Introduction to Residential Rooftop PV Field Inspections

Sertaç Akar and Jeff Cook

Online Training

December 8, 2023

Highlights

1. Introduction
2. Field Inspection Overview
3. Preparing for Field Inspection
4. Performing Field Inspection
5. Field Inspection Examples for Different PV Systems
6. Field Inspection Best Practices
7. Key Takeaways

Introduction

What is the National Renewable Energy Laboratory (NREL)?

What are we covering today?

- The focus of this training is on field inspection for residential distributed rooftop photovoltaic (PV) systems.
  - *Processes are required when conducting field inspection of residential rooftop PV systems.*
  - *There are additional inspection requirements for PV systems, including energy storage systems (ESS).*

What is outside the scope of this training?

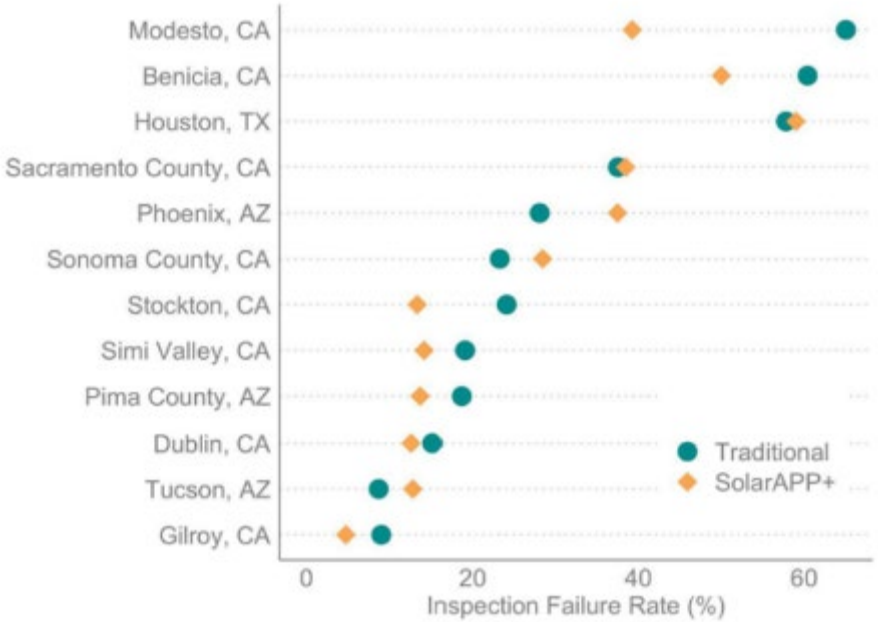
- Multifamily or commercial applications, ground mounted systems, and some energy storage applications.

Field Inspection Overview

Why are inspections necessary for solar?

1. Last line of defense to enforce public health and safety.
    i. Perfect plan does not always equal perfect install.

2. Many projects fail inspection.
    i. NREL data shows that, on average, 24% fail in 12 authorities having jurisdiction (AHJs).
    ii. 58% of the identified failures were related to a work quality issue, meaning that the system was not installed per the code.



Inspection failure rates (%) by AHJ

Cook et al., 2023
https://www.nrel.gov/docs/fy23osti/85827.pdf

How are inspections done today?

