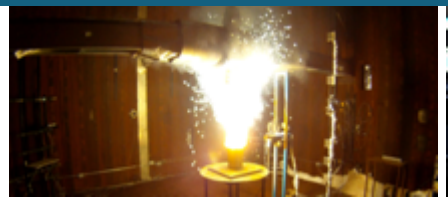
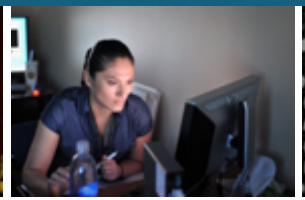
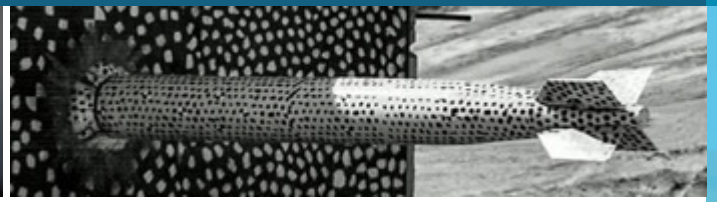
SAND2021-4914C

Sandia National Laboratories

The continuing evolution of Energy Storage Safety Strategy







Joshua Lamb

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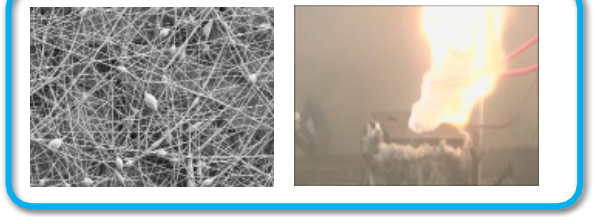
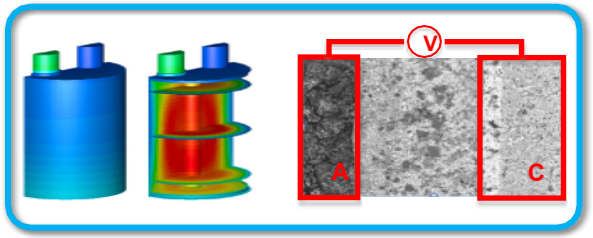
Battery Safety – Stationary Storage



Materials R&D to date:
- Non-flammable electrolytes
- Electrolyte salts
- Coated active materials
- Thermally stable materials

Materials R&D needs:
- Viable flow batteries
- Aqueous electrolyte batteries
- High specific heat suppressants
- Vent gas composition

