Using Amperage Data To Detect Hardware Faults at Solar Plants

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Introduction

- Hardware fault detection at PV plants is commonly performed by use of aerial imaging but is typically performed on an annual or bi- annual basis[1].
- Infrequent fault scanning results in significant performance gaps at PV plants, where production lags an estimated 5-13% from original projections, even after accounting for weather[2].
- PV plants have instrumentation throughout the DC collector field available for detection of subtle underperformance in PV hardware.

Objectives

- Create generic fault detection method capable of working with differing PV plant hardware and architecture
- Accurately detect hardware faults using commonly collected metrics such as amperage, irradiance, and time
- Develop method such that monitoring is available on a shorter time frame than aerial imaging, preferably on a week-to-week basis
- Validate model against aerial IR and RGB scans

Method

Pre-Processing

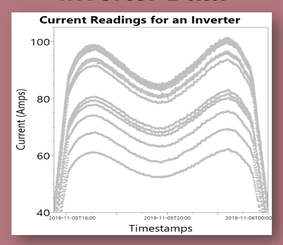
- Collect current data detailing an amperage reading for each combiner box
- Identify modular subarrays repeated across plant
- Subarrays match granularity of data available
- Use real weather data to identify sunny, clear sky days

Filter Data

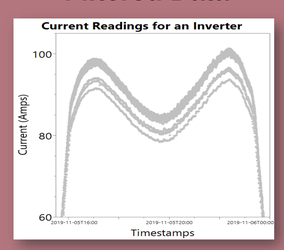
- Filter data to a single day with sunny, clear skies
- Filter data to modular groups of combiner boxes (usually grouped by an inverter)
- Filter data to compare only combiner boxes of the same string counts

Detecting Hardware Faults

Inverter Data

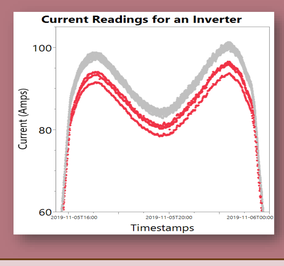


Filtered Data



- Hardware faults such as string outages and tracker issues are visible in current data
- Significant drops in current data relative to similar combiner boxes indicate faults
- Capture combiner boxes below peak currents and label as faulted

Fault Prediction



Post-Processing

- Detect faults at combiner box level
- Run studies for multiple days of appropriate weather
- Collect list of faulted combiner boxes in need of repair

Validate Results

	Amperage Method Detected Issue	Amperage Method DID NOT Detect Issue
IR/RGB Detected Issue	True Positive Rate 46%	False Negative Rate 54%
IR/RGB DID NOT Detect Issue	False Positive Rate 8%	True Negative Rate 92%

- Model detects presence of faults on a day-to-day basis
- Aerial scans are treated as “ground truth”
- Validated at combiner box-level

Results

Site	True and False Positive Rate Summary	
	TPR	FPR
1	35%	10%
2a	48%	3%
2b	42%	2%
3	36%	30%
4	19%	11%
5a	50%	5%
5b	44%	12%
Overall	46%	8%

Results were grouped by site to show relative performance. Some sites showed much better results than others. This discrepancy could be due to mis-labelling of historian data tags.

Conclusions

- Monitoring amperage data is an effective means of detecting faults in PV plant data
- Utilizing amperage data collected at the combiner box gives plant operators an up-to-date list of faulted equipment, allowing them to coordinate maintenance needs at much shorter intervals than previously
- Shorter maintenance intervals will increase PV plant production levels, narrowing the gap between expected and actual PV plant performance
- The amperage monitoring method performs at a high level, with a string-outage related fault detection True Positive Rate of 46% and False Positive Rate of 8%

References

- [1] R. R. Hill, G. T. Klise. And J. R. Balfour, “Precursor report of data needs and recommended practices for PV plant availability, operations, and maintenance reporting”. https://osti.gov/search/identifier:1169447.
- [2] Dobos, Aron, “Closing the Reality Gap: Optimizing Solar Plant Performance with Shade Loss Mitigation”. https://www.nextracker.com/blog/energy-insights/closing-the-reality-gap-optimizing-solar-plants-performance-with-shade-loss-mitigation/..
- [3] M. Kontges, et al. “Performance and reliability of photovoltaic systems, subtask 3.2: Review on failures of photovoltaic modules,” IEA Photovoltaic Power Systems Programme, Task 13, 2013, ISBN 978-3-906042-16-9.

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