Combined Lost Energy and Fault Analysis for DC-Coupled PV+BESS

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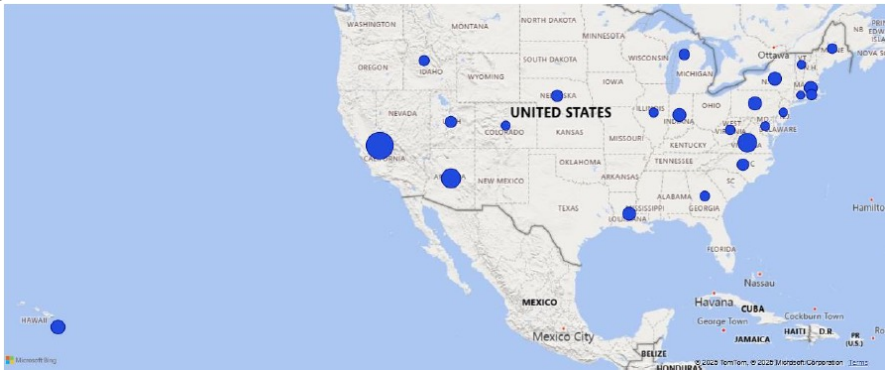
About AES

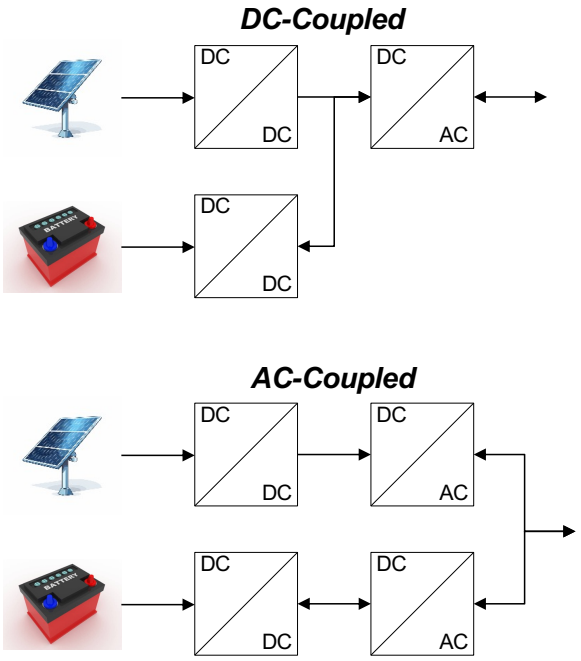
- Owner/operator of more than 600 solar, wind and BESS sites across 29 states
- Current: 39 Plants across 6 states
- Total Operating Capacity: 429 MWAC/609 MWDC
- Total Storage Capacity: 1,572 MWh
- Additional 11 AC-Coupled PV+BESS Plants across 2 additional states (2,140 MWAC/2,756 MWDC/9,122 MWh)