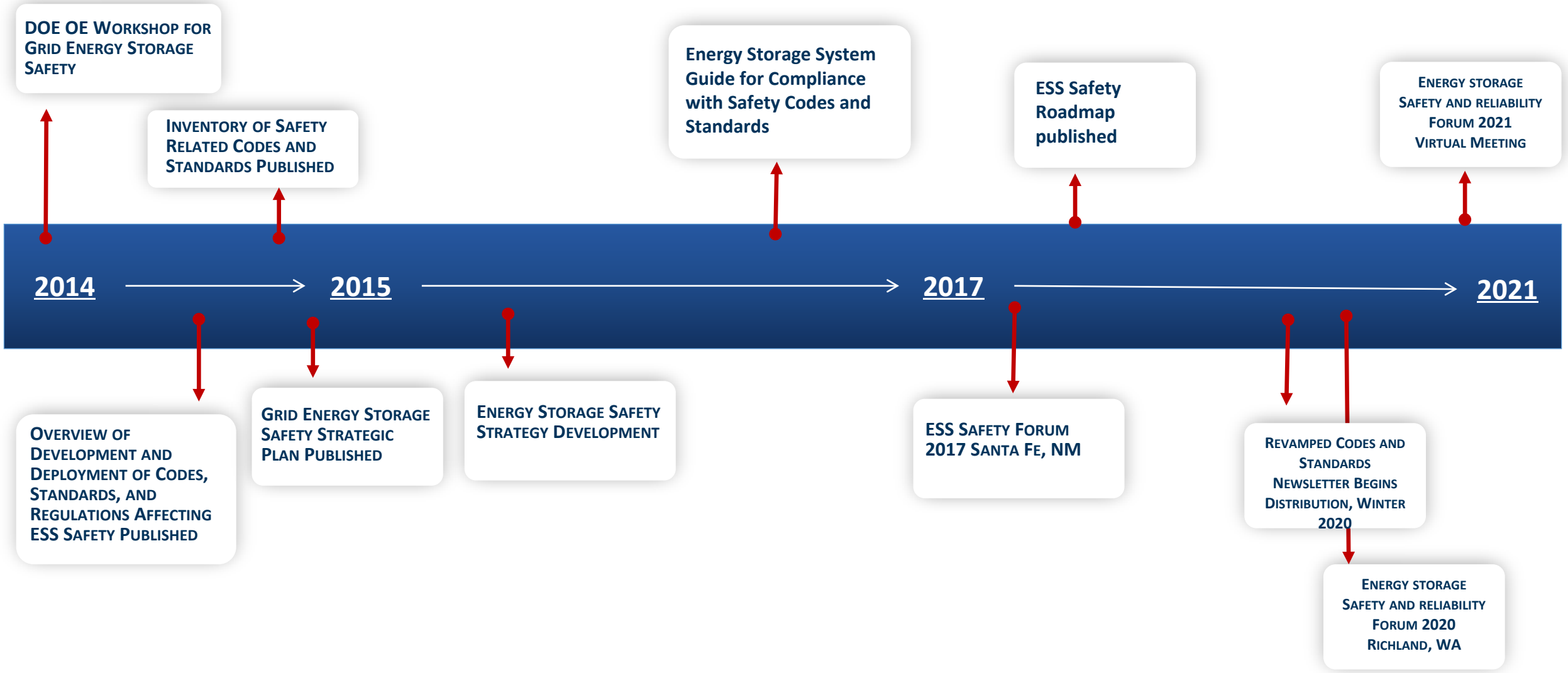
Testing
- Electrical, thermal, mechanical abuse testing
- Failure propagation testing on batteries/systems
- Suppressants and delivery with systems and environments
- Large scale thermal and fire testing (TTC)



Simulations and Modeling
- Multi-scale models for understanding thermal runaway
- Validating failure propagation models
- Fire Dynamic Simulations (FDS) to predict the size, scope, and consequences of battery fires

Procedures, Policy, and Regulation
- UL 1973-13 Batteries for Use in Stationary Applications
- ANSI/UL 9540-P (ESS Safety)
- UL 1974 (Repurposing)
- IEEE 1635-12 (Ventilation and thermal management)

Timeline of Grid Scale Battery Safety



Why the focus on batteries?

- Lithium-ion batteries were fielded in consumer electronics devices without a large base of knowledge on their safety issues
- After their rapid adoption high profile events occurred in consumer electronics devices
- About the same time, their usefulness in large battery systems became apparent




Consumer Cells (0.5-5 Ah) → Large Format Cells (10-200 Ah) → Transportation Batteries (1-50 kWh) → Utility Batteries (MWh)

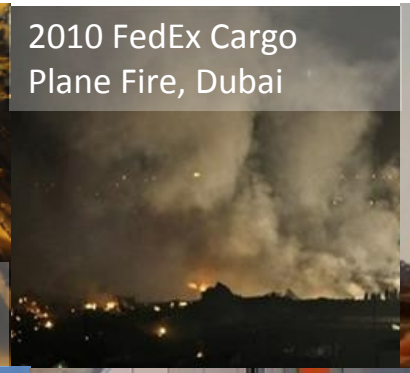
www.ford.com www.samsung.com www.saftbatteries.com

