Energy Storage Codes and Standards Activities in the US

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Agenda

- NEMA standards activities
  - Measuring Energy Storage System Performance
- National Electric Code (NEC)
  - Article 706 - Energy storage systems
- National Fire Protection Association (NFPA)
  - 855 - Installation standard for Stationary Energy Storage Systems
- UL Standards
- Modular Energy Storage Association
  - ESS Specifications for Utility-Scale Storage
- IEC TC120 (Electrical Energy Storage Systems)
- Summary

The National Electrical Manufacturers Association (NEMA)

Expand market opportunities, remove business barriers and reduce manufacturing costs through

- development and delivery of consensus-based standards and other intellectual property,
- effective advocacy, and
- decision-quality business information and analytics.

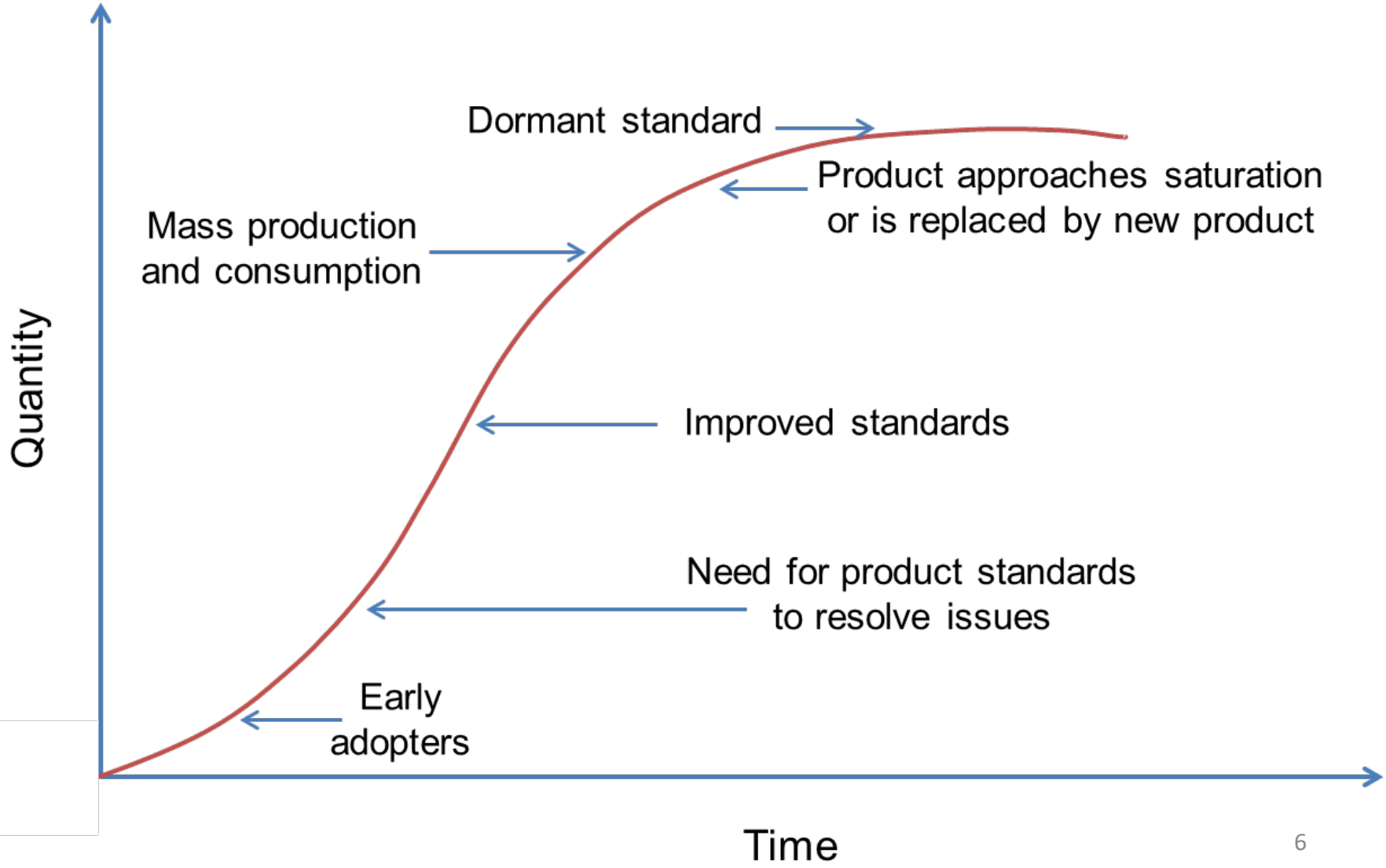
NEMA Energy Storage Systems Section

- Scope Includes
  - Storage device/medium
  - Power conversion systems
  - Control & management systems
- Grid connected or off grid
- Utility side or consumer side

NEMA ESS Section Activities

- Energy Storage Systems Performance Standard
- Lead NEMA member public inputs on related ES codes and standards
