A Review of Current and in Progress Standards for Electricity Storage

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Abstract

Electricity storage has been classified as "the silver bullet" for the smart grid. It is increasingly being seen as an ancillary electrical utility service and a key to integrating renewables into the power grid. Electricity storage is also a key to implementation of micro grids and energy efficient buildings. With all this deserved attention, the engineering community has embarked on development of a number of Standards, Codes and Recommended Practices that will provide the technical background and basis for installation, design and commissioning of electricity storage systems. This paper will review a number of these standards. Some of the important characteristics and the use of the following standards are examined.

1. IEEE P2030 ™ - Series for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure
2. DOE/EPRI 2013 - Electricity Storage Handbook in Collaboration with NRECA
3. NIST - Framework and Roadmap for Smart Grid Interoperability Standards
4. DOE PNNL - Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems
5. IEEE SCC21 - 1547 Series of Interconnection Standards
6. US TAG to IEC TC120 - Electrical Energy Storage Systems
7. NFPA - National Electrical Code (NEC NFPA 70)
8. BSR/ASHRAE/NEMA Standard 201P - Facility Smart Grid Information Model
9. Underwriters Laboratories 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

Keywords: Electricity Storage Standards, Electricity Storage Association, Energy Storage Standards

Introduction

The standards in the above abstract are up to 350 pages, so this paper will present a cursory look at some important aspects of each these standards and try to direct readers to an appropriate standard for their use. One should understand that multiple standards, codes and economic models will be used in the successful installation and operation of electricity storage systems. The Electricity Storage Association's website is an important "Librarian of Electricity Storage Technical Information" and is recommended as an updated source of technical and commercial knowledge.

Electricity storage standards are being developed in many venues. The storage of electricity is critical to the optimized operation of the utility grid, micro grids and many off grid applications. Different groups have different emphasis on what individual standards address. Interoperability, physics and chemistry of storage, testing for reliability, safety, and economics all play a part in the different foci of specific standards. This review is a cursory look at some standards that have input by USA participants.

IEEE P2030™ **Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads** "This document provides guidelines for smart grid interoperability. This guide provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and loads. The guide discusses alternate approaches to good practices for the smart grid."

IEEE P2030.1 **Draft Guide for Electric-Sourced Transportation Infrastructure** "This document provides guidelines that can be used by utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles and related support infrastructure in addressing applications for road-based personal and mass transportation."

IEEE P2030.2™ **Draft Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure.** "This document provides guidelines for discrete and hybrid energy storage systems that are integrated with the electric power infrastructure, including end-use applications and loads. This guide builds upon IEEE Std 2030."

IEEE P2030.3™ **Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications "**Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures need to provide both repeatable results, at independent test locations, and have flexibility to accommodate the variety of storage technologies and applications."

DOE/EPRI 2013 **Electricity Storage Handbook in Collaboration with NRECA** "The Electricity Storage Handbook is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects. The Handbook also serves as an information resource for investors and venture capitalists, providing the latest developments in technologies and tools to guide their evaluations of energy storage opportunities."

NIST Framework and Roadmap for Smart Grid Interoperability Standards NIST Special Publication 1108 "Under the Energy Independence and Security

Act (EISA) of 2007, the National Institute of Standards and Technology (NIST) is assigned 'primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems'"

DOE PNNL **Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems** "This protocol provides a set of 'best practices' for characterizing energy storage systems (ESSs) and measuring and reporting on their performance. It serves as a basis for assessing how individual ESSs will perform with respect to key performance attributes relevant to different applications. It is intended to provide a valid and accurate basis for the comparison of different ESSs".

IEEE SCC21 **1547 Series of Interconnection Standards** This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).