Safety issues should become paramount with increasing battery size

Battery safety incidents

2006 Sony/Dell battery recall 4.1 million batteries

2008 Navy, $400M Advanced Seal Delivery Sub, Honolulu



2010 FedEx Cargo Plane Fire, Dubai

2011 NGK Na/S Battery Explosion, Japan (two weeks to extinguish blaze)

2018 Tesla Model S catches on fire during normal traffic/no accident

2011 Chevy Volt Latent Battery Fire at DOT/NHTSA Test Facility

2012 Battery Room Fire at Kahuku Wind-Energy Storage Farm

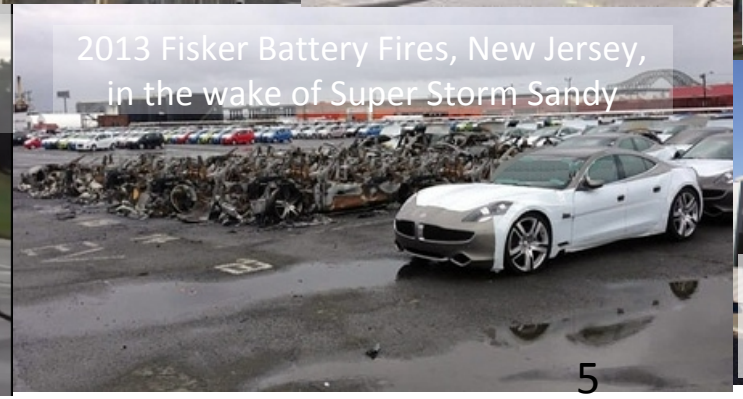
2012 GM Test Facility Incident, Warren, MI

2013 Storage Battery Fire, The Landing Mall, Port Angeles, (reignited one week after being “extinguished”)

2018-2019 A string of 21 energy storage system fires in South Korea leads to suspension of new projects

