Crafting effective safety metrics and criteria requires recognition of two interconnected components, i.e., the myriad of stakeholders involved in the process and the complex and differing documentation required for each component, module, system, and deployment environment.

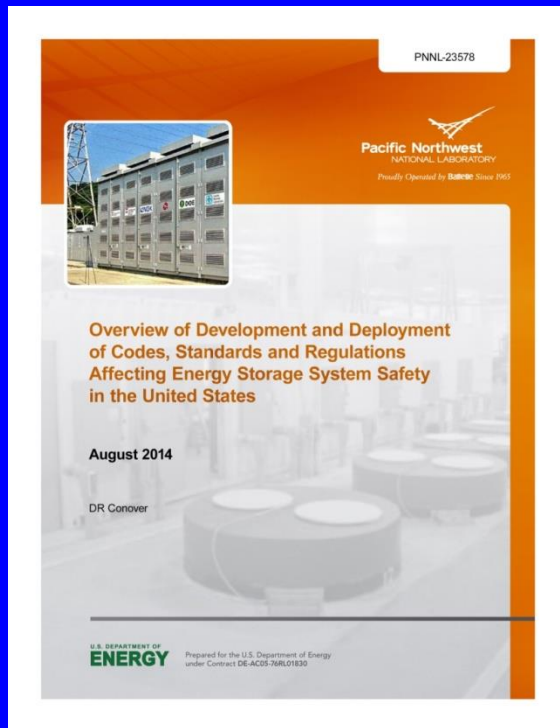
Proposed Solutions

- Develop new or enhance current codes, standards and regulations

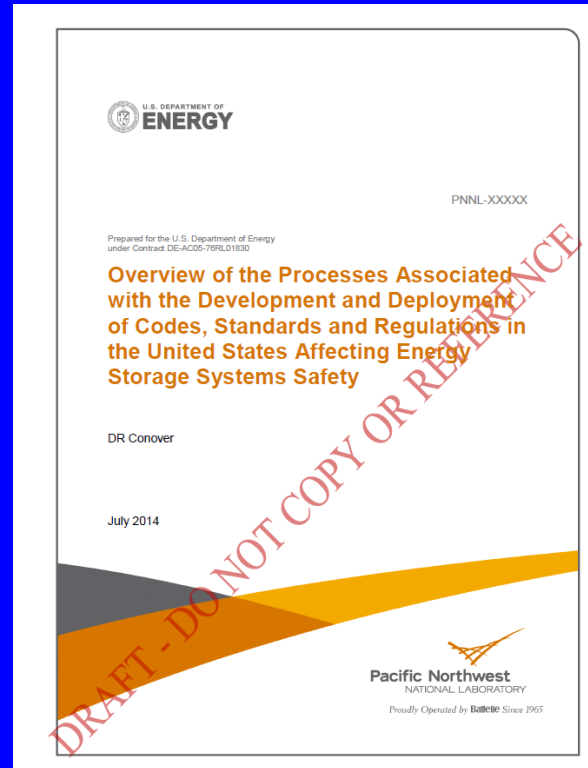
Current Projects towards Safety

- Mechanisms of Component-level Safety
 - Improve safety and reliability for long cycle life hybrid flow batteries by addressing the inherent failure modes in this chemistry.
- Mechanisms of System-level Safety
 - Analyze and improve grid scale energy storage.
- Energy Storage Commissioning
 - Develop commissioning manual that will be published on-line to provide support to the industry by increasing the safety and decreasing the cost of new energy storage installations.

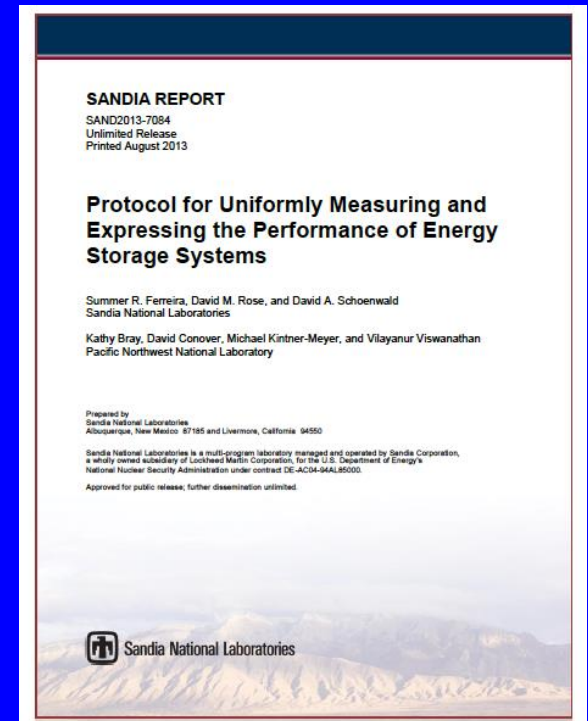
Safety Web site: http://www.sandia.gov/ess/saf_main