1. Scheduling Inspections

i. In-person
ii. Online
iii. Over the phone
iv. Combination

2. Day-of inspection planning

i. Two-hour window
ii. Half-day window
iii. Full-day window
iv. Uncertain window

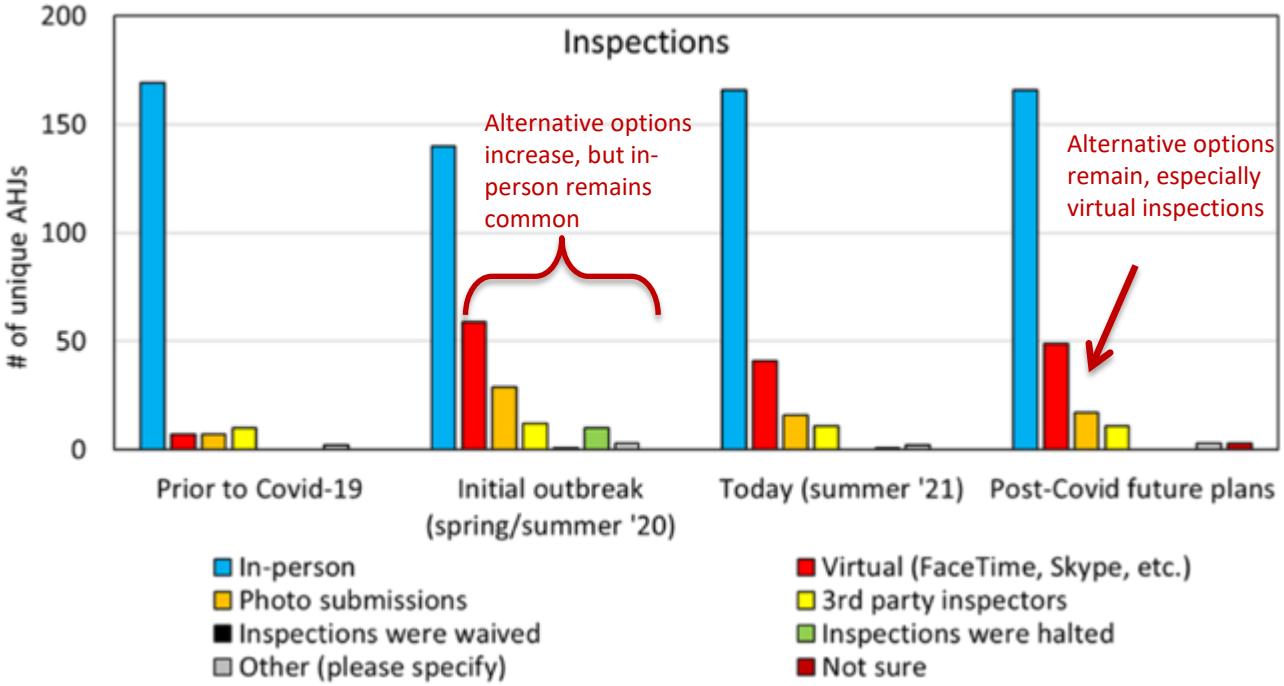
3. Who does the inspection?

i. Solar inspectors
ii. Combination inspector
iii. Inspector assigned to region of community
iv. Some combination

Photo from Cadmus Group

How have inspection processes evolved over time?

- Impact of COVID-19 on residential rooftop PV inspection processes



Cruce et al., 2022
https://www.nrel.gov/docs/fy22osti/83529.pdf

Preparing for Field Inspection

Who and what is needed to carry out an inspection?

1. Who is needed to carry out an inspection varies by AHJ.

2. What is needed to perform an inspection also varies by AHJ.
   i. Plans might include a single (or three) line diagram(s), site layout, spec sheets, installation manuals, load/structural/electrical calculations, and/or photos.

3. What if my community adopts SolarAPP+ (Platinum Designation)?
   i. Inspection processes are modified.
      a. SolarAPP+ inspection checklist is used in lieu of traditional plans.

SolarAPP+

Roof and PV Array		Pass
The system will be installed on a permitted structure		☐
Racking System Model Number	RL Universal	☐
Racking System Manufacturer	SnapNRack	☐
The module and racking system shall be installed per the racking manufacturer's installation instructions regarding grounding and bonding, fire, and load ratings	Yes	☐
Attachment points of the mounting system are staggered	No	☐
Maximum spacing in inches between adjacent attachment points of the mounting system	72"	☐
Roof penetration sealant method has been installed per the manufacturers instructions.		☐
The distance from the lowest point of the module to the roof surface does not exceed	10 in	☐
The roof structure appears to be structurally sound, without signs of alterations or significant structural deterioration or sagging.		☐
Quantity and spacing of structural attachments match the installation instructions per manufacturer.		☐
Array conductors are secured and supported. Installed so as not to damage the cable, at intervals not exceeding 1.4 m (4.5 ft) and within 300 mm (12 in.) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings.		☐
PV Module model number	JAM60S17-325/MR	☐
PV Module manufacturer	JA Solar	☐
PV Module quantity	26	☐
Module fire rating type	2	☐
MLPE equipment listed as PVRSS or PVRSE installed on each module.	Yes	☐
All rooftop conduits are mounted at least 7/8" above the roof surface.		☐
All PV Source Circuit conductors installed without raceway are listed as PV Wire or USE-2.		☐

Performing Field Inspection

Context Setting

- Key challenge: Inspectors have time constraints and must perform many inspections.
- Inspectors must use their discretion in the field and may adjust their processes based on characteristics of their local community and contractor community.