2013 Boeing Dreamliner Battery Fires, FAA Grounds Fleet

2013 Tesla Battery Fires, Washington, resulting from a highway accident

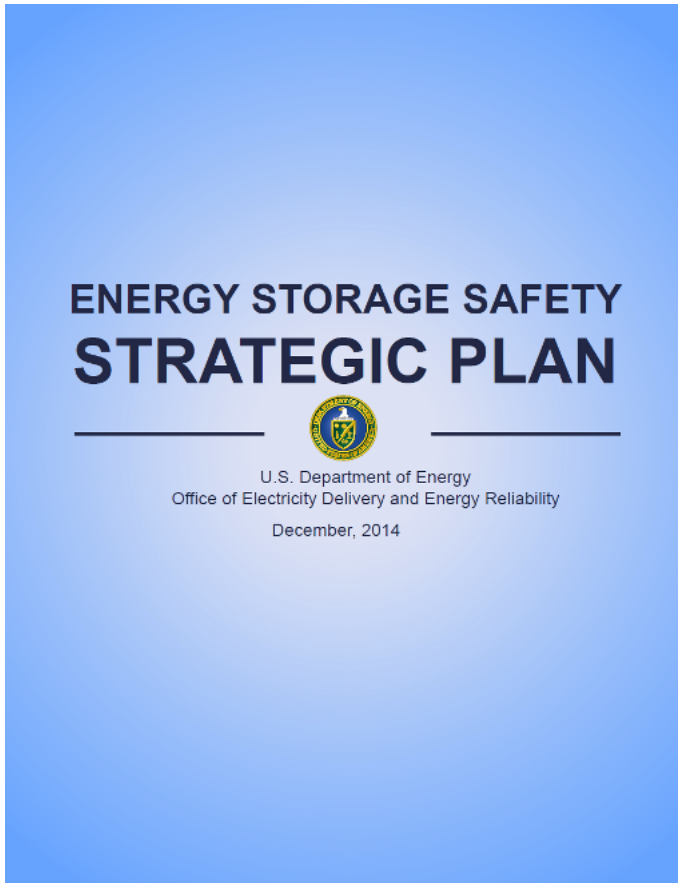


2013 Fisker Battery Fires, New Jersey, in the wake of Super Storm Sandy

2019 A fire in an ESS in Surprise, AZ leads to an explosion injuring first responders

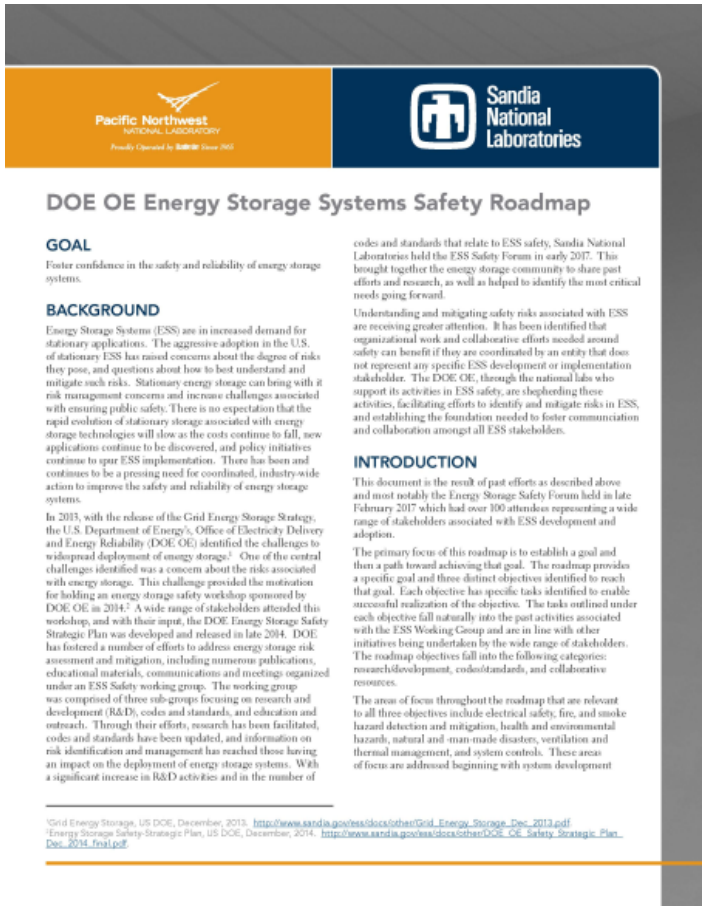
Energy Storage Safety Strategy and Roadmap documents

