Energy Storage System Safety Roadmap Codes and Standards Update

SAND2017-10520PE

Web Meeting

September 26, 2017

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

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Hosted by

Dave Conover
Pacific Northwest National Laboratory

PNNL-SA-129440

Energy Storage System Safety Roadmap Codes and Standards Update

3:00 p.m. – 3:05 p.m.	Welcome, Purpose, Expected Outcome and Overview of the Webinar
3:05 p.m. – 3:10 p.m.	ESS Safety Roadmap Codes and Standards Objective and Efforts
3:10 p.m. – 4:45 p.m.	Update on standards/model codes activities (ASME, DNV GL, FM Global, CSA, ICC, IEEE, NECA, NEMA, NFPA and UL)
4:45p.m. – 5:00 p.m.	Suggested actions and adjourn

Energy Storage System Safety Roadmap
Codes and Standards Update

Purpose of the meeting

Report on current activities in the voluntary sector codes and standards community that are relevant to ESS safety

Expected Outcome

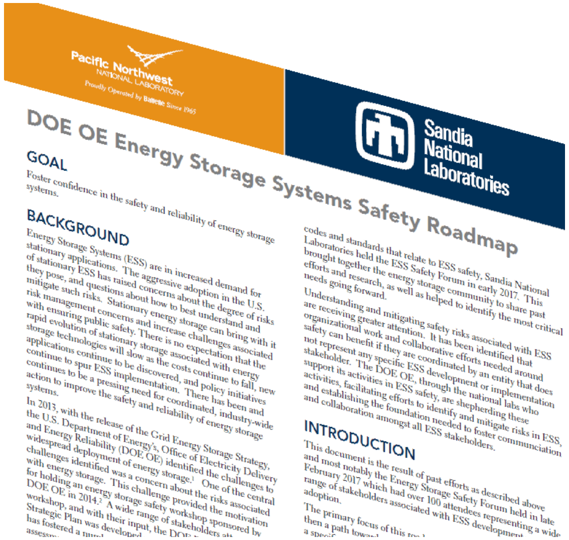
An update on development of new standards and updating of existing standards and model codes impacting ESS design, construction, installation, commissioning, operation, repair, renewal and decommissioning

ESS Safety Roadmap Update

- Supported by the DOE Office of Electricity Energy Storage Program

- The goal of the DOE OE ESS Safety Roadmap is to *foster confidence in the safety and reliability of energy storage systems.*

- Roadmap objective focused on codes and standards - To apply research and development to support efforts that are focused on ensuring that codes and standards (CS) are available to enable the safe implementation of energy storage systems in a comprehensive, non-discriminatory and science-based manner.



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DOE OE Energy Storage Systems Safety Roadmap

GOAL

Foster confidence in the safety and reliability of energy storage systems.

BACKGROUND

Energy Storage Systems (ESS) are in increased demand for stationary applications. The aggressive adoption in the U.S. of stationary ESS has raised concerns about the degree of risks they pose, and questions about how to best understand and mitigate such risks. Stationary energy storage can bring with it risk management concerns and increase challenges associated with ensuring public safety. There is no expectation that the rapid evolution of stationary storage associated with energy storage technologies will slow as the costs continue to fall, new applications continue to be discovered, and policy initiatives continue to spur ESS implementation. There has been and continues to be a pressing need for coordinated, industry-wide action to improve the safety and reliability of energy storage systems.

In 2013, with the release of the Grid Energy Storage Strategy, the U.S. Department of Energy's, Office of Electricity Delivery and Energy Reliability (DOE OE) identified the challenges to widespread deployment of energy storage.[1] One of the central challenges identified was a concern about the risks associated with energy storage. This challenge provided the motivation for holding an energy storage safety workshop sponsored by DOE OE in 2014.[2] A wide range of stakeholders att… workshop, and with their input, the DOE … Strategic Plan was developed … has fostered a num… assessm…

codes and standards that relate to ESS safety, Sandia National Laboratories held the ESS Safety Forum in early 2017. This brought together the energy storage community to share past efforts and research, as well as helped to identify the most critical needs going forward.

Understanding and mitigating safety risks associated with ESS are receiving greater attention. It has been identified that organizational work and collaborative efforts needed around safety can benefit if they are coordinated by an entity that does not represent any specific ESS development or implementation stakeholder. The DOE OE, through the national labs who support its activities in ESS safety, are shepherding these activities, facilitating efforts to identify and mitigate risks in ESS, and establishing the foundation needed to foster communciation and collaboration amongst all ESS stakeholders.

INTRODUCTION

This document is the result of past efforts as described above and most notably the Energy Storage Safety Forum held in late February 2017 which had over 100 attendees representing a wide range of stakeholders associated with ESS development … adoption.

The primary focus of this ro… then a path toward… a speci…

Acknowledgment

Dr. Imre Gyuk

DOE-Office of Electricity Delivery and Energy Reliability

U.S. DEPARTMENT OF ENERGY

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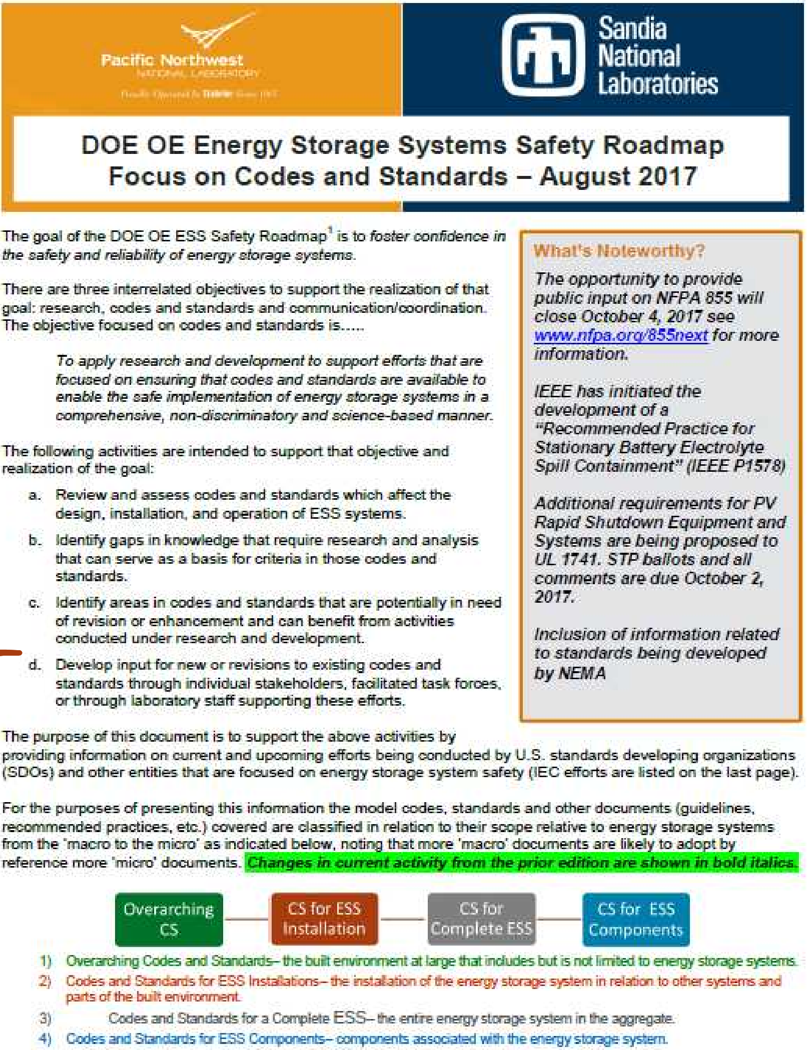
Overview of ESS Safety Codes and Standards Activities

Activities to support the codes and standards objective

1. Review and assess CS which affect ESS design, installation, and operation
2. Identify gaps in knowledge that require research and analysis that can serve as a basis for criteria in those CS.
3. Identify areas in CS that are potentially in need of revision or enhancement and can benefit from R&D activities.
4. Develop input for new or revisions to existing CS through individual stakeholders, facilitated task forces, or through laboratory staff supporting these efforts.



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DOE OE Energy Storage Systems Safety Roadmap
Focus on Codes and Standards – August 2017

The goal of the DOE OE ESS Safety Roadmap[1] is to *foster confidence in the safety and reliability of energy storage systems.*

There are three interrelated objectives to support the realization of that goal: research, codes and standards and communication/coordination. The objective focused on codes and standards is.....