US TAG to IEC TC120 **Electrical Energy Storage Systems Standardization** in the field of grid integrated EES systems implementing system approaches to understand their complex constructions

NFPA National Electrical Code (NEC NFPA 70)

- **Definition** - Battery System. Interconnected battery subsystems consisting of one or more storage batteries and battery chargers, and can include inverters, converters, and associated electrical equipment.
- 480 Storage Batteries - Scope. The provisions of this article shall apply to all stationary installations of storage batteries.
- 490 Equipment Over 1000 Volts, Nominal
- 500 Special Occupancy Classified Areas, Health Care Facilities, Trailer Parks, Theaters, Recreational Vehicles
- 625 Electric Vehicle Charging System
- 690 Solar Photovoltaic (PV) Systems
- 694 Wind Electric Systems
- 700 Emergency Systems
- 840 Premises-Powered Broadband Communications Systems

NFPA 111- "**Standard on Stored Electrical Energy Emergency and Standby Power Systems** covers performance requirements for stored electric energy systems providing an alternate source of electrical power in buildings and facilities during an interruption of the normal power source. NFPA 111 covers power sources, transfer equipment, controls, supervisory equipment, and accessory equipment needed to supply electrical power to selected circuits. This Standard also covers installation, maintenance, operation, and testing requirements as they pertain to the performance of the stored emergency power supply system (SEPSS)."

US TAG to IEC TC120 Electrical Energy Storage Systems "Standardization in the field of grid integrated EES systems implementing system approaches to understand their complex constructions." IEC 120 treats the "energy storage device, e.g. battery, as a black box and specifies the information requirements from the device but does not discuss the internal operation of the device.

BSR/ASHRAE/NEMA Standard 201P - Facility Smart Grid Information Model "This model provides the basis for common information exchange between control systems and end use devices found in single - and multi-family homes, commercial and institutional buildings, and industrial facilities that is independent of the communication protocol in use. It provides a common basis for electrical energy consumers to describe, manage, and communicate about electrical energy consumption and forecasts. The model defines a comprehensive set of data objects and actions that support a wide range of energy management applications and electrical service provider interactions including:

- on-site generation,
- demand response,
- electrical storage,
- peak demand management,
- forward power usage estimation,
- load shedding capability estimation,
- end load monitoring (sub metering),
- power quality of service monitoring,
- utilization of historical energy consumption data, and
- direct load control"

Underwriters Laboratories 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

Scope

- These requirements cover inverters, converters, charge controllers, and interconnection system equipment (ISE) intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Utility-interactive inverters, converters, and ISE are intended to be operated in parallel with an electric power system (EPS) to supply power to common loads.
- For utility-interactive equipment, these requirements are intended to supplement and be used in conjunction with the Standard for Interconnecting Distributed Resources With Electric Power Systems, IEEE 1547, and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1.
- These requirements cover AC modules that combine flat-plate photovoltaic modules and inverters to provide AC output power for stand-alone use or utility-interaction, and power systems that combine other alternative energy sources with inverters, converters, charge controllers, and interconnection system equipment (ISE), in system specific combinations.
- These requirements also cover power systems that combine independent power sources with inverters, converters, charge controllers, and interconnection system

equipment (ISE) in system specific combinations.
- The products covered by these requirements are intended to be installed in accordance with the National Electrical Code, NFPA 70.

Discussion The above Standards and Test Requirements form a library of options for use of each of the individual standards in selecting, operation and testing the electricity storage devices. Each standard has a focus and "blind spots" that are not addressed. The following are some of the categories the standards can be judged by.

- Chemistry/Physics
- Storage Capacity
- Storage management
- Application
- Information only from Storage
- Economic Characteristics
- Grid interface
- Grid Operation Standards
- Testing
- Safety

For instance a UL or the NFPA NEC does not address economics while the DOE/EPRI 2013 Electricity Storage Handbook assumes safe operation will be provided by referring to the following codes which do focus on safety.

- ANSI American National Standards Institute
- IEEE Institute of Electrical and Electronics Engineers
- NEC National Electrical Code
- NEMA National Electrical Manufacturers Association
- NESC® National Electrical Safety Code®
- NFPA National Fire Protection Association
- OSHA Occupational Safety and Health Administration
- UL Underwriters Laboratories

Appendix A contains a start on categorization of the above factors and radar charts for some of the standards reviewed here. These are the authors "opinions" and can be changed through industry input, but it is a start draft.