2014



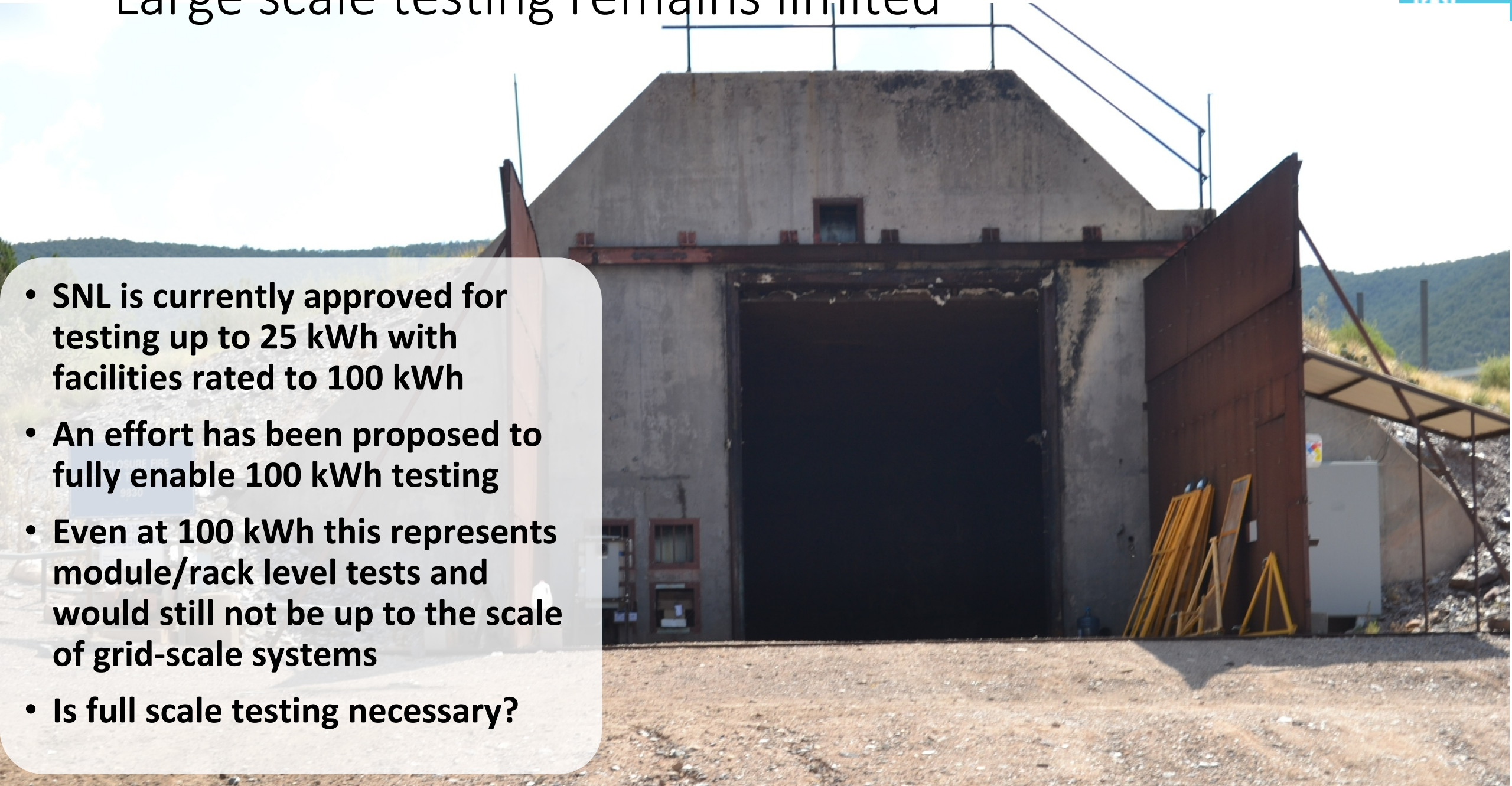
https://www.sandia.gov/ess-ssl/docs/other/DOE_OE_Safety_Strategic_Plan_Dec_2014_final.pdf

2017



https://www.sandia.gov/ess-ssl/publications/EnergyStorage_safetyroadmap_2017.pdf

Large scale testing remains limited

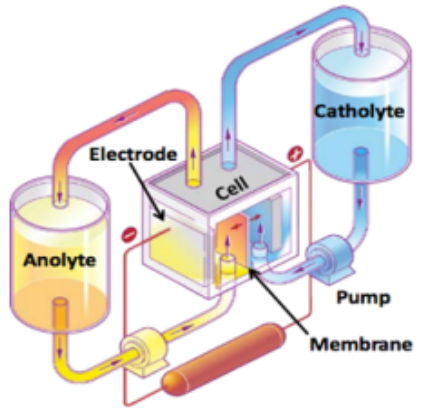


- **SNL is currently approved for testing up to 25 kWh with facilities rated to 100 kWh**
- **An effort has been proposed to fully enable 100 kWh testing**
- **Even at 100 kWh this represents module/rack level tests and would still not be up to the scale of grid-scale systems**
- **Is full scale testing necessary?**

Testing is largely focused on li-ion

- New technologies are being introduced
  - Is testing adequate to new technologies?
  - Li-ion – High energy anode materials
  - Li metal
  - Advanced aqueous batteries
  - Molten salt batteries
- Large storage systems targeting non-traditional locations, and areas near populations
- Grid-scale systems are incredibly complex, including not only a large battery but sophisticated power electronics
  - Back to the question, is full-scale testing necessary?


