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Panel Session II. Connector Failures Field and Lab Findings: Macro-level Forensics

Steven DiGregorio

Postdoctoral Appointee
Photovoltaics & Materials Tech
Sandia National Laboratories

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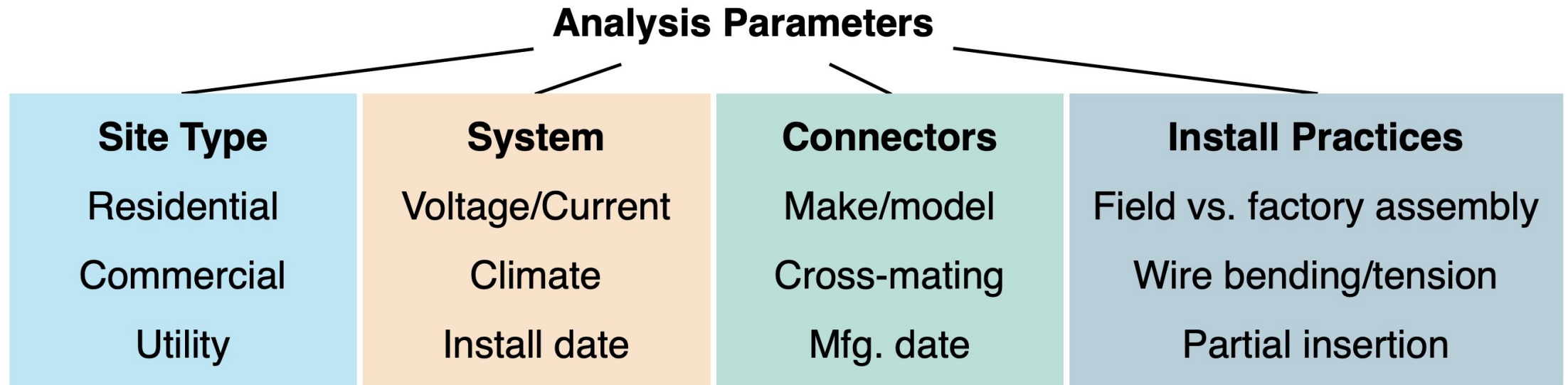


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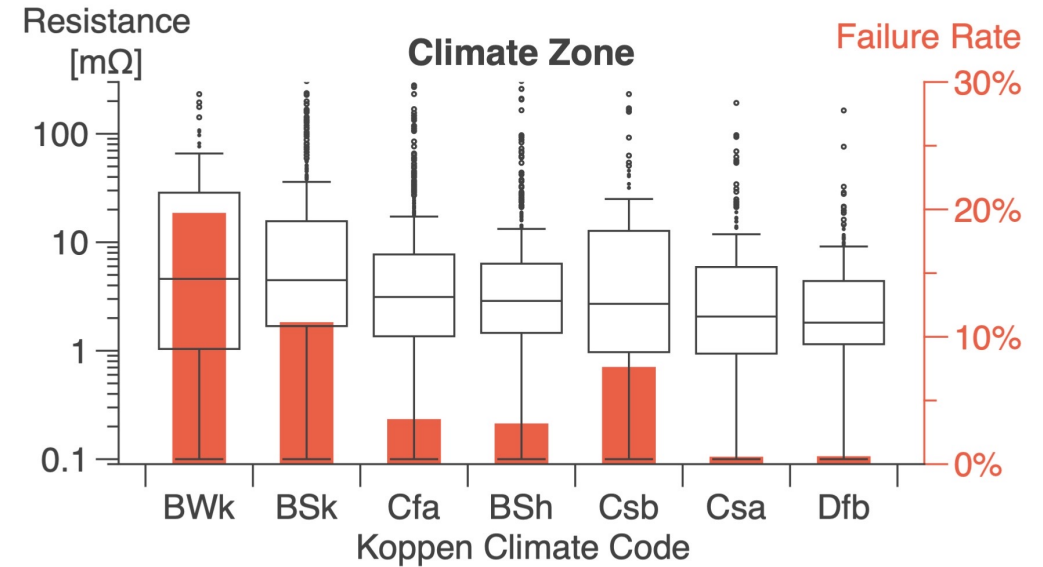
- First ever attempt to aggregate population-level connector data
- Data-driven quantification of prevalence and severity of connector issues



Why this matters:

- Next-level understanding
- Data > opinions
- Predict lifetimes
- Inform best practices
- More accurate TEA models