> *To apply research and development to support efforts that are focused on ensuring that codes and standards are available to enable the safe implementation of energy storage systems in a comprehensive, non-discriminatory and science-based manner.*

The following activities are intended to support that objective and realization of the goal:

a. Review and assess codes and standards which affect the design, installation, and operation of ESS systems.
b. Identify gaps in knowledge that require research and analysis that can serve as a basis for criteria in those codes and standards.
c. Identify areas in codes and standards that are potentially in need of revision or enhancement and can benefit from activities conducted under research and development.
d. Develop input for new or revisions to existing codes and standards through individual stakeholders, facilitated task forces, or through laboratory staff supporting these efforts.

What's Noteworthy?

The opportunity to provide public input on NFPA 855 will close October 4, 2017 see www.nfpa.org/855next for more information.

IEEE has initiated the development of a "Recommended Practice for Stationary Battery Electrolyte Spill Containment" (IEEE P1578)

Additional requirements for PV Rapid Shutdown Equipment and Systems are being proposed to UL 1741. STP ballots and all comments are due October 2, 2017.

Inclusion of information related to standards being developed by NEMA

The purpose of this document is to support the above activities by providing information on current and upcoming efforts being conducted by U.S. standards developing organizations (SDOs) and other entities that are focused on energy storage system safety (IEC efforts are listed on the last page).

For the purposes of presenting this information the model codes, standards and other documents (guidelines, recommended practices, etc.) covered are classified in relation to their scope relative to energy storage systems from the 'macro to the micro' as indicated below, noting that more 'macro' documents are likely to adopt by reference more 'micro' documents. ***Changes in current activity from the prior edition are shown in bold italics.***

Overarching CS — CS for ESS Installation — CS for Complete ESS — CS for ESS Components

1) Overarching Codes and Standards– the built environment at large that includes but is not limited to energy storage systems.
2) Codes and Standards for ESS Installations– the installation of the energy storage system in relation to other systems and parts of the built environment.
3) Codes and Standards for a Complete ESS– the entire energy storage system in the aggregate.
4) Codes and Standards for ESS Components– components associated with the energy storage system.

Codes and Standards Update

Each SDO will present the following information

- Overview of the SDO Standards Development Process and other high level relevant information to set the stage for a summary of ESS-relevant standards activities.
- Identification of ESS-relevant standards activities as to title, scope, schedule, etc. and if desired some very high level insight on content (the webinar will not allow time to go into details associated with the standards covered).
- Web site for more information on their activities

Codes and Standards Update - ASME

Standards & Certification Development Committees

- Standards development principles
- Committee procedures, policies and guidelines
- Web based participation

American Society of Mechanical Engineers (ASME)—www.asme.org

Codes and Standards Update - ASME

TES-1 Safety Standard for Thermal Energy Storage Systems – Molten Salt TESS

- Design, construction, installation, commissioning, operation, maintenance and decommissioning of TESS (the storage medium and associated storage vessels, controls and system components)
  - Chapter 1 Scope, Definitions and References
  - Chapter 2 Planning and Design
  - Chapter 3 Construction, Installation and Commissioning
  - Chapter 4 Inspection, Operation and Maintenance
  - Chapter 5 Decommissioning

- Draft is being finalized by a committee of 15 members and 6 contributing members and is expected to be available for public review and comment late in 2017.

ENERGY



ENERGY

GRIDSTOR: Recommended Practice on safety, operation and performance of grid-connected energy storage systems

DNVGL-RP-0043

Who we are –
DNV GL Energy: services along the energy value chain

GL Group

KEMA

NOBLE DENTON

GARRAD HASSAN

ADVANTICA

DNV·GL

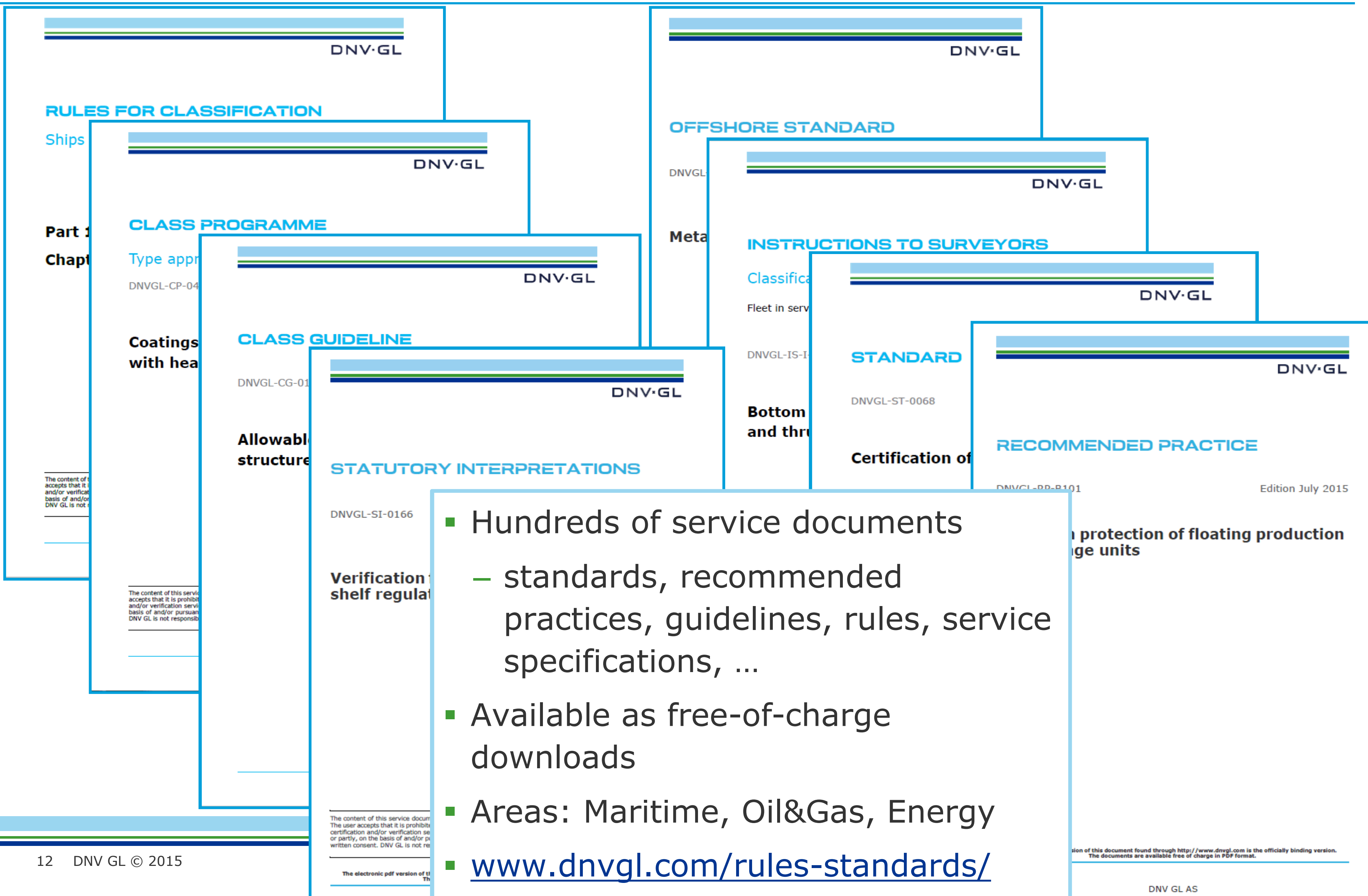
What we do –
DNV GL Energy: Energy storage services

Impact
- Technology and market assessment
- Business case analysis
- (Grid) modelling
- Due diligence
- Technology selection

Performance
- Modelling
- Testing
- Power failure investigation
- Prototype development
- Inspection

Implementation
- Owners engineer
- Bankability assessment
- Procurement and commissioning support
- Acceptance test

