

A photograph showing a vast array of solar panels installed on a hillside or large roof. The panels are blue with white frames and are mounted on a metal frame. The perspective is from a low angle, looking up at the rows of panels.

# Third-party Installation Review, Testing and Commissioning

*Jeff Gilbert*

# What is Commissioning (CX)?



- Verify that the design, construction and operation meets contract requirements
- Note that CX must **first** be defined in the contract
- CX should comply with IEC 62446 International Standard

# Who Should Perform CX

## Typical responsible parties

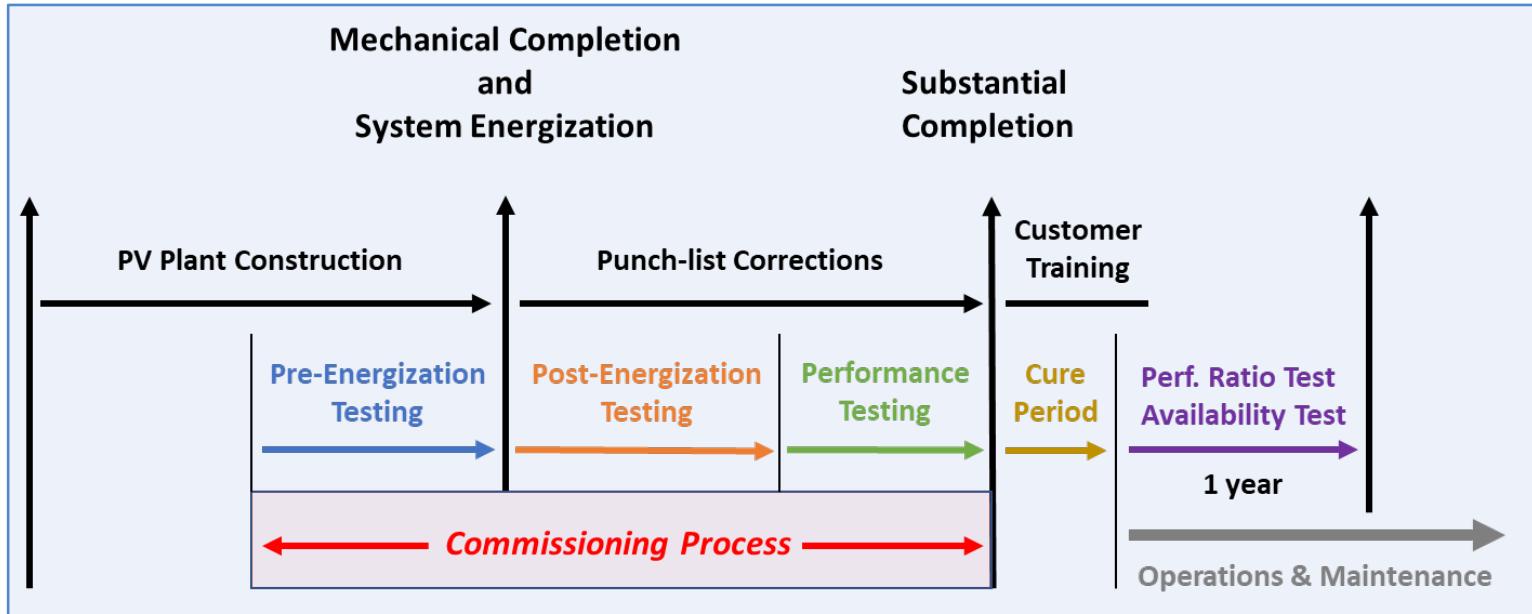
- EPC (*usually oversees CX*)
- Installing contractor (*usually performs tests and reports to EPC*)
- 3<sup>rd</sup> party CX agent (*<20%*)
- Manufacturer's agent (*central inverters*)

## CX Technician Qualifications

- Specific training for CX testing
- Safety training
- NABCEP Certified (*residential and C&I*)
- ANSI and NETA Certification (*utility scale*)
  - grounding
  - insulation resistance testing (IRT)
  - transformer CX
  - large circuit breaker testing