Directory of Applicable Codes



Storage Safety 101

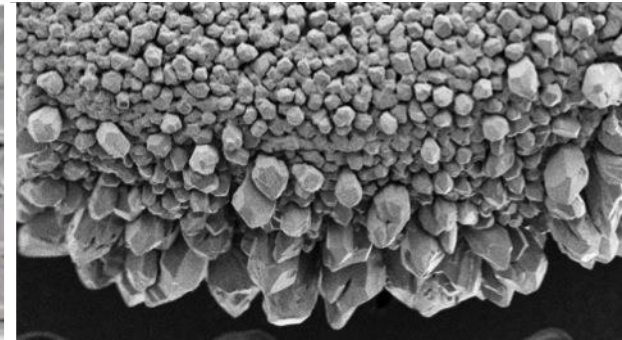


Storage Performance Protocol

Proposed Future Actions

- Establishment of a **framework for risk assessment** and management and the associated processes to evaluate and manage ESS technology risk at all stages of its life
- **Technical research** to a) characterize fundamental safety-related attributes of ESS technologies and b) address risk reduction ranging from alternative material sets for various technologies to engineered safety methods including hazard suppression
- Development of prudent **life-cycle safety testing** and evaluation methodologies
- Development of new or enhancement of existing **codes, standards** and regulations (CSR), including the necessary safety documenting to accommodate existing knowledge, and translation of the growing body of experience and results of other ESS Safety initiative activities into future CSR
- Establishment of ESS requirements for ensuring **safety of first and second responders** (including post event re-commissioning or decommissioning), ranging from ESS design parameters (consistent with prudent risk management) to on-site signage, training, and information sharing
- Creation of a **comprehensive information resource** to serve as a clearinghouse of related reports and information, share progress in activities listed above, and document relevant safety incidences and off-normal events that are reported for deployed systems

Exceptional service in the national interest



Validation Techniques for Energy Storage Safety

January 14, 2015

Sean J. Hearne

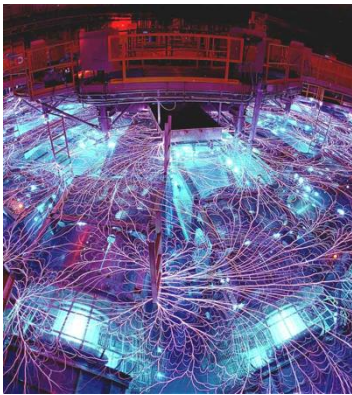
Manager, Energy Storage Technology & Systems



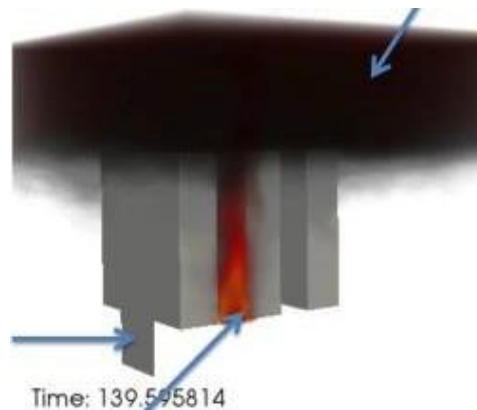
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