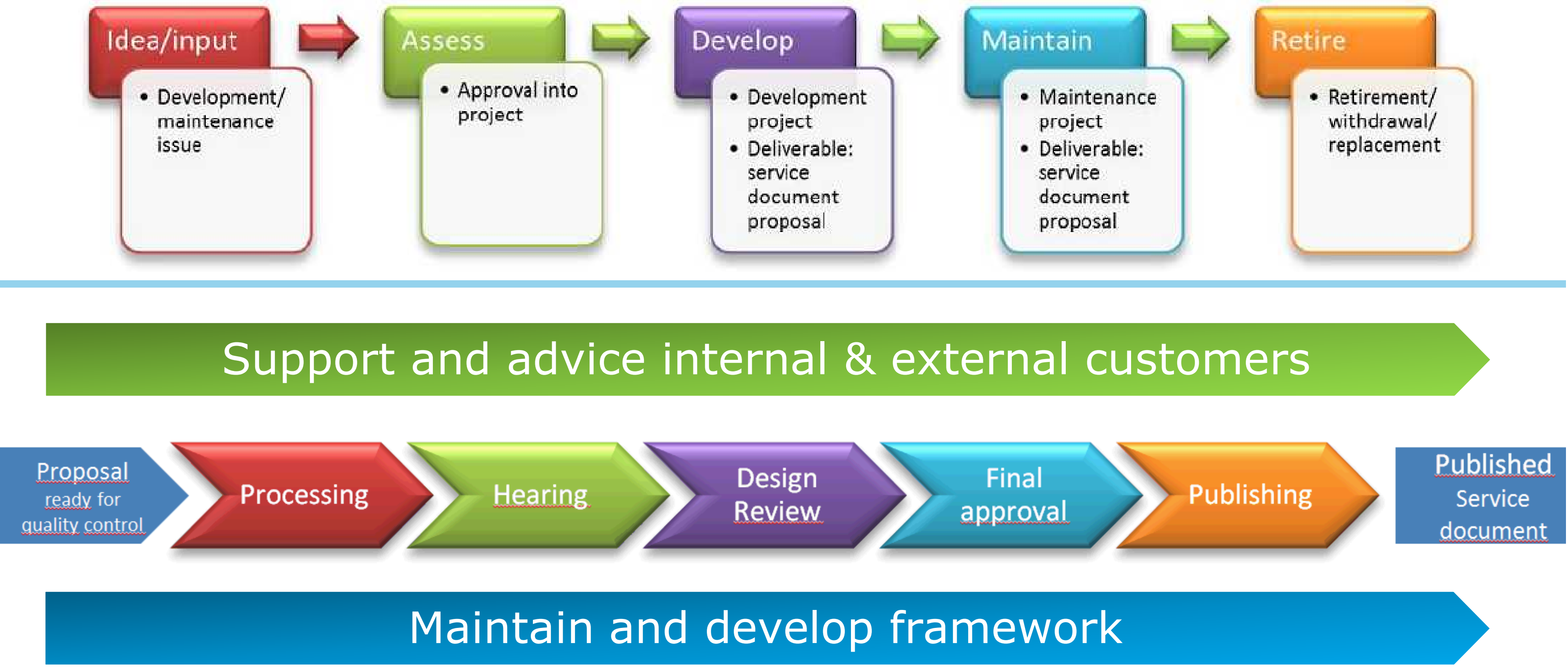
DNV GL service documents



- Hundreds of service documents
  - standards, recommended practices, guidelines, rules, service specifications, …
- Available as free-of-charge downloads
- Areas: Maritime, Oil&Gas, Energy
- www.dnvgl.com/rules-standards/

DNV GL service document process and governance

- Governance objective: To ensure consistency in the way service documents are governed and managed throughout their life cycle including a clarification of authorities, responsibilities and tasks for key stakeholders involved.



Joint Industry Projects: creation and review by the industry itself

GRIDSTOR consortiums 2015 + 2017:

Hearing participants 2015 + 2017

- Alliander
- Clean Energy Council
- Denchi Power
- Ecovat Renewable Energy Technologies
- Electricity Storage Network
- Enel, Ingegneria & Ricerca SpA
- GE Energy Storage
- GNB Industrial Power
- MuGrid analytics
- New York Battery and Energy Storage Technology Consortium (NY-BEST),
- Norton Rose Fulbright LLP
- Scholt Energy Control
- Scottish and Southern Energy Power Distribution (SSEPD)
- UK Power Networks
- Younicos
- ..and 125 other organizations

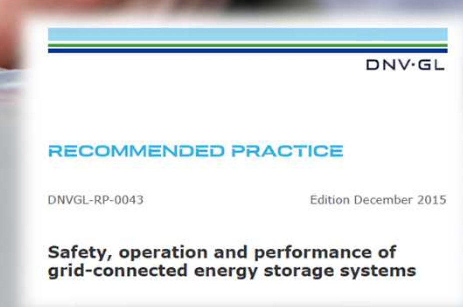
GRIDSTOR (DNVGL-RP-0043, publ. 2015)

DNV GL issued a Recommended Practice (DNVGL-RP-0043) on **grid-connected energy storage**

- Guidelines and methods to evaluate, assess and test safety, operation and performance of grid-connected energy storage systems
- Referencing ISO, IEC, IEEE, UL etc. standards (197) if possible and relevant, enhancing where needed
- Approach: technology agnostic, specific where necessary; worldwide application

Defining building blocks for an open competitive market place

Continuous updates following technology development and end-user applications


DNV·GL

RECOMMENDED PRACTICE

DNVGL-RP-0043 Edition December 2015

Safety, operation and performance of grid-connected energy storage systems

Update published September 2017

GRIDSTOR RP scope and approach

Based on feedback key players

Refined with consortium

Comprehensive

References to existing standards

New content if required

Free to use

SAFETY
FMEA/Bowtie analysis
Risks and mitigation
Design consequences
Procedures & documentation

OPERATION
Monitoring
Control
Grid connection
Environmental analysis

PERFORMANCE
Definitions
Conditions
Measurement
Life cycle costs

APPROACH
System and component level
Technology-agnostic and -specific
Applications and life cycle phases
Standards, guidelines and regulations

GRIDSTOR 2017: updated elements

- Additions / expansions: cyber security, communication protocols, microgrids, conformity assessment incl. FAT/SAT testing, warranty, decommissioning, tendering and procurement, bankability, residual value, greenhouse gas emissions calculation.
- Technology-specific recommendations and background was added on (sub-)technologies: inorganic lithium ion batteries, compressed air energy storage (CAES), liquid air energy storage (LAES), supercapacitors, lead crystal batteries
- Technology-specific safety recommendations for Li-ion batteries were updated
- Recommendations regarding first responders, fire considerations and thermal management were updated
- Overview of normative and informative references was actualised and expanded to include the RP updates described above
- Section 3 was expanded by three applications, previously belonging to other categories: ramp rate control, generation peak shaving, capacity firming
- Section 7 was reorganised for clarity and a more elaborate introduction was added
- Section 10 was turned into Appendix B
- Section 5.2's paragraphs on levelized cost of storage (LCOS) and life cycle costs were moved to the new section 10
- Section B.2 (previously 10.2) was updated and expanded to better reflect the American and European situation
- Various small refinements, corrections and additions were made throughout the RP

Benefits of GRIDSTOR for specific organisations

Utilities and grid service providers

- Independent guideline documents
- Manual for all process phases/aspects
- Confidence in performance as specified

Manufacturers/system integrators

- Proof of quality, reliability, performance
- Distinction from competition

Insurance companies

- Reduced risks by independent and open guidelines based on industry experience

Investors

- Confidence in investment (reduced risks)
- Understanding of technologies and systems

For all: **up-to-date document, reflecting rapid and recent developments, accelerating the market**

GRIDSTOR: real-life examples of mitigated risks

Feasibility risks

- **System dimensioned on minimum CAPEX instead of TCO**
- **Market saturation not taken into account**
- **Sub-optimal combination of technology and applications**

Performance risks

- **Cycle life data under different conditions (DoD, temperature, C-rate)**
- **Standby losses not taken into account**

Contract risks

- **Conditions warranty and guarantees unclear**
- **System boundary unclear – e.g. safety responsibility**

Regulation/certification risks

- **System specification not in line with market regulation / grid code**
- **Systems not meeting standardisation**

Commissioning risks

- **FAT / SAT testing inadequate**
- **Handover unclear**

Safety risks

- **Fire suppression for li-ion batteries**
- **No FMEA analysis, no adequate measures and training**
- **Cyber safety**

Thank you!

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SAFER, SMARTER, GREENER

Data Sheet 5-33,

Electrical Energy Storage Systems

Clinton Marshall

Sr. Staff Engineer

Who is FM Global

- We are an HPR, Mutual insurance company
- Our only focus is property insurance
- Our philosophy is "A majority of all loss is preventable"
- Our method, we utilize engineers to analyze and assess the risks to our client's facilities, and provide cost effective loss prevention solutions to minimize or eliminate those risks

Engineers	1,812
Serviced Locations	62,218
Engineering Visits/Yr	108,109
Countries Serviced	152

Who is FM Global

- FM Global has different business units, including:
  - Underwriting
  - Engineering,
  - Research,
  - FM Approvals,
  - Training,
  - Staff, etc.
- Engineering Standards

Why are we involved in Li-on ESS?