  - National Electric Code (NEC) 706
  - National Fire Protection Association (NFPA) 855
- Serve as secretariat for IEC TC 120

Standards Development Cycle



NEMA ESS-1-2019

Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems

- Lack of a uniform and repeatable method for determining and expressing system performance
- Project initiated under the Department of Energy
- Development of a protocol/pre-standard for immediate use and a basis for US and International standards
- NEMA actively participated in the process

NEMA ESS-1-2019

Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems

- Focus is on electrical energy storage systems
- Provides a set of “best practices” for characterizing ESS and measuring and reporting their performance
- Serves as a basis for assessing how an ESS will perform relevant to different applications
- Provides a valid and accurate basis for the comparison of different ESSs
- Enables more informed decision-making in the selection of ESSs for various stationary applications

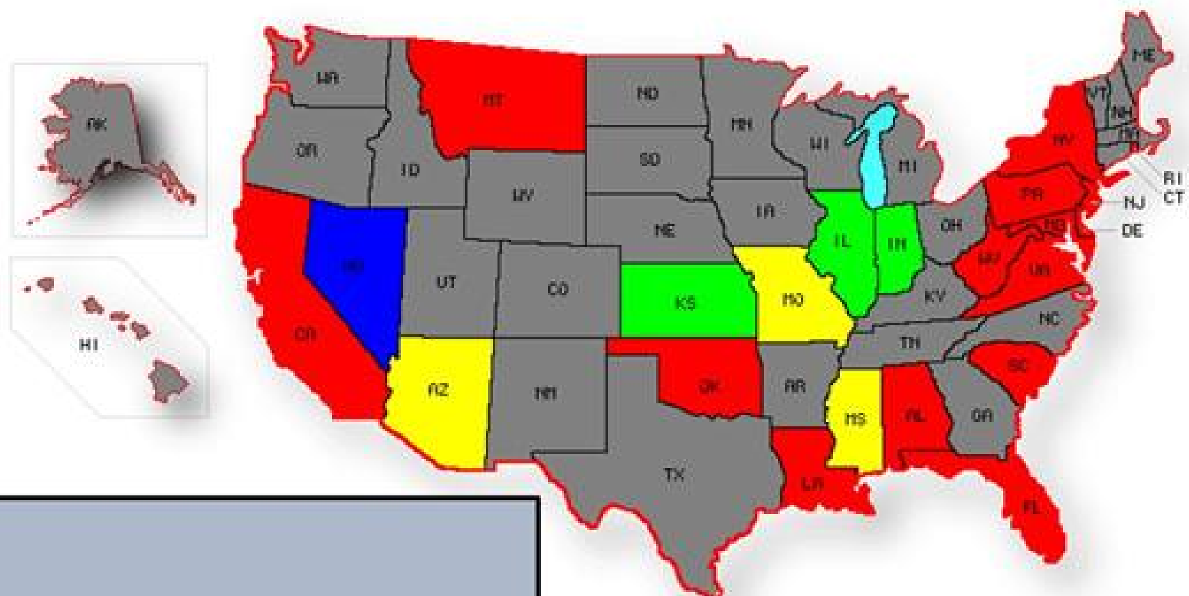
Applications Addressed

- Frequency regulation
- Peak shaving
- Islanded microgrids
- Volt/Var support
- Power quality
- Frequency control
- PV smoothing
- PV firming