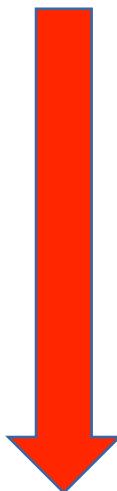
# PV Plant Commissioning Timeline



- CX should be defined in RFP and in contract
- RFP and contract should include
  - standards for adherence
  - specific tests to be performed
  - acceptance criteria
  - defined cure process for failures to perform

# Types of Performance Tests

Construction



End of Service life

- Functional {
  - Is everything installed and in working order?
- Capacity {
  - Short term output test; used for substantial completion
- Performance {
  - Mid-term output test; used to prove out performance of plant
- Availability {
  - Are the inverters running often enough?
- Warranty {
  - Backstop to ensure components are meeting the basic levels of reliability

# Pre-Energization Testing

- Design conformity
- Visual and mechanical inspections
- Electrical and functional testing
  - measure Voc and Isc (or IV curve)
  - ground resistance
  - polarity
  - Insulation Resistance Testing (IRT)
  - ground continuity
  - phase rotation tests
  - trackers (if PV powered)



# Post-Energization Testing

- Operational current (Imp) measurements
- Energized inverter tests
- Switchgear testing
- Thermographic studies
- Monitoring and control system testing
- Trackers (if grid powered)



# Performance Testing

Measured vs. Expected  
(based on site conditions)

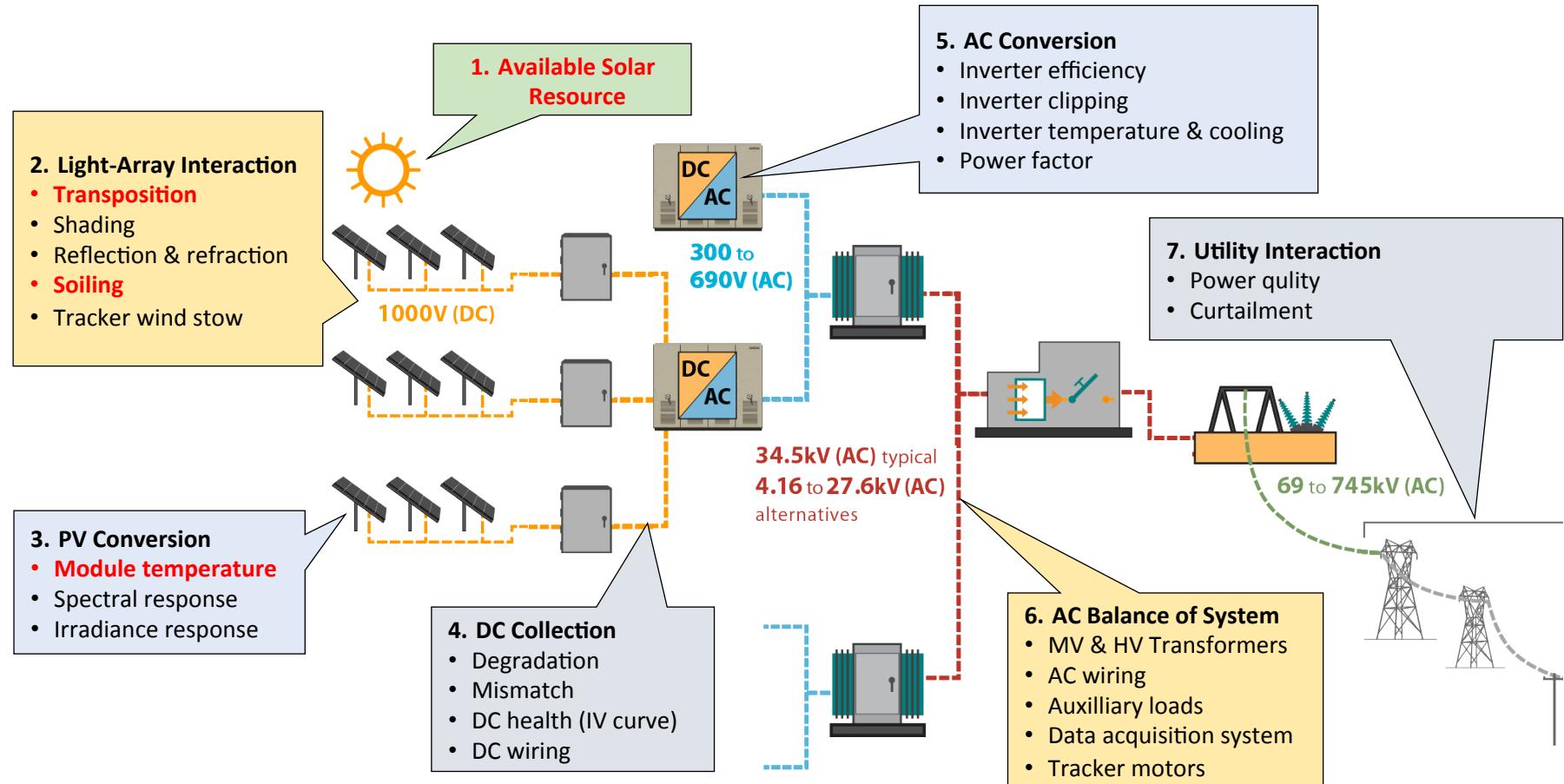
Acceptance values of 95% - 97% of the mutually agreed upon simulation are common