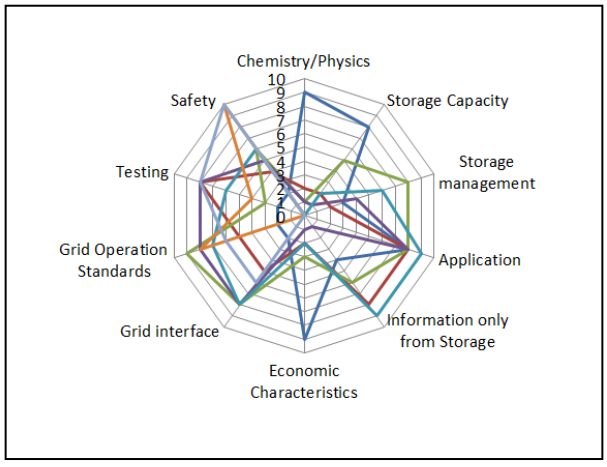


Figure 1

Figure 1 shows the radar chart of a number of standards plotted against the criteria above. See the enlargement in Appendix A for the key to which ones are which. The point here is there is a method to see what standards are useful in the design of a system.

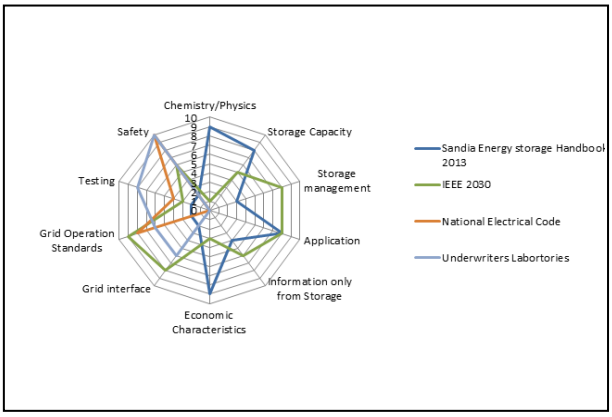


Figure 2

Figure 2 is an example of using the Sandia Handbook, IEEE 2030 and the National Electrical Code and Underwriters Laboratories for the strategy for selection and codes for implementation of an electricity storage system.

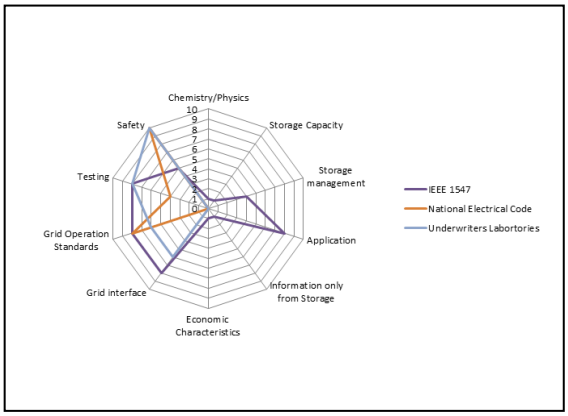


Figure 3

Figure 3 is used when a system is specified and the implementation of the installation and commissioning is required.

Conclusion: This paper is basically a reference to the available standards, and the scope of each as is stated in the standard itself. The focus of each standard is highlighted. Some standards are published and approved, while others are works in progress.