Subway regen system, SEPTA



Redox Flow Battery


SAFT 10 MWh storage system

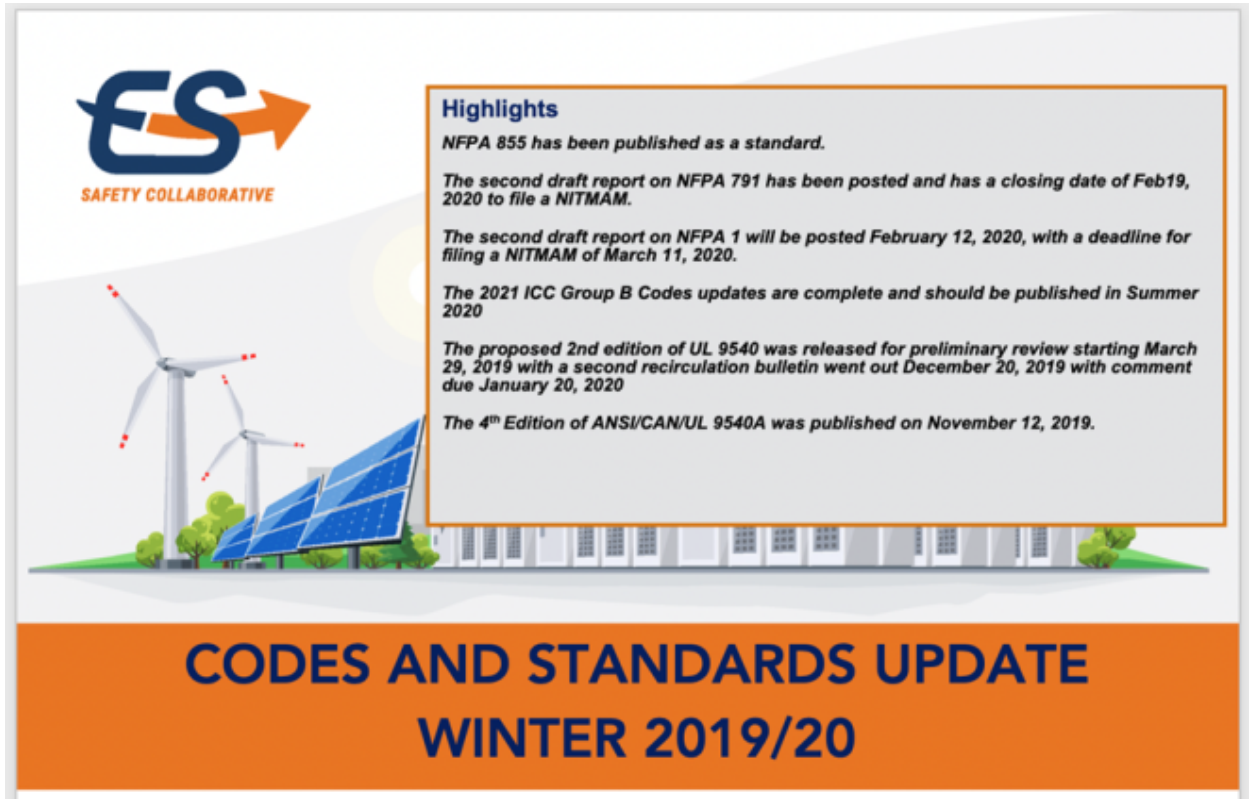

US Marine Corps FOB, Afghanistan

A need for stakeholder and subject matter expert input

- How can we adequately prepare for new technologies to enable their rapid adoption?
- The current gaps in safety research
- How can we better understand new technologies?
- What gaps still hinder lithium-ion adoption? How best to ensure stakeholders are adequately informed of the risk they accept?
- Is full-scale testing necessary, and if so, is there lab capacity to adequately perform it.

Energy Storage Safety Collaborative Reports

Get the free reports to remain alerted to key ESS Codes & Standards updates!



Take photo of code to sign-up to receive quarterly reports

https://public.govdelivery.com/accounts/USDOESNLEC/subscriber/new?topic_id=USDOESNLEC_195

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