Energy Storage Systems
Overview of the Technology, Safety Related Issues and Codes/Standards

SAND2017-4428 C

PNNL-SA-125788

Purpose and Expected Outcome

Purpose – To introduce new and emerging energy storage technologies, safety-related issues, and how those issues are being addressed.

Expected Outcomes

- A basic understanding of energy technologies – FUNDAMENTALS
- Identification of safety-related issues associated with energy storage systems – SAFETY ISSUES
- Identification of the standards and codes applicable to energy storage systems and what they cover – CODES AND STANDARDS
- Knowledge about the various applications for energy storage in the built environment – APPLICATIONS

Source - Southern California Edison

Energy Storage Fundamentals

An overview of the…

- **Market drivers** for energy storage
- **Basic functions** of the different types of energy storage systems

Market Drivers

- Energy supply does not exactly track with or match demand.
- Energy produced from renewable, waste heat and other energy sources may not be acceptable for its intended use.
- Energy cost may change between peak and off-peak periods making it advantageous to “buy low and use high.”
- More traditional sources of energy may have periods when they are not readily available.
- Consumers want to move “off the grid.”
- Utilities need to more effectively operate and improve the grid.

Policy Incentives and Mandates

The demand for energy storage can be accelerated through policy initiatives and incentives that provide needed support until the market matures.

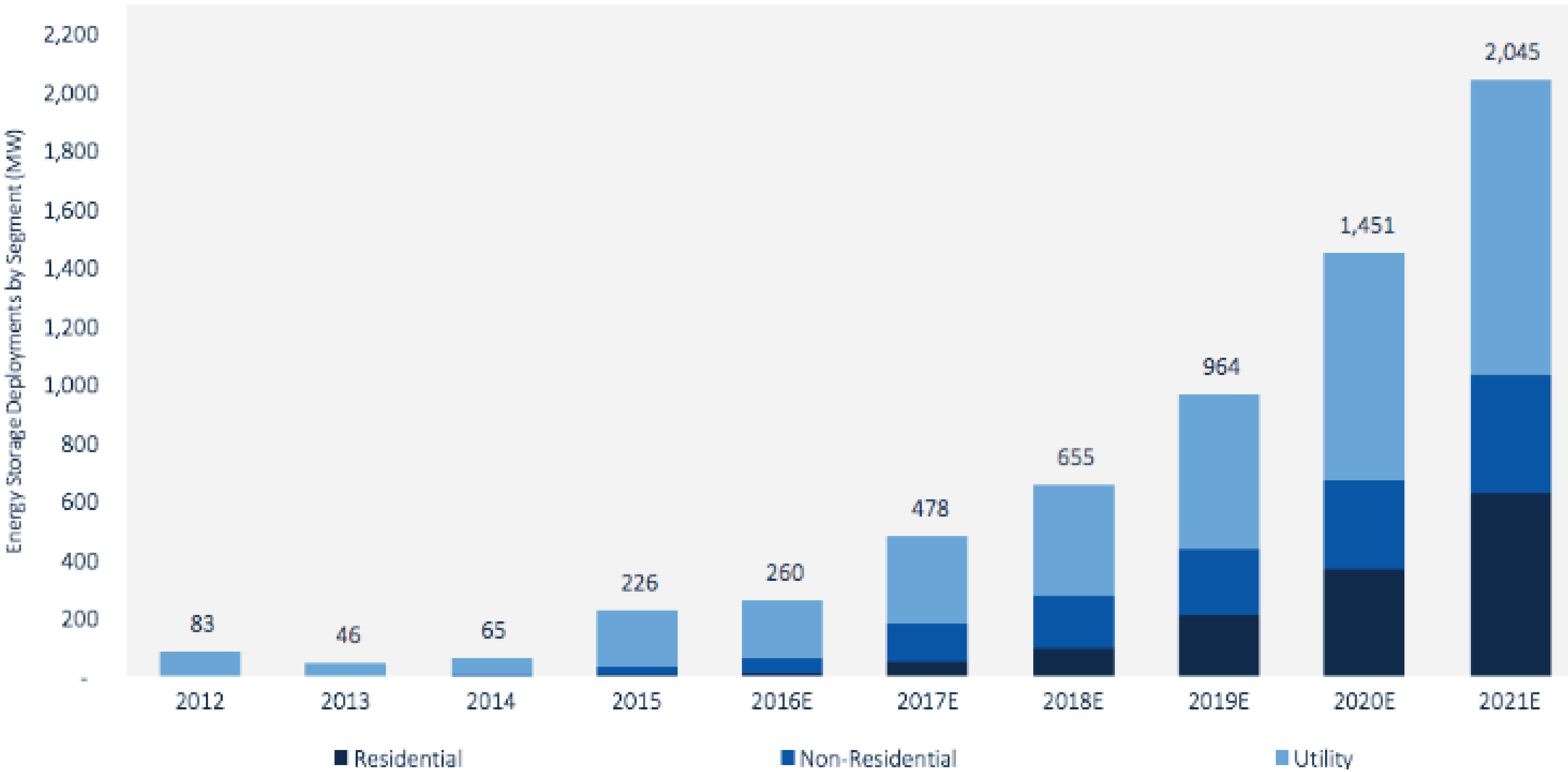
- Install 1.4 gigawatts of storage capacity in New York City
- CA PUC initiative
- MA storage requirement
- OR storage requirement

California Public Utilities Commission

Oregon PUC Public Utility Commission

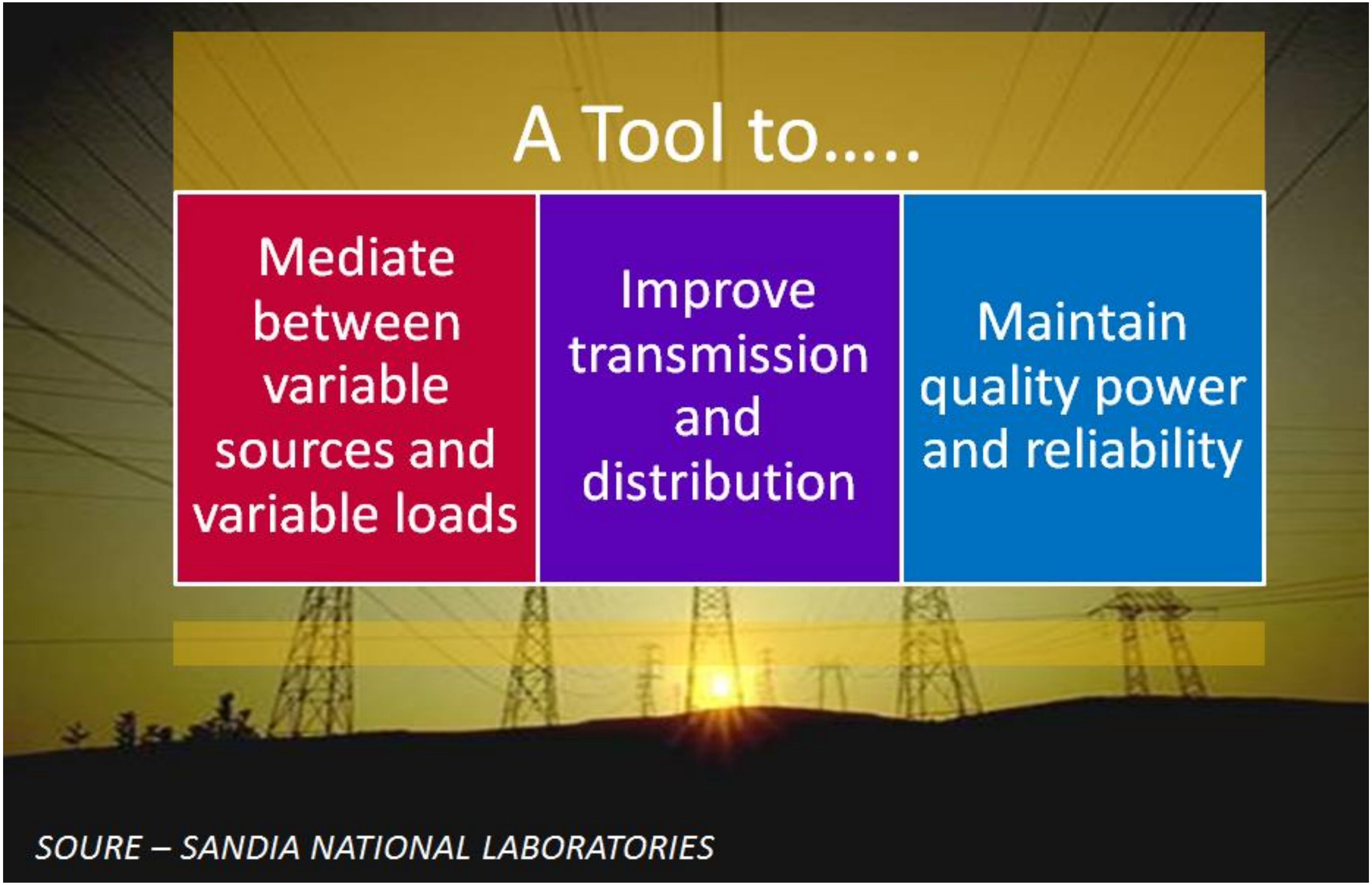
Energy and Environmental Affairs

Energy Storage – Projected Deployment



Source – Green Tech Media Inc.

