AN INTRODUCTION TO THE IEEE 1679 FAMILY OF DOCUMENTS

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Abstract

The Institute of Electrical and Electronics Engineers (IEEE) has a long history of creating documents that provide the industry with best practices based on the consensus opinion of a broad spectrum of viewpoints. Within the Power and Energy Society of IEEE, there is an Energy Storage and Stationary Battery (ESSB) committee. The function of this committee is to create and maintain the Guides, Recommended Practices and some of the Standards that IEEE publishes regarding energy storage in stationary applications. ESSB has recognized that there is a need for documents guiding the industry to properly characterize and evaluate newer technologies for stationary applications.

In IEEE parlance, the three levels of documents are Guides, Recommended Practices, and Standards. Guides are documents that are intended to lead the user through the process of selection or specifying equipment or practices. Guides are characterized using the terms “may” or “it is suggested.” Recommended Practices are documents that provide the best practice guidance and are characterized by the use of the terms “should” or “it is recommended.” Standards are documents that specify what must be done in order to comply with the standard and are characterized by the terms “shall” or “shall not.”

The “parent” document, *IEEE 1679 Recommended Practice for the Characterization and Evaluation of Energy Storage Technologies in Stationary Applications* was created first, and initially released in 2010. There are several “child” documents that address various technologies. Each “child” document covers a specific technology to provide information and guidance for one specific storage system.

This paper will provide an overview of the IEEE 1679 family of documents and how the use of these “child” documents in conjunction with the “parent” document will provide guidance and information that will be helpful in evaluating and selecting an energy storage technology.

Background

Ever since the beginning of the industrial revolution, there has been a concern for how to store energy for future use. Storage methods as diverse as electrochemical storage batteries, flywheels, and pumped-storage hydroelectricity are products searching for an efficient way of storing energy. All of these were invented prior to 1900.

With the coming of the information age, the rise of large-scale data centers, and the Internet of Things (IoT), the focus on energy storage intensified dramatically. New technologies came into being, older technologies have been updated and improved, and new ways of applying technologies have been developed. In order to provide up to date information on the available energy storage solutions, IEEE have updated or developed Recommended Practice and Guide documents related to a broad variety of energy storage technologies.

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These technologies range from those invented in the middle of the 19th century to those that have been developed in the last two decades. To provide the most up to date information available on the newer technologies, the ESSB committee has recently developed and published a Recommended Practice document that covers some of the new technologies, and some that have previously been used in applications that have not been described as “stationary” applications.

The “parent” document

IEEE 1679-2020 is the basis by which any number of various energy storage technologies can be objectively evaluated and compared, even though the technologies have differing characteristics and performance.

This document leads the user through the labyrinth of data that needs to be examined to be able to properly understand the performance envelope of an energy storage product. Specifics covered include:

- Information on characterizing the technology
- Qualification testing
- A description of the technology
- Regulatory issues
- Evaluation techniques

Each of these clauses is further expanded to provide the user a full understanding of the various aspects of a given technology so that any technology under consideration may be compared on a relatively level playing field. There are, of course, many differences in how some technologies might fit into an energy storage hierarchy, but following the information gathering and testing recommendations within this document will allow the user to discover and understand how these differences may be a benefit or a detriment in the particular hierarchy. It is required that the “parent” document be used to properly utilize any of the “child” documents, as it is what is referred to as a “normative reference.” This means that it must be used in conjunction with any document where it is so described. Each of the “child” documents follows the same basic format as the “parent” so that they may be directly compared to, and used in conjunction with, the “parent” document.

The “child” documents

The “child” documents are those that pertain to a specific energy storage technology, or group of similar energy storage technologies. At the time of this paper, there are two published child documents and two documents that are under development.

The two published documents are 1679.1-2017 IEEE Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications, and 1679.2-2018 - IEEE Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications. Each of these guides provide information regarding one of the two families of electrochemical energy storage technologies that are covered today.

The two documents in development are P1679.3 Draft Guide for the Characterization and Evaluation of Flow Batteries in Stationary Applications, and P1679.4 Draft Guide for the Characterization and

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Evaluation of Alkaline Batteries in Stationary Applications. As indicated by the "P" preceding the document number, and the word "draft" at the beginning of the official IEEE designation, these documents are being developed under a Project Authorization Request, or PAR, as it is referred to in the IEEE parlance. With that being understood, and with these being actively developed at this time, any and all parties that are interested in these (and other) technologies are encouraged to come to the Energy Storage and Stationary Battery Committee meetings to offer input and commentary on the documents as they are being written. There are several members of the IEEE ESSB in attendance at Battcon, and any of them will be happy to provide information on how someone can become involved in the process.