*Weighted by operating capacity

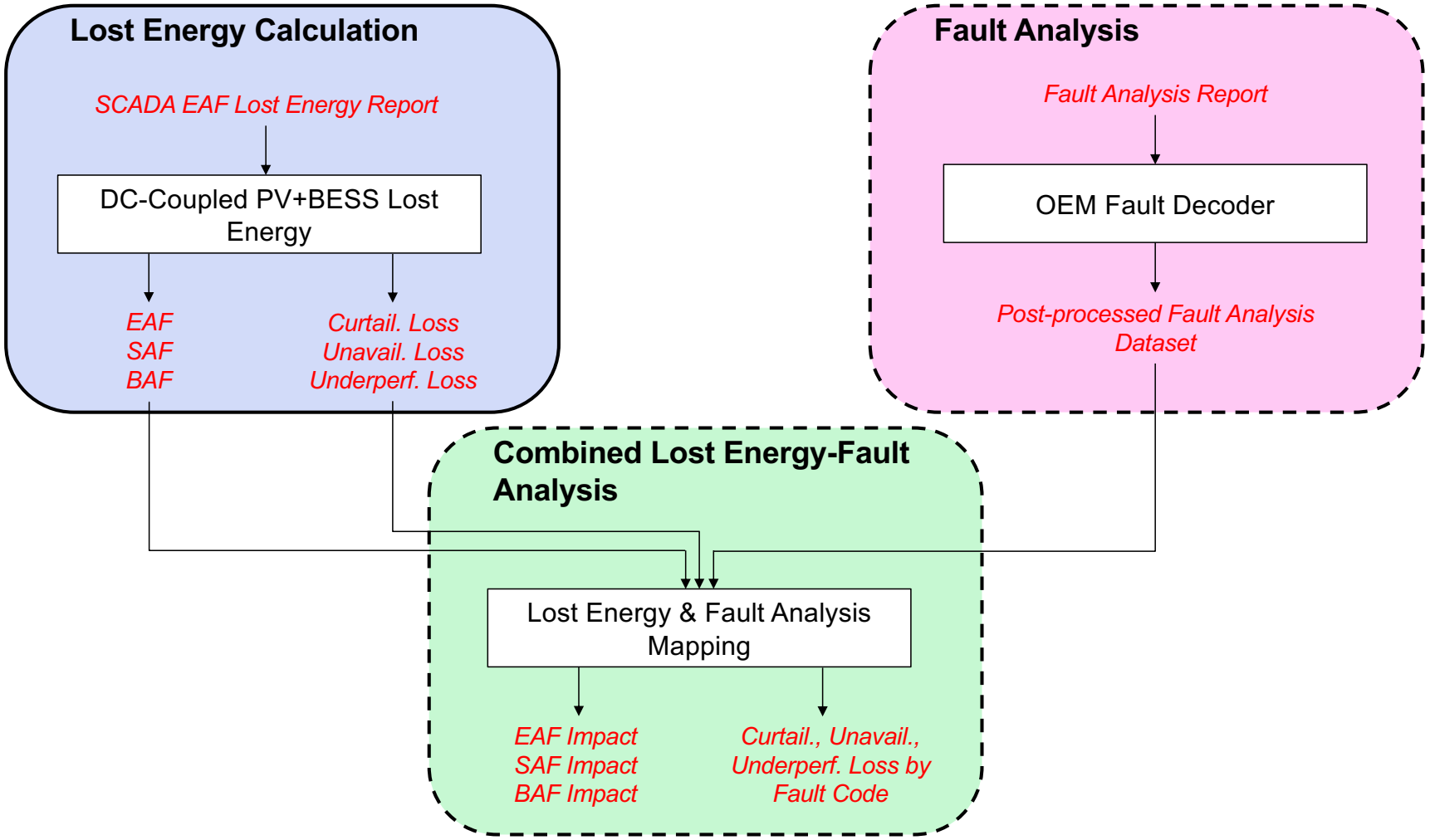
Background

- Monthly lost energy analysis accomplished
  - Energy-based → DG
  - Time-based → Utility, DC-Coupled PV+BESS
- Fault codes provided causes for site underperformance
  - Vary by provider/manufacturer
  - Vary by lost energy category (e.g.: DC underperformance)
- Opportunity to link lost energy to fault codes