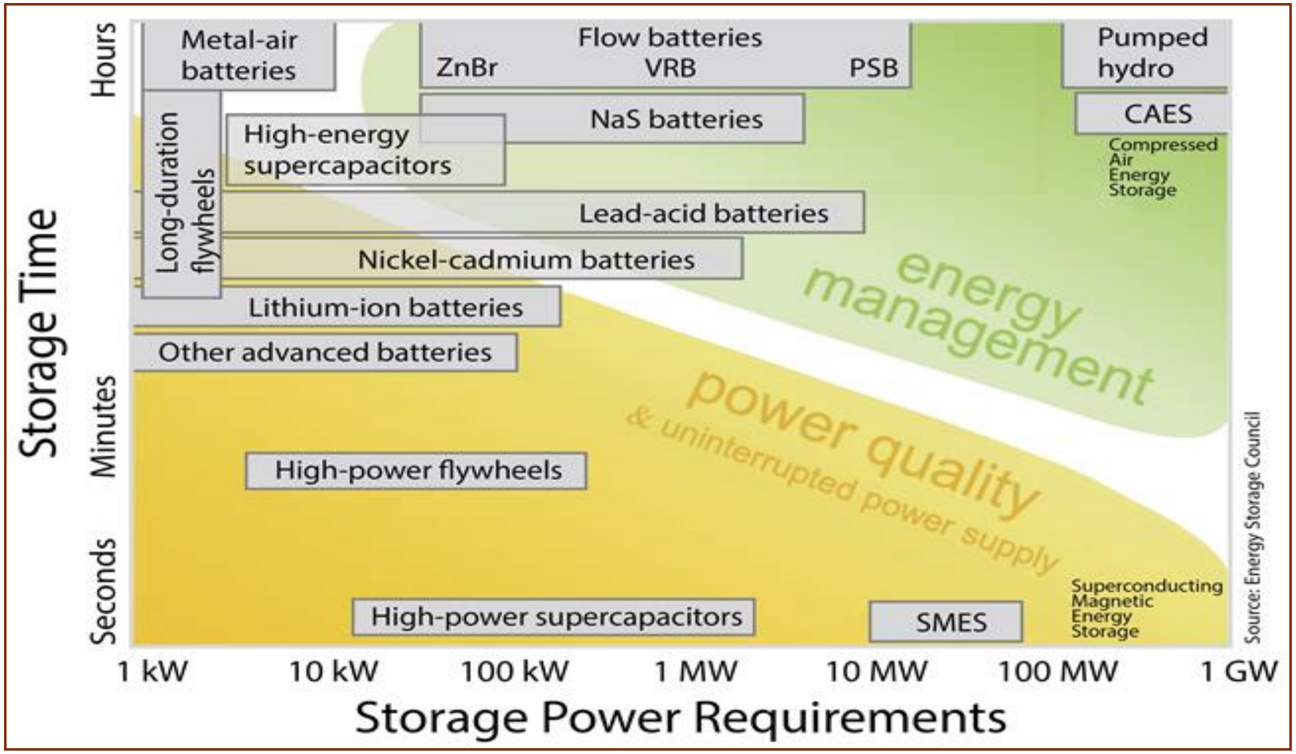
What is Energy Storage?



Energy Storage Technologies

Energy – long discharges (min to hr) ala a "10K"

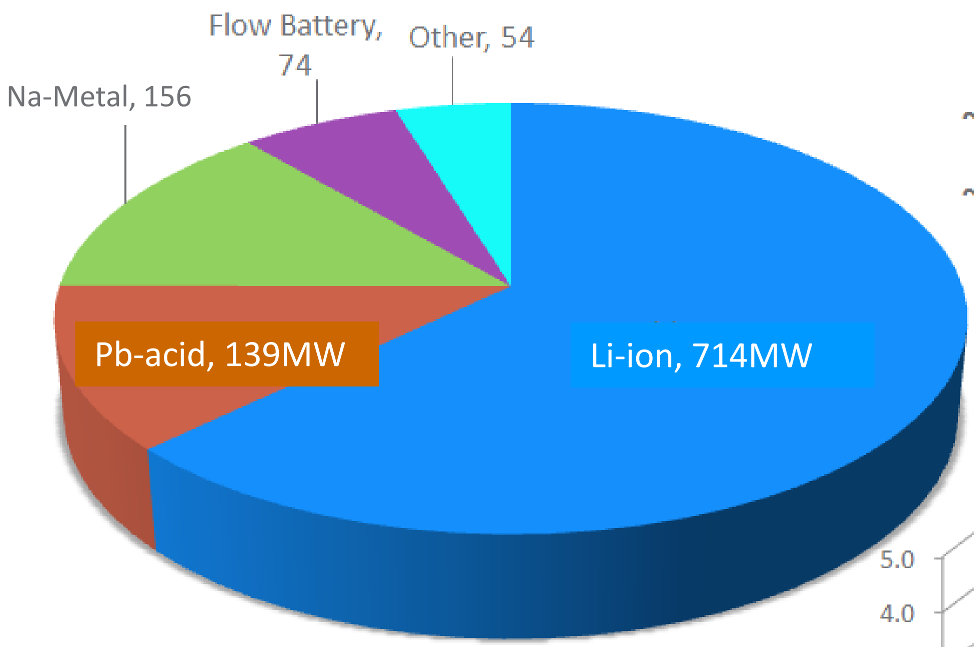
- Pumped Hydro
- Compressed Air Energy Storage (CAES)
- Electrical Storage (Batteries)
- Sodium Sulfur (NaS)
  - Flow Batteries
  - Lead Acid
  - Advanced Lead Carbon
  - Lithium Ion
- Flywheels
- Electrochemical Capacitors



Power – short discharges (sec to min) ala a "100 m sprint"

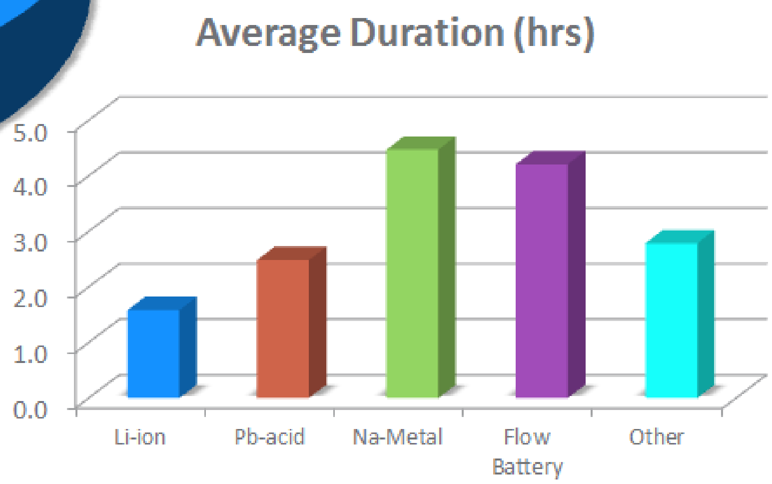
Global Energy Storage Deployments (Battery Only)

BASICS



~ 1.1 GW of Battery Energy Storage

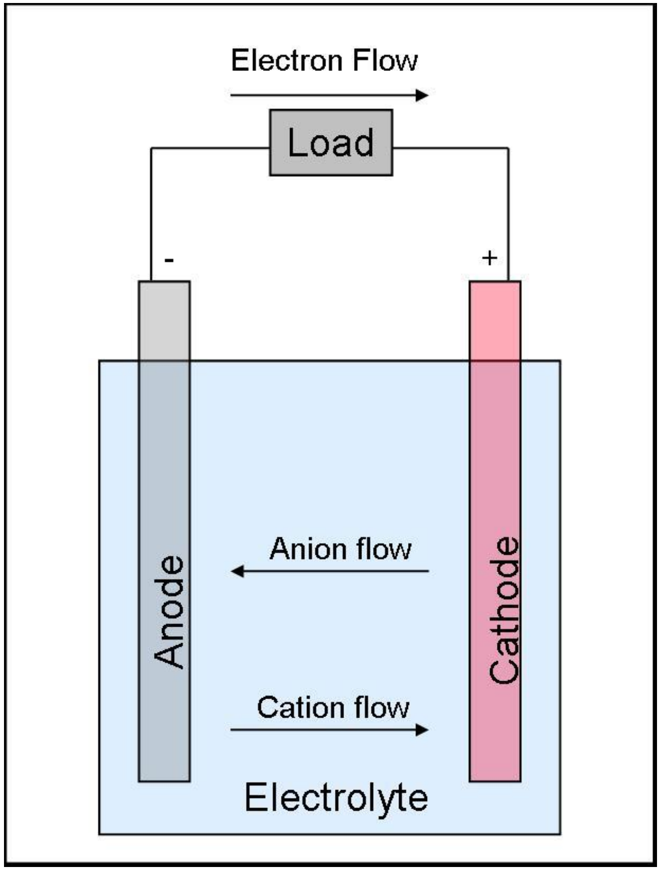
~110 GW of Pumped Hydro



Source: *DOE Global Energy Storage Database http://www.energystorageexchange.org/*
July 2015

Battery Basics

- Batteries store energy chemically and through electrochemical reactions produce electricity.
- The presence of an anode, cathode, and electrolyte provides the basis for storing energy and satisfying energy loads.
- There are a wide range of battery types, sizes, designs, operating temperatures, control mechanisms, and chemistries.
- Beyond storing energy, all batteries are not created equal.