- Roughly 6 years ago, our clients began asking us for guidance on ESS
- ESS has become more cost effective, with more options for our clients
- We wanted to provide consistent guidance

What is Data Sheet 5-33?

- FM Global's loss prevention guidance for Li-Ion based energy storage systems
- Recommendations cover construction and location, fire protection, electrical system protection and design, operation and maintenance, training, human element, utilities, and contingency planning
- The intent is to ensure limited risk, with an appropriate level of protection, to minimize the impact of a loss on our clients' locations

Li-Ion ESS Timeline

- Late 2016 we started developing DS 5-33, *Electrical Energy Storage Systems*
- Our initial focus was primarily on outdoor units
- Based on a risk assessment of ESS failure modes, to better quantify the risks

DS 5-33

- This document is free to the public at:

  www.fmglobaldatasheets.com

- Register with name, email, organization, job title, and job function

FM Global
Property Loss Prevention Data Sheets **5-33**

January 2017
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ELECTRICAL ENERGY STORAGE SYSTEMS

Table of Contents

Page

What is next for DS 5-33?

- Revision process starting in 2018, including:
  - Increased focus on fire protection criteria
  - Expanded guidance for indoor installations
  - Guidance for evaluating features of the BMS/SOH
  - Address new technology trends
  - Other applicable issues not addressed previously

CSA Energy Storage System Standards Update

Mohsen M. Sepehr, Ph.D.
Program Manager, Renewables & Energy Storage
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CSA Group

Power Conversion Equipment

CSA C22.2 No 107.1-2016, Power Conversion Equipment

- Applies to ac and dc type power conversion equipment, which can be associated with an ESS
- 4th Edition of the standard, last issued in 2016
- Under continuous maintenance and will be updated as warranted
- Bi-national via C

CSA Group

Energy Storage Systems

UL 9540, Standard for Energy Storage Systems and Equipment

- Bi-national in US and Canada
- Product certification and Field Evaluation/Special Inspection possible
- In Ontario, June 9th memo from Electrical Safety Authority (ESA) provides the following direction:
  - "Field evaluation agencies performing an inspection on an Energy Storage System shall refer to CAN/ANSI/UL 9540-16 and ensure that the additional requirements from this standard have been addressed and complied with during evaluation."

CSA Group

Compliance by Market Segment

Residential

- Systems generally require a certification mark from a NRTL
- IEC developing international standards

C US

Commercial/ Industrial (C/I)

- Local AHJ dictates requirements
- Components certified
- Field evaluation programs are an option versus full certification

Utility/Community

- Compliance driven by internal safety procedures and AHJ
- Full system standards increasingly popular
- Field evaluation combined with component certification

CSA Group

FCAC ESS Work Group Update
Evolution of ESS Requirements

Beth Tubbs, FPE

International Code Council

Legacy Stationary Battery Systems

- Primary use
- Emergency and standby power for buildings
- UPS
- Telecommunication system backup power

Legacy Stationary Battery Systems

- Lead acid system hazards:
- Hydrogen gas produced during charging
- Corrosive liquid spills
- Large quantities of electrical energy

2015 IFC Battery Systems Requirements

- Since 1997 (lead-acid) battery systems allowed in incidental use areas
- 1 or 2 hour fire-rated separations
- Hazmat requirements exempted
- Spill control, ventilation, smoke detection
- Battery quantities unlimited
- Location in building not regulated
- Standby & emergency power, UPS use

Current codes do not adequately protect newer battery technologies

FCAC ESS Working Group Strategy

Have something in the 2018 fire codes to address hazards
Conservative requirements due to lack of field experience, fire testing and research
Allow modifications based on a HRA and full scale fire and fault condition testing


Six month deadline to prepare proposals for the 2018 fire codes

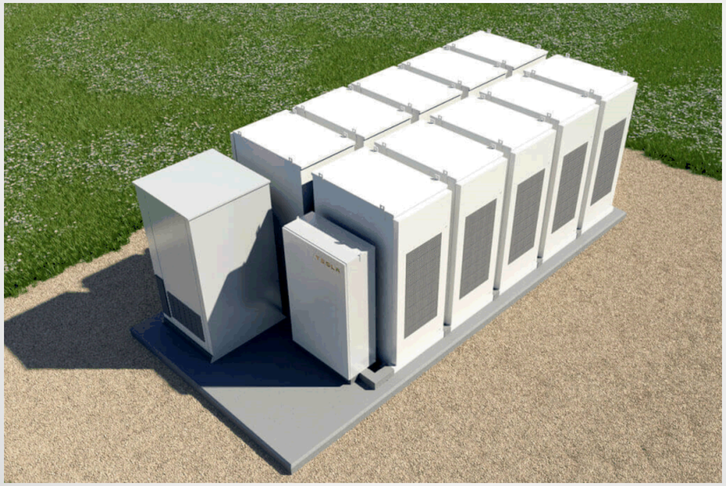
2018 Fire Codes

- Initial requirement to address new technologies and applications

Hazard mitigation analysis

Size/spacing/MAQ limits

UL 9540 Listing



Outdoor installation

BMS

Location in building

Technology specific protection

Exceptions for large scale fire/fault condition testing

2021 Code Proposal Focus
Cover Risks with Various Installation Scenarios

Mixed Occupancy Building

Dedicated ESS Building

Outdoors Near Building

Rooftop Installations

Outdoors Remote

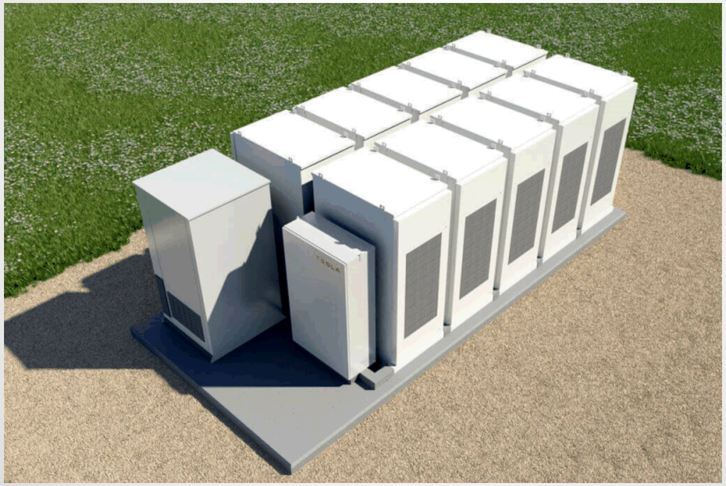
2021 Code Change Focus Areas

- Being explored by the FCAC ESS work group

Installation scenarios

Review size/spacing/MAQs

Commissioning/ Decommissioning



Exhaust/deflagration venting

Fire propagation tests (UL 9540A)

BMS performance

Evaluate sprinkler effectiveness

Better categorize batteries

Mobile ESS operations

Used Li-ion battery storage

2021 IFC Code Proposal Direction Reorganization of Section 1206 (ESS)

ALL ESS

- 1206.1 General requirements related to permits, construction documents, commissioning, etc.
- 1206.2 Installation and equipment requirements, general items such as listings, electrical connection/protection details, vehicle impact, combustible storage, etc.

Electrochemical ESS (EESS)

- 1206.3 EESS (i.e. battery and capacitor systems).
  - 1206.3.1 – Indoor installations.
  - 1206.3.2 - Outdoor installations.
  - 1206.3.3 – Special installations (Rooftop and open parking garages).
  - 1206.3.4 – Mobile EESS operations
  - (Requirements for these installations are in table format)
- 1206.4 EESS protection that can be provided in the various 1206.3 installations. Protection is selected by the 1206.3 tables. Mix and match!
- 1206.5 EESS technology specific requirements – Protection needed for individual EESS technologies, i.e. spill control not needed if batteries don't have liquid electrolyte.

2021 IFC Proposal on ESS

- To be reviewed by FCAC at October 4-5th meeting
- In general they agree with the work group approach
- FCA will ultimately vote on ESS proposals to be submitted
- Code hearing April in Columbus, OH

National Electrical Contractors Association (NECA)

National Electrical Installation Standards (NEIS)

National Electrical Contractors Association (NECA)

- NECA is the voice of the $130 billion electrical construction industry that brings power, light, and communication technology to buildings and communities across the U.S.

- NECA contractors strive to be solution-providers for their customers, and their industry expertise benefits everyone working on an electrical construction project.