What is meant by Safety Validation

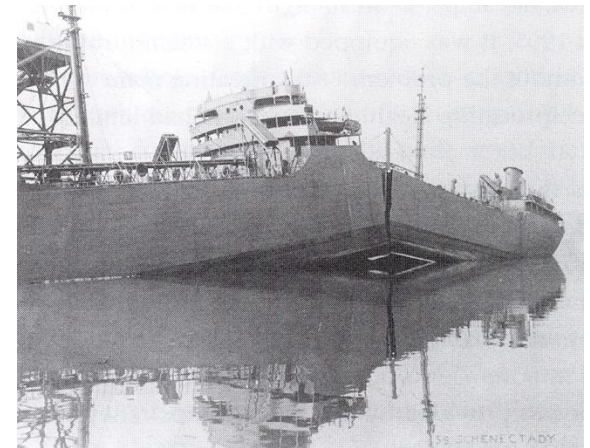
As with any system that stores energy there is a potential for unintended release of that energy.



Arc



Combustion



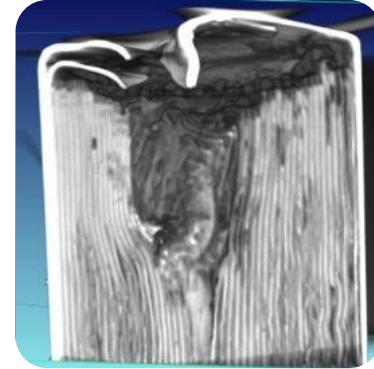
Mechanical Failure

Therefore, there is a need to validate that the safety measures implemented mitigate that chance of accidental release of the energy.

Current Approach to Safety Validation

Test our way into safety¹

- Extensive destructive tests for safety (crush, burn, etc.)
- Large engineering margin used when all failure modes are not known.



Shortcoming of the current approach:

- Expensive and time consuming
- Large systems are difficult to test
- Lacks capability to predict untested failure mechanisms with high reliability, i.e. can only design to prevent known failure modes.
- There are few published codes and standards for safety of storage systems.



¹ 'Power Grid Energy Storage Testing Part 1.' Blume, P.; Lindenmuth, K.; Murray, J. EE – Evaluation Engineering. Nov. 2012.

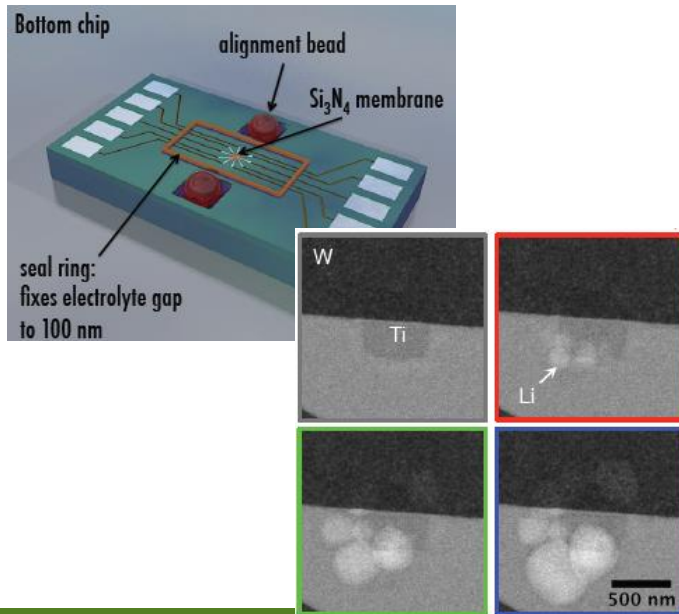
What is Needed:

- Scientific basis for safety
- Validated engineering controls and system design
- Predictive models for safety performance
- Testing and analysis protocols for safety

Scientific Basis for Safety

A scientific understanding of the fundamental processes and the device physics are needed:

- **Materials** – Electrolyte / anode or cathode interactions, failure of the constituent materials during operation, additives
- **Devices** – Dielectric breakdown, manufacturing defects, interface interactions



Some Key Questions:

- What are the failure modes?
- What are the boundaries of operation?
- What are the active processes and how can they be optimized or improved?

The current focus has largely been on research of devices, e.g. battery cells. This leaves a sizable gap in the study of:

- monitoring needs of batteries,
- effectiveness of means to separate battery cells within modules,
- various fire suppression systems and techniques.

Key considerations:

System design - circuit design, plumbing, pumping and tanks, vacuum systems, factory assembled or built on site.

