Sandia National Laboratories

Enhancing Grid Reliability using Energy Storage Systems

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Project Objective

Develop frameworks for enhancing grid reliability using energy storage systems (ESS) including an open-source tool for grid reliability assessment, degradation and failure models for ESS, and characterizing uncertainties in the grid for better ESS sizing.

Motivation

- Energy storage systems widely deployed for **grid reliability applications** including mitigating uncertainties, providing flexibility, serving as back-up power
- Crucial to accurately model ESS **failure and operational characteristics** in grid reliability studies to understand contribution of these flexible resources
- *Failure model:* Current frameworks *generalize cell degradation models* to system-level capacity fade
- Uncertainties due to *unreliable non-dispatchable resources* not fully captured by current tools

Approach

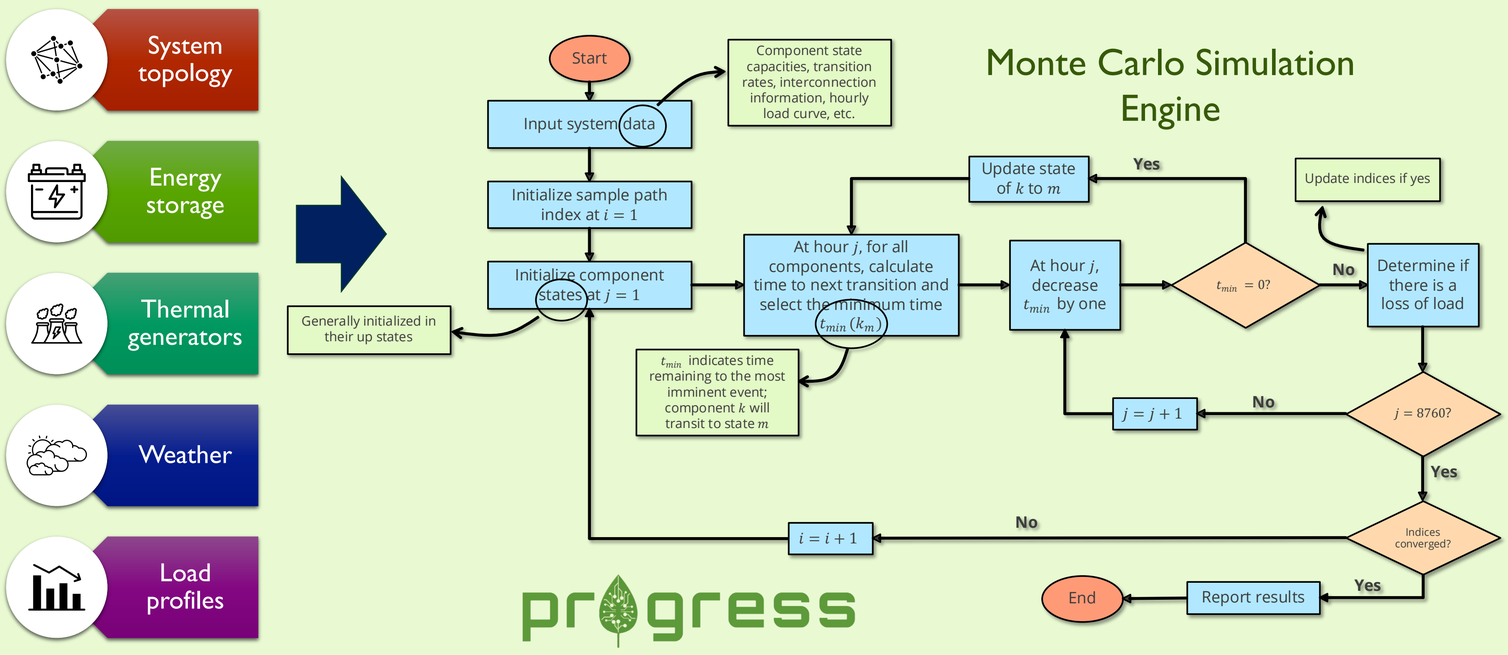
- Develop open-source *grid reliability assessment* tool that integrates state-of-the-art energy storage models — *Probabilistic Grid Reliability Analysis with Energy Storage Systems (ProGRESS)*
- Develop ESS failure models — refine cell degradation models with real-world data, consider *impact of cell-cell variation and battery topology* on system capacity fade*
- Develop data-driven models for characterizing *uncertainties associated with non-dispatchable resources* and synthesizing diverse scenarios to stress test reliability health of the grid and *size ESS to achieve desired reliability levels***

*This task is part of this project and is described in a different poster.
** This task is complete.