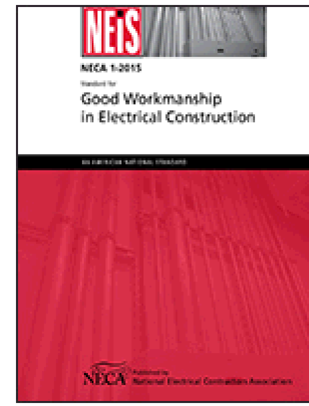
- NECA contractors set industry standards for traditional and integrated electrical systems and lead the industry in the practical application of new technologies.

National Electrical Installation Standards (NEIS)

- National Electrical Installation Standards (NEIS) are a series of quality installation standards for electrical products and systems.
- NEIS extend beyond the minimum installation and safety requirements of the National Electrical Code® (NEC®).
- Address quality and performance aspects of electrical construction.

National Electrical Installation Standards (NEIS)

- National Electrical Installation Standards are the first quality standards for electrical construction.



- Developed by the National Electrical Contractors Association (NECA) to clearly define the actions needed to perform an installation in a “neat and workmanlike manner”, as often referenced in the National Electrical Code (NEC, NFPA-70).

- American National Standards Institute (ANSI) – accredited and developed by consensus with industry involvement, updated per ANSI Revision cycles.

National Electrical Installation Standards (NEIS)

- National Electrical Installation Standards provide additional quality and training for electricians and contractors.

- NEIS are used by contractors, consulting engineers, facility managers and electrical inspectors.

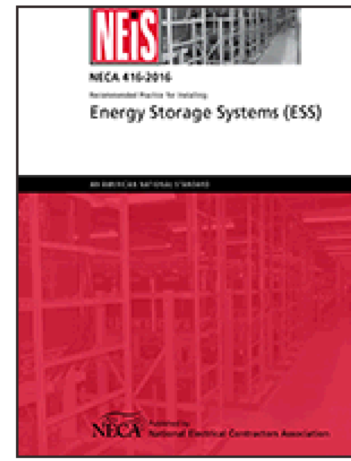
- NECA Flagship NEIS Standard is NECA 1 – 2015, Standard for Good Workmanship in Electrical Construction

NECA 416-2016
Recommended Practice for Installing Energy Storage Systems (ESS)

- NECA 416-2016 is an ANSI-accredited National Electrical Installation Standard for Installing Energy Storage Systems.

- NECA 416-2016 describes methods and procedures used for installing multiple types energy storage systems.

- NECA 416-2016 also includes information about controlling and managing energy storage systems, in addition to commissioning and maintaining energy storage systems.



National Electrical Installation Standards (NEIS)

- Other Related NEIS Standards available from NECA
  - NECA 1-2015, Standard for Good Workmanship in Electrical Construction (ANSI)
  - NECA 90-2015, Recommended practice for Commissioning Building Electrical Systems (ANSI)
  - NECA 100-2013, Symbols for Electrical Construction Drawings (ANSI)
  - NECA 701-2013, Standard for Energy Management, Demand Response and Energy Solutions (ANSI)

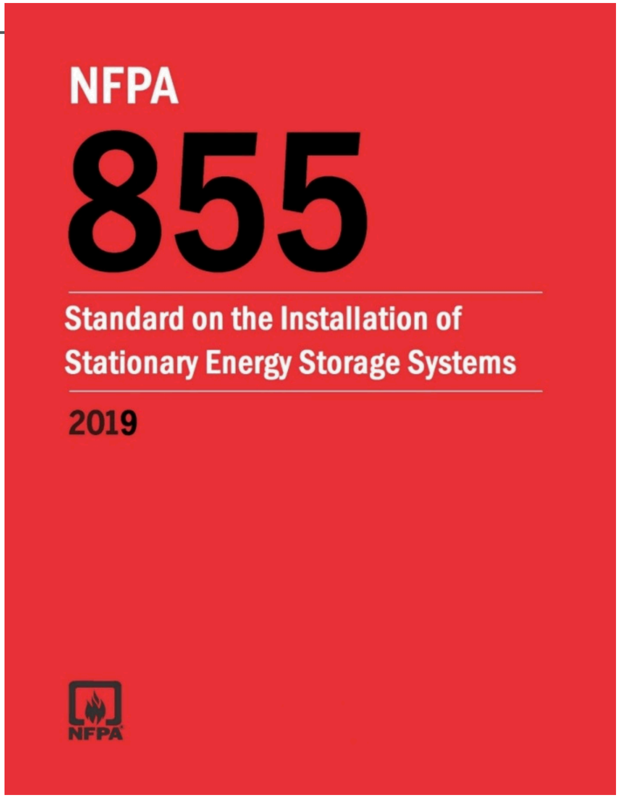
NFPA Standards on ESS

NFPA 1, NFPA 70, NFPA 855

September 26, 2017 | Brian O'Connor, Fire Protection Engineer

NFPA 855 Status

- April 2016, Project Approved
- August 2016, Committee Formed
- Drafting Meetings
  - January 2017
  - April 2017
  - May 2017
- August 2017 Draft Approved
- First Draft Meeting Oct. 23, 2017
  - Dallas, Texas



NFPA 855 Scope

ESS TECHNOLOGY	Aggregate CAPACITY[a]
BATTERY ESS	
Lead acid	70 KWh
Nickel cadmium	70 KWh
Lithium-Ion	20 KWh
Sodium	20 KWh
Flow batteries	20 KWh
Other battery technologies	10 KWh
Batteries in residential occupancies	1 KWh
CAPACITOR ESS	
Capacitors, all types	3 KWh
OTHER ESS	
All other ESS	70 KWh

NFPA 855 Chapters

4. General
5. System Interconnections
6. Commissioning
7. Operation and Maintenance
8. Decommissioning
9. Electro-Chemical ESS
10. Capacitors
11. Fuel Cell Energy Storage Systems

NFPA 855 Reserved Chapters

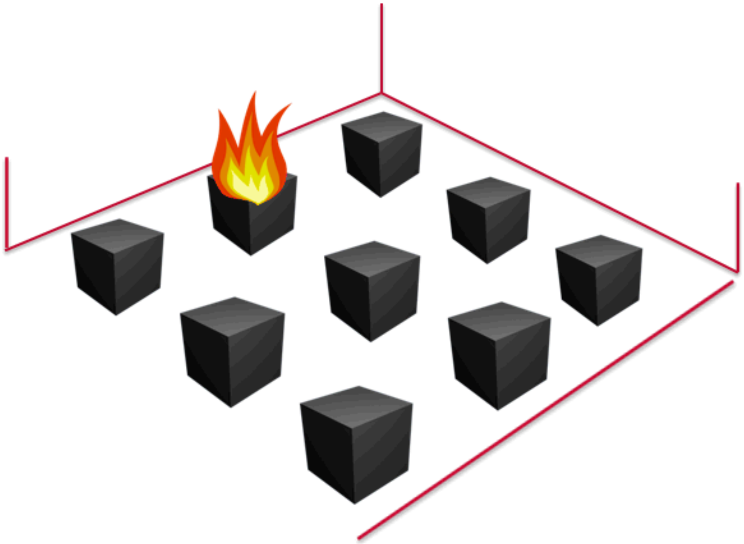
12. Superconducting Magnetic Energy Storage
13. Flywheel
14. Pumped Hydro
15. Compressed Air ESS
16. Hydrogen ESS
17. Thermal ESS

NFPA 855 Annexes

A. Explanatory Material
B. Energy Storage System Hazards
C. Fire-Fighting Considerations
D. Overview of ESS Technology
E. Permits, Inspections, Approvals and Connections
F. Informational References

NFPA 855 Size and Separation (Indoor)

- 250 kWh groups
- Spaced 3ft from groups and wall
- Other arrangements based on large scale fire test



NFPA 855 Size and Separation (Outdoor)

- 10ft separation from exposures
  - 3ft with 1hr fire barrier
- Transformer Separation Criteria
- Rooftop Installations
- Remote Installations