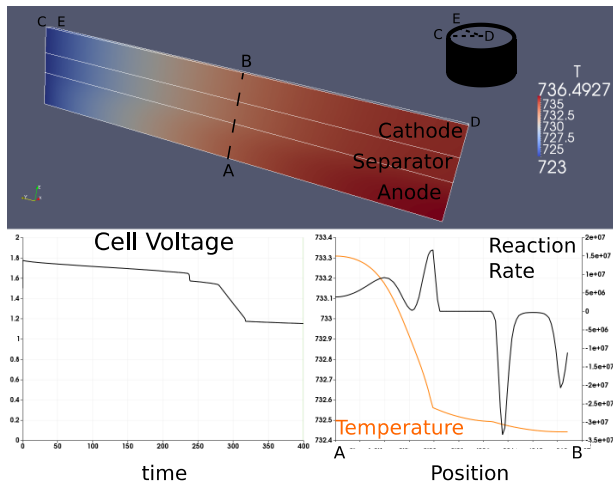
Cascading failure - fault detection and limiting the cascade.

Software and control architecture- is the system monitored, redundant, does it have mechanical overrides, is the software a critical component of the safety system?

Predictive Modeling

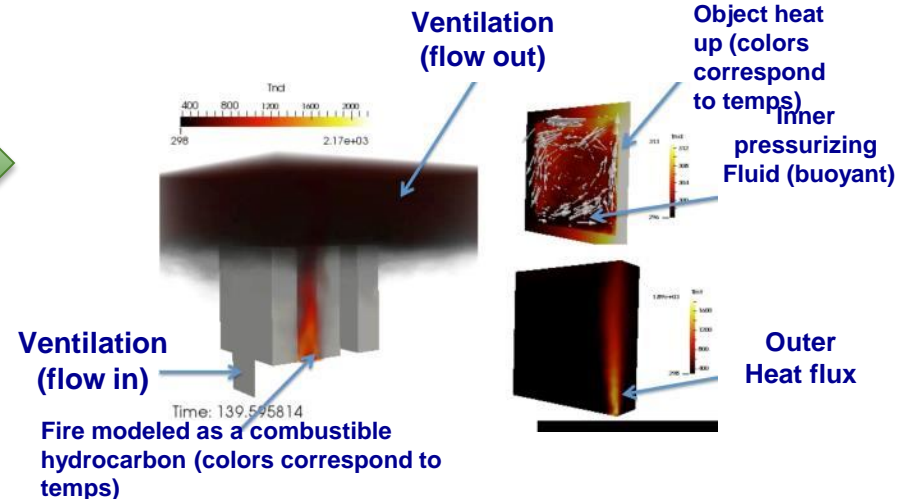
- Models must link cell performance and safety to system level performance.
- The models must be predictive to provide the greatest impact and elevate the need for system level destructive testing.
- Models must be validated at all scales.

Modeling thermal events in cell



System level models of fire propagation

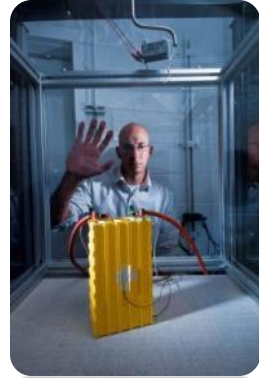
Model of fire propagation between storage packs



Validated Testing and Analysis Protocols

Testing methodologies in the electric vehicle space are well established, e.g.:

- **Electrical** – current flow, abnormal charging, forced discharge
- **Mechanical** – crush, impact, shock, vibration
- **Environment** – thermal cycle, low ambient pressure



Currently, most storage tests are specifically designed for Li-ion batteries and are not always applicable to other energy storage technologies.

Tests must be designed that:

- account for the varied deployment possibilities, e.g. built on-site vs. factory built systems.
- account for the varied technology challenges, e.g. flow batteries, sodium batteries and flywheels.
- Be have a science basis and linked to system and deployment considerations.

Concluding Thoughts on Safety Validation

- Tests to validate the safety of a system must be rooted in a scientific basis.
- These test must be limited in their scope, but thorough enough to provide assurance of system safety.
- There is still significant work needed to develop the most efficient and cost effective testing protocols.



