The Challenges Associated with Assessing Energy Storage Performance and Reliability with Large Amounts of Field Data

Lessons Learned from the First Year of EPRI’s Energy Storage Performance and Reliability Data Initiative

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Goals of this Presentation

- Discuss the challenge of assessing energy storage performance and reliability with less-than-perfect data sets.
  - How can we maximize value from all data sets?
Barriers to “Utility-Grade” Energy Storage

- Grid assets must have **consistent performance** with **minimal downtime**
  - Commercial energy storage systems must prove themselves

- **Objective, independent analysis** is needed to better understand performance and reliability characteristics:
  - Vendor calculated performance characteristics:
    - SOC, SOH, efficiency, energy capacity, etc.
  - Vendor specified reliability characteristics:
    - Mean time to failure, component failure rates, degradation drivers, etc.

We must develop a track record for fielded energy storage systems!
Energy Storage Performance and Reliability (P&R) Data Initiative

- **3-year project started in early 2018**
- **Motivation**: Develop grid-scale energy storage track record
- **Desired Outcomes**:
  - *Performance*: Develop the ability to independently quantify key metrics like SOC, SOH, efficiency, standby losses, etc.
  - *Reliability*: Understand the causes and implications of non-performance to inform better O&M practices
- **Strategic Partnerships**:

<table>
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<tr>
<th>Utility Partners</th>
<th>EPRI</th>
<th>National Labs Collaboration</th>
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<tbody>
<tr>
<td>• Own and operate fielded ESSs</td>
<td>• Facilitate data transfer and storage</td>
<td>• Cell degradation and failure expertise</td>
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<td>• Collect and share data with EPRI</td>
<td>• Develop algorithms and perform analysis</td>
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<td>• Provide input and guide research</td>
<td>• Share meaningful results with members</td>
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Current Challenges with Field Data Collection and Analysis

- Visibility into the system, i.e. what measurements are reported?
  - Large-scale data collection is usually not a design consideration
- How the data is recorded and stored by the system host
  - Recorded to SCADA first?
  - Can EPRI poll directly from the ESS historian?
- Host cyber-security policies
- Data intermittencies and outages
  - Especially with data coming from SCADA
## Performance and Reliability Data of Interest

### Example of Data
- SOC & SOH
- Voltage & current at various points
- Parasitic loads

### Example of Uses
- Develop analysis algorithms to characterize true system performance
- Self-discharge rate, degradation, efficiency, etc.

### Data of Interest in the P&R Initiative

<table>
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<tr>
<th>Operational (Quantitative) Data</th>
<th>Non-performance (Qualitative) data</th>
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<tr>
<td>• SOC &amp; SOH</td>
<td>• Binary errors and alarms</td>
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<tr>
<td>• Voltage &amp; current at various points</td>
<td>• Event descriptions/explanations from system operators</td>
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<td>• Parasitic loads</td>
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### Change in 1% SOC Energy Over Time

- **Regime 1 Charging Events Slope = -0.065 Wh/day**
- **Regime 1 Discharging Events Slope = 0.019 Wh/day**
- **Regime 2 Charging Events Slope = -0.055 Wh/day**
- **Regime 2 Discharging Events Slope = -0.324 Wh/day**

### Percentage of Reported Incidents by Component

- System non-functional
- System partially operational
- System fully operational
Capturing Operational Data
## Visibility into Operational Data

- Based on initial design, host systems have varying degrees of system visibility

### Sparse Data vs. Robust Data

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<th>Sparse Data</th>
<th>Robust Data</th>
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<td><strong>Pros</strong></td>
<td><strong>Cons</strong></td>
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</table>
| - Smaller data sets are easier to deal with | - Missing valuable data
| - No problem’s recording all data | - Difficult to develop meaningful analysis results
| - Generally less confusion about data definitions | - Massive amounts of data

- What should you keep?
- Difficulties transferring data

- Increased temporal resolution opens the door to new analysis methodologies

### Spatial Resolution

- Cell
- Module
- Rack
- Sub-System
- System

### Temporal Resolution

- Hours
- Minutes
- Seconds
Diverse Data within the P&R Initiative

The initiative currently has 6 systems enrolled.
Data reporting capabilities vary widely.

Analysis algorithms developed for high resolution, robust data-sets do not translate to sparse sets.

- Second resolution
- Separate auxiliary load meter
- Minute resolution data at system level
- Minute resolution data for all 38 strings in 6 ESS containers
- Historical data from late 2016
- Second resolution data from system to cell

- Only 3 measurements currently available
- >30,000 points available
- >1,000 data points recorded
- Data comes from SCADA leading to odd raw data characteristics
- Difficulties transferring data
- 1 year of data ~250GB uncompressed CSV
- No DC-level data
- No reported SOC
- Only 3 measurements currently available
- Difficulties transferring data
The Path Forward with Operational Data

Sparse Data
- Work with operators to fill gaps in operational knowledge
  - e.g. system with no SOC reporting
- Retrofit hardware to supplement reporting capabilities
  - Modems, packet sniffers, etc.
- Develop sparse-data analysis algorithms
  - Communicate any caveats for results

Robust Data
- Trim down data points without leaving valuable data on the table
- Store large data sets in an efficient, query-able database
  - EPRI’s DIAMOND Database
- Develop generalizable and automatable robust-data analysis algorithms

Regardless of robustness, we must extract maximum value from all data sets
Capturing Non-Performance Data
Non-Performance Data

Binary alarms reported by the ESS
✓ Alarms provide a general sense of what’s wrong
✗ Do not tell the full story

These tend to be the first measurements cut from large data sets…

System Operator Reporting
✓ Avenue to collect detailed information on system non-performance
✗ Inherently messy, difficult to collect and analyze

Need a way to effectively collect, consolidate, and analyze this data?
The Path Forward with Non-Performance Data

Binary Alarms
- Ensure we do not inadvertently cut these points when storing data
- May only report when something is wrong
  - Saves on storage cost

System Operator Data
- Create a portal where operators can easily input detailed information
- Create a way to classify non-performance events

Non-Performance Event Classification
- Scheduled Outage
- Unscheduled Outage
- External Cause
  - Grid Issue
  - Auxiliary Related
  - Control Power
- Communication Error
- Disruptive Event
- Operator Error
- Internal Cause
  - Power Conditioning System (PCS)
  - Battery Related
  - Battery Management System
  - Communication Error

For best results, connect the dots between the these data
Conclusion

▪ Fielded ESSs do not report out useful data by default
  – Acquiring system visibility is an arduous, but necessary part of the ESS design process
▪ Gaining access to system data is only part of the puzzle
  – Efficient and thoughtful data collection, storage, and analysis techniques are the keys to maximizing performance and reliability insights

More information, collaboration opportunities, or to contribute:

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