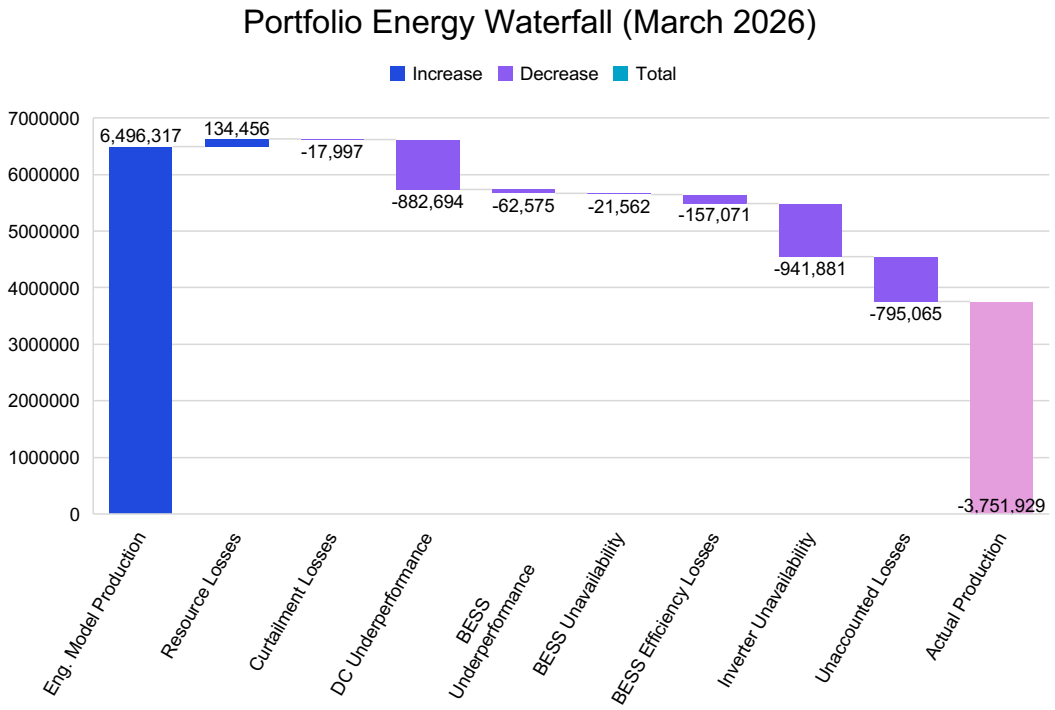


Tool Development, Goal & Objectives

- *Goal*: Develop tools to help improve KPIs across each site/portfolio
- *Question*: Can KPIs of DC-coupled PV+BESS sites be improved by linking lost energy with fault analyses?
- *Specific Objectives*:
  - Verify the monthly lost energy/availability
  - Classify the lost energy/availability by site
  - Classify the lost energy/availability by fault code


Lost Energy Calculation
SCADA EAF Lost Energy Report
DC-Coupled PV+BESS Lost Energy
EAF
SAF
BAF
Curtail. Loss
Unavail. Loss
Underperf. Loss
Fault Analysis
Fault Analysis Report
OEM Fault Decoder
Post-processed Fault Analysis Dataset
Combined Lost Energy-Fault Analysis
Lost Energy & Fault Analysis Mapping
EAF Impact
SAF Impact
BAF Impact
Curtail., Unavail., Underperf. Loss by Fault Code

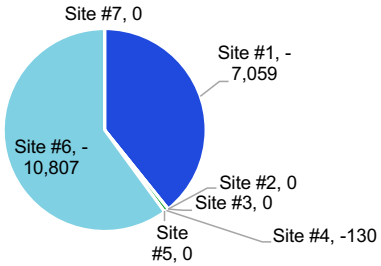
Results & Discussion – Energy Waterfall



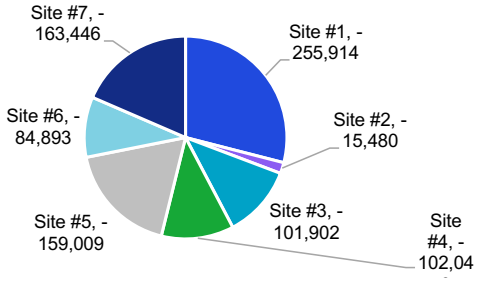
Category	Description
Resource Losses	Lost/gained energy from bad/good overall monthly irradiance
Curtailment Losses	Lost energy intentionally reduced/not used due to grid limitations or system constraints
DC Underperformance	Lost energy that is expected at the inverter, but does not make it from the array/BESS
BESS Underperformance	Lost energy when the BESS is available but does not use all available excess energy above the inverter clip
BESS Unavailability	Lost energy when the BESS system is unavailable to capture the energy
BESS Efficiency Losses	Lost energy when round-trip efficiency is lower than expected
Inverter Unavailability	Lost energy due to the inverters being offline
Unaccounted Losses	Lost energy due to other reasons (e.g., AC losses)

Results & Discussion – Site Breakdown

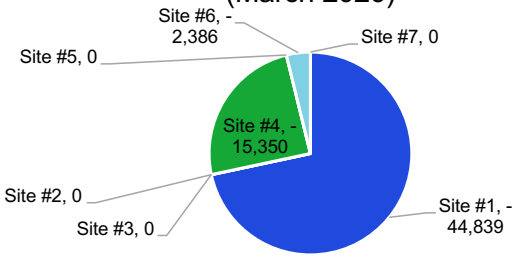
Portfolio Curtailment Loss (March 2026)