$$\text{Capacity Test} = \frac{\text{Measured power}}{\text{Expected power}}$$

$$\text{Performance Test} = \frac{\text{Measured energy}}{\text{Expected energy}}$$

$$\text{Availability Test} = \frac{\text{Measured operational hours}}{\text{Expected operational hours}}$$

# Site-Specific Considerations



# Commissioning Energy Storage Systems



Verify battery's ability to respond to market signals or its ability to follow a prescribed charge/discharge schedule

**Resource:**

Energy Storage Integration Council (ESIC) Energy Storage Test Manual 2016

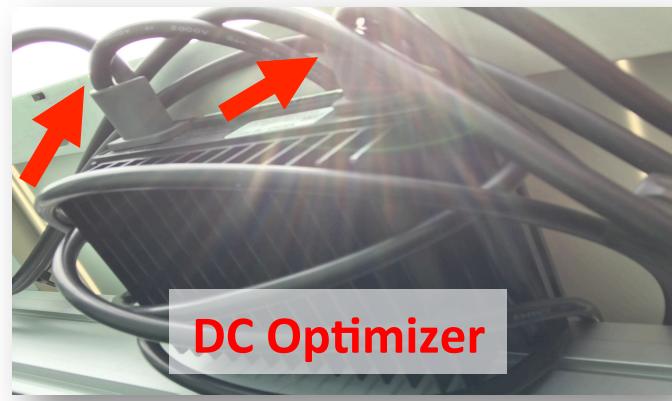


# Most Common CX Failures

# Wire Management Issues



Wire and connectors laying on roof



- Bend Radius too tight
- Sloppy wire management



Wire and connectors laying on roof

# High Resistance at Module Connectors



Causes of failure include

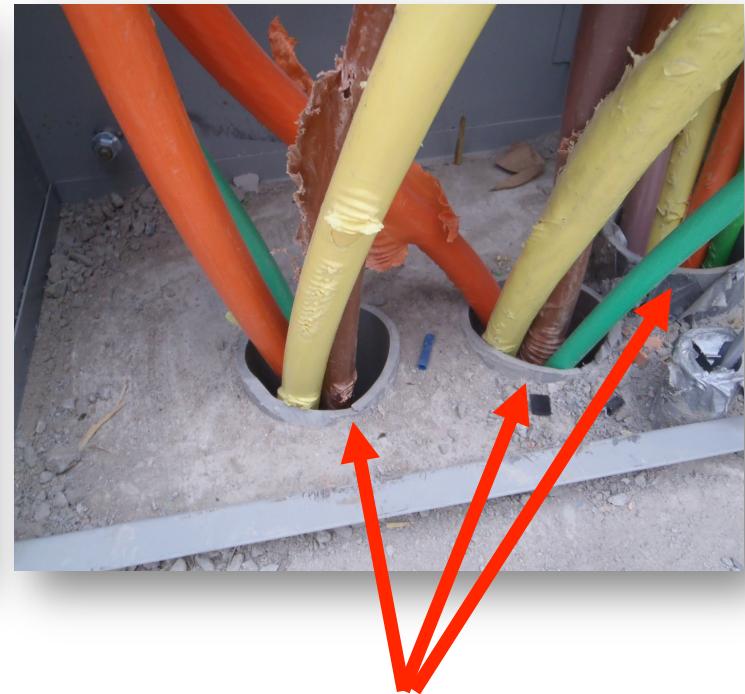
- incompatible manufacturers
- improper crimping
- not fully “clicking”  
connectors

