Building Investor Confidence in Energy Storage through Comprehensive Testing and Evaluation

B. Taube*, R. Johnson**, A. McQuilling*, P. Leufkens*, B. Hamzavy*, and C. Thompson**

*Southern Research, Energy & Environment
757 Tom Martin Dr, Birmingham, AL, USA, btaube@southernresearch.org
**Acelerex, Boston, MA, USA, randell.johnson@acelerex.com

ABSTRACT

The integration and implementation of energy storage to the grid, especially to support mission critical infrastructure, requires a deep understanding of system functions and performance. In order to build investor confidence in the area of emerging energy storage technologies, extensive testing, evaluation, analysis and modeling must be conducted. This paper describes the role of testing in building investor confidence in energy storage. These test services include: system level (front-of-meter and behind-the meter) and module level function and performance testing, stacked services testing and visualization, economic analysis, witness testing, commissioning, and factory and site acceptance testing. This full suite of testing services will enable the continued development of energy storage technologies and its wider adoption into the mission-critical, operational power delivery infrastructure.

Keywords: function and performance testing, stacked services testing and visualization, economic analysis, commissioning, and factory and site acceptance testing

1 BACKGROUND AND INTRODUCTION

There are few facilities that are designed to support the wide range of testing, research and evaluation services required to build investor confidence in grid-scale and behind-the-meter energy storage; a nmber of these facilities have been described in previous work done by the energy storage team at Southern Research [1], [2]. Systems need to be able to be evaluated both on-site and remotely; additionally, test facilities need to be able to serve a range of technologies and system sizes to fully support all industry stakeholders ranging from utilities and system and componentvendors to project investors and developers. The Energy Storage Research Center (ESRC) at Southern Research, is able to offer a broad range of both onsite and remote testing. The ESRC is home to front-of-the-meter and behind-the-meter testbed infrastructure, and through the software-hardware infrastructure at the site, is also able to provide remote testing. The following sections offer an overview of testing needed to support the energy storage market.

2 OVERVIEW OF TESTING TYPES

As the energy storage industry is growing and developing quickly, its evaluation must be multi-faceted in order to build investor confidence in the wide range of available technologies. The following sections describe the types of testing included in a comprehensive test plan to fully evaluate energy storage systems (Figure 1).

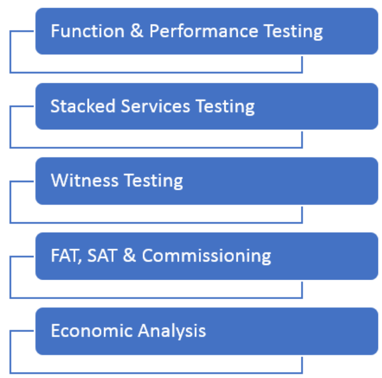

Figure 1: Energy Storage Testing and Evaluation types to build investor confidence.

2.1 System and Module-level Function and Performance Testing

The first types of testing that are essential to build investor confidence in energy storage are system functional and performance evaluation. There are a number of key references that can be utilized to develop a test plan for evaluating the energy storage system function and performance. These include the EPRI Energy Storage Test Manual [3], the SNL/PNNL Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems [4], among others [5], [6]. This testing can be conducted either onsite or through a remote platform enabled by an IoT approach, such as the one available through the software-hardware infrastructure at the Southern Research ESRC. Figure 2 shows these key references.

Figure 2: References for ESS functional and performance testing.

2.2 Stacked Services Testing

Energy storage systems are often able to provide multiple services simultaneously or at different times during the day or times of year. Stacking services, sometimes called value stacking, can boost profitability, improving the economics of storage installation [7]–[9]. However, the ability of the system to perform these multiple functions needs to be validated in order for utilities and other stakeholders to fully realize energy storage system benefits. Significant efforts have been made at the Energy Storage Research Center to address the unique testing demands to validate system performance of stacked services (Figure 3).

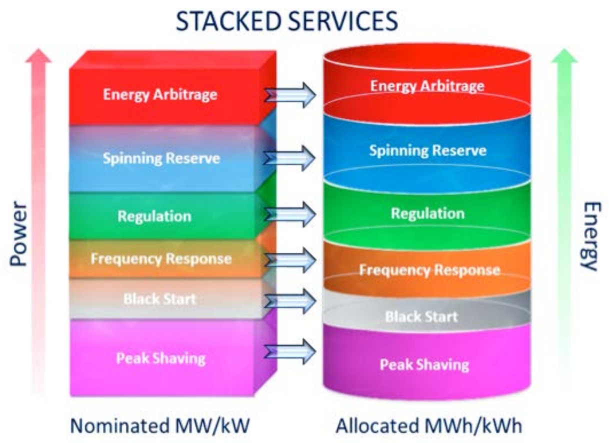

Figure 3: Stacked services overview—allocated power and capacity.

2.3 Witness Testing

Per the report from Sandia entitled *Sandia Third-Party Witness Test of UniEnergy Technologies 1 MW / 3.2 MWh Uni.System*, “Witness testing verifies that the energy storage system that is installed can meet its performance specifications through a thorough evaluation which includes testing, document review, and physical inspection [10].”

