Identifying key applications for cost-effective deployment of energy storage systems in the Southeastern United States

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ABSTRACT

By combining backward- and forward-looking analyses of energy storage technologies currently in use, Southern Research has been able to describe the key technical, functional, and safety attributes for energy storage systems deployed in the Southeast, and identify key technological and economical risks for the deployment of energy storage in the region. Energy storage will play a vital role in the future to provide reliable and reasonably priced power to utility consumers, especially as more renewables are integrated into the grid and load growth continues to occur unevenly. In order to provide for its application, it is important to understand and evaluate the function, performance, and cost-effectiveness of technologies prior to their deployment to ensure that systems provide the benefits needed to justify investment in that technology. Key use cases in the Southeast are often related to the increasing integration of renewable energy into the grid as a result of both residential, commercial and industrial installations, and utility-scale solar farms.

Keywords: energy storage, stacked benefits, system deployments, economic valuation

1 INTRODUCTION

Based on our review of existing deployments, energy storage, in general, thrives in an ISO (independent system operator) market environment. The majority of the Southeast is relatively traditionally regulated and not widely served by ISOs (only parts of the region are a part of the PJM interconnect). This is also consistent with findings from the Retail Industry Leaders Association [1] in their Corporate Clean Energy Procurement Index ranking: "The growth of state policies and regulations that help enable corporations to procure Renewable Energy – or remove barriers to doing so – is a key factor to install (…) renewables and create jobs."

Energy storage adoption in the Southeast has been thus far limited by the costs of energy storage systems and the utility and regulatory environment found in the region. While a number of utilities have begun to deploy demonstration-scale energy storage systems, widespread adoption of energy storage has not yet occurred. However, as costs for energy storage systems continue to decrease due to improvements in technology and energy storage markets, energy storage will be more widely implemented in the region to support the delivery of safe and reliable electric power. The key to this transition will be to understand the attributes and risks that drive value for energy storage deployment.

The analysis described in the following sections was developed from references including all relevant use cases, utilizing both government databases and peer-reviewed literature [1]–[5].

2 ENERGY STORAGE APPLICATIONS AND KEY ATTRIBUTES

The most important attributes of an energy storage system are inextricably linked to the service(s) it will provide. The following graphic (Fig. 1) shows key performance requirements for energy storage use cases.

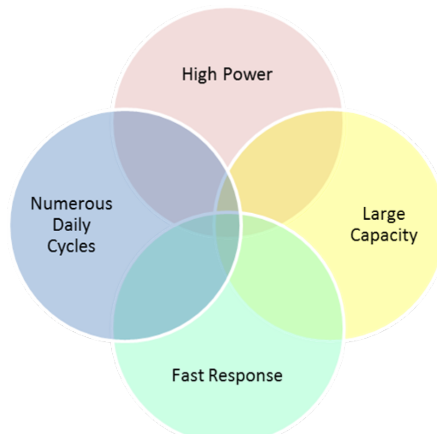

Figure 1: Key Performance Requirements for Energy Storage Systems

Based on interviews with local utilities, survey responses and additional analysis, it was determined that key applications for the Southeast in the near future will include: renewables firming, transmission and distribution upgrade deferral, transmission congestion relief, and resiliency. The analysis that follows describes the key attributes for each of these critical applications for the deployment of energy storage systems throughout the Southeastern US.

2.1 Renewables Firming

Renewable energy generation tends to be intermittent. To reduce intermittency over shorter and longer intervals (e.g. to support solar when there is brief cloud cover or for overnight hours), energy storage can be used to compensate for this inconsistent generation. For capacity firming, i.e.

smoothing fast wind-induced power variations and fluctuations in power output from solar generation due to clouds and can require high power output for momentary periods of time, the energy storage system employed should provide a fast response time, ideally less than 1 second [6], [7]. This application can have a few 100% DOD cycles over the course of 1 day [8]. If renewables generation shifting is more important, the system will be energy-focused and so attributes that characterize capacity of the system are critical to understand its performance in response to this use case. A summary of key attributes for both these use cases are included below (Table 1).