- Describes and defines the application
- Develops appropriate duty cycles

The US National Electrical Code

NEC® in Effect
2/1/2019



2017 NEC® - 28
2014 NEC® - 15
2011 NEC® - 1
2008 NEC® - 3
County/Municipality NEC® regulation only - 3

Source: diymaps.net (c)

NEC Article 706 - Energy Storage Systems

General Criteria

- Scope, Definitions and Precedence over other Articles
- Components must be listed and pre-packaged self-contained systems can be listed as a complete ESS
- Multiple systems are acceptable
- Disconnecting means
- Connection to other energy sources
- ESS locations (ventilation, guarding of live parts, working spaces, egress and illumination)
- Directory (schematic plaque)

Circuit Criteria

- Sizing and current
- Overcurrent protection
- Wiring (to and from)
- Charge control

NEMA is developing a guide on the changes from the 2017 to 2020 NEC

NFPA 855 - Standard for the Installation of Stationary Energy Storage Systems

- Design
- Construction
- Installation
  - Indoor
  - Outdoor
  - Rooftop and open parking garage
  - Mobile
- Commissioning

Approximately three years to develop Standard

NFPA 855 – Location: Indoors

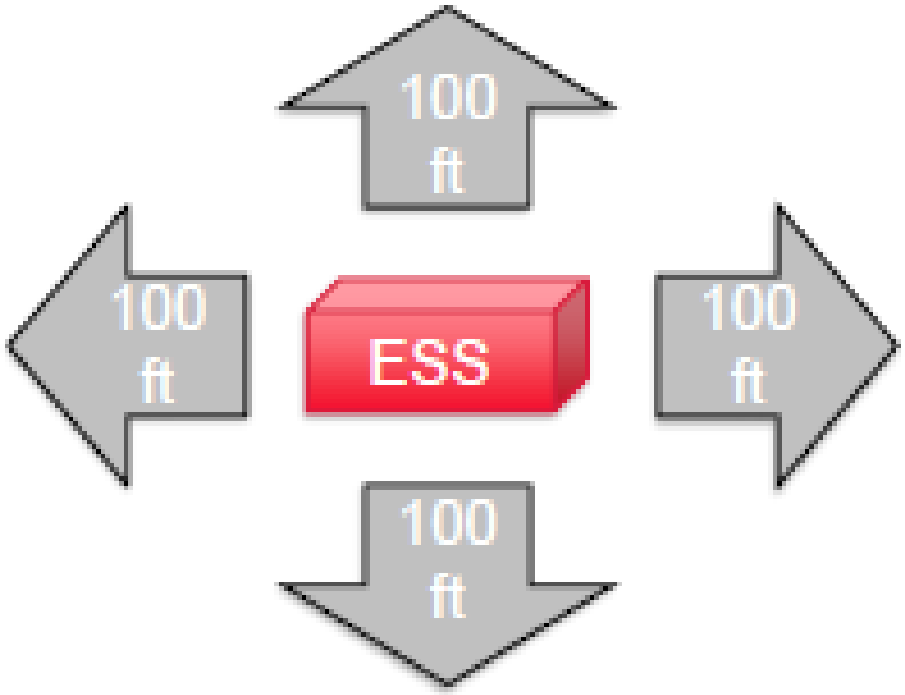
- Dedicated use buildings
- Non dedicated use buildings
- Dwelling and sleeping units