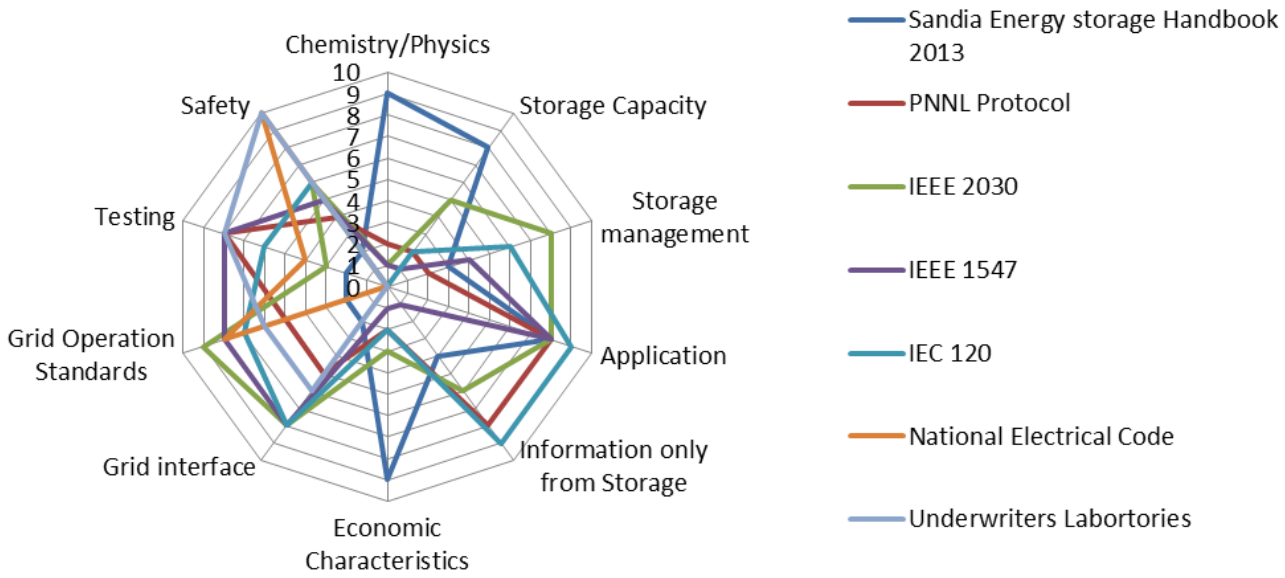
Additional information on each of the standards can be found by Goggling the Standard Title. It is a rewarding effort to participate in standards development and the author highly recommends it, especially for young engineers. Chet Sandberg can be reached at csandberg@enervault.com.