Source – Kamath, EPRI ES Technology Overview

BASICS

Battery Terminology

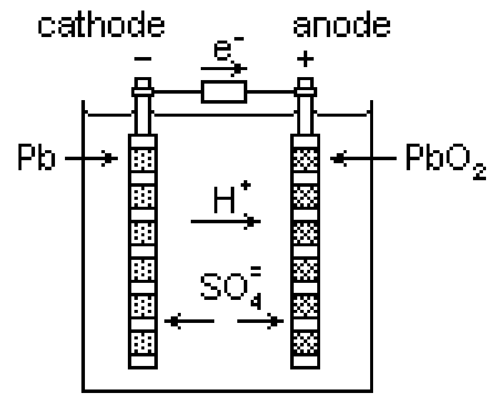
- Electrochemical Cell: Cathode(+), Anode (-), and Electrolyte (ion-conducting intermediate)
- D.C. Efficiencies
  - Columbic – Measure of difference in charge/discharge
  - Voltage – Function of internal resistance
  - Energy – CE x VE
- Energy (kWh) = Voltage (V) difference between anode and cathode multiplied by amount of ion the electrodes are able to store – given as Amp-hours (Ah) of capacity
- Energy Density (Wh/kg or Wh/L): Used to measure the energy density of a battery
  - Low cost/ubiquitous
  - Note: Number often given for cell, pack, and system
  - Generally: Pack = ½ cell energy density, and system is fraction of the pack

Lead-Acid (LA) Batteries

Two electrodes (one lead and one lead-dioxide) immersed in sulfuric acid

- **Pros**
  - Low cost/ubiquitous
  - Mature technology
  - Familiar

- **Cons**
  - Limited lifetime and degradation w/ deep discharge
  - Poor cycle life/need for replacement
  - Often needs maintenance
  - Low specific energy (30–50 Wh/kg)
  - Overcharging leads to H_2 evolution
  - Sulfation from prolonged storage



$$Pb + SO_4^= \rightarrow PbSO_4 + 2e^-$$

$$PbO_2 + SO_4^= + 4H^+ + 2e^- \rightarrow PbSO_4 + H_2O$$

Lead-Acid Storage Cell

- **Includes**
  - SLI
  - Flooded SLA
  - Valve-regulating LA

Nickel-Cadmium (Ni-Cd) Batteries

Two electrodes (one nickel and one cadmium) immersed in an aqueous potassium-hydroxide electrolyte

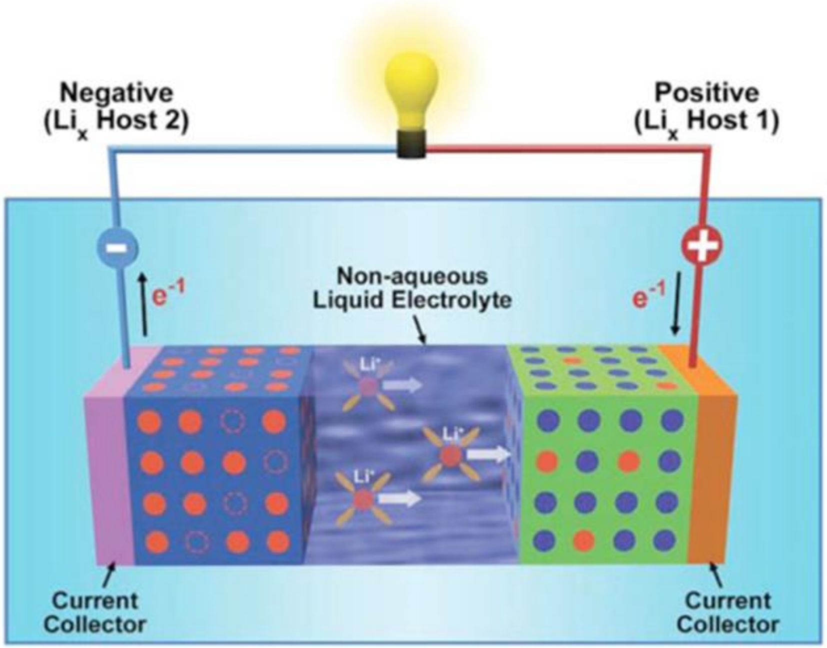
- **Pros**
  - Mature technology
  - Relatively rugged
  - Greater energy density than LA batteries
  - Better life cycle than LA batteries
- **Cons**
  - More expensive than LA batteries
- **Safety**
  - Thermal runaway
  - Contains cadmium

BASICS

Lithium Ion (Li-ion) Batteries

Pros

- Decreasing costs – Stationary on coattails of increasing EV.
- Ubiquitous – Multiple vendors.
- Fast response.
- Higher efficiency.



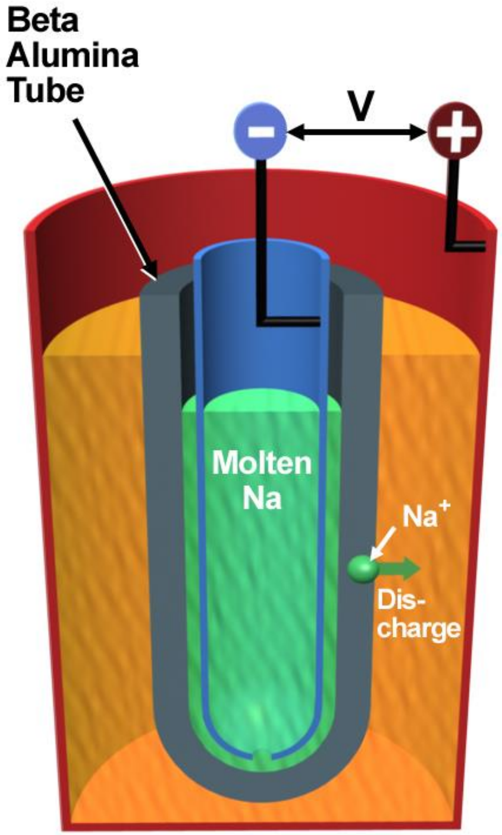
Cons

- High temperature.
- Typical operating window 0–50°C.
- Operation above this temperature can lead to organic electrolyte decomposition and flammable gas.
- Different chemistries have different heat generation.
- Parasitic loads like HVAC often are not included.
- Overcharging: Max voltage depends on materials; overcharging can lead to Li metal plating on anode, potential for short.

BASICS

Na-Metal Batteries Basic Chemistry

- Batteries consisting of *molten sodium anode* and *β''-Al_2O_3 solid electrolyte* (BASE).
  - Use of low-cost, abundant sodium → low cost
  - High specific energy density (120~240 Wh/kg)
  - Good specific power (150–230 W/kg)
  - Good candidate for energy applications (4–6 hr discharge)
  - Operated at relatively high temperature (300~350°C)
- Sodium-sulfur (Na-S) battery
  - **$2Na + xS \rightarrow Na_2S_x$** (x = 3~5)
    - E = 2.08~1.78 V at 350°C
- Sodium-nickel chloride (Zebra) battery
  - **$2Na + NiCl_2 \rightarrow 2NaCl + Ni$**
    - E = 2.58V at 300°C
    - Use of catholyte ($NaAlCl_4$)