NFPA 855: Indoor ESS Installations

Compliance Required	Dedicated Use Buildings	Non dedicated use buildings	Reference
Maximum stored energy	No	Yes	4.8
Size and separation (modules)	Yes [c]	Yes	4.6
Separation (rooms)	NA	Yes	4.3.6
Fire control and suppression	Yes [d]	Yes	4.11
Water supply	Yes [c]	Yes	4.13
Smoke and fire detection	Yes [d]	Yes	4.10

NFPA 855 – Location: Outdoors

- Remote
- Near exposures
- Rooftop & open parking garages



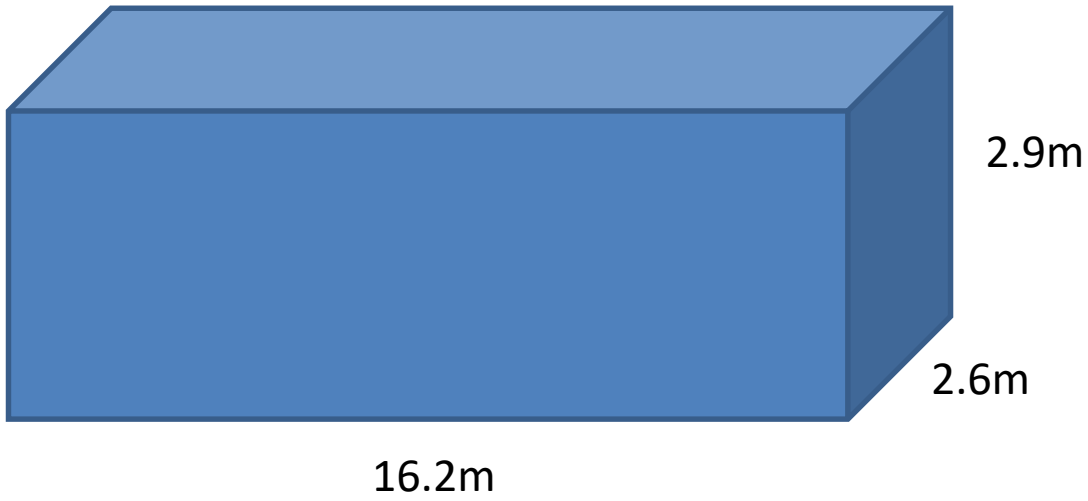
Example of remote location.

Source: NFPA

NFPA 855 Outdoor Stationary ESS Installations

Compliance Required	Remote Locations	Location Near Exposures	Reference
Maximum size	Yes	Yes	4.4.3.2
Clearance to exposures	NA	Yes	4.4.3.2
Walk in units	Yes	Yes	4.4.3.5
Vegetation control	Yes	Yes	4.4.3.6
Enclosures	Yes	Yes	4.4.3.7
Size and separation	No	Yes [c]	4.6
Maximum stored energy	No	Yes	4.8
Fire control and suppression	Yes [d]	Yes	4.11
Water supply	Yes [d]	Yes	4.13

Outdoor Walk in Container



Not including HVAC and other equipment

NFPA 855 – Exterior Wall Installations

- ESS permitted outdoors on exterior walls if:
  - Maximum stored energy of individual ESS <20 kWh
  - ESS units separated by 3 ft
  - ESS separated from doors, windows, HVAC inlets by > 5ft
  - Smaller separation distances permitted based on large scale fire testing

Rooftop and open parking garage ESS

- Has similar requirements as outdoor and indoor installations
- HVAC air inlets
- Fence with locked gate