# Careless Wire Pulls



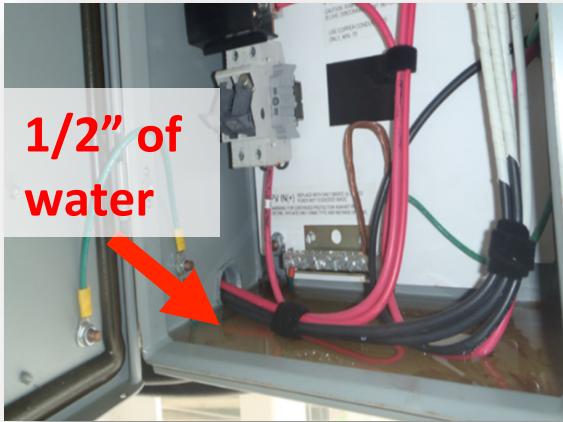
**Damage to wire  
sheathing**

**No service  
loop**

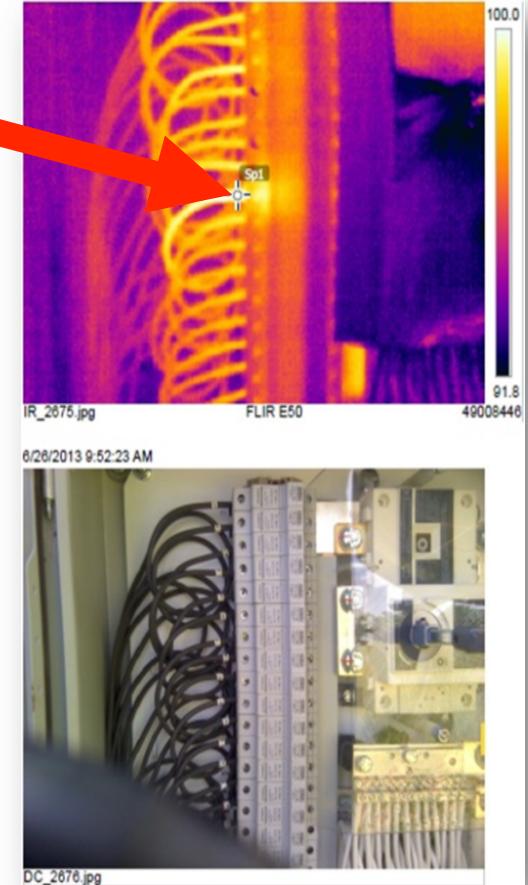


**Bushings not installed**

# Combiner Box Issues



Hot spots  
from loose  
terminal  
connections



- Water in enclosures (common)
- Bad torque values creating hot spots (common)
- Incorrect fuse ratings (type and current rating)
- Fuse holders left open
- Reversed polarity of source circuits
- Bend radius of conductors too tight
- Non code compliant grounding

# Inverter Commissioning Issues



- Firmware not up to date (common)
- Loose wire terminations
- IGBT failures upon startup
- Incorrect ac output settings
- Water ingress from condensation