Use Case	Renewables Time Shift	Renewables Capacity Firming
Key Attributes	• State of Charge Excursions • Self-Discharge Rate • Total Efficiency • Available Capacity • Depth of Discharge • Overload Capacity • Rated Continuous Power • Energy Stability	• Ref. Signal Tracking • Charge Duration • Communication Latency • Response, Rise, and Settling Time • Charging Efficiency • RT Efficiency • Cycle Lifetime

Table 1: Key Use Case Attributes for Renewables Time Shift and Renewables Capacity Firming

2.2 Transmission and Distribution Upgrade Deferral

The benefits associated with installing energy storage for T&D Upgrade Deferral are derived from the ability to defer the need to replace or to upgrade existing transmission and distribution equipment or to increase the equipment's existing service life [6]. This use case can be served by either a stationary energy storage system (likely with a larger power and capacity rating) or by transportable systems which can be moved to where they are needed most on the grid. For this use case, available capacity and various aspects of system efficiency are critical to characterizing performance; key attributes are summarized in Table 2 below.

	T&D Upgrade Deferral
Key Attributes	• State-of-Charge Excursions • Total Efficiency • Stand-by Energy Loss • Available Capacity • Depth of Discharge • Overload Capacity • Rated Cont. Power • Energy Stability

Table 2: Key Use Case Attributes for Transmission and Distribution Upgrade Deferrral

2.3 Transmission Congestion Relief

Electricity storage can be used to avoid congestion-related costs and charges when there isn't sufficient capacity on transmission lines [9]. Energy would be stored when there is no transmission congestion, and it would be discharged to reduce peak transmission capacity requirements [10], [11].
This application is expected to increase in importantce as future imports of renewable wind energy (especially to meet commercial and industrial renewable portfolio requirements) could create transmission congestion problems at the edges of the Southeast region of the United States. Key characteristics of systems used for this application include: high power output, fast charge/discharge times, high ramp power rates, high cycling times, and fast response times; key attributes are summarized in Table 3 below.

	Transmission Congestion Relief
Key Attributes	• Reference Signal Tracking • Communication Latency • Self-Discharge Rate • Total Efficiency • Stand-by Energy Loss • Available Capacity • Depth of Discharge • Overload Capacity • Reactive Power

Table 3: Key Use Case Attributes for Transmission Congestion Relief

2.4 Resiliency

Resiliency, as a use case, refers to the use of energy storage "to improve the reliability and stability of the grid by regulating variable generation and improving microgrid and smart-grid functionality [6], [12]." For end users, a grid that is resilient to failure is unlikely to have widespread outages; it tends to be a more energy (capacity) focused use case though peak power and rated continuous power are important as well. Key attributes for the use case are presented in Table 4.

	Resiliency
Key Attributes	• Ref. Signal Tracking • State-of-Charge Excursions • Comm. Latency • Stand-by Energy Loss • Available Capacity • Peak Power • Rated Cont. Power • Mean Time Between Failures

Table 4: Key Use Case Attributes for Resiliency

Resiliency is expected to be an important use case in the Southeast due to the extreme weather events that the region can experience over the course of the year. Extreme events ranging from tornadoes in the East South Central States, to hurricanes along the gulf coast and eastern seaboard, as well as ice and snow storms in the more northern states included in the region, especially Virginia, Maryland, and West Virginia. Reliability (as indicated by mean time between failures) and stand-by energy loss are important attributes of systems installed for resiliency as they may not be operated frequently, but its performance is critical when it is called upon.

3 ENERGY STORAGE RISKS

There are a number of references in the literature that focus on energy storage risks, especially those related to technical safety issues like fire in Li-ion batteries [9]. Additionally, there are many papers that focus on economic and regulatory concerns, but there is little documentation regarding other general risks [1], [13], [14]. As energy storage systems are more widely adopted it will be critical to characterize all potential risks related to energy storage deployment in order to mitigate them and ensure systems are operated as safely and effecitvely as possible.

3.1 Approach to Analysis

Through analysis based on literature review and discussions with key stakeholders, potential energy storage risks that were important to the region have been identified in the following categories: regulatory/legal risks, technological (Hardware/ Software) risks, operational/ maintenance risks, environmental risks, safety risks, and economic risks.

