Operations and Maintenance Considerations for PV+Storage

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Motivation

- Photovoltaic (PV) technology is a rapidly developing technology in response to supply-demand balancing needs.
- Although there is some understanding of costs associated with PV O&M, costs associated with emerging technologies such as PV plus storage lack details about the specific systems and/or activities that contribute to the cost values.

Study Objectives

Study Focus:
Establish a baseline understanding of utility-scale photovoltaic (UPVS) operations and maintenance (O&M) cost drivers

- This study aims to:
  - Identify specific factors and drivers contributing to utility-scale PV plus storage (UPVS) systems O&M costs,
  - Understand how particular storage technologies were selected
  - Learn how O&M data is being collected and used by owners and operations
  - Catalog ongoing challenges and needs in this space from field.

Methods

- Obtain insights from industry experts
  - Online questionnaire
  - Semi-structured interviews
  - Snowball sampling
    - Word of mouth
    - Advertising in industry publications

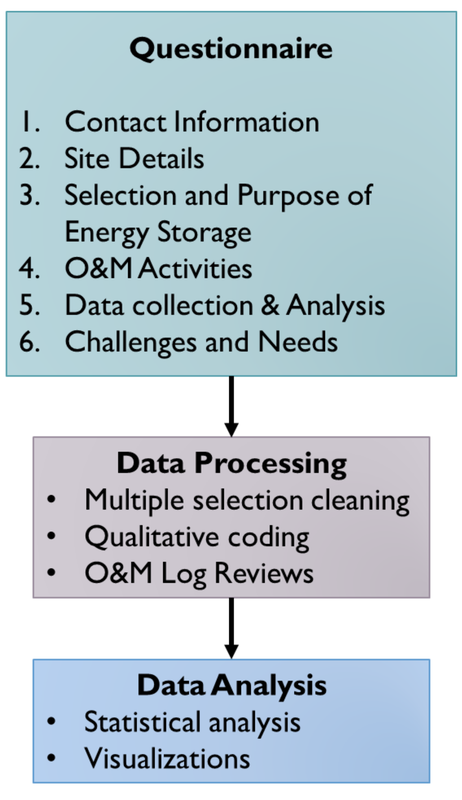

Figure 1. Overview of questionnaire, data processing, and data analysis used in this study.

Questionnaire Demographics and Site Details

- Insights from 81 sites (14 partners) with co-located PV+Storage captured Geographic distribution spans 13 states
- Total PV system size: 51.1 MW
- Total Battery Storage size: 64.1 MWh
- Site age: Mean = 5.2 years, Range = 0-11 years
- Storage technologies: Li-ion (77%), Lead Acid (23%)
- Metering location: Back (69%), Front (19%)
- Percentage of storage technology's energy source coming from PV at the site: Mean = 51.6%

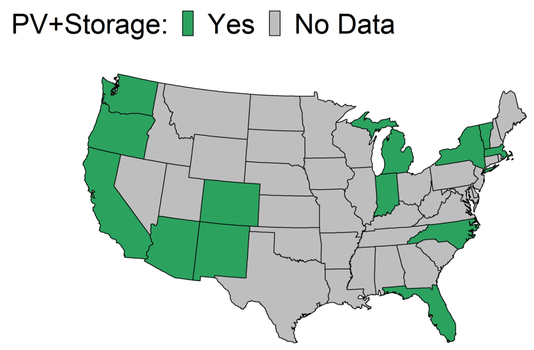

Figure 2. Geographic distribution of states with PV+Storage sites in this study.

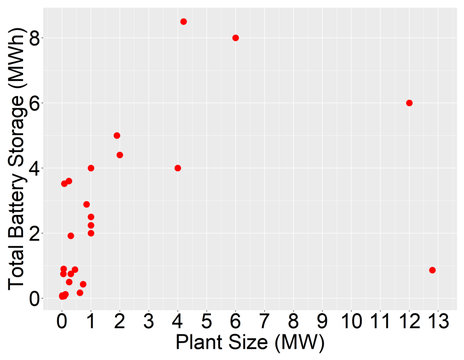

Figure 3. Nameplate PV plant size versus total battery storage.

Study Findings

Selection and Purpose of Energy Storage

- Storage is most often cycled daily

Table 1. Mean reported values for storage system parameters by storage technology

Parameter	Storage Technology	
	Li-ion	Lead Acid
Capital cost ($ per kWh)	487-594	500-667
Expected Lifetime (years)	13.6±1.3	15.4±3.6
Degradation rate (%/year)	1.4±0.2	1.57±0.4

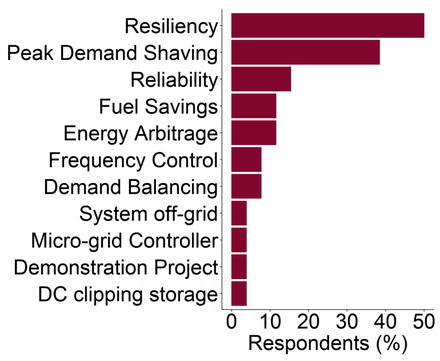

Figure 4. Primary storage system functions.