BASICS

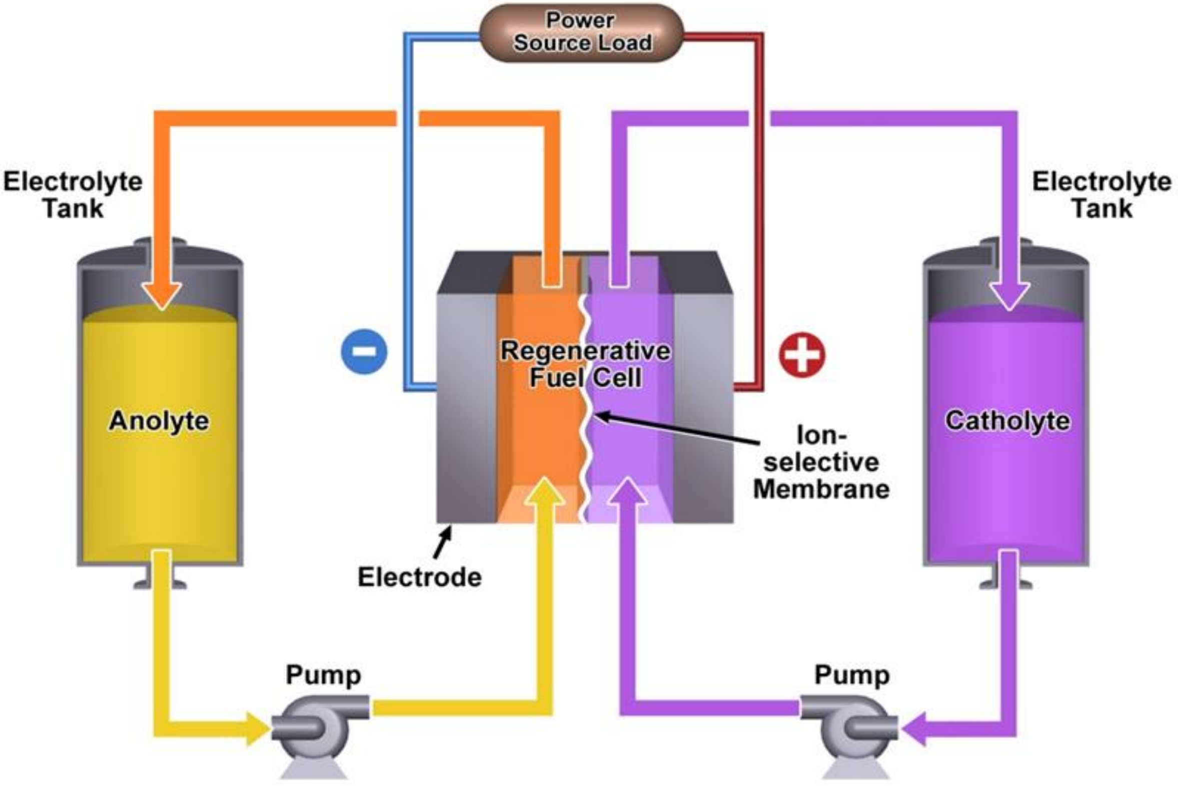
Na-Metal Batteries

- **Temperature**
  - Fewer over-temperature concerns; typical operating window 200–350°C; additional heaters needed when not in use.
  - At <98°C, Na metal freezes out; degree of distortion to cell dictated by SOC of battery (amount of Na in anode).
- **Charging/Discharging Limitations**
- **Safety Concerns**
  - Low cost/ubiquitous.
  - Solid ceramic electrolyte keeps reactive elements from contact.
  - Failure in electrolyte can lead to exothermic reaction (Na-S).

Redox Flow Battery: Basic Chemistry

Key Aspects

- Energy supply does not exactly track with or match demand.
- Power and energy are separate, thereby enabling greater flexibility and safety.
- Suitable for wide range of applications 10's MW to ~ 5 kW.
- Wide range of chemistries available.
- Low energy density ~30 Wh/kg.
- Lower energy efficiency.



BASICS

Redox Flow Batteries

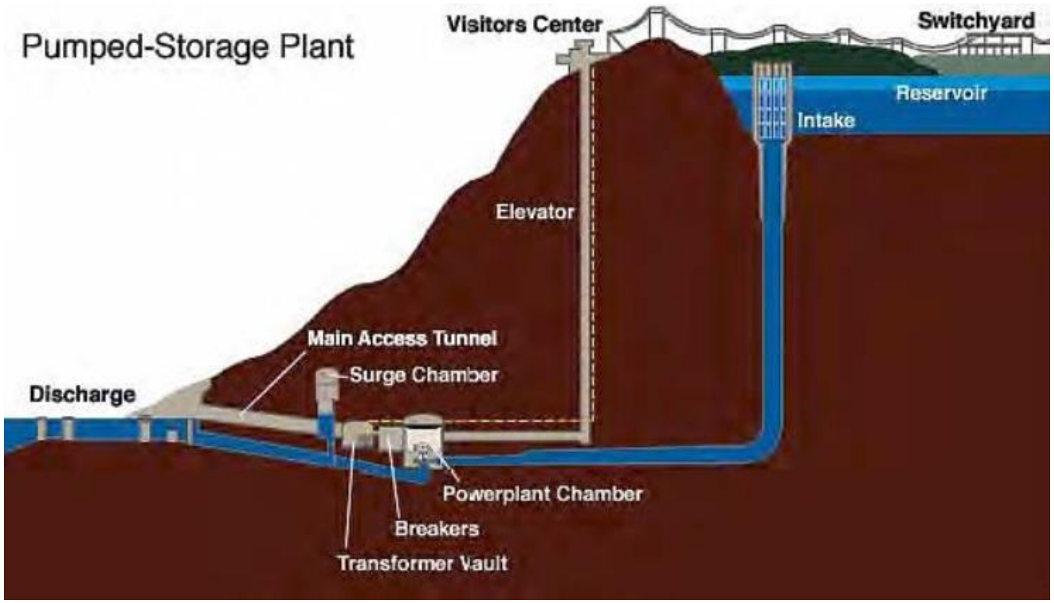
- **Temperature**
  - High/low temperatures can lead to precipitation of species
  - Typical range -10–60°C
- **Charging**
  - Overcharging can lead to evolution of hydrogen (H_2O electrolysis)
- **Toxicity of Elements**
  - Solutions are in a pumped system, susceptible to leaks
- **Minimal Fire Hazard**
  - Electroactive element in aqueous solution
- **High Degree of Flexibility**

Thermal and Mechanical Systems

Pumped Hydroelectric Storage

Energy is stored in the form of a water reservoir at a higher altitude that is released through turbines to a lower reservoir. During low energy demand the water is pumped back up to the higher reservoir.

- **Pros**
  - Large-scale and mature technology (20+ GW in USA, 129+ GW worldwide)
  - Long-term storage
- **Cons**
  - Requires water and specific geography availability
- **Safety Issues**
  - Overfilling
  - Containment failure



DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA

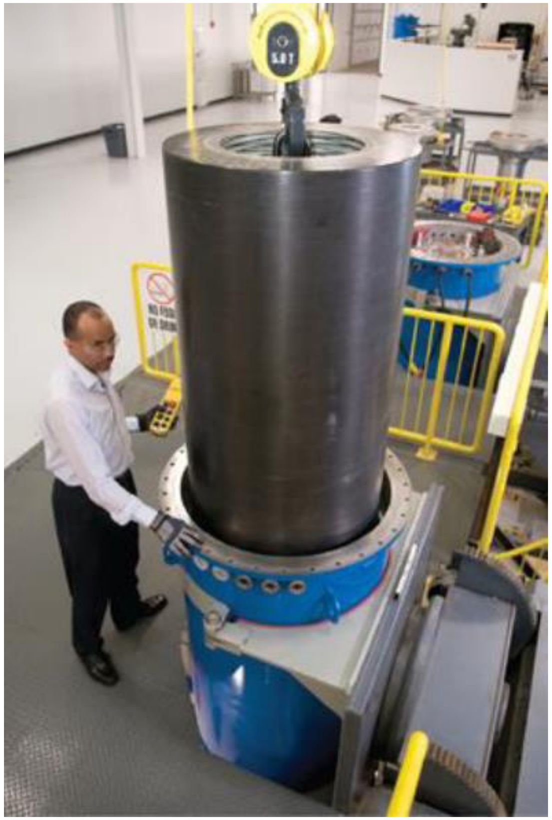
Thermal and Mechanical Systems

BASICS

Flywheels

A spinning mass in its center that is driven by a motor. When energy is needed, the spinning force drives a turbine, which slows the rate of rotation. The system is recharged by the motor increasing its rotational speed.

- **Pros**
  - Fast charge/discharge (<5 ms)
  - No hazardous materials
- **Cons**
  - Not attractive for large-scale or long-term storage



SAND2015-10759 “*Recommended Practices for the Safe Design and Operation of Flywheels*”
http://www.sandia.gov/ess/publications/SAND2015-10759.pdf

Flywheels

BASICS

Safety Issues

- Rotor Failure: energetic projectiles
  - Mitigation – 2X design margin
  - Containment not cost-effective – 10X mass required to contain
- Loose Rotor: unintended energy release
  - Failure of bearing, shaft, or hub
  - Mitigation – prevent contact between rotor and housing, manage energy release

FLY-WHEEL EXPLOSION UNION BREWING CO., ST. LOUIS, MO., 40,000-POUND WHEEL ON ICE MACHINE RUNNING NORMALLY AT ONLY 50 R.P.M. MACHINE RACED AND BURST WHEEL BY CENTRIFUGAL FORCE, HURLING 8,000-POUND CHUNKS GREAT DISTANCES. RIM SECTION WAS 13"x16", TO BREAK WHICH REQUIRED 4,000,000 POUNDS. LOSS $13,423. WHEEL INSURED.

Key Takeaways

- There are a wide range of energy storage technologies today and there will be more in the future.
- Energy, economic. and environmental issues are creating a demand for energy storage, and policy initiatives are accelerating that demand.
- Energy storage includes batteries but also thermal and mechanical technologies.
- Beyond storing energy, all batteries are not the same.
- The wide range of battery types, chemistries, sizes, designs, control mechanisms, operating temperatures and potential locations suggest an almost infinite number of possibilities.
- Just when you think you have all the information you need there will be new energy storage technologies to keep you engaged.

What Are the Safety Issues?

