Standardization and Semi-Automation of Battery Energy Storage System Capacity Test Reporting

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ABSTRACT

This project developed a standardized, semi-automated reporting framework for capacity test results in a utility-scale battery energy storage operations environment. An analysis of existing reporting workflows identified inefficiencies caused by vendor-specific formats and manual data handling. A standardized reporting template and a semi-automated data processing approach were implemented to improve consistency and repeatability. The proposed framework demonstrates the feasibility of reducing manual reporting effort, improving consistency across multiple vendors, and enhancing data traceability. The framework provides a foundation for scalable capacity-test reporting across distributed BESS portfolios.

INTRODUCTION

Utility-scale battery energy storage systems (BESS) play a critical role in grid reliability, renewable energy integration, and operational flexibility. Capacity testing is used to verify usable energy, assess degradation, and confirm compliance with contractual and warranty requirements. In practice, capacity test reports are delivered in vendor-specific or project-specific formats, requiring significant manual processing by engineering operations teams and limiting scalability across large BESS portfolios.

BACKGROUND

Capacity testing is widely used to quantify usable energy delivery and compare measured performance against design or contractual specifications. While industry standards provide guidance for BESS testing procedures, the reporting structure and data presentation remain inconsistent across vendors and projects. Consequently, asset owners receive technically compliant reports that vary in format, terminology, and level of detail, increasing the effort required for internal review and cross-asset comparison.

PROBLEM STATEMENT AND OBJECTIVE

Challenge

Manual capacity test reporting workflows reduce efficiency, increase error risk, and limit scalability across large BESS portfolios.

Objective

Develop a standardized and semi-automated reporting framework to reduce manual effort, improve consistency, and enable repeatable application across multiple BESS assets.

METHODOLOGY

Phase 1: Workflow Review

- Reviewed existing capacity test reporting workflows
- Identified manual processes and data handling challenges.

Phase 2: Template Development

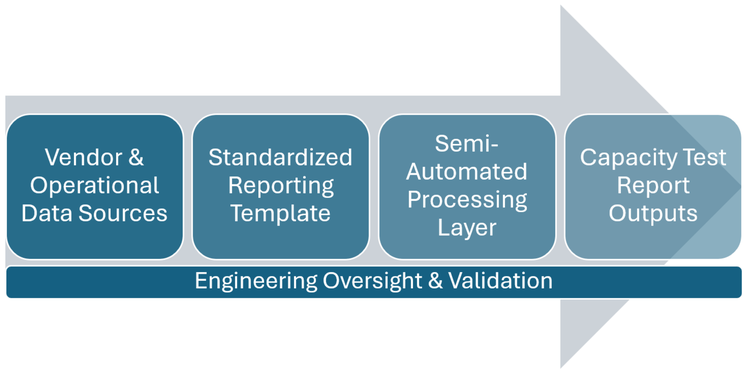
- Developed a standardized reporting template
- Defined required inputs, calculated metrics, and uniform formatting

Phase 3: Semi-Automation

- Implemented semi-automated data extraction and processing
- Maintained engineering oversight and validation of results

RESULTS

Conceptual Reporting Framework



Conceptual standardized, semi-automated capacity test reporting framework illustrating functional components and engineering oversight.

Framework Components and Roles

Vendor & Operational Data Sources

Provide OEM capacity test files and operational measurements from SCADA systems.

Standardized Reporting Template

Defines required inputs, calculated metrics, and consistent formatting across reports.

Semi-Automated Processing Layer

Supports rule-based calculations and population of standardized report outputs.

Capacity Test Report Outputs

Provide standardized capacity test reports and summary artifacts for internal and external stakeholders.

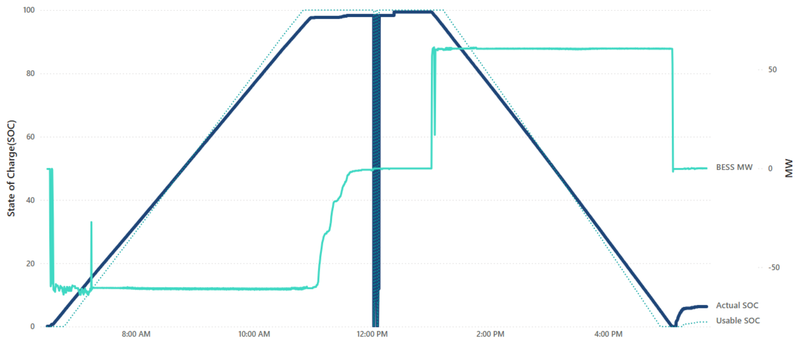
Engineering Oversight & Validation

Ensures data accuracy, traceability, and quality through human review.

Key Improvements:

- Reduced manual effort and reporting time
- Improved consistency across vendors and system configurations
- Enhanced data traceability and overall data quality

Standardized Report Output – Capacity Test Profile



Excerpt from a standardized capacity test report output, illustrating usable SOC limits relative to actual SOC during controlled charge and discharge.

QUALITATIVE IMPACT OF THE STANDARDIZED REPORTING FRAMEWORK

Before Framework

- High, manual, iterative report preparation
- Manual data extraction and calculations
- Frequent vendor clarification cycles
- Low consistency across reports
- Limited calculation traceability

After Framework

- Reduced reporting effort through standardized workflows
- Semi-automated data processing
- Fewer vendor clarification cycles
- Improved consistency across reports
- Enhanced calculation traceability

Qualitative comparison derived from observed workflow changes.

CONCLUSIONS

- Standardized capacity test reporting can improve efficiency and consistency in BESS operations
- Semi-automation can reduce error risk while preserving engineering oversight
- The framework supports repeatable application across diverse assets and vendors
- Standardization provides a foundation for scalable, data-driven performance monitoring

FUTURE WORK

- Integration with enterprise analytics platforms (e.g., Microsoft Fabric)
- Portfolio-wide expansion of standardized capacity test reporting
- Incorporation of degradation analysis using historical data
- Extension to rack-level performance diagnostics

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REFERENCES

- IEC 62933-2-1, Electrical Energy Storage (EES) Systems – Unit Parameters and Testing Methods, International Electrotechnical Commission, 2017.
- IEEE 2030.2.1, Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, IEEE, 2019.
- Electric Power Research Institute, ESIC Energy Storage Commissioning Guide, EPRI Report 3002027455, 2023.
- National Renewable Energy Laboratory, Performance and Health Test Procedure for Grid Energy Storage Systems, NREL/CP-5D00-67419, 2017.