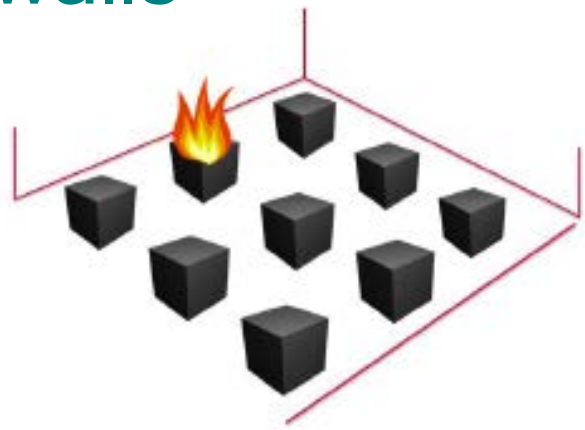
NFPA 855 – Maximum Stored Energy

ESS Type	Maximum rated energy (kWh)
Lead acid batteries	1000
Nickel-cadmium batteries	1000
Lithium-ion batteries	600
Sodium batteries	600
Capacitors	20
Flow batteries	600
Other battery technologies	200

Exempt: Dedicated use buildings & remote locations

NFPA 855 – Size and Separation

- 50kWh groups
- Spaced 3ft from groups and walls
- Other arrangements based on large scale fire test
- Remote locations exempt



Source: NFPA

- Lead acid and nickel cadmium battery systems < 50 V ac, 60 V dc exempt

UL Standards

- **UL 9540 – *Standard for Energy Storage Systems and Equipment***. Provides the basis for documenting and validating the safety of an ESS as an entire system or product.
- **UL 9540A – *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems***. Offers a test method for evaluating thermal runaway propagation in battery ESS.
- **UL 1974 - *Safety Standard of repurposed (i.e., second use) batteries***. Process of repurposing, grading and sorting. Published fall 2018.
- **UL 1973 - *Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications*.** Focuses on the system or component side, provides a standard for ensuring batteries are safe. That standard was updated and a new edition was published in early 2016.

MESA - ESS Specifications for Utility-Scale Storage

- The Modular Energy Storage Architecture Standards Alliance (MESA) is an industry association comprised of electric utilities and technology suppliers.
- Accelerate the growth of energy
- Members include utilities and energy storage solution providers

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MESA

IEC Technical Committee 120

- Standardization in the field of grid integrated EES systems. Focuses on:
  - Systems rather than devices
  - Interaction between EES Systems and electric power systems
  - System aspects and the need for new standards for EES systems
- Safety requirements for grid integrated EES systems electrochemical based systems

IEC TC-120 Liaisons to other IEC TCs

- **TC8:** Systems aspects for electrical energy supply
- **TC21:** Secondary cells and batteries
- **SC21A:** Secondary cells & batteries containing alkaline or other non-acid electrolytes
- **TC22:** Power electronic systems and equipment
- **SC22E:** Stabilized power supplies
- **TC57:** Power systems management & associated information exchange
- **TC 82:** Solar photovoltaic energy systems
- **TC 88:** Wind energy generation systems
- **TC 105:** Fuel cell technologies

IEC TC 120 Documents

IEC Number	Name	Current Status	Next Stage
62933-1 Edition 1	Electrical Energy Storage (EES) systems – Part 1: Terminology	International Standard Published 2/27/18	-
62933-2-1 Edition 1	Electrical Energy Storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specifications.	International Standard Published 12/13/17	-
62933-3-1 Edition 1	Electrical Energy Storage (EES) systems – Part 3-1: Planning and installation – General specifications.	Registered as a technical specification 6/29/18	-
62933-4-1 Edition 1	Electrical Energy Storage (EES) systems – Part 4-1: Guidance on environmental issues.	Technical Specification published 7/26/17	-
62933-5-1 Edition 1	Electrical Energy Storage (EES) systems – Part 5-1: Safety considerations related to grid integrated EES systems.	Technical Specification Published 7/12/17	-
62933-5-2	Electrical Energy Storage (EES) systems - Part 5-2: Safety considerations related to grid integrated electrical energy storage (EES) systems – Batteries	CC circulated 1/18/19	CDV (TBD)
62933-2-2	*Electric Energy Storage Systems; Part 2-2: Unit parameters and testing methods – Applications and Performance testing*	*New Work Item Proposal*	*CD*