2.4 Factory and Site Acceptance Testing and Commissioning

Factory acceptance testing (FAT), site acceptance testing, and commissioning are critical to ensure the energy storage system is built to the functional specification of the client. FAT is performed at the vendor’s facility while SAT is performed at the point of installation. Commissioning is a process that includes “clearly defined roles, responsibilities, and tests…[commissioning] tests ensure that the system and sub-systems—such assafety, protection, and communication and control—were properly installed and are operating within specification [11].” Commissioning data can be used to benchmark performance throughout the operational lifetime of the system. Figure 4 shows the progression of these tests.

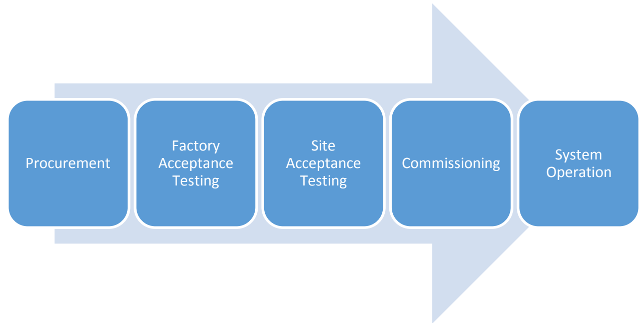

Figure 4: Progression of FAT, SAT and Commissioning for energy storage system.

2.5 Economic Analysis

In addition to ensuring an energy storage system operates in the expected manner through the testing types described above, investor confidence must also be built through the completion of rigorous economic analysis. This analysis translates performance information into real values for the consumer/investor. Proper economic analysis, begins before procurement to inform the sizing of the system (power and capacity), as well as its siting. Additional economic analysis is conducted as the system operates to ensure that expectations regarding the value of system performance are realized. Economic analyses involve both technical understanding of the system as well as knowledge regarding the markets in which the system will operate, which vary wildly from state to state across the country.

3 RISK MITIGATION

Previous work completed by the ESRC at Southern Research has elaborated on the risks identified with energy storage installation and operation. They have been broadly described by the following categories: technical, economic, and environmental, each elaborated in the Table below. All three of these risk categories can be mitigated through comprehensive testing and evaluation of the energy storage systems; the role of each testing type in mitigating risk is described in the following subsections. Reduced risk contributes to increased investor confidence in the sector.

Type of Risk	Description
Economic & Regulatory	These are risks associated with the ESS not providing the value expected and risks associated with a changing regulatory environment
Technical	This refers to the risk that the ESS does not operate, age, or perform in any other way as expected
Safety & Environmental	These refer to the risk of system failure resulting in either safety concerns or potential environmental damage

Table 1: Overview of risks associated with energy storage.

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3.1 System and Module-level Function and Performance Testing

The completion of a comprehensive functional and performance evaluation of the ESS can guard against both technical and economic risk and may help identify future safey and/or environmental risks with the system. By completing these types of testing, the customer will have data demonstrating that the system performs required functions and its overall performance has been characterized. This can ensure that there is a benchmark to compare system performance to at a later point to validate expected system performance over time. Additionally, any issues that arise within these tests can be an early indicator of potential safety or environmental issues, and so can be addressed before becoming more detrimental to the project.

3.2 Stacked Services Testing

The ability to provide multiple services during a given day or performing multple applications simultaneously often drives investor interest in energy storage. However, failure of the system to perform these stacked services can derail the economics of a project and reduce investor confidence in the technology. As such, implementing stacked services testing can validate stacked services performance and reduce the economic risk that the investor may be exposed to during project development.

3.3 Witness Testing

Witness testing combines some of the aspects of other types of testing described above—including functional and performance assessment, and through the review of the system specification and other documentation review, and physical inspection, critical issues that may occur with the system can be identified. This has the potential to reduce risks associated with the operation and maintenance of the system and its safety.

3.4 Factory and Site Acceptance Testing and Commissioning

Factory acceptance testing (FAT), site acceptance testing, and commissioning are designed to reduce risk throughout the project's development. The FAT can assist in the identification of design flaws prior to the systems' arrival onsite. Site acceptance testing ensures that the system arrives onsite intact and meets the specifications laid out by the customer. Finally, commissioning ensures the system is operating as expected at the beginning of its life.

3.5 Economic Analysis

Economic analysis and modeling complements the types of testing described in sections 3.1-3.4. It can reduce economic risks to the project throughout development and installation by identifying potential areas of concern, especially those related to market potential and regulatory environment, and ensure investors, developers and other stakeholders understand a range of potential outcomes for the performance and economics of the project. This kind of analysis can be done throughout the project to adjust expectations regarding performance and revenue to ensure stakeholders have the best information possible, especially as the energy storage sector rapidly grows and develops.

4 CONCLUSIONS

Energy storage testing can help build investor confidence by mitigating technical, economic, and environmental risks associated with the technology. While there are a range of facilities that can conduct certain tests, few can offer as wide of a range of testing as the ESRC at Southern Research at its front-of-meter and behind-the-meter infrastructure.

5 ACKNOWLEDGMENTS

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