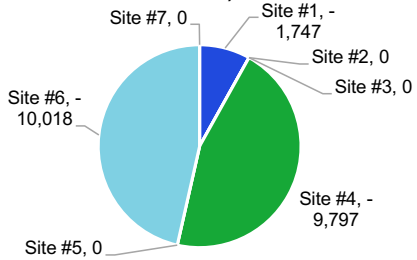
Portfolio DC Underperf. Loss (March 2026)



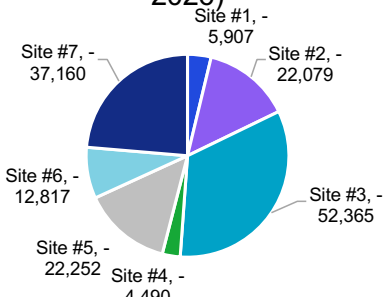
Portfolio BESS Underperf. Loss (March 2026)



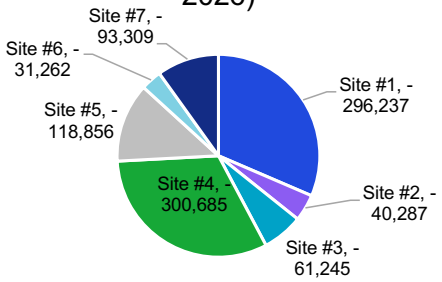
Portfolio BESS Unavail. Loss (March 2026)



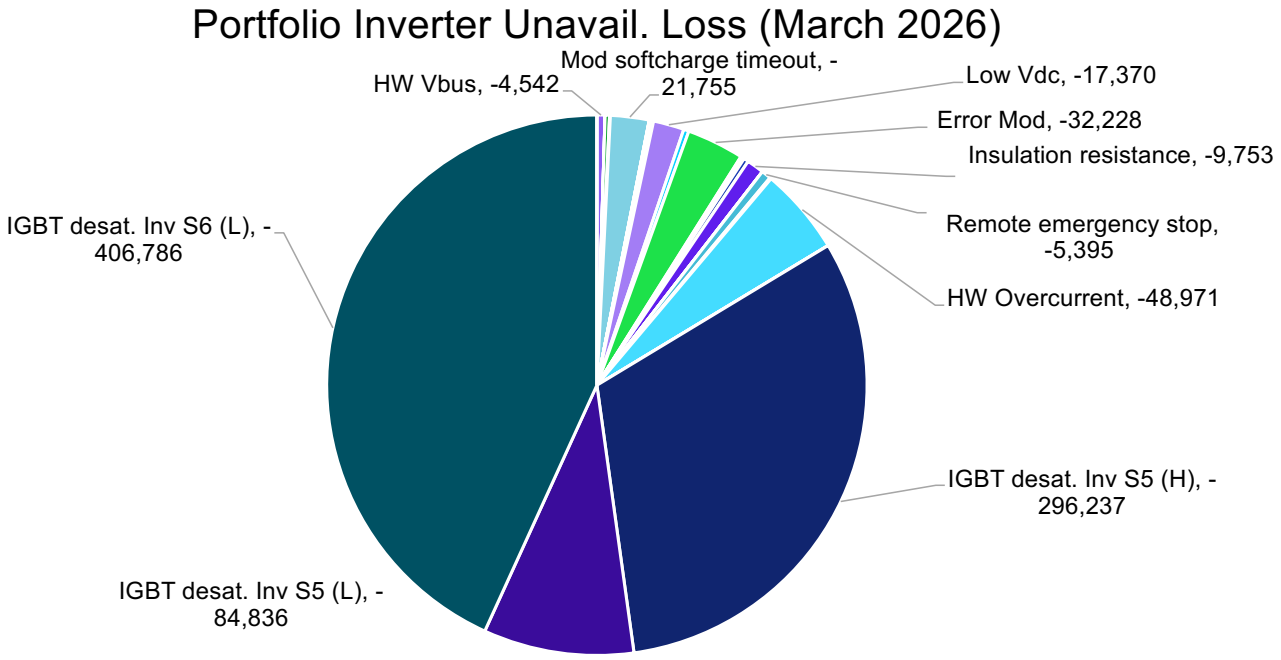
Portfolio BESS Efficiency Loss (March 2026)