Main Objectives



- Develop Methodologies
 - Plant-level data collection
 - Measure connector performance (resistance or temp.)
 - Document installation details & metadata

- Data Analysis
 - Test connector failure anecdotes
 - Leading factors for failure
 - Average lifetimes & replacement rates
 - Establish anonymized public database

- Massive data collection undertaking
- Representative sampling of climates, system parameters, manufacturers, etc.
- Partner with asset owners, EPCs, and O&Ms

Harvested Connectors



- Direct resistance measurement
- Rarely complete set
- Destructive

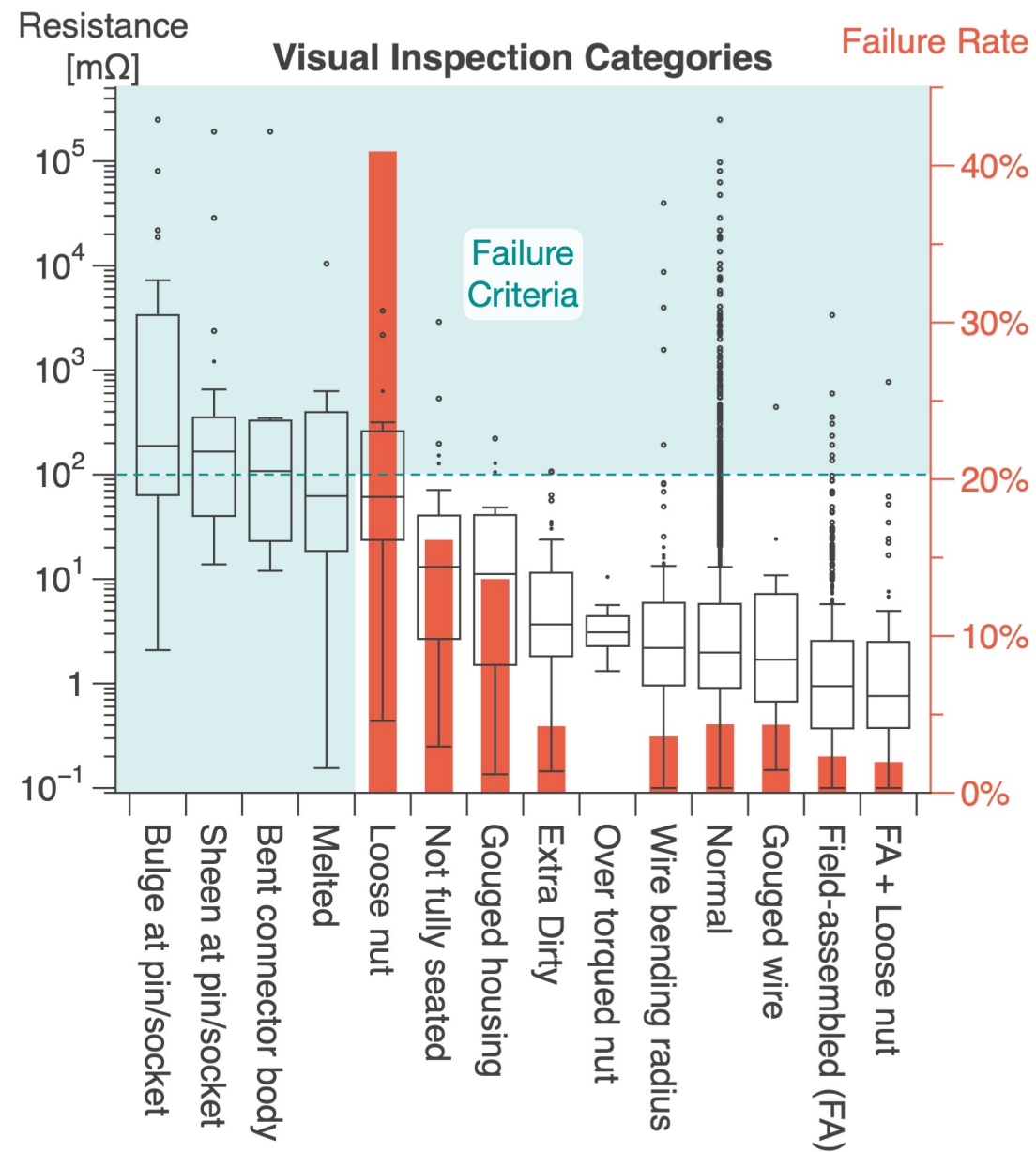
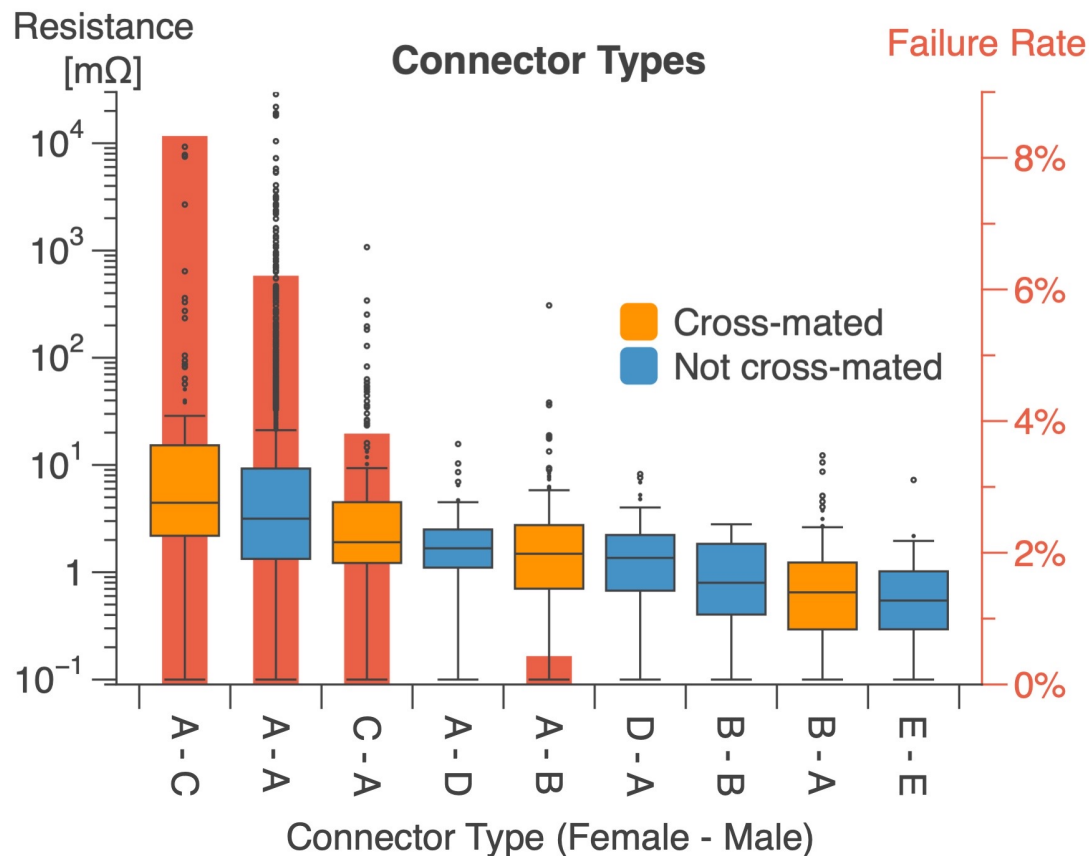
- Fast (robotic inspection)
- Installation practices evident
- Non-destructive
- Track individual connectors
- Infer resistance from temp.