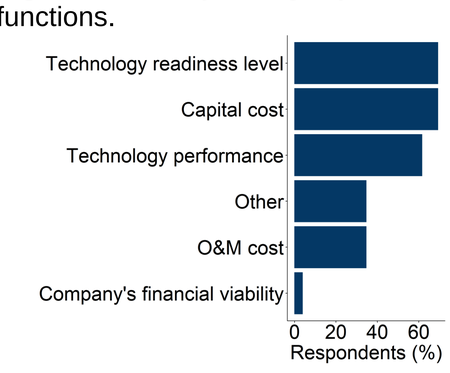

Figure 5. Technology selection factors.

O&M Activities

- Storage system's maintenance is primarily performed by system vendor or in-house
- 61% respondents have observed no change in O&M costs over time
- 50% respondents have a warranty period of at least 5 years
- 35.8% of sites have already filed a warranty

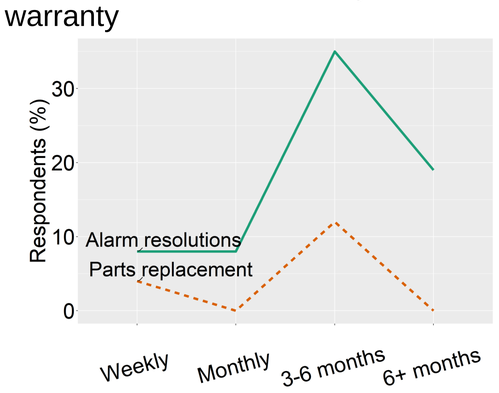

Figure 6. Frequency of corrective O&M. Alarm resolutions and parts replacement most often occur ~3-6 months.

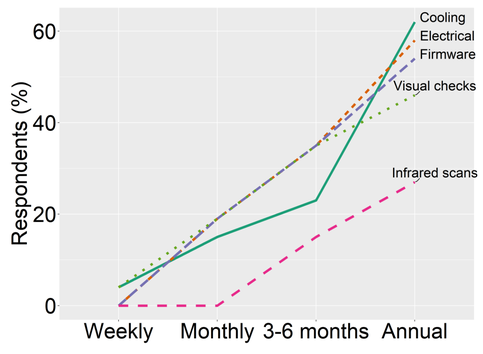

Figure 7. Frequency of preventative O&M. All activities most often occur annually.

- Summary of Storage-Related Entries in PVROM
  - 14 sites (out of ~800) contain storage-related O&M tickets
  - Typical storage capacity: < 1 MW_{DC}
  - 152 tickets were labeled under "Energy Storage/Battery" or "Battery (Solar + storage facilities)"
- Common PVROM O&M ticket themes
  - Underperformance (64%)
  - Production outages (19%)
  - Communications-related outages (16%)

Table 2. Median operations and maintenance ticket duration by completion activity from PVROM.

Completion Activity	Ticket Duration (minutes)
Refit (Reset)	114,240
Remote Troubleshooting	567
Replace/Repair	3,487
Self-Resolved	1,200

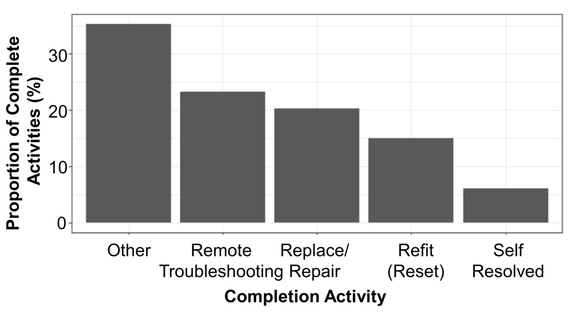

Figure 8. Distribution of completion activities by type based on PVROM O&M tickets.

Challenges and Needs

- New processes needed to set up PV+storage contracts
- Missing PV+storage performance metrics
- Prior experience of individual technologies but no experience combining technologies
- Long-term vendor availability and reliability
- Data management and handling
- Expected versus actual storage lifetimes, field performance
- Storage technology obsolesce
- Locally available technicians and parts for servicing O&M needs
- Changing standards and codes affect equipment availability

Ongoing and Future Work

- Collect more data to update the database
  - Participating site performance data
  - Operations and maintenance logs
- Expand PV cost model to include battery storage and more public information
- Industry suggested opportunities
  - Validation of name plate battery life
  - Predictive maintenance and alarm tools
  - Refinement of analysis tools and metrics

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