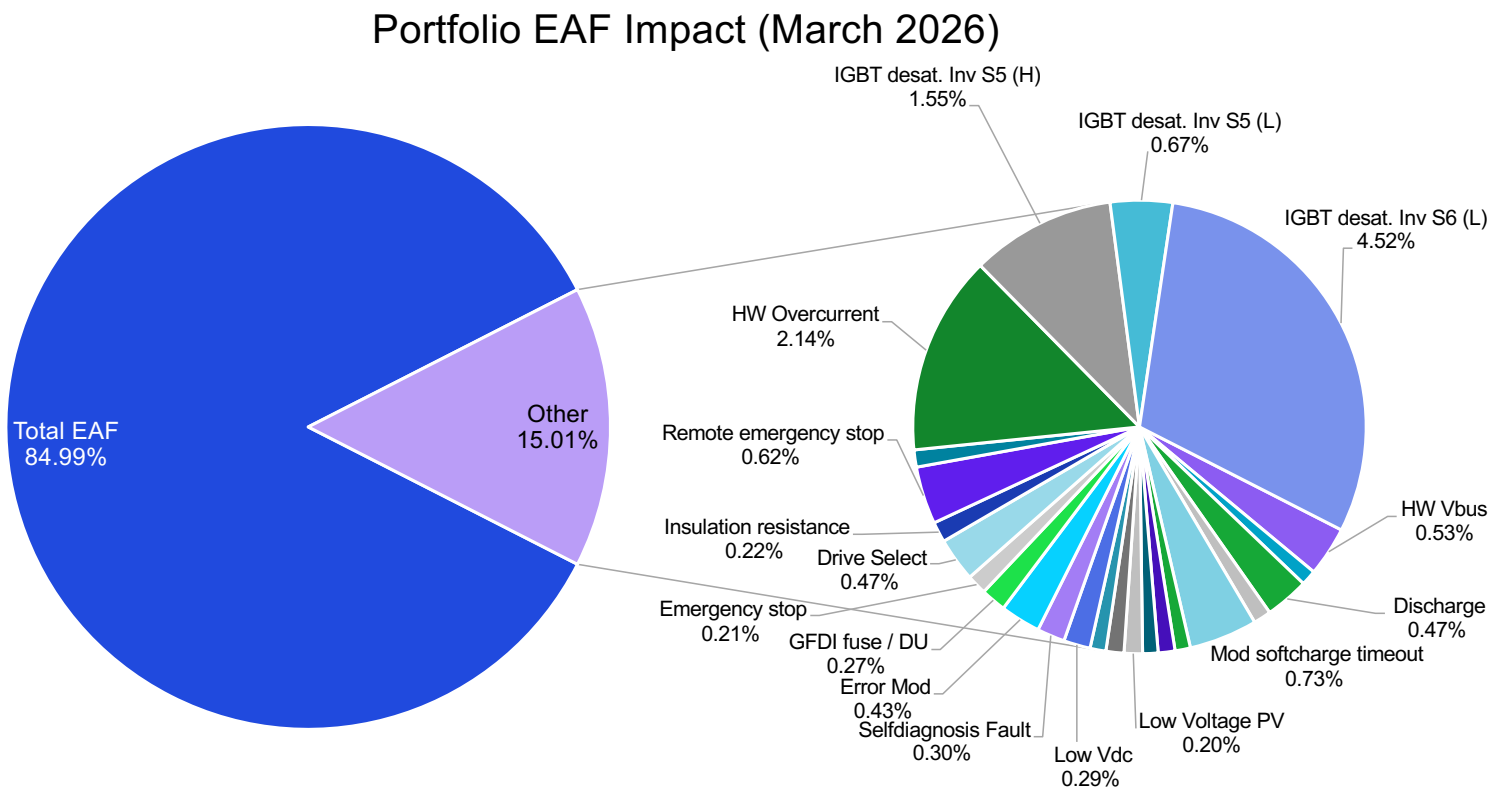
Portfolio Inverter Unavail. Loss (March 2026)



Results & Discussion – Fault Breakdown



Results & Discussion – Availability



Summary & Next Steps

- Monthly lost energy/availability consistent with previous work
- DC underperformance, inverter unavailability are highest impact
- IGBT, overvoltage/overcurrent faults have highest energy impact
- Next steps
  - Incorporate this analysis for all OEMs [*completed*]
  - Generate lost energy by fault for entire portfolio [*completed*]
  - Integrate/scale-up tool into dashboard [*in progress*]

Thank you!

Questions?

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