PV array. *Photo from Brooks Engineering*

Common Types of Major Code Violations

- Safety first; ensure that the system is NOT energized.
- Start the inspection at the solar array and follow the electrical path to the grid point.
- Look for the most common and most serious code violations.
- If time is limited, focus on inverter, array, grid connection, and junction boxes.

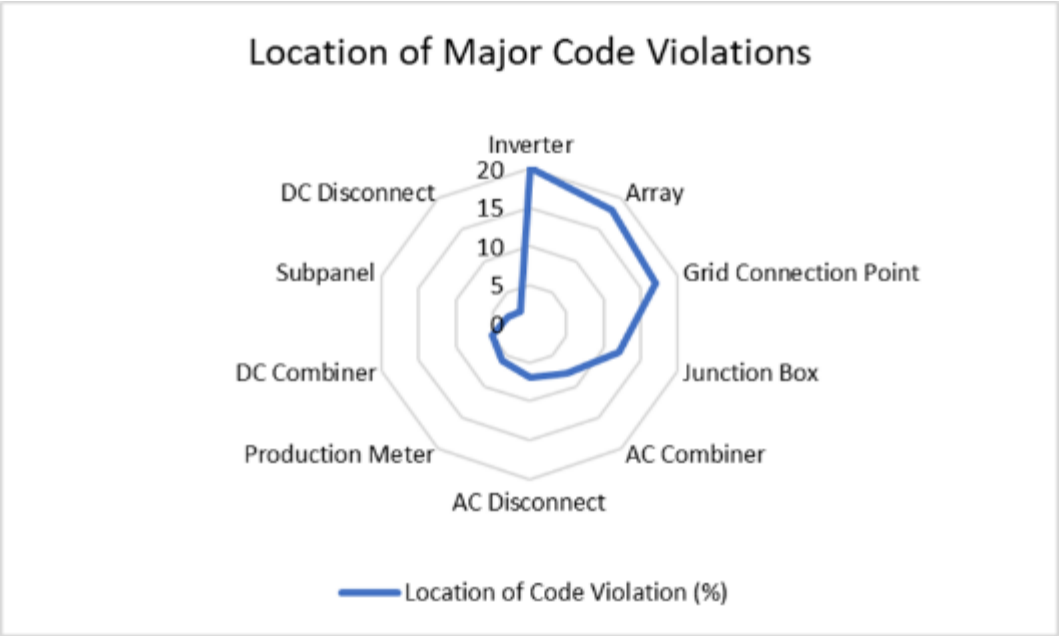


Figure: Cadmus Group

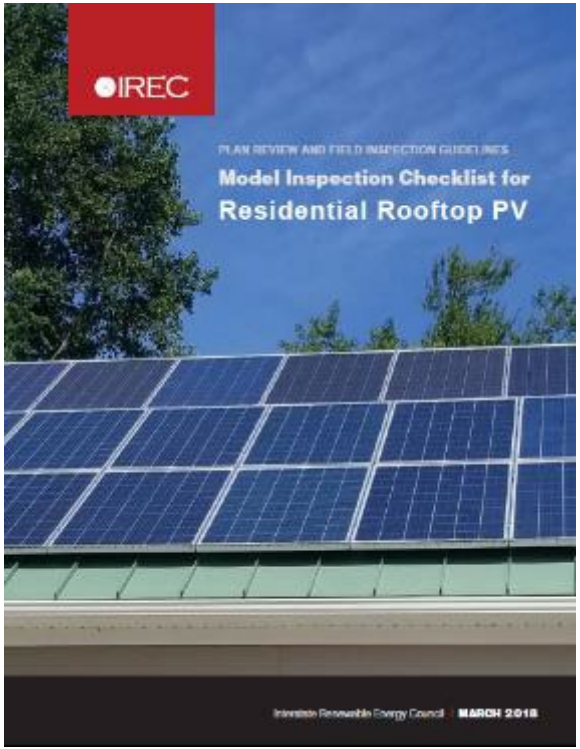
Inspector Guides/Checklists

Many entities have created checklists to inform solar inspections.

- **SOLARAPP+**
  https://solarapp.nrel.gov/docs/approval-document-pv-example.pdf
  https://cleanenergytraining.org/code-official-training#solarapp
- **SolSmart**
  https://www.dvrpc.org/solar/pdf/field_inspection_checklist_for_rooftop_photovoltaic_final_dvrpc.pdf
- **EERE Sustainable Energy Resources for Consumers**
  https://www1.eere.energy.gov/wip//pdfs/solarpv_checklist.pdf
- **Interstate Renewable Energy Council (IREC)**
  https://irecusa.org/blog/local-energy-climate-solutions/new-guide-for-solar-plan-review-and-inspection-checklists/

What are the key elements in these checklists?