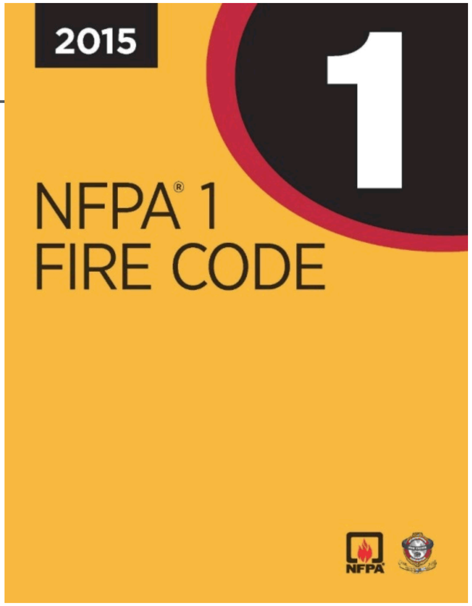
NFPA 855 Fire Control and Suppression

- Sprinkler System per NFPA 13 with 0.3 gpm/ft^2 density
- Sprinkler System per NFPA 13 with density based on large scale testing
- Other fire suppression method based on large scale testing

NFPA 855 Additional Content

- Ventilation
- Thermal Management
- Detection Systems
- System interconnections
- Commissioning
- Operation and maintenance

NFPA 1, Chapter 52 (2015)



- Venting
- Thermal Runaway
- Location & Separation
- Seismic Protection
- Neutralization
- Signs
- Spill Control
- Smoke Detection

NFPA 1, Chapter 52 (2018)

- Available October 27th, 2017
- Prescriptive or Alternative with Testing
- Separates out more mature battery technologies
  - Lead-Acid
  - Nickel-Cadmium

NFPA 1, 2018 Edition

- Lead Acid and Nickel-Cadmium Batteries
  - Sprinklered Building: >100gal Electrolyte
  - Unsprinklered Building >50gal of Electrolyte
- Additional Battery Technologies
  - Lithium Ion 20KWh
  - Sodium 20KWh
  - Flow Batteries 20KWh
  - Capacitors 70KWh
  - Other 10KWh

NFPA 1, 2018 Edition

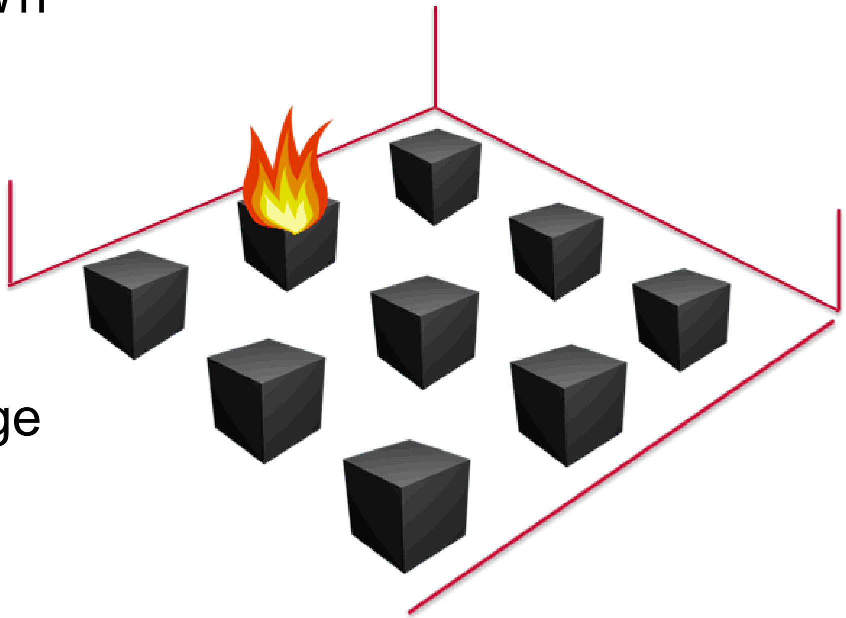
- Location
  - No more than 75ft above fire department vehicle access
  - No more than 30ft below lowest exit discharge
- Separation
  - 1 or 2 hour fire rated barrier, depending on occupancy
  - 3ft from container walls

NFPA 1, 2018 Edition

- Maximum Allowable Quantities
  - Lithium Ion 600KWh
  - Sodium 600KWh
  - Flow Batteries 600KWh
  - Other 200KWh

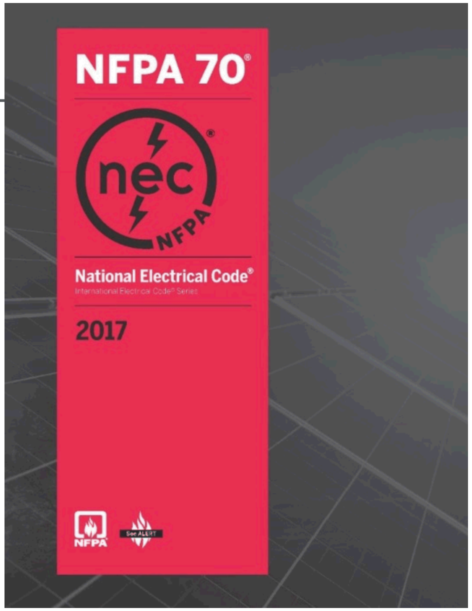
NFPA 1, 2018 Edition

- Battery Arrays
  - Segments not exceeding 50KWh
  - 3ft Separation from walls and other arrays
  - Max 250 KWh for Listed Systems
  - Other arrangements as approved by AHJ based on large scale fire and fault condition testing



NFPA 70, Article 706

- Circuit Requirements
  - Overcharge protection
  - Charge Control
- Equipment need to be listed
- Disconnecting means
- Connection to other energy sources
- Location & Ventilation



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NFPA 70, 2020 Edition Timeline

- Public Input Closing Date: September 7, 2017
- First Draft Meeting January 8 - 20, 2018, Hilton Head, SC
- First Draft Report Posting Date: July 6, 2018

Thank You

DOE OE Energy Storage Program - Codes and Standards Update

UPDATE ON UL STANDARD ACTIVITY RELATED TO ENERGY STORAGE SYSTEMS

Laurie Florence

September 26, 2017

AGENDA

UL Standards Activity:

- UL 9540
- UL 1973
- UL 1974
- UL 1741
- Other UL Related Standards

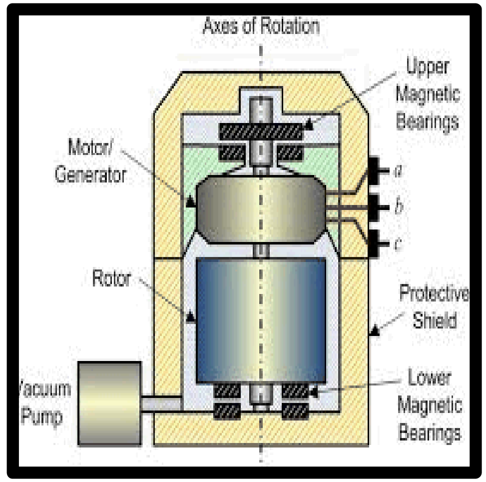
Energy Storage Systems and Equipment

- Safety Standard
- Includes energy storage systems that are
  - Standalone to provide energy for local loads;
  - In parallel with an electric power system, electric utility grid; or
  - Able to perform multiple operational modes.
  - For use in utility-interactive applications in compliance with IEEE 1547 and IEEE 1547.1 or
  - Other applications intended to provide grid support functionality,
  - May include balance of plant and other ancillary equipment of the system

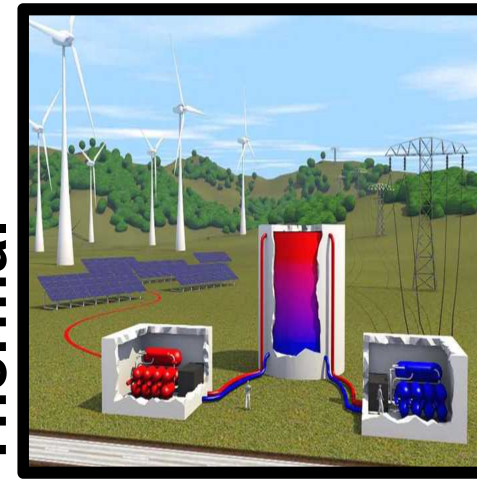
UL 9540 OVERVIEW

Types of Energy Storage Technologies within Scope of UL 9540

Mechanical



Thermal



Electrochemical

Chemical

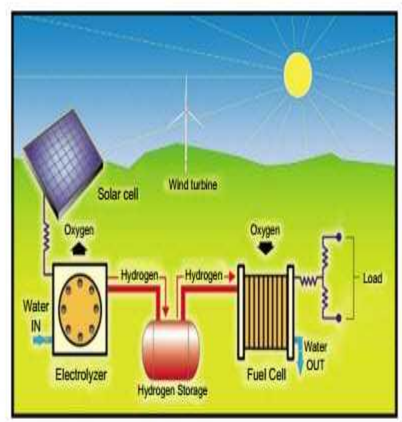


FIGURE 10.9 A hydrogen energy storage system.