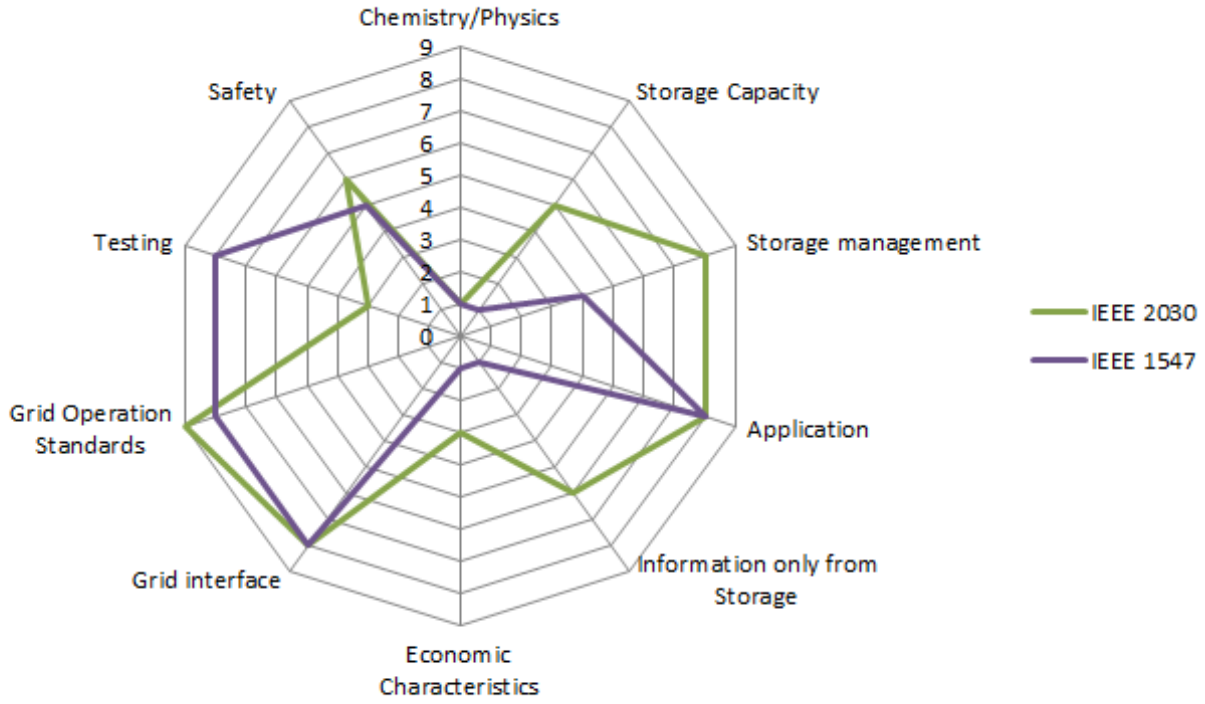
Appendix A

Comparison of Electricity Storage Standards

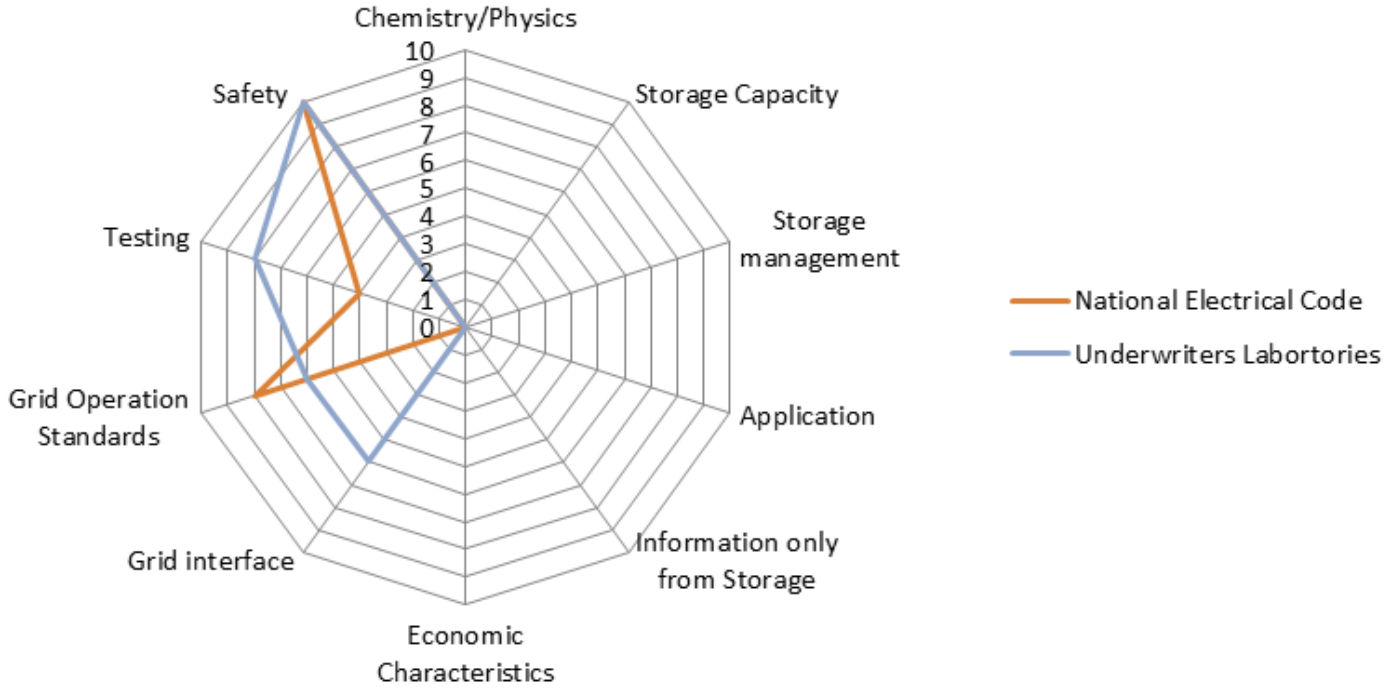
Criteria 0 to 10 - 10 Most Comprehensive for Category

	Sandia Energy storage Handbook	PNNL Protocol	IEEE 2030	IEEE 1547	IEC 120	National Electrical Code	Underwirters Labortories
Chemistry/Physics	9	2	1	1	0	0	0
Storage Capacity	8	2	5	1	2	0	0
Storage management	3	2	8	4	6	0	0
Application	8	8	8	8	9	0	0
Information only from Storage	4	8	6	1	9	0	0
Economic Characteristics	9	2	3	1	2	0	0
Grid interface	2	5	8	8	8	0	6
Grid Operation Standards	2	5	9	8	7	8	6
Testing	2	8	3	8	6	4	8
Safety	2	4	6	5	6	10	10





IEEE Suite



UL and NEC Focus