National Fire Protection Association
The authority on fire, electrical, and building safety



DOE OE Energy Storage Safety Strategic Plan

Ken Willette, NFPA

Matt Paiss, IAFF

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Basic Understanding of ESS

New technology/chemistries
Application of CSR

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Commodity Classification

NFPA 13 does not include Lithium Ion

Testing on consumer battery storage and ev batteries

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Expanded Applications

Residential

Hi rise

Commercial

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Preplanning & Risk Analysis

Critical for education of first responders

Essential for determining appropriate response

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Gap Areas

Fire suppression & protection systems

Commodity classification

Verification & control of stored energy

Post-incident response and recovery

First responder awareness & response practices

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Thank you!

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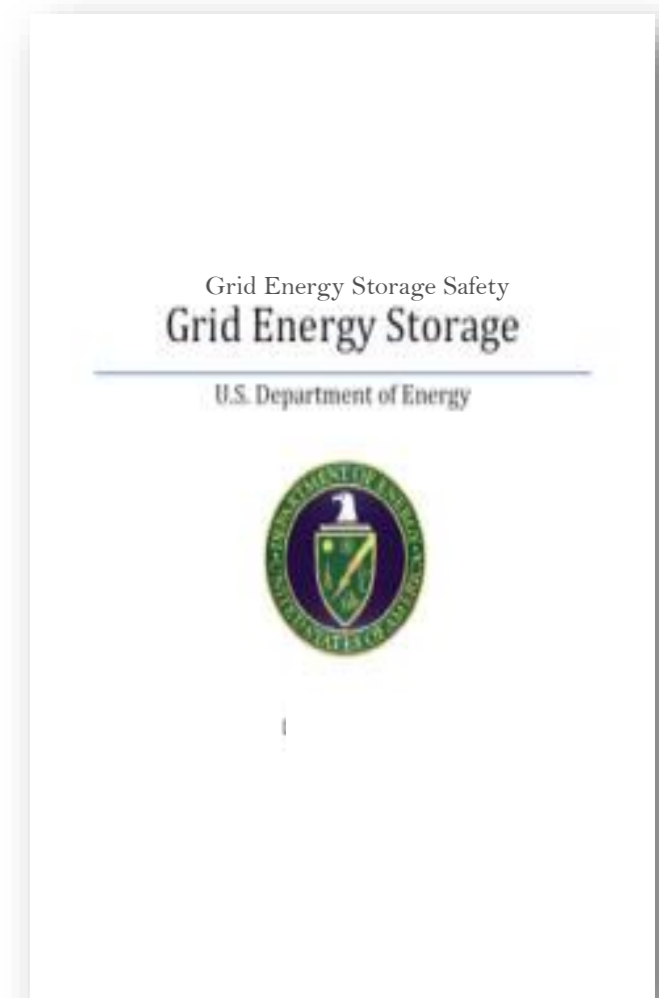
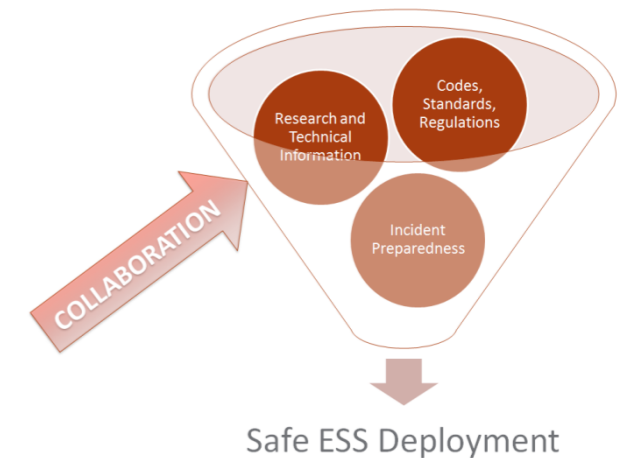
Matt Paiss, mpaiss@gmail.com

January 14, 2015

DOE OE Strategic Plan on Safety

Incomplete and dispersed codes, standards and regulations (CSR)