UL 9540 OVERVIEW

Some Proposed changes:

From 1 year of use and updates/developments in codes

- Clarification of scope
- Clarification of mechanical test methods
- Modification of ISO containers/impact on strength
- Addition of grounding connections details
- Reference to new fire code criteria with regard to fire detection and suppression
  - Addition of large scale fire test standard reference UL 9540A
- Global revisions to ensure more enforceable language

UL 9540 OVERVIEW

Significant Dates in The UL 9540 Timeline

June 30, 2014

- UL Subject 9540 Published
  - Non consensus standard

August 24, 2016

- Referenced in 2017 NEC

November 21, 2016

- ANSI/CAN/UL 9540 published
- Bi-national consensus standard for the USA and Canada

3rd Quarter 2017

- Proposals submitted
- 2nd edition (TBD)
- Referenced in 1st Draft of NFPA 855, (July 2017)

UL 1973 OVERVIEW

UL 1973, Batteries for use in Light Electric Rail (LER) and Stationary Applications

Scope

- Safety standard for Cells, Modules and Battery Systems
- Non technology specific and includes specific criteria for
  - Lithium ion
  - Nickel
  - Lead Acid
  - Sodium Beta
  - Flow Batteries
  - Electrochemical Capacitors (*ultracaps*)
- Construction & Testing (type and routine) Criteria

UL 1973 OVERVIEW

Under revisions for 2^{nd} edition of UL 1973

Include Canadian requirements (for bi-national standard)

Revisions to the internal fire test

- Renamed to single cell failure tolerance test
- Broken up into lithium ion test and other technology (lithium metal, sodium beta and lead acid) tests
- New Appendix F to outline cell failure methods

Include arc flash calculation information in instructions

Short circuit current rating and check value during short circuit test

Change terminology throughout standard (change from “energy storage system” to “battery system”)

UL 1973 OVERVIEW

Significant Dates in The UL 1973 Timeline

October 6, 2010

- UL Subject 1973Published
  - Non consensus standard

February 15, 2013

- ANSI/UL 1973 published
- Consensus standard for the USA

August 24, 2016

- Referenced in 2017 NEC

4th Quarter 2017

- Proposals submitted
- 2nd edition draft
- Bi-national standard for USA and Canada

UL 1974 OVERVIEW

UL 1974, Standard for Evaluation for Repurposing Batteries

Scope:

- covers the sorting and grading process of battery packs, modules and cells that were originally configured and used for other purposes, such as electric vehicle propulsion, and that are intended for a repurposed use application, such as for use in stationary energy storage and other applications.
- The process of sorting and grading these devices is essentially determining the state of health and other parameters to identify continued viability and the rating mechanisms the manufacturer may use for those that are determined suitable for continued use.

UL 1974 OVERVIEW

- UL 1974 is a “manufacturing process” standard that looks at the methods used to determine safety and performance of batteries, modules and cells from used EV battery systems (i.e. repurposing process)
- Assembled batteries need to meet the end product when re-assembled into a 2^{nd} use battery
  - UL 1973 for stationary batteries

UL 1974 OVERVIEW

Significant Dates in The UL 1974 Timeline

June 1, 2010
- UL Subject 1974 bulletin out for review

September 2017
- UL Subject 1974 Ballot out for review and voting

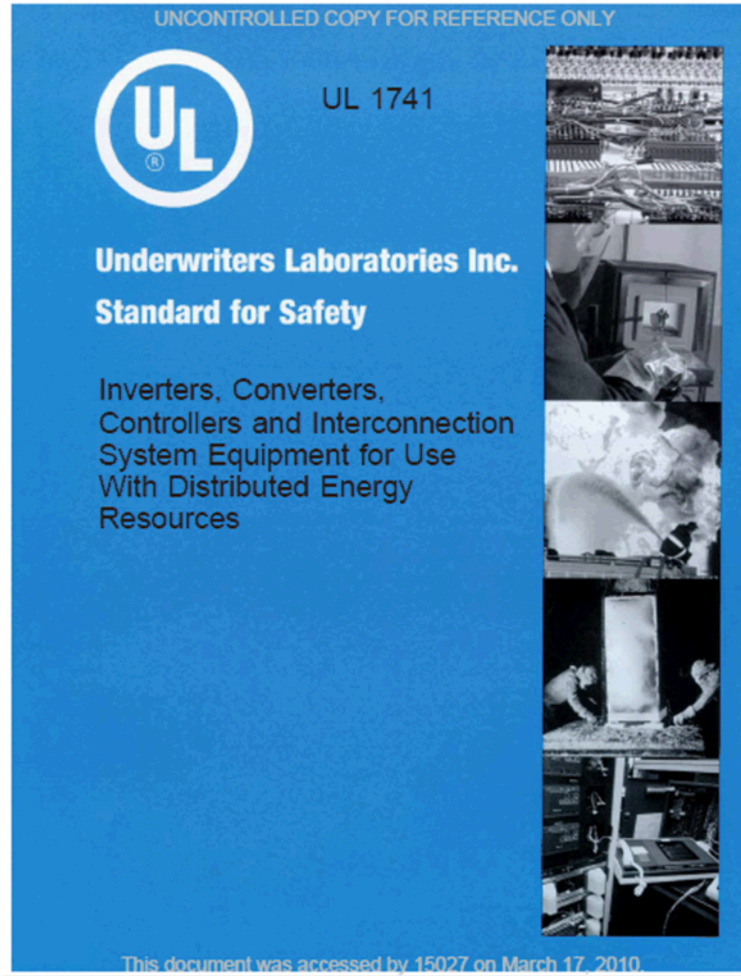
2017 4th Quarter
- UL 1974 Recirculation Bulletin out for review and voting

1st Quarter 2018
- 1st edition UL 1974 published
- Bi-national standard for USA and Canada

UL 1741 OVERVIEW

UL 1741 Covers Power Conversion and Protection Equipment for the Following Types of DR products:

- Photovoltaics, PV
- Fuel Cells
- Micro-turbines
- Wind and Hydro Turbines
- Engine Generator Set
- Utility Interactive Inverters
- Stand Alone Inverters
- Multi-Mode Inverters
- AC Modules
- Charge Controllers
- PV Balance of Systems,
- Combiner Boxes, GFDIs, etc



UL 1741 OVERVIEW

UL1741 SA - Grid Support Utility Interactive Supplement to “bridge the gap” until the new IEEE 1547 and IEEE 1547.1 Grid Support revisions are completed.

Utility-Interactive and Multi-Mode Inverters with Capability to Actively Control and Limit Grid Export Output

Need to specify functionality, characteristics and operational parameters.

- Actively limited output real power commanded or scheduled.
- Communications protocol, means and response characteristics.
- Time schedule with specified response characteristics.
- Power output changes with respect to generation limits.
- Power output changes in response to abnormal voltage and frequency excursions on the area EPS, with specified response characteristics.

Need to Differentiate Utility Interactive Products

Utility Interactive	Grid Support Utility Interactive	Special Purpose Utility Interactive
Traditional UL1741 IEEE 1547 & 1547.1 Interconnection Requirements	UL 1741 SA Grid Support Functions	Specific Mfr / Utility Defined UL Verified Compliance

- The above categories clearly define product functions and ratings per the product's markings, ratings, manual, and certification documentation.

UL 1741 OVERVIEW

Significant Dates in The UL 1741 SA Timeline

UL 1741SA 2016 – Sept 7, 2016

- UL1741 SA used to fulfill Grid Support Interactive Inverters certification needs of early adopters like **CA - Rule 21 & HI - 14H**.

→

Updates to IEEE 1547 should be published in **late 2017**.

→

Updates to IEEE 1547.1 Should be published in **mid to late 2018**.

→

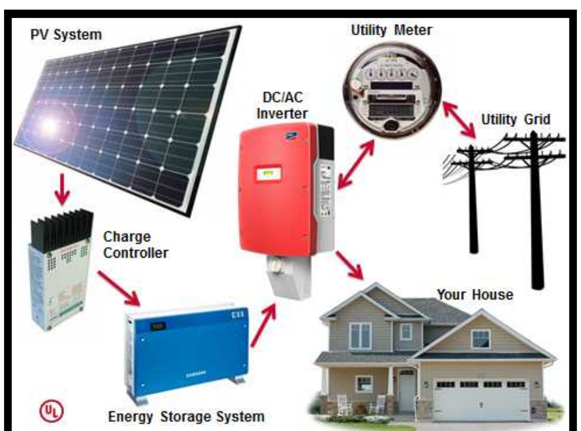
UL 1741 will be revised to replace the Supplement SA with references to the newly revised IEEE 1547 and IEEE 1547.1.