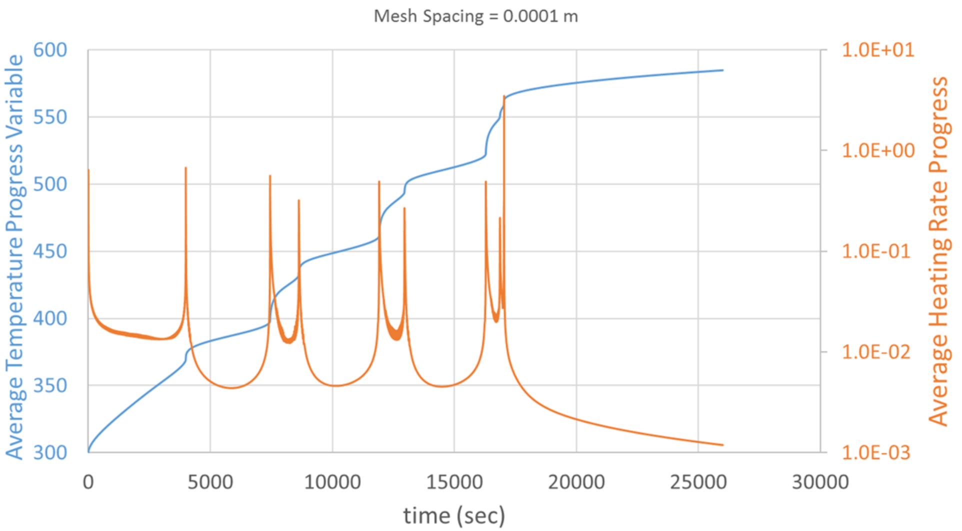
Identifying the **safety issues that are relevant to energy storage systems**

- Energy supply does not exactly track with or match demand.
- Siting (location, loads, protection, egress/access, maximum quantities of chemicals, separation, etc.).
- New versus existing systems and new versus existing building/facility applications.
- Ventilation, thermal management, exhausts (when necessary, flow rates, how controlled, etc.).
- Interconnection with other systems (energy sources, communications, controls, etc.).
- Fire protection (detection, suppression, containment, smoke removal, etc.).
- Containment of fluids (from the ESS and from incident response).
- Signage and markings.
- Identification of the applicable authorities having jurisdiction (utility, federal, state or local government, etc.).

Fire Protection

SAFETY ISSUES

- **Water Based Systems – Battery Storage**
  - Research by Fire Protection Research Foundation, Exponent and FM Global
  - Confirmed sprinkler protection criteria for Li-ion battery storage in cartons
  - "Storage up to 4.6 m (15 ft) under ceiling heights up to 12.2 m (40 ft) **was adequately protected** by a fire protection system comprised of pendent sprinklers having a K-factor of 320 L/min/bar½ (22.4 gpm/psi½), with a nominal 74°C (165°F) temperature rating and a nominal RTI of 27.6 m½s½ (50 ft½s½), installed on 3.0 m by 3.0 m (10 ft by 10 ft) spacing at an operating pressure of 2.4 bar (35 psig)."



- **Gaseous Systems**
  - Reignition issues due to thermal runaway phenomenon
  - Dwell time

More information available at:
http://www.nfpa.org/news-and-research/fire-statistics-and-reports/research-reports/hazardous-materials/other-hazards/lithium-ion-batteries-hazard-and-use-assessment
"Modeling for understanding and preventing cascading thermal runaway in battery packs", 2017 Energy Storage Systems Safety & Reliability Workshop, Feb.22-24, 2017, Santa Fe, NM.

Key Takeaways

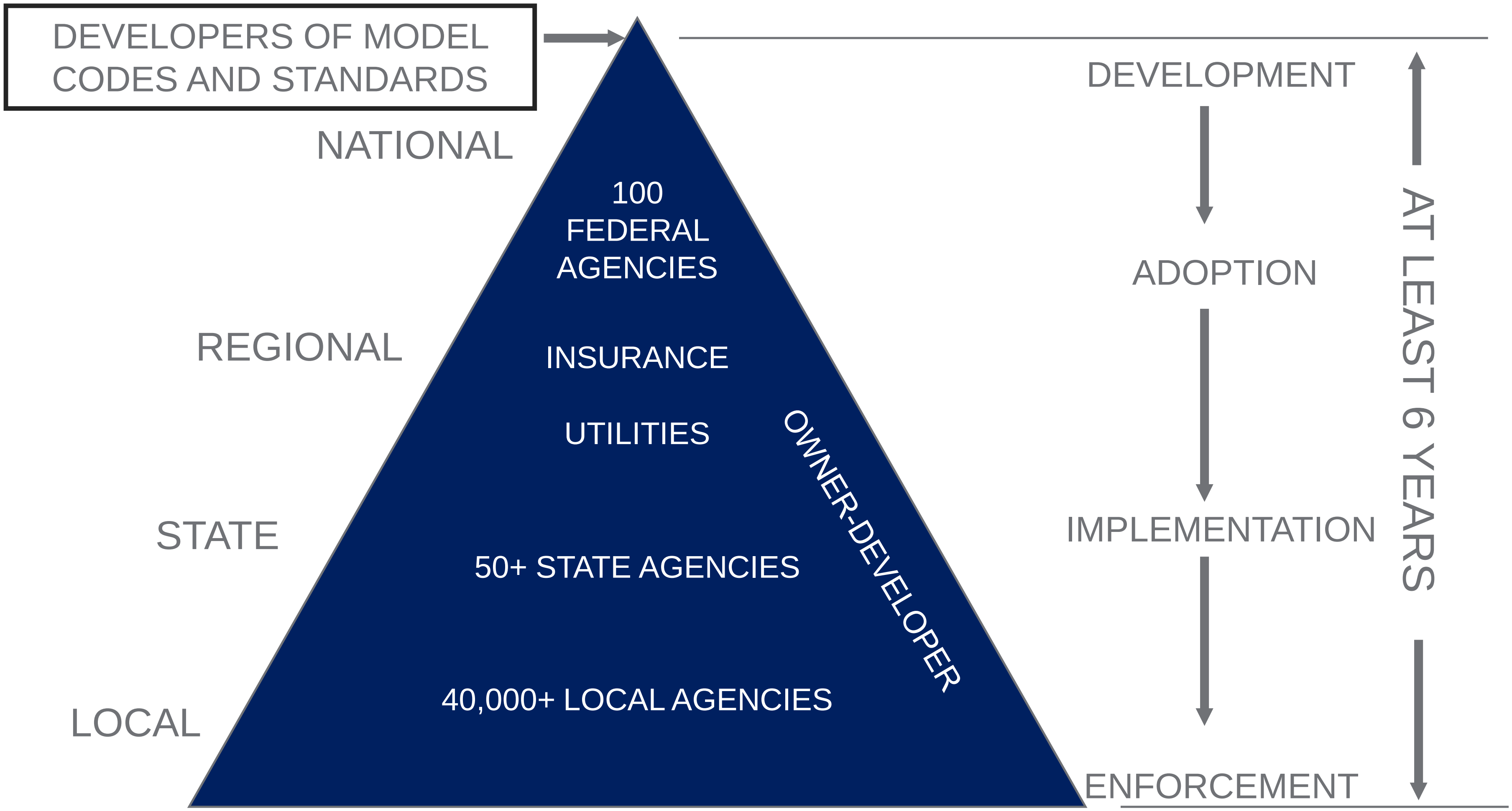
- Energy storage technologies may or may not be similar to other technologies; the system and its component parts must be validated as being safe.
- The safety of an energy storage technology is also affected by the location in which it is installed and manner in which that installation is implemented.
- While there are a set number of safety issues, the manner in which they are addressed to ensure safety is significant due to the number of variables associated with the technologies and their relationship with the built environment.
- Safety does not stop when a new system is commissioned, and the safety issues remain relevant through operation, repair, or renewal of the system and finally through decommissioning or recommissioning.

Model Codes and Standards

Identifying the **codes and standards that address the safety issues**

- Model codes and standards in the aggregate address the design, construction, commissioning, rehabilitation, operation, maintenance, repair, and demolition of components of the built environment, such as buildings, facilities, products, systems, and equipment therein.
- Standards each have a very specific scope and where needed will reference other standards.
- Model codes reference standards.
- Regulations, rules, laws, specifications, tariffs, contracts, and other means are the vehicles by which those model codes and standards are adopted.
- When adopted, the model codes and standards must be satisfied subject to any penalties associated with non-compliance.

Development and Deployment



U.S. Model Codes and Standards

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

Model codes and standards have varying scopes relative to energy storage systems

- **Overarching – cover the built environment at large and that includes energy storage systems.**
- **Installation – address the installation of the energy storage system in relation to other systems and parts of the built environment.**
- **Complete – the entire energy storage system in the aggregate.**
- **Components – components associated with the energy storage system.**