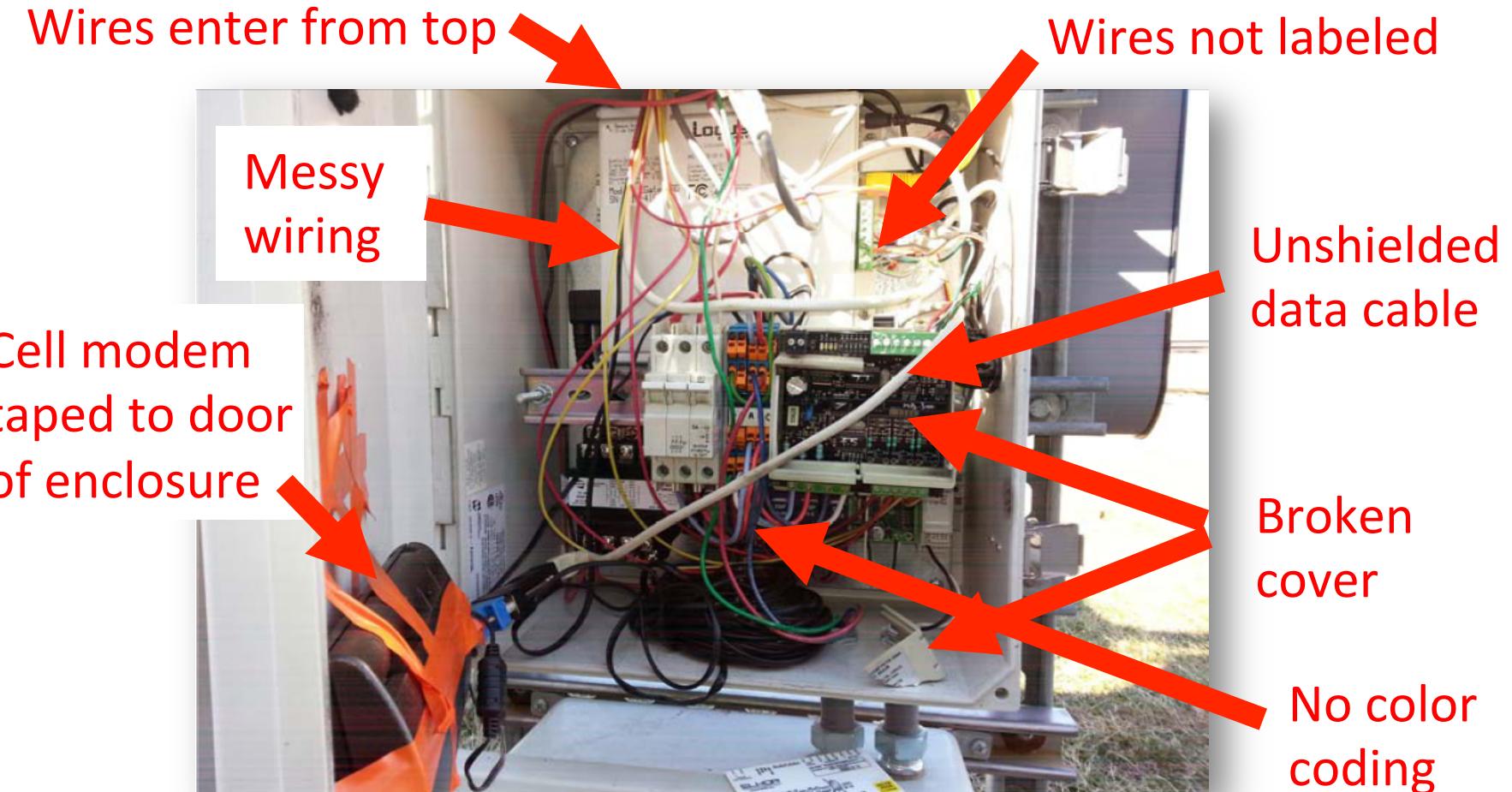
**Fire from reversed polarity wiring**

# Racking and Tracker Issues

1. Inaccurate tracking
2. Tracking dampers
  - a. Wind damage requiring more dampers
  - a. Manufacturer's defects
  - b. Incorrect installation
3. Wire management
4. Ground wires not connected
5. Tracker UPS failure in cold weather
6. Motor control wiring issues
7. Trackers that utilize pulleys and cables require recalibration until "broken in"



# Data Acquisition System (DAS) Issues



# A Useful Resources on PV Commissioning

## 1. Commissioning for PV Performance

Authors: Joseph Cunningham, Paul Hernday, James Mokri

Program Manager: TJ Keating



## 2. IEC 62446 International Standard

Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection. ISBN 2-8318-1037-6



## 3. ASTM E2848-13 Test Method for Reporting PV Performance

## 4. IEC 61724 PV Performance Monitoring

# Thank you

*Jeff Gilbert*

*jeff.gilbert@azimuthsolar.net*

*301-509-7945*