Q1 of 2019

OTHER UL STANDARDS DEVELOPMENT

UL 3001, Distributed Energy Generation and Storage Systems

- Scope: Safety of a distributed generation system with storage
- Status:
  - STP established
  - First edition bulletin under development



UL 9540A, Thermal Runaway Fire Propagation within Battery Energy Storage Systems

- provide fire test data and acceptance thresholds
  - to meet fire safety objectives included in the model fire and other codes (*large scale fault and fire testing*).
- Status
  - Outline of Investigation standard
  - To be Published in September 2017
- Long term goal to include as Appendix in UL 9540

FIND US ON…

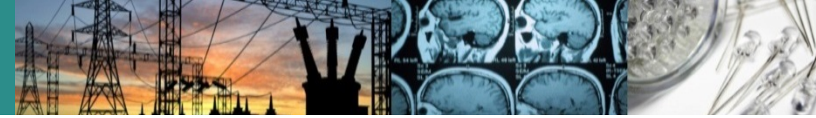
NEMA Energy Storage Systems Section

➢ Scope (Excerpt)

- Includes
  - Storage device/medium
  - Power conversion systems
  - Control & management systems
  - Up to point of common coupling with a grid or premise
- Grid connected or operate independent of the grid
- Operator (utility) side or consumer side of the electric power system

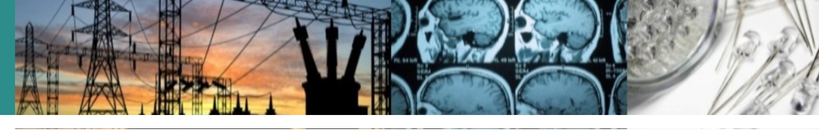
NEMA ESS Standards Activities

- Secretariat for the ANSI Accredited Standards Committee (ASC) on Energy Storage Systems
- ANSI fundamental standards development requirements:
  - Openness
  - Lack of dominance
  - Balance
  - Consideration of views and objections
  - Consensus vote



ANSI/NEMA Standard on ESS

- Initiated ANSI/NEMA process to develop a ESS standard based on the PNNL/SNL protocol
- Developed a consensus body with appropriate balance
- Focus is on electrical energy storage systems
- Held four calls to develop and resolve comments
- Standard published by end of year



Canvass Process

1. Establish Consensus Body
2. NEMA (Section, Counsel and C&S) Approve Project
3. Submit PINS to ANSI
4. Develop Document as an ANS
5. Announce in ANSI Standards Action
6. Ballot Draft to Consensus Body
7. Resolve Comments
8. Recirculate Unresolved Comments & Votes to Consensus body
9. Submit Documentation to ANSI - BSR-9
10. Approval by ANSI
11. Edit final draft
12. Publish standard as ANS

Thank you.

Contact Info:

Steve.Griffith@nema.org
Brian.Marchionini@nema.org

IEEE SCC18 & ESSB Committee Safety Code Efforts

Christel Hunter, SCC18 Chair

Chris Searles, ESSB Chair

Bill Cantor, ESSB Safety Codes & Standards WG Chair

PRELIMINARY WIP

Who are IEEE SCC 18 and IEEE ESSB and What do they do?

IEEE

- **Name: Standards Coordinating Committee 18**
- Reports to: IEEE Standards Association
- Type of Committee: 1 (does not write standards)
- Leadership:
  - Chris Hunter, Chair
  - Dennis Nielsen, Vice Chair
  - Paul Myers, Secretary/Treasurer
  - Arthur Smith, Elections Officer
  - Bill McCoy, Membership Officer
  - Mario Spina, Webmaster
  - Ed Larsen, Past Chair

  - **Staff liaison: Pat Roder**

- **Name: IEEE Energy Storage & Stationary Battery Committee**
- **Reports to: IEEE Power and Energy Society Technical Committee**
- **Type: 2 (does write standards)**
- **Leadership:**
  - Chris Searles, Chair
  - Curtis Ashton, Vice Chair
  - Babu Chalamala, Secretary
  - Tom Carpenter, Treasurer
  - Jim McDowall, Standards Coordinator
  - Paul Hectors, Webmaster
  - Rick Tressler, Past Chair
  - Kurt Uhlir, SBEE Subcommittee
  - Steve Vechy, DCRS Subcommittee
  - **Staff liaison: Michael Kipness**

- **IEEE SCC 18** is responsible for coordinating and establishing the IEEE position on certain National Fire Protection Association (NFPA) technical committees.

- **IEEE ESSB** represents the IEEE on various National Fire Protection Association (NFPA)Technical Committees
  - **NFPA 70 – *National Electrical Code***
    - ✓ ***Bill Cantor – ESSB WG Chair/NEC 70-CMP 13 [Batteries]***
  - **NFPA 70B – *Recommended Practice for Electrical Equipment Maintenance***
    - ✓ ***Bill Cantor – ESSBWG Chair/Primary Rep [Electrical Maintenance]***
  - **NFPA 855 – *Standard for the Installation of Stationary Energy Storage Systems***
    - ✓ ***Bill Cantor – ESSBWG Chair/Nominated as IEEE Representative***

IEEE ESSB and SCC 18 Opportunities

- **SCC 18** Membership is open to those who are:
  - IEEE members above student grade, and
  - Standards Association (SA) members, and
  - Sponsored by an IEEE society, department, committee or subcommittee

- **SCC18** members come from…
  - Electrical Safety Committee: 2
  - Industrial &Commercial Power Systems Dept.: 13
  - Petroleum & Chemical Industry Committee: 8
  - Power & Energy Society: 4
  - Computer Engineering Society: 2

- There are currently several open positions on NFPA TCs or CMPs that need to be filled -
  - If you are interested or want to learn more, contact Chris Hunter or visit the SCC 18 web page:

    http://sites.ieee.org/scc18/home/about/.

- Does belonging to SCC 18 mean I can be on an NFPA TC?
  - An IEEE SA and NFPA application process is required
  - The NFPA requires IEEE representatives to be users, or be able to represent users (consultants)
  - Employees of producers (manufacturers) are not eligible

- **IEEE ESSB** is open to all who have the following interests:
  - Have an interest in developing a technical understanding of the technologies related to energy storage, stationary batteries and related dc power systems.
  - Wish to help in the writing of standards (Best Practices and Guides) that ensure the safety, performance and reliability for the industry.
  - Willing to share SME knowledge thru technical symposiums, tutorials, etc.

- **IEEE ESSB** membership is made up of ….
  - Electrical, Chemical, Mechanical and other Engineers
  - Project, Test and Maintenance Engineers, Technicians
  - Installation and Testing Experts
  - Academia and R&D Scientists
  - Government Regulatory Engineers

CURRENT ESSB COMMITTEE STANDARDS ADDRESSING SAFETY ISSUES/CONCERNS

Standard	Description	Standard	Description
IEEE 450	Maintenance & Testing VLA's	IEEE 1657	Qualifications for Installation/ Maintenance Technicians
IEEE 1188	Maintenance & Testing VRLA's	IEEE 1679	Characterization/Evaluation of Emerging Technologies
IEEE 1375	Protection of Stationary Batteries	IEEE 1679.1	Characterization & Evaluation of Lithium-Based Batteries
IEEE 1578	Spill Containment & Management	IEEE 1679.2	Characterization & Evaluation of Socium-Based Batteries
IEEE 1635	Ventilation & Thermal Management of SB's	To be Proposed	Characterization & Evaluation of Flow-Based Batteries

IEEE

Suggested Actions, Next Webinar on Codes/Standards Adjourn

- Suggested activities we should be undertaking or facilitating under the ESS safety roadmap efforts related to codes and standards
- Codes and standards reports to continue on a monthly basis
- The PPT used today with Q/A appended will be sent out and serve as the September C/S Report
- The next webinar date is TBD (January 2018?)
- Details on next webinar to be sent and will follow the same format as this webinar with advance materials forwarded via e-mail
- If there is something we should be covering in the monthly codes and standards report that we are not covering please let us know

THANK YOU

For more information on ESS safety related efforts….

david.conover@pnnl.gov

pam.cole@pnnl.gov

http://www.sandia.gov/energystoragesafety/

Acknowledgment

Dr. Imre Gyuk

DOE-Office of Electricity Delivery and Energy Reliability

PNNL-SA-129440