Deliverables

1. Released ProGRESS v1.0 in December 2024 on GitHub
2. Released ProGRESS v1.2.0 in June 2025 with new features, GUI improvements, and bug fixes
3. Full ProGRESS API reference and user documentation published on GitHub pages
4. Paper on ProGRESS models presented at *2025 IEEE EESAT* conference, Charlotte, NC
5. Abstract on BESS failure modeling accepted at *2026 IEEE EESAT*
6. Paper on synthetic data generation accepted for presentation at the *2025 IEEE PES General Meeting*, Austin, TX

ProGRESS Overview

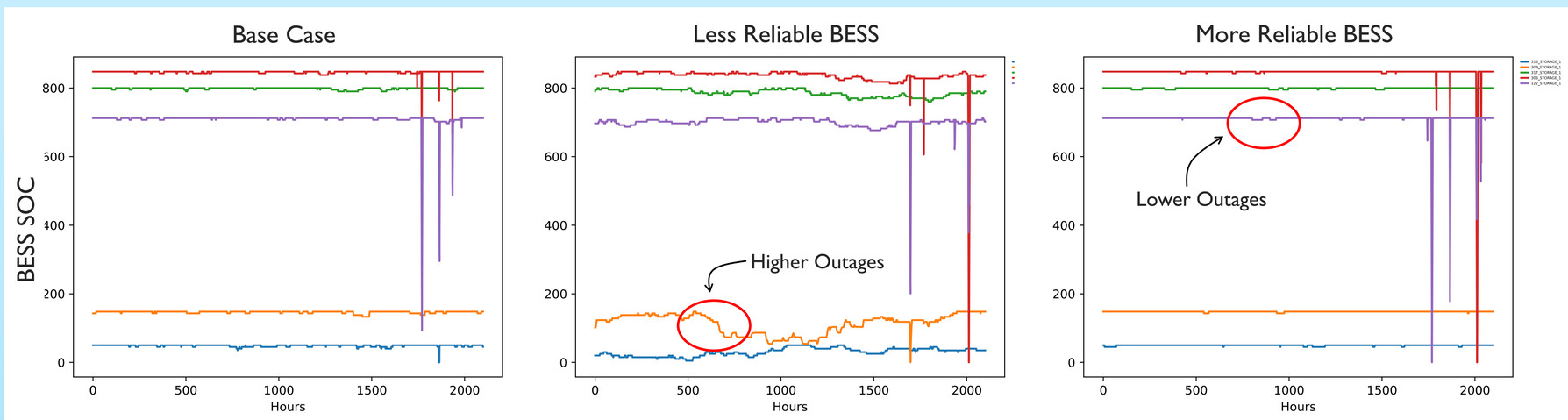


Next Steps

- Incorporate new *ESS operation modes* in ProGRESS including economic and hybrid (economic + reliability) modes
- Integrate ProGRESS with other QuESt tools — QuESt Planning and PCM for *integrated grid planning with ESS*
- Perform case study for US systems to determine role of ESS in delivering **affordable and reliable** power to customers — consider *load growth due to data centers* and *firm capacity retirements*

Case Study

How do BESS failures affect grid reliability?



System Reliability Metrics

Case	MTTF (h)	MTTR (h)	LOLE (d/y)	nEUE (ppm)
Base	100	20	0.349	7.0
Less Reliable BESS	40	30	0.391	8.0
More Reliable BESS	250	20	0.340	6.9

MTTF: Mean Time to Failure; **MTTR:** Mean Time to Repair
LOLE: Loss of Load Expectation; **nEUE:** normalized Expected Unserved Energy

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