IEC 62933-5-1

- Technical Specification, specifies safety considerations (e.g. hazards identification, risk assessment, risk mitigation) applicable to EES systems integrated with the electrical grid
- Provides criteria to foster the safe application and use of electric energy
- Covers storage systems of any type or size intended for grid-integrated applications

IEC 62933-5-2 (Batteries)

- "The safety culture of stakeholders (integrators, operators and end-users) of such systems may vary from a high level to nearly full ignorance"
- BESS may have additional safety hazards due to chemicals
- BESS are complex at the systems level due to the variety of potential battery options and configurations
- Compliance with standards and related material produced specifically for the safety of subsystems does not ensure absolute intrinsic safety of the overall system

Summary and Key Takeaways

- Codes and Standards (C&S) provide a basis for the safe installation, application and use of ESS
  - Newer and traditional battery technologies are of concern to public safety officials, fire departments, and building inspectors.
- C&S lag technology development
- Equipment manufacturers should be aware of the increased demands for test data, fault data, and fire simulation testing.
- End users, consulting design engineers and installers also need an understanding of these codes and standards
- Active participation by stakeholder affected by safety code development bodies is greatly encouraged

Thank you for your attention!

NFPA 855 – Outdoor ESS Installations

- Walk-in units spacing is not required between ESS and the enclosure walls
- Walk in containers or enclosures w/ESS shall not exceed 53 ft x 8 ft x 9.5 ft high
  - Units that exceed these dimensions are treated as indoor installations (and comply with 4.4.2)
- Clearances to buildings are permitted within 3 feet where the enclosure of the ES has a 2 hour fire resistance
- Shall not apply to lead acid and nickel cadmium battery systems less than 50v ac and 60V dc
- Where approved by the AHJ, the fire control and suppression systems, the size and separation requirements, and the water supply are permitted to be omitted in dedicated-use buildings located more than 100 ft (30.5 m) from buildings, lot lines, public ways, etc

NFPA 855 – Walk in Units

- The unit shall only be entered only for inspection, maintenance, and repair of ESS and equipment and shall not be occupied for other purposes
- Areas within 10ft (3m) on each side of outdoor ESS shall be cleared of combustible vegetation and other combustible growth
- Fire department access roads shall be provided to outdoor ESS installations in accordance with the local fire code

Container language 4.3.5.1

- Approved signage shall be provided in the following locations:

(1) On the front of doors to rooms or areas containing ESS or in approved locations near entrances to ESS rooms

(2) On the front of doors to outdoor occupancy ESS containers

NFPA 855 Issues

- Second draft reduces spacing requirement of ESS modules (250kWh to 50kWh)
- Alignment with 2021 International Fire Codes

Fire Control & Suppression

- Sprinkler system 0.3gpm/ft^2 over 2,000 ft^2
- Other fire protection systems
  - Large scale fire test
  - UL 9540A

UL 9540 - Standard for Energy Storage Systems and Equipment

- Covers electrochemical, chemical, mechanical and thermal storage
- Includes systems intended to be used in a standalone mode (e.g. islanded and those used in parallel with the electric utility grid
- The installation instructions indicate that the energy storage systems are to be installed in accordance with the national and local electrical codes and other applicable codes
- This standard assumes that the final installation of the energy storage system will be performed by qualified service personnel in accordance with the applicable installation instructions, installation practices and national installation codes
- ESS are intended for installation subject to approval by the Authority Having Jurisdiction

MESA Spec (cont')

- MESA plans to update the MESA-ESS specification – a standard framework for utility-scale energy storage system data exchanges.
- The update will address configuration management, operational state, and functions applicable under the DNP3 profile for advanced DER functions.
- This project continues through March 2019 and is funded in part by the California Energy Commission