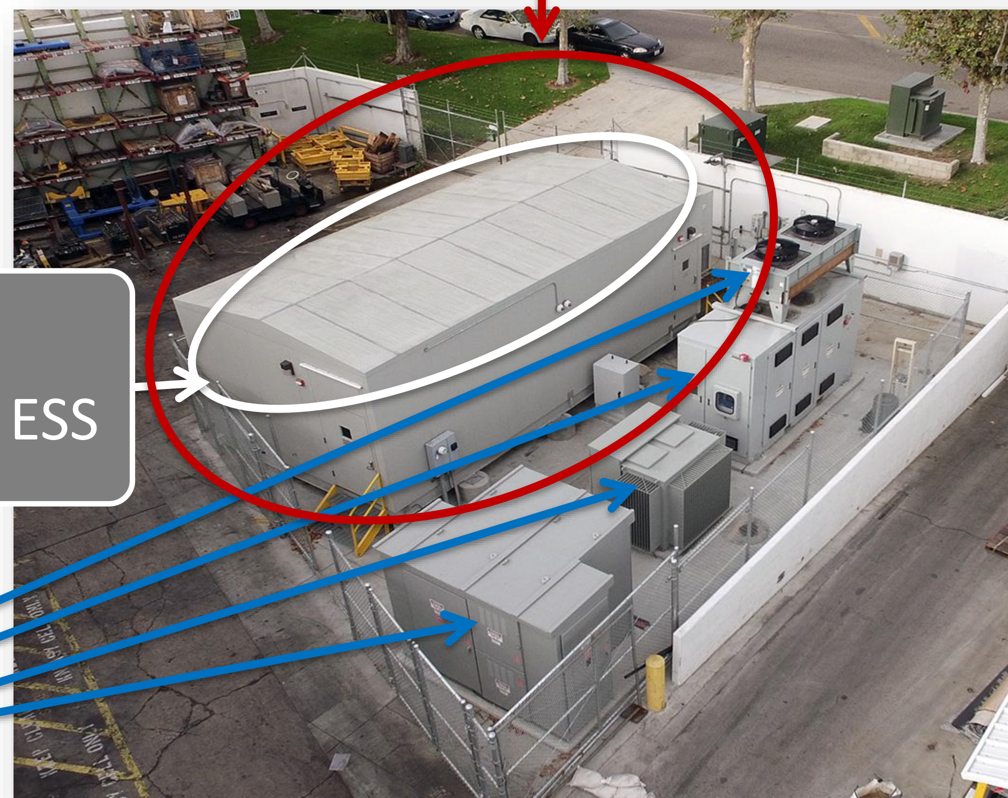
U.S. Model Codes and Standards

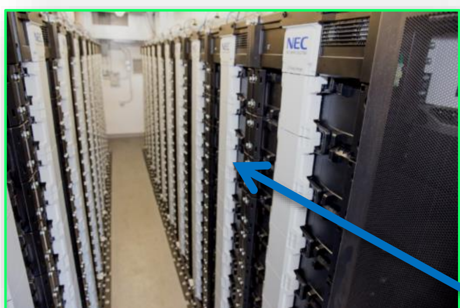
Overarching CS

CS for ESS Installation

CS for Complete ESS

CS for ESS Components





U.S. Model Codes and Standards

Specific Overarching CS

- NFPA
  - 1-15 – Fire Code
  - The next activity is to publish the 2018 edition and then develop the 2021 edition
  - 70-17 – National Electrical Code
  - The next activity is to develop the 2020 edition – proposed changes due September 7, 2017
  - 5000-15 – Building Code
  - The next activity is to publish the 2018 edition and then develop the 2021 edition)
- ICC
  - 2015 International Fire Code
  - 2015 International Residential Code
  - 2015 International Mechanical Code
  - 2015 International Building Code
  - The next activity is to publish the 2018 editions of these codes and then develop the 2021 editions – proposed changes are due January 8, 2018 to the IFC, IMC and portions of the IRC and IBC that are likely to impact ESS
- IEEE
  - C2-17 – National Electrical Safety Code
  - The next activity is to develop the 2022 edition – proposed changes due July 15, 2018

U.S. Model Codes and Standards

CS for ESS Installation

- NFPA
  - 855-X – Standard for the Installation of Stationary Energy Storage Systems
  - First draft available for first public input Fall 2017 with a goal of approval to publish in June 2018
- NECA
  - 416-17 – Recommended Practice for Installing Stored Energy Systems
  - Approved for publication and a new appendix containing a compliance checklist is under development

U.S. Model Codes and Standards

CS for ESS Installation

- IEEE
  - 1653-2012 – Guide for Ventilation and Thermal Management of Batteries for Stationary Applications
  - An update is under development

  - IEEE P1578 Recommended Practice for Stationary Battery Electrolyte Spill Containment
  - New project initiated and invitation to enroll posted

U.S. Model Codes and Standards

CS for Complete ESS

- **ASME**
  - TES-1 – Safety Standard for Thermal Energy Storage Systems
  - First draft is under development
- **NFPA**
  - 791-14 – Recommended Practice and Procedures for Unlabeled Electrical Equipment
  - The next activity is to publish the 2018 edition for publication and then develop the 2021 edition
- **UL**
  - 9540 – Safety of ES Systems and Equipment
  - Under continuous maintenance, proposed changes to the standard were accepted until July 20, 2017 and action on those will result in a revised version of the document

U.S. Model Codes and Standards

CS for ESS Components

- **UL**
  - **810A – Electrochemical Capacitors**
  - **1642 – Standard for Lithium Batteries**
  - **1741 – Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources**
  - **1973 – Batteries for Use in LER and Stationary Applications – revisions are underway**
  - **1974 – Evaluation of Batteries for Repurposing – a new standard has been drafted and review of comments from the STP for this effort is underway**
  - **All UL standards are under continuous maintenance**

- **CSA**
  - **CSA C22.2 No. 107.1-2016 – Power Conversion Equipment**

U.S. Model Codes and Standards

CS for ESS Components

- IEEE
  - P1697.1 Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications
  - Undergoing final comment resolution and approval expected in 2017

  - IEEE P1679.2 Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications
  - Recently out for public review and the drafting committee is resolving comments

U.S. Model Codes and Standards

Ongoing information on model codes and standards is provided through ….

- ✓ Regular webinars involving the relevant standards development organizations
- ✓ A monthly codes and standards report

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DOE OE Energy Storage Systems Safety Roadmap Focus on Codes and Standards – July 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 proposal review work area in CSDS for the proposed second edition of UL 1973 is open and will close August 29, 2017.

UL is developing an Outline of Investigation (OI) that can serve as a starting point for a standardized method of conducting a full scale fire test for an ESS. The OI will be available for review, through a task group UL forms, by September 1, 2017.

The draft of NFPA 855 has been sent to the NFPA Standards Council and is in Part 5 of the agenda for their August 15 to 17, 2017 meeting for their approval of the document for first public input.

UL is initiating development of a new standard 5500 covering the remote updating of software elements having an influence on safety via the product manufacturer's recommended process or steps.

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.

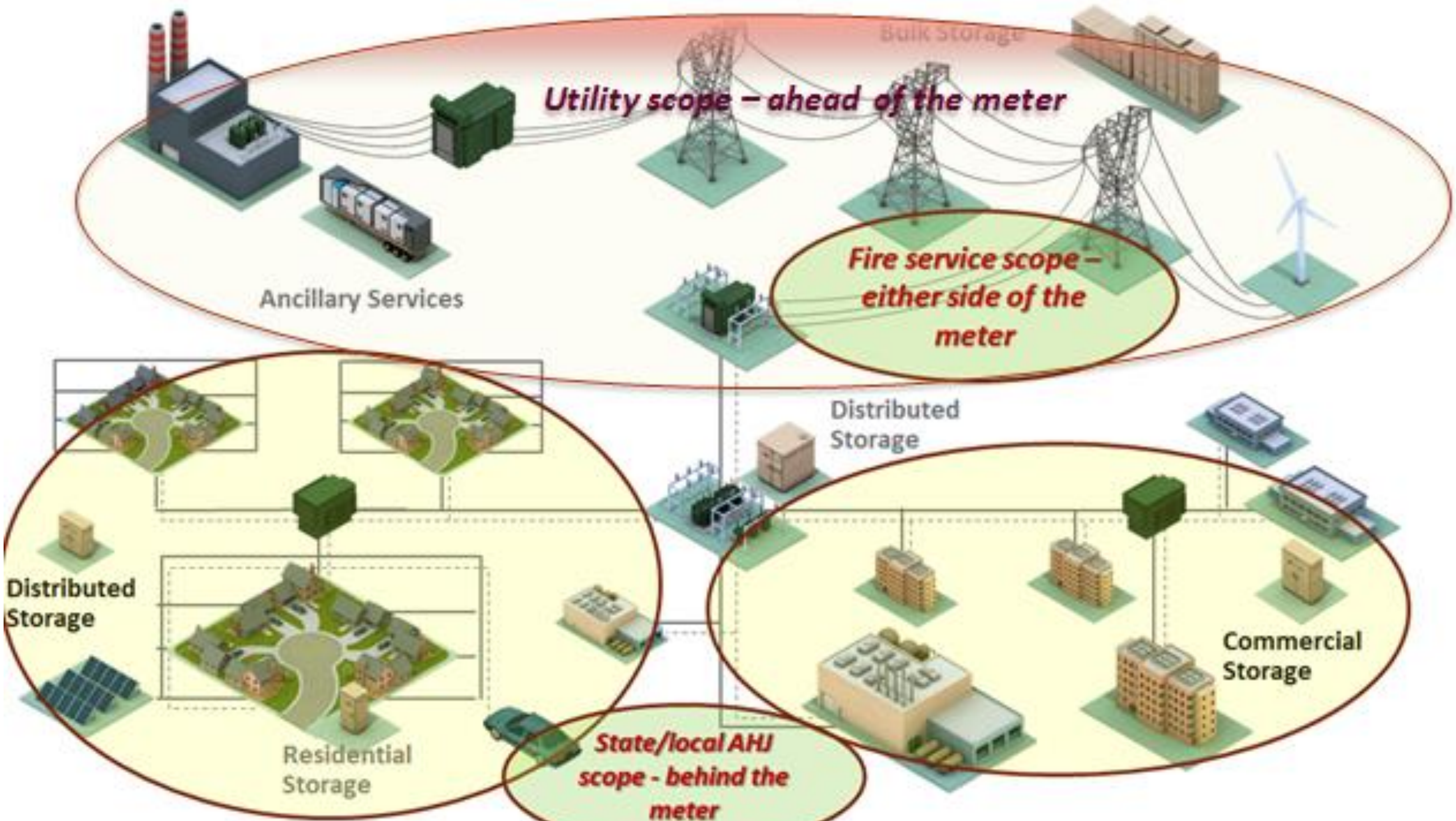
[1] DOE OE Energy Storage Systems Safety Roadmap, PNNL-SA-126115 I SAND2017-5140 R

Key Takeaways

- Development and maintenance of U.S. model codes and standards is an ongoing process open to all interested parties and is facilitated by a number of standards development organizations.
- Advancements in energy storage technology and lessons learned from existing system installations will necessitate continual updating and enhancement of codes and standards.
- Once codes and standards are published there are a myriad of entities that will adopt and focus on ensuring compliance with those codes and standards.
- Participation by all relevant parties in the development, adoption, and implementation of codes and standards will help ensure energy storage technology can be deployed safety and in a timely less complicated manner.