Information provided in these "child" documents (mentioned above) is specific to an energy storage technology, and as an example, it is valuable to understand what information is included in these Guide documents. An example of one of these guide documents is the IEEE 1679.1 document, which covers lithium-based batteries. In this Guide, the following aspects of the lithium chemistry are examined:

- Technology description
    - Storage medium
    - Intended applications
    - Components and construction
    - Power and energy characteristics
    - Maintenance requirements
- Characterization information
    - Aging mechanisms and failure modes
    - Safety
- Qualification testing
    - Functional testing
    - Abuse tolerance
    - Fault tolerance
    - Standards compliance testing
- Regulatory issues
    - Transportation
    - Regulatory requirements for safety
    - Code compliance
- Evaluation techniques
    - Application considerations
    - Safety
    - Life-cycle costing

There is much more information contained within the document, but this listing provides an idea of the scope of the valuable data contained in these documents.

Each of the "child" documents follow the same basic format and aim to provide the same level of information for an end user to be able to compare on an "apples-to-apples" basis. While storage technologies currently covered, and those that may be added in the future, may vary widely in their characteristics and suitability for a given application, using this series of documents it is possible to

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determine which technology would be most suitable for a given application using information based on a common format and descriptive language.

Similar to the lithium information included in IEEE 1679.1, IEEE 1679.2 provides information on the sodium-nickel chloride and similar sodium-beta (such as sodium-sulfur) high temperature battery designs. These designs have special thermal characteristics and require their own specific control systems. Just as in the lithium systems, each type has its own characteristics and these are described in the document, along with other evaluation and characterization information.

IEEE 1679.3 covers several unique flow battery designs and would be of interest to parties working with grid-scale and/or other long duration discharge profiles. Flow batteries utilize several different electrochemical technologies, with the commonality being that the liquid electrolyte is pumped across an electrode stack, the positive and negative half cells typically being separated by a membrane, causing the ionic exchange to occur. The biggest difference of a flow battery from other electrochemical storage technologies is that the "power" (rating in kW or MW) rating of the "stack" is decoupled from the energy storage capacity (rating in kWh or MWh) of the catholyte and anolyte tanks, and thus the energy storage capacity of the system can grow over time (by adding tanks) without growing the power rating (the "stack").

The purpose of IEEE 1679.4 is to provide information on aqueous alkaline electrochemistries other than nickel-cadmium. Nickel-cadmium is already well documented in the IEEE library, while many other alkaline chemistries have been underrepresented. Older technologies such as nickel-iron and nickel-zinc have not been previously covered, nor have some of the newer chemistries such as nickel-metal hydride and zinc-manganese. In some instances, these chemistries were not covered because they were not commercially available at the time other standards were being developed. Some of these chemistries were not yet invented or at a level where they were commercially feasible and in a few instances the chemistry was not used in a stationary application until recently.

The IEEE, with this series of documents is hopeful that more Energy Storage Systems (ESS) types will be added to the Energy Storage portfolio in the future by providing useful information to help compare, evaluate, and select newer ESS technologies.

This is the aim of the 1679 series of documents. There are many other technologies with potential to be used in stationary applications. It is very helpful to have some guidance in the evaluation and characterization of those technologies, and in some cases, energy storage technologies with great potential have been overlooked. At the very least, they have not been considered for stationary applications, as there was no documentation to help with understanding the capabilities of those products.

It is not the aim of the IEEE PES ESSB to develop guides for every single potential energy storage technology, but for those that are gaining market share or have more of a chance to gain market share. For example, SMES (Super-Conducting Magnetic Energy Storage) has long been in the literature as a potential energy storage technology, and a handful of "demonstrations" have been installed. However, at present, the general consensus is that the outlook for this technology to be economically competitive in anything resembling the near future is not there.

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At the time of this paper, all of the energy storage technologies represented in the IEEE 1679 family are electrochemical in nature. As other energy storage products (e.g., supercapacitors, flywheels, "gravity"-based devices besides pumped hydro, other battery technologies, etc.) are commercialized and begin to be deployed in higher numbers, and there is enough interest from the community to find willing volunteers to write, it is anticipated that additional Guide documents will be created so that they may be effectively compared to all of the other available technologies. For standards and application information regarding mechanical, fuel cells, stored gases or water, and other methods of producing an electrical output from various methods of storage, one should investigate other standards organizations, such as ASHRAE, UL, CSA, and IEC, among others.

The IEEE encourages all individuals to participate in the development of the documents so that a broad spectrum of inputs can help produce a consensus document based on the best practice. Input from parties as diverse as end users, installers, maintainers, consulting engineers and manufacturers is not only valuable, but highly encouraged.

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