Site Inspection (thermal images)



Preliminary Data: 4500 Rooftop Connectors

- Donated by residential solar installer
- 4-step rapid characterization
 - Strip wires, barcode, inspect, 4-wire resistance



- **Industry-Wide Challenge:** Addressing connector issues requires a collaborative approach
- **Pioneering Effort:** This is the first large-scale statistical connector analysis of its kind
- **Trusted Partner:** Sandia is independent with a proven track record of data confidentiality
- **Call to Action:** Your collaboration and data are essential to our success!
- Please contact:
 - Laurie Burnham: lburnha@sandia.gov
 - Bruce King: bhking@sandia.gov
 - Steven DiGregorio: sdigre@sandia.gov

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PSEL Team



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Wayne Li

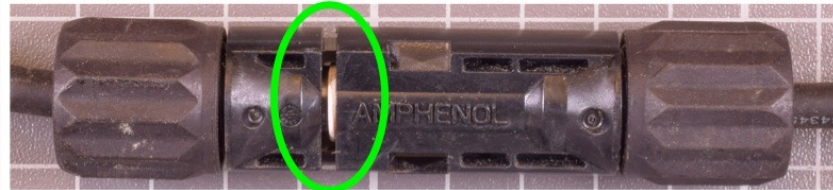
Tap Lolla

Inspection Categories

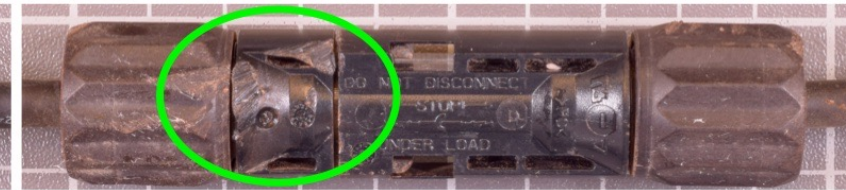
Melted Thermal events



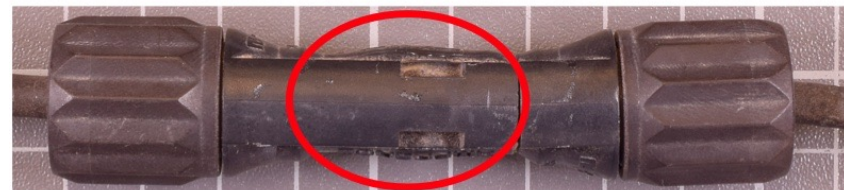
Not fully seated



Gouged housing



Bulge at pin/sleeve



Loose nut



Gouged wire



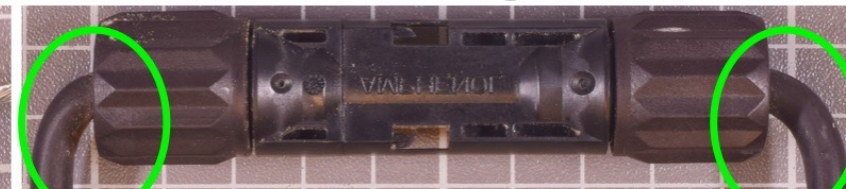
Sheen at pin/sleeve



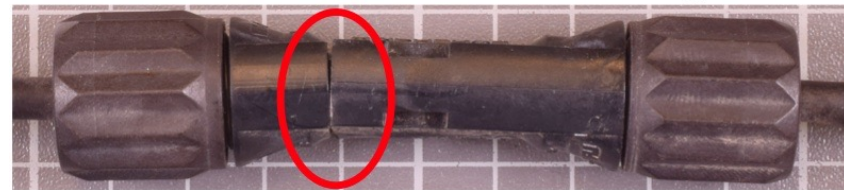
Over-torqued nut



Wire bending radius



Bent connector body



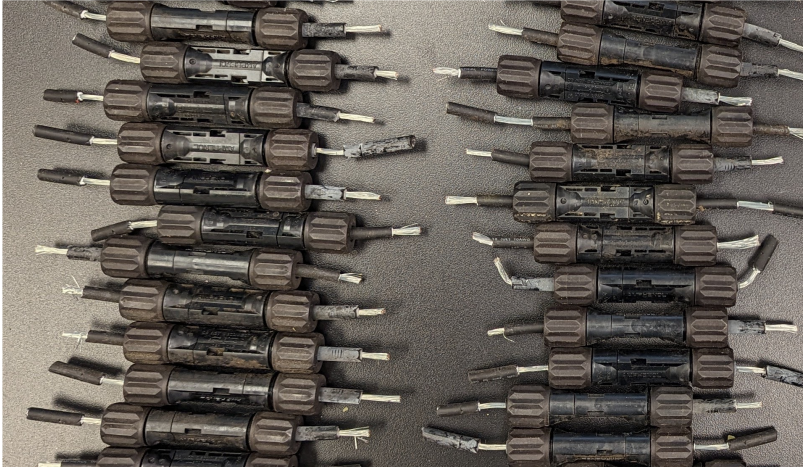
Extra dirty



Field-assembled



Harvested Connector Characterization



1. Strip wires
 2. Apply unique barcode to each connector
 3. Visual inspection (melting, types, etc.)
 4. 4-wire resistance measurement
- Approach designed for fast screening (not high accuracy)

Custom Control App

Connector Screening App

ID Input Method: Scanner

Female End: H4

Male End: MC4

Swap Ends

Total Length [cm]: 10

Retain Values?

Visual Indicator 1: Melted

Visual Indicator 2: Not fully seated

Bare Copper Wire?

Other Notes:

Clear Values

Connector ID:

Keithley Multimeter

Connector w/ Barcode

Kelvin Clips

Barcode Scanner