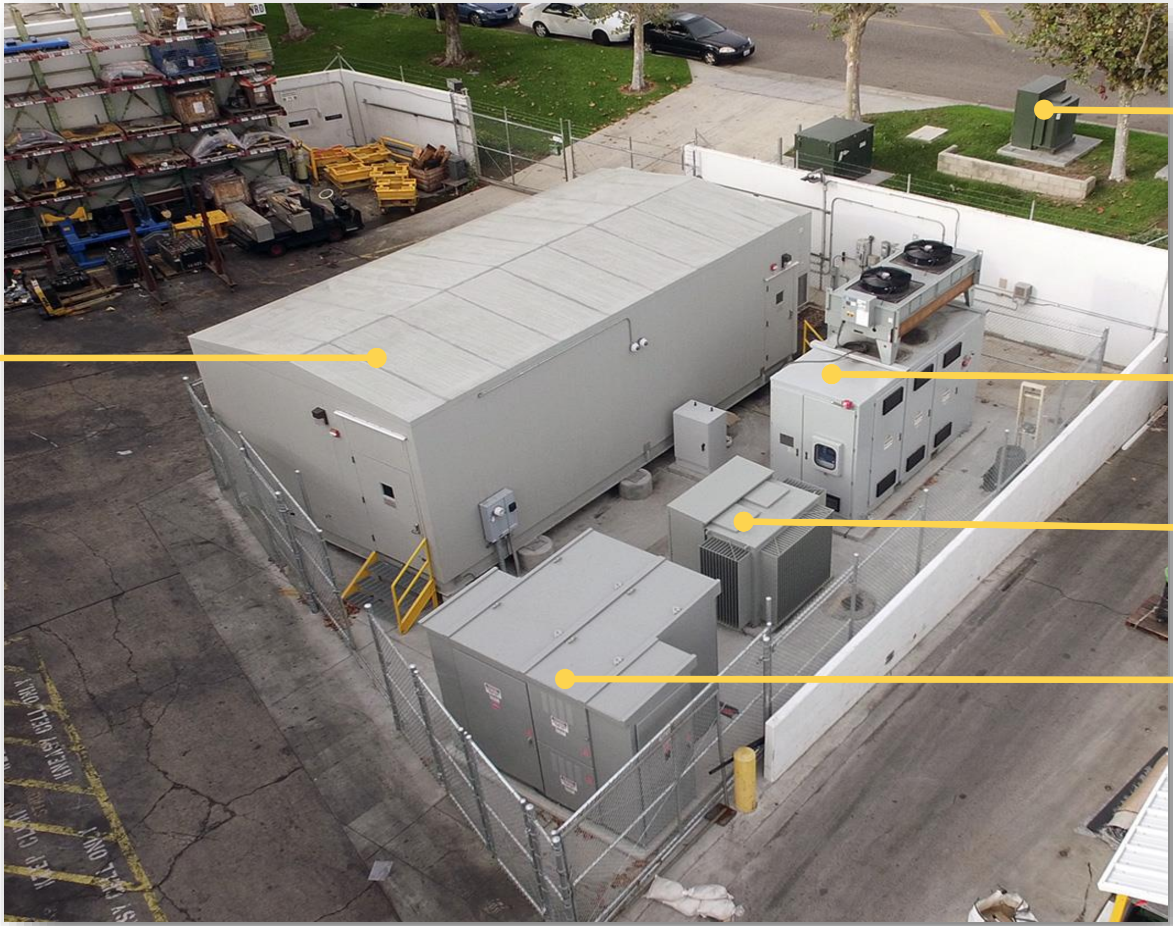
Applications of Energy Storage Systems

An overview of **where and how energy storage systems are being applied**



ESA Basics of Energy Storage Workshop 2011/SNL-EPRI

SCE DESI Site



Source - Southern California Edison

SCE DESI ESS

- Key Components
  - Low cost/ubiquitous
  - Battery System
  - Power Conversion System (PCS)
  - Medium Voltage Transformer
  - Medium Voltage Switchgear and Protection

Source - Southern California Edison

SCE DESI

Source - Southern California Edison

Castle & Cooke Installation

- 1.125 MVA Dynamic Power Resource
- 1.5 MW DC/1.2 MW AC solar farm
- Purpose is to double the output of the solar system and control the ramp rate
- Advanced lead-acid battery technology
- 15 minutes duration at rated power
- Commissioned 9-1-2011
- Located in Lanai, HI
- Technology provider (Xtreme Power filed Chapter 11 in 2015)

Ownership Model	Customer-Owned
Equity Owner 1	Castle & Cooke
Equity Owner 1 Percentage	100%
Energy Storage Technology Provider	Xtreme Power
Integrator Company	Younicos

DOE ESS Database http://www.energystorageexchange.org/

Hawaiian Properties

- 60 kW zinc bromine flow battery
- Part of an elevator system in an R-2 building that uses grid power and power from a 20 kW PV array
- Purpose is to double the output of the solar system and control the ramp rate
- 2.5 hours duration at rated power
- Commissioned 7-1-2012
- Honolulu, HI

Ownership Model	Customer-Owned
Equity Owner 1	Hawaiian Properties Ltd.
Energy Storage Technology Provider	ZBB Energy Corporation
Power Electronics Provider	ZBB Energy Corporation
Integrator Company	NIDON

DOE ESS Database http://www.energystorageexchange.org/

Confidential

- 48 kW nickel iron battery
- Powered by a pole mounted solar array
- Purpose is to double the output of the solar system and control the ramp rate
- 10 hours duration at rated power
- Las Cruces, NM

Ownership Model	Customer-Owned
Equity Owner 1	Confidential
Equity Owner 1 Percentage	100%
Energy Storage Technology Provider	Iron Edison Battery Company
Power Electronics Provider	Apollo Solar
Integrator Company	Iron Edison Battery Company

DOE ESS Database http://www.energystorageexchange.org/

Long Island Railroad

- Manufacturer – Maxwell Technologies
- Type – Electro-chemical Capacitor
- Location – Long Island RR (NY)
- Application – voltage support to assist traction power system (capture and store energy produced by trains to help with acceleration)
- Rating/Duration – 1,000 kW/1 min.

DOE ESS Database http://www.energystorageexchange.org/

Scripps Ranch Community Center

- ESS Manufacturer – SAFT
- Power Electronics Provider – Princeton Power
- Type – Lithium-ion
- Location – Scripps Ranch Community Center (CA)
- Application – PV (30 kW) storage
- Rating/Duration – 100 kW/1 hr.

DOE ESS Database http://www.energystorageexchange.org/

Montezuma Canyon UT

- Manufacturer – Iron Edison
- Type – Nickel Iron Battery (700 Ah 24V)
- Location – adjacent parking structure
- Application – PV storage (2.8 kW of panels with 3.2 kW pure sine wave inverter and dual 80 amp MPPT charge controllers)
- Rating/Duration – 17 kW for 10 hours

DOE ESS Database http://www.energystorageexchange.org/

SE PA Transportation Authority

- Manufacturer – SAFT
- Type – Li-ion battery
- Location – SEPTA
- Application – Capture energy from railcars through regenerative braking and re-use it to accelerate trains
- Rating/Duration – 800 kW for 30 minutes