After discussion, a list of 47 risks in these six overarching categories were identified. Each of items was then rated based on their likelihood and their impact, on a scale from 1 to 3. We defined the product of these two values as the “severity” of the risk. The relevance of each risk specifically for the Southeast region and the relevance for internal use when a lab is built were also considered. The risk for the Southeast region was deemed to have greater significance so it was weighed higher, with high, medium, and low risk corresponding to values of 5, 3, and 1; the risk for internal use had risk evaluations corresponding to values of 3, 2, and 1. Prioritized risks for the Southeast are presented in Section 3.2.

3.2 Summary of Results

Risks were assesssed based on the combination of the three factors described above—severity, relevance to the region, and relevance for the Southern Research test lab (ESRC). Moreover, each of the high importance risks had a top value (6, 5, or a 3 for severity, southeast, and internal) for at least one category, giving confidence to the ranking methodology.When applying mitigations to the risks, we found that five of the six categories could mostly be mitigated by adherence to standards; the only one that did not feature many standards was economics. Existing standards mainly focus on specifications on physical parts of the ESS and the risks in the device, environmental, operation & maintenance, regulatory, and safety categories were mainly focused those physical attributes. Economic risks were mainly mitigated through better understanding of energy storage markets and systems and the development of better economic models. Prioritized risks are summarized in Table 5 below.

Category	Risk	Severity	Relevance to the Southeast	Priority for the ESRC
Device	Human Error	6	5	2
	Cybersecurity	6	5	1
	IT Infrastructure	6	3	2
Economic	Use Case Assumptions	6	5	3
	Competition by Alternative Solutions	6	5	2
	Operating Lifetime	4	5	3
	Business Concerns in the ES Industry	4	5	1
Environ.	EOS ZnBr (zinc-bromide)-Specific risks	4	5	3
	Off-gassing	4	5	3
O&M	Unit Commercialization	6	5	3
	Aging	4	5	3
	Site-Specific Climate	4	5	3
Regulation	Slow Development of Codes and Standards	6	5	3
	Retail Choice	6	5	3
Safety	Other hazards	6	3	2

Table 5: Risks related to Energy Storage for the Southeast prioritized by Southern Research

4 CONCLUSIONS

The regulatory and economic environment in the Southeast is, on average, less supportive of renewable and energy storage than many other parts of the country, so identifying and quantifying economic benefits for the region will be critical. The use cases that energy storage systems designed to meet vary regionally, and economic valuation may be different in the Southeast than in the rest of the country.

Key attributes of energy storage systems depend heavily on the types of services that the systems will be expected to provide; lithium ion installations appear to serve the widest range of potential use cases.

For use cases expected to drive deployments in the Southeast, key attributes have been highlighted in Tables 1-4 of the document.

Risks for energy storage deployment and adoption have also been discussed in this paper at length in Section 3; risks that have identified as high priority, due to their severity or their relevance to the Southeast region are summarized in Table 5.

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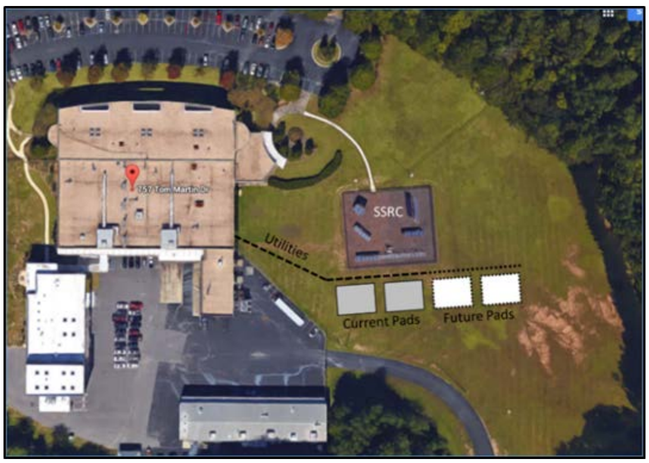

Figure 2: ESRC Layout

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