1. Wiring Management
   i. Conductors
   ii. Conduit, raceway, cable assembly
   iii. Connectors
2. PV modules
3. Racking
4. Inverter
5. Point of utility interconnection
6. Grounding, overcurrent protection, and disconnects
7. Rapid shutdown
8. Signs and labels



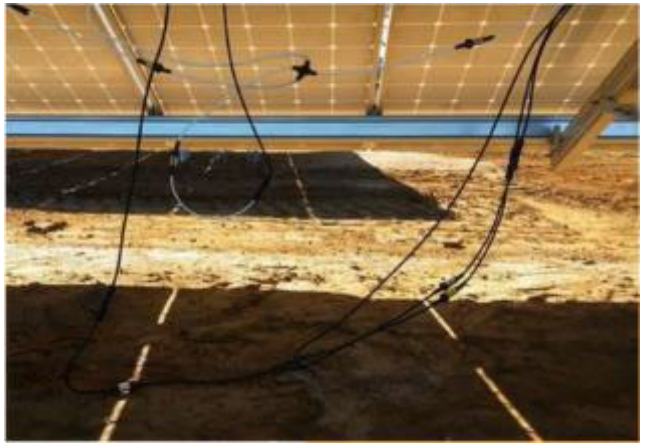
https://irecusa.org/blog/local-energy-climate-solutions/new-guide-for-solar-plan-review-and-inspection-checklists/

Wiring Management:

All Jobs

Wiring Management (Conductors)

Inspection	Related Code
Bonding fittings are used for ferrous metal conduits enclosing grounding electrode conductors.	National Electrical Code (NEC) 250.64(E)
Bonding fittings are used on concentric/eccentric knockouts with metal conduits for circuits over 250 volts to ground.	NEC 250.97 (see also exceptions 1 through 4)
For conductors installed where ambient temperatures exceed 30°C, conductor ampacities should be corrected for higher temperatures.	2017 NEC Table 690.31(A)
PV source and output circuits must be separated from non-PV system circuit conductors and inverter output circuit conductors.	NEC 690.31(B)
DC positive and negative conductors should not be identified with white or grey except for solidly grounded PV system conductors.	NEC 690.31(B)(1)
Single conductor cables are secured within 12 inches of each box, cabinet, conduit body, or other termination.	NEC 690.31(C)



Photos from Brooks Engineering

Wiring Management (Conductors)

Inspection	Related Code
PV system conductors shall be grouped and identified.	2017 NEC 690.31
Single conductor cables are secured by staples, cable ties, straps, hangers, or similar fittings at intervals that do not exceed 4.5 feet.	NEC 690.31(C)
Exposed single conductor wiring is a 90°C, wet-rated and sunlight-resistant type USE-2 or listed PV wire. If the wiring is in a conduit, it is 90°C, wet-rated type RHW-2, THWN-2, or XHHW-2.	NEC 690.31(C) and NEC 310.15
DC conductors inside a building are in a metal raceway or metal-clad (MC) cable that complies with 250.118(10), or metal enclosures.	NEC 690.31(G)
Properly sized equipment grounding conductor is routed with the circuit conductors.	NEC 690.45, 250.134(B) & 300.3(B)
Separate grounding electrodes, if used, are bonded together.	NEC 690.47, 250.50 & 250.58

Photos from Brooks Engineering

Wiring Management (Conduit, Raceways, and Cables)

Inspection	Related Code
Terminals containing more than one conductor are listed for multiple conductors.	NEC 110.14(A) and 110.3(B)
DC wiring in buildings is installed in metallic conduit or raceways.	International Fire Code (IFC) 605.11.2 and NEC 690.31(G)
Conduit runs between subarrays and DC combiner boxes are installed in a manner that minimizes total amount of conduit on the roof by taking the shortest path from the array to the DC combiner box.	IFC 605.11.2
DC combiner boxes are located so that conduit runs are minimized in the pathways between arrays.	IFC 605.11.2
Expansion fittings must be installed where necessary to compensate for thermal expansion, deflection, and contraction.	NEC 300.7(B)

Photo from Cadmus Group

Wiring Management (Connectors)