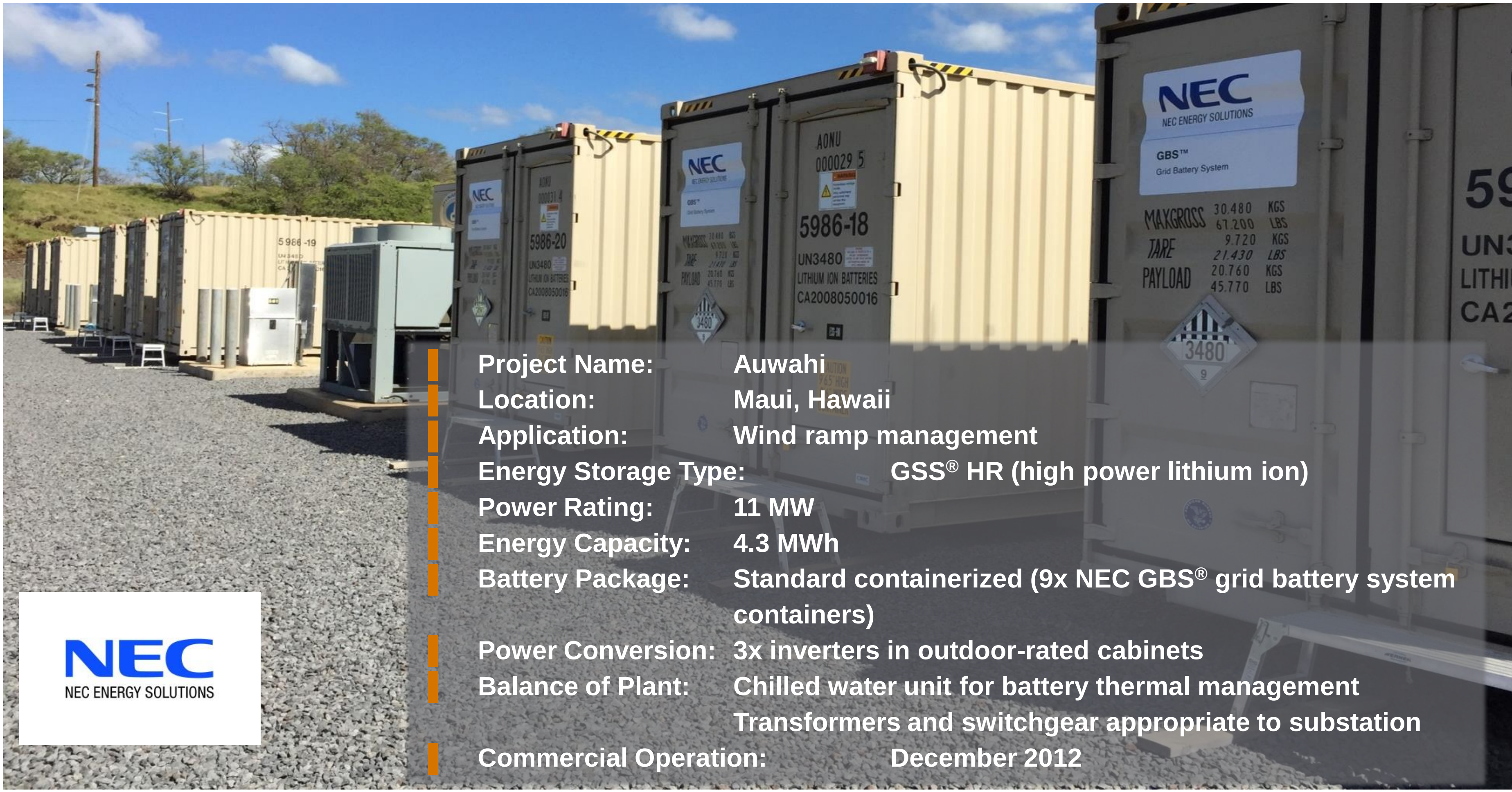
DOE ESS Database http://www.energystorageexchange.org/

Santa Clara Data Center

- Manufacturer – Mitsubishi
- Type – Electro-chemical (VLRA)
- Location – CoreSite Realty Corp. (CA)
- Application – UPS for 101K sf. Data Center
- Rating – 1,500 kW

DOE ESS Database http://www.energystorageexchange.org/

Auwahi Wind Farm, HI



- **Project Name:** Auwahi
- **Location:** Maui, Hawaii
- **Application:** Wind ramp management
- **Energy Storage Type:** GSS® HR (high power lithium ion)
- **Power Rating:** 11 MW
- **Energy Capacity:** 4.3 MWh
- **Battery Package:** Standard containerized (9x NEC GBS® grid battery system containers)
- **Power Conversion:** 3x inverters in outdoor-rated cabinets
- **Balance of Plant:** Chilled water unit for battery thermal management
  Transformers and switchgear appropriate to substation
- **Commercial Operation:** December 2012

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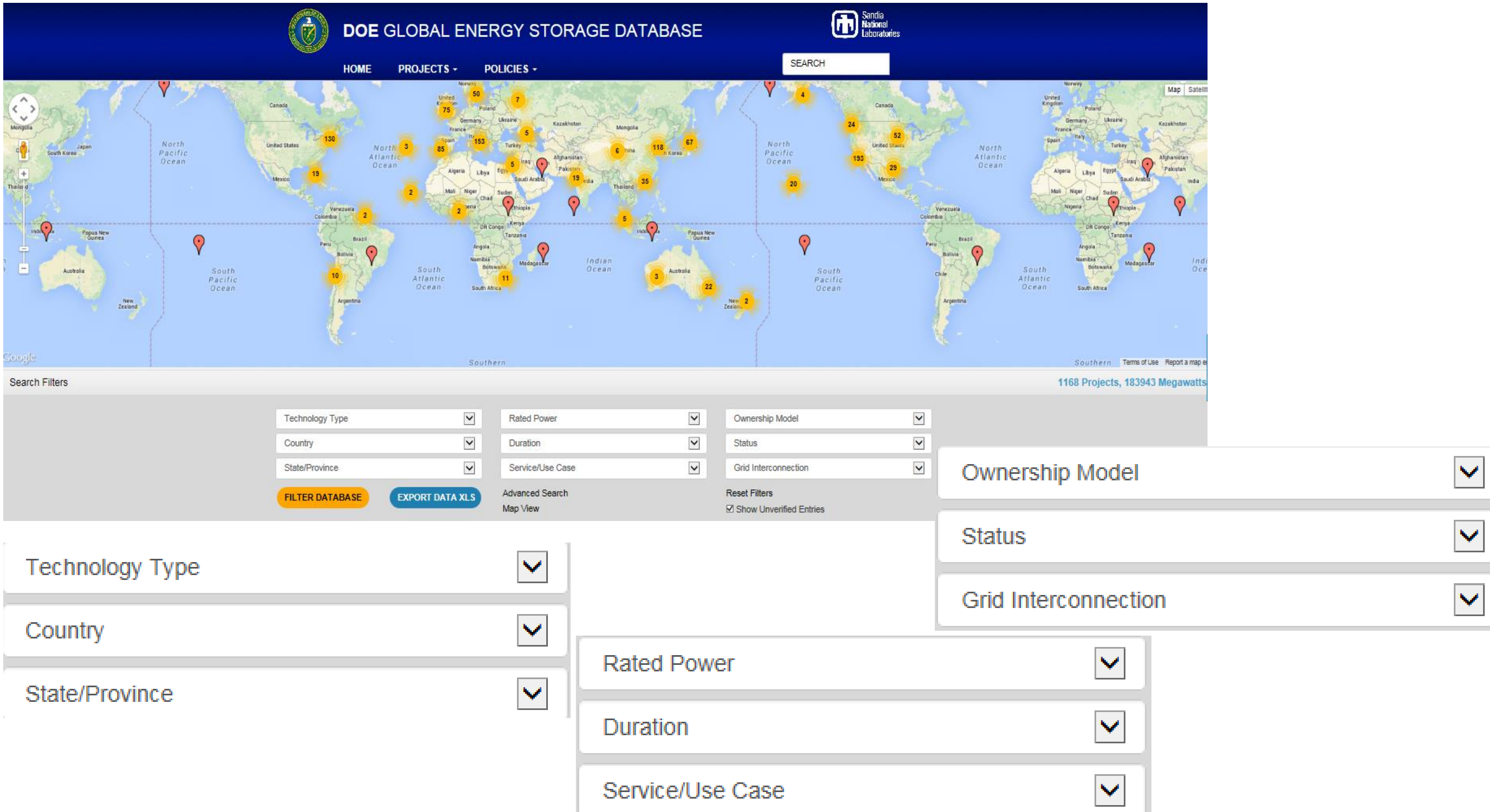
Database of Applications



http://www.energystorageexchange.org/

Key Takeaways

- Batteries are much more than just lead acid or Li ion and are one of many energy storage technologies.
- Economic incentives, policy initiatives, and increased use of renewables are spurring more demand for energy storage.
- Development of new energy storage technologies is evolving at a considerable rate.
- Energy storage technology deployment is increasing in scope, location, size of installation, and interaction with other systems.
- There is a need to ensure that energy storage “products” and system installations are safe.

Summary

- Energy storage technology development and deployment are dynamic and touch on a number of critical safety issues.
- Due to energy, economic, and environmental influences a significant increase in the application of energy storage systems can be expected in the near term and beyond.
- Traditional roles determined based on the location of a technology relative to the electric meter are likely to become more complex.
- While safety issues have been and are being identified, the research and information necessary to define how to address each one for each technology application many not exist.
- Codes and standards are updated regularly and are available for adoption to help ensure system safety as designed, installed, and during/after safety related incidents.
- Gaps between what we know and can prescribe in codes and standards can be filled through testing, failure modes and effects analysis, hazard mitigation guidance, and collaboration by all interested parties to address safety issues.

Website

ESS Safety WORKING GROUP

Research & Development

- Research & Development Overview
- Safety Research Priorities
- Finding Research Collaborators
- Collaborative Research Publications

Codes & Standards

- Overview of Codes and Standards
- Status of Codes and Standards
- Adoption of Codes and Standards
- Documenting and Verifying Compliance

Task Forces

- Large Scale ESS Fire Performance Testing Protocol

Publications

External Resources

For more information on the Energy Storage Safety Working Group (ESSWG) visit our website

The goal of the energy storage safety working group is to ***"Foster confidence in the safety and reliability of energy storage systems."***

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

Acknowledgment

Dr. Imre Gyuk, DOE-Office of Electricity Delivery and Energy Reliability

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

Thanks

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