- Energy storage technologies and applications are increasing at a very rapid rate
- CSR's guide technology safety but cannot easily anticipate new technology – they generally lag development and deployment of new technology
- Current CSR's are based primarily on more traditional ESS technology and may not provide needed guidance on safety for all ESS - they need continual updating due to rapid advances in storage technologies and an increasing menu of installation scenarios
- Research is needed to form the basis for assessing system safety and providing the basis for needed safety guidance and updates to CSR
- Until needed safety criteria are included in CSR's ESS safety can be assessed on a case by case basis where ESS performance is documented as equivalent in safety with the intent of the current CSR's
- The outcomes of safety-related research and experiences with system installations and operations are needed as a basis for specific criteria and guidance in new CSR's and revision to existing CSR's
- The CSR's for energy storage are dispersed throughout many sources - there is a need to update all the CSR's in a comprehensive manner and ensure they are coordinated and where possible all relevant criteria consolidated



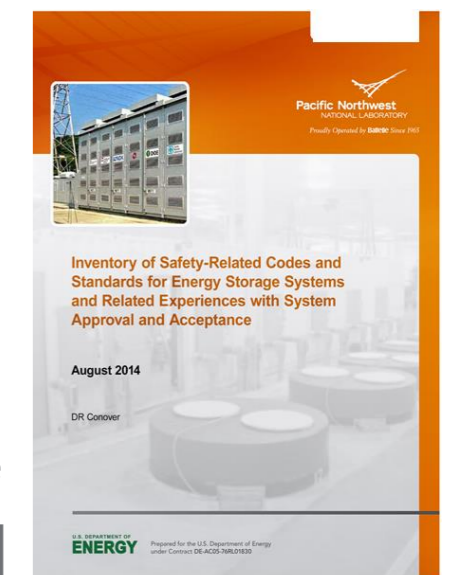
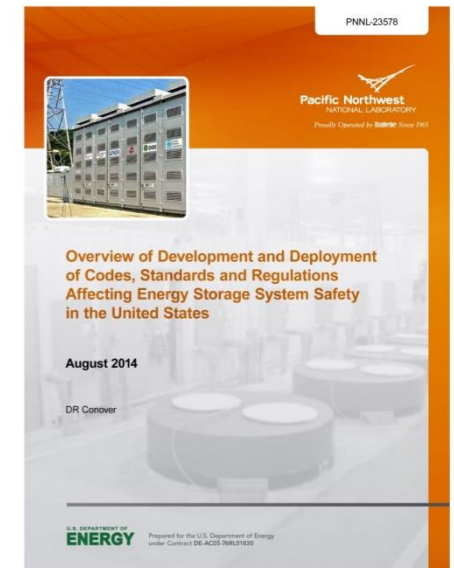
First Steps Addressing ESS CSR



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- **CSR Overview – understand the process**
 - Acquaint stakeholders with CSR importance
 - Foster an in depth and uniform understanding of CSR
 - Enhance communications and spur collaboration
 - Basis for education in 2015 to build collaboration
- **CSR Inventory – know where you are**
 - ID current CSR related to ESS safety
 - Gather and report experiences to date with securing approval of ESS under CSR
 - Provide information needed to secure ESS approval where current CSR may not specifically apply to what is proposed
 - ID gaps between ESS technology and current CSR's to
 - drive performance of needed research
 - support development of future CSR



Next Steps for ESS CSR



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- ID gaps between ESS technology and criteria in CSR
- Develop templates for typical ESS installations and document CSR compliance
- Conduct research and close gaps in CSR criteria with the results
- Current and upcoming CSR opportunities
 - Support for a new article 706 on energy storage systems for the National Electrical Code (NFPA 70)
 - Participation in development of UL 9540 on energy storage system safety
 - Development of proposed changes to the ICC International Fire Code due January 2016
 - Development of proposed changes to the IEEE National Electrical Safety Code due 2019
 - Development of proposed changes to ESS relevant standards from NFPA, ASME, NEMA, IAPMO, CSA, IEC, ISO and others
- Continually track and support needed CSR revisions
- Look at CSR as ESS technology evolves and identify and address criteria gaps
- Identify needed research and opportunities to develop new or revisions to CSR to address gaps
- Regularly update CSR inventory information to serve as a focal point to support safe system development and deployment and to ID the needs for research and documentation to support new and revisions to existing CSR

ESTAP Contact Information

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ESTAP Website: <http://www.cesa.org/projects/energy-storage-technology-advancement-partnership/>

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