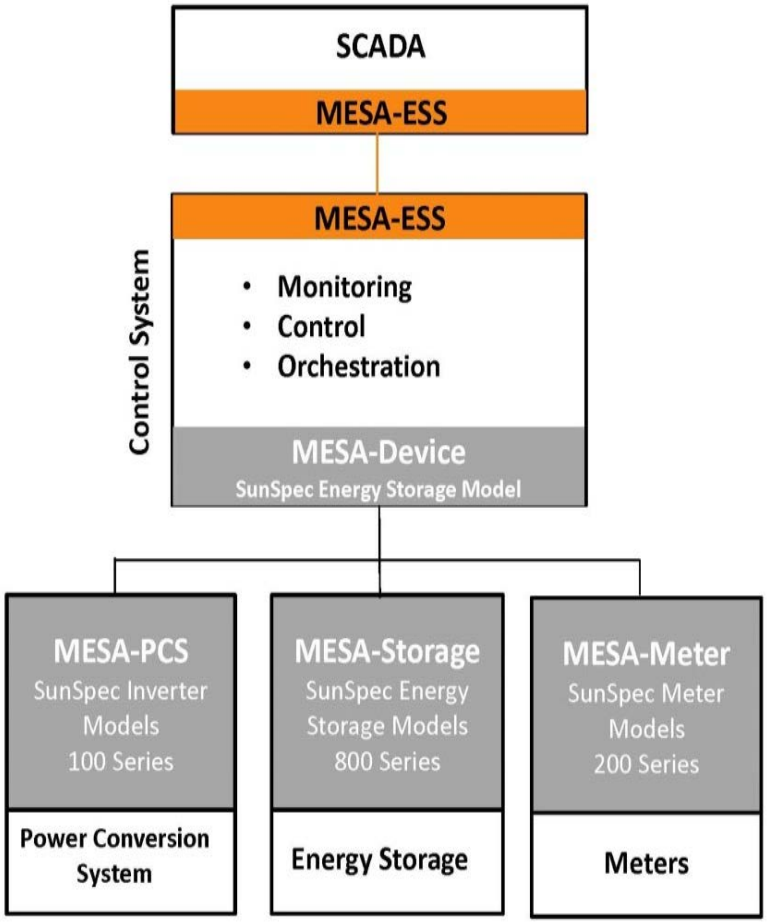
List of Grid Code Functions from Rule 21, IEEE 1547, and Europe – Mandatory and Market Capabilities

1. Disconnect / Connect Function
2. Cease to Energize / Return to Service Function
3. High/Low Voltage Ride-Through (Fault Ride-Through) Mode
4. High/Low Frequency Ride-Through Mode
5. Dynamic Reactive Current Support Mode
6. Frequency Watt Mode (Frequency Sensitivity Mode)
7. Volt-Watt Mode
8. Fixed (Constant) Power Factor Mode
9. Fixed (Constant) Reactive Power Mode
10. Volt-Var Mode
11. Watt-Var Mode
12. Watt-PF Mode
13. Active Power Limiting Mode
14. Active Power Setting Mode
15. Low Frequency-Watt Emergency Mode for Demand Side Management (fast load shedding)
16. Low Voltage-Watt Emergency Mode for Demand Side Management
17. Monitoring key status, alarm, and measurement values
18. Scheduling of Power Settings and Modes

Overview of MESA Specifications

Gray Developed by MESA and SunSpec

Orange Developed by MESA Alliance



- (Interface #1) MESA-ESS SCADA Specification with DNP3 Protocol mapped from IEC 61850-7-420 for Distributed Energy Resources (DER):
  - Operational Management
  - Monitoring
  - Control Functions
  - Smart ESS Modes
  - Scheduling
- Control System contains ESS Vendor Applications
- SunSpec Inverter Models Map Modbus to the MESA-Device Energy Storage Model:
  - MESA-PCS: Power Conversion System
  - MESA-Storage: Energy Storage
  - MESA-Meter: Meters

Development Process for MESA-ESS Specification:

Referencing the EPRI DNP3 App Note and Potentially Becoming a Standardized 61850/DNP3 Profile