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Measuring Energy Storage System Performance: A Government/Industry-Developed Protocol Briefing Summary

The U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability Energy Storage Systems Program, through the support of Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (Sandia) and in collaboration with many stakeholders and interested parties, developed a protocol (i.e., pre-standard) for measuring and expressing the performance characteristics for energy storage systems in 2012. The application and use of that initial protocol (PNNL 22010/SAND2013-7084) has enabled a more informed manner of considering the performance of energy storage systems, and provided a platform for more comparable consideration of system options in meeting our energy, economic and environmental challenges. Without such a document, there is no common basis for comparing system performance, making it difficult for users to know what they are getting and making it more challenging to evaluate manufacturer claims about the performance of their products.

Most importantly the protocol has served as the basis for formal standards being developed by U.S. standards development organizations (SDO) and internationally through the International Electrotechnical Commission. The access to such a protocol or pre-standard by any SDO significantly reduces the time it can take to develop formal standards. Recognizing energy storage technology development and deployment is growing at a significant rate. In response to market needs, PNNL and Sandia, with the assistance of a wide range of stakeholders, have completed an updated version of the protocol. This revised protocol (PNNL 22010 Revision 2/SAND2016-3078R) increases the number of applications covered from three to eight, adds a number of new performance-related metrics, enhances the initial protocol criteria related to system testing and re-organizes the document to significantly ease its application.

"This document was intended to serve as a firm foundation for further development of national and international standards, and it has done that," said Dr. Imre Gyuk, OE's program manager for Energy Storage. Dr. Gyuk further stated "Having addressed an immediate need in 2012 the increasing application and use of energy storage systems and the demand to address new applications, more metrics and improve the document supported the development of an updated protocol. We are proud to serve proponents and users of energy storage technologies in presenting relevant information about system performance and facilitating the consideration of that information by storage system users."

PROTOCOL DEVELOPMENT PROCESS

The enhancements to the 2012 protocol were developed through an open and transparent public-private collaboration composed of more than 100 individuals representing approximately 60 organizations and companies. These stakeholders remained involved in the protocol update efforts and served on any of four subgroups focusing on metrics or how to appropriately assess six new applications for energy storage systems. Anyone wishing to participate was welcomed and encouraged to do so.

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PROTOCOL OVERVIEW

From the outset of these efforts in March 2012, it was determined that the protocol would cover all energy storage technology, be agnostic with respect to the type and size of storage technology and that single use or non-rechargeable storage devices and storage devices that were not coupled with power conversion systems would not be covered by the protocol. Published in late 2012, the protocol (www.pnl.gov/main/publications/external/technical_reports/PNNL-22010.pdf) covered peak shaving and frequency regulation applications, provided information necessary to define the system boundaries, measurements to be taken during system testing, the duty cycle to be applied to the system for each application, and the methods for determining and reporting system performance from the resultant operational data. Both of those applications were evaluated with respect to capacity, round trip energy efficiency, response time and duty-cycle round trip efficiency. The frequency regulation application is also evaluated for ramp rate and reference signal tracking. In June 2014 a revision 1 to the protocol was released and increased the scope of the protocol to the application of an ESS as an islanded micro grid.

What is new in the March 2016 revision 2 of the protocol is listed below:

- New organization of the content to make it much easier to apply - determine the system boundary, identify the intended applications for the ESS, subject the ESS to the duty cycle provided for each of those applications, gather the data and then use those data and other required information to report ESS performance.
- Enhancements to the existing protocol to clarify technical detail and reduce the complexity associated with applying some of the criteria.
- Five new applications – PV smoothing, volt/var, renewables firming, power quality and frequency control.
- The addition of a number of ESS informational and technical specifications important to an ESS user that are universally applicable to any ESS in any application.
- Delineation of performance metrics that are not dependent on duty cycle or application – stored energy at rated power, cumulative round trip efficiency at rated power, individual cycle round trip efficiency, stored energy at various percentages of rated discharge and charge power, response time, ramp rate, internal resistance, reactive power response time, reactive power ramp rate, standby energy loss rate and self-discharge rate.
- Details associated with now eight duty cycles (one for each ESS application) that are applied and the associated test data used to determine duty-cycle round trip efficiency, reference signal tracking, state of charge excursions, and energy stability. For volt-var applications, a number of additional metrics are provided that indicate the difference in ΔSOC, discharge and charge energy between the volt-var operating state and active standby. For frequency control applications peak discharge power and charge power, and for power quality, peak discharge power, for fixed durations, are also covered.

WHAT'S NEXT?

During 2016 and beyond PNNL and Sandia will continue to assist national and international standards developers that choose to use the protocol as a basis for any future standards covering a determination of system performance as well as other entities that want to apply the protocol to facilitate their consideration of energy storage systems or assess the performance of those systems they have deployed. In addition, based on market needs and experiences gained in using the protocol, they will continue to support a working group overseeing and developing protocol enhancements. Longer term, when formal national and international standards are approved and published, which is anticipated in 2017, these DOE efforts under the leadership of PNNL and Sandia can evolve to a role of providing needed research and input to those standards development processes.

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