Inspection Method	Related Code
Connectors and terminals used for fine strand conductors are listed for use with such conductors.	NEC 110.3(B) and 110.14(A)
Crimps on terminals are listed and installed using a listed tool specified for use in crimping those specific crimps.	NEC 110.3(B) and 110.14
Pressure terminals are listed for the environment and tightened to manufacturer recommended torque specifications.	NEC 110.3(B), 110.11, and 110.14(D)
Connectors are listed for the voltage of the system and have appropriate temperature and ampere ratings.	NEC 110.3(B) and 110.14

Photos from Brooks Engineering

Module, Racking, and Inverter Equipment:

All Jobs

PV Modules

Inspection Method	Related Code
Module manufacturer, make, model, and number of modules match the approved plans.	International Building Code (IBC) 107.4 - Amended Construction Documents
Modules are properly marked and labeled.	NEC 110.3, 690.4(B), and 690.51 or 690.52
Modules are attached to the mounting structure according to the manufacturer's instructions and the approved plans.	NEC 110.3(B), 2009 and 2012 IBC 107.4
Module connectors are tight and secure.	NEC 110.3(B) and 110.12

Photo from Green Sun

Photo from Cadmus Group

PV Modules

Inspection Method	Related Code
Grounding - modules are bonded in accordance with manufacturer's installation instructions using the supplied hardware or listed equipment specified in the instructions and identified for the environment.	NEC 110.3(B) and 690.43(A)
If the racking system is used to bond the modules, the module/rack assembly is listed to bonding attribute of UL 2703.	Underwriter Laboratories (UL) 2703
Where PV circuits are embedded in built-up, laminate, or membrane roofing materials in roof areas not covered by PV modules and associated equipment, the location of circuits shall be clearly marked.	NEC 690.31(G)(1)

Photos from Institute for Building Technology and Safety

Racking

1. Roof penetrations are flashed to prevent moisture from entering the roof [International Residential Code (IRC) Chapter 9, Section R903, R324.4.3].

2. Racking and PV system support structures are installed and torqued per manufacturer's instructions and approved plans.

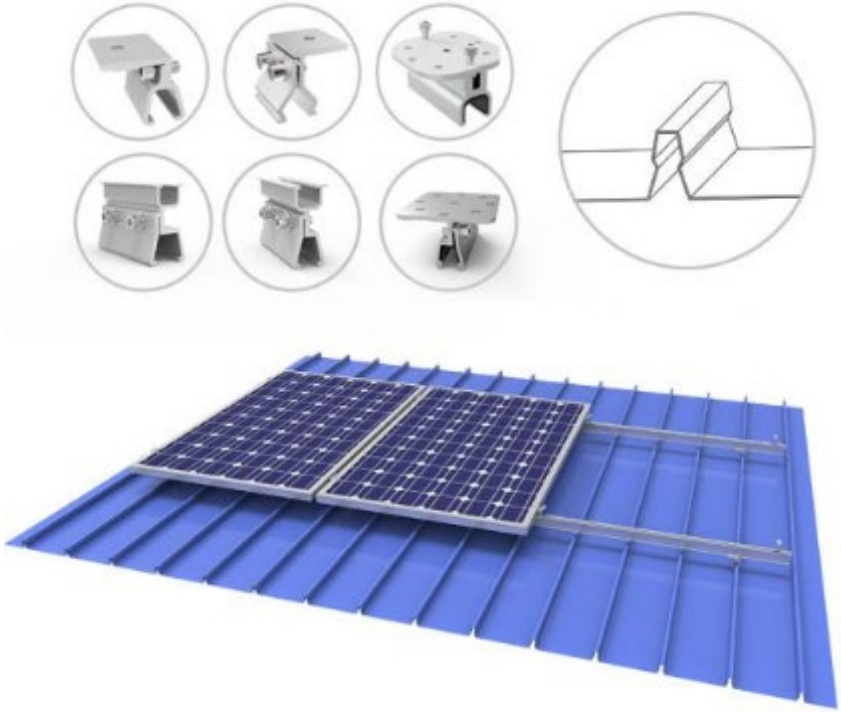


Figure from CORIGY Solar

Inverter

Inspection	Related Code
Inverter is properly secured with manufacturer's required clearances.	NEC 110.3(B), 110.13
AC and DC terminations are properly torqued.	NEC 110.14(D)
Verify that inverter or other listed equipment provides DC ground-fault protection for the DC PV array.	NEC 690.41(B)
Verify that inverter or other listed equipment provides DC arc-fault protection where PV systems operate over 80 volts.	NEC 690.11
Required labels per Signage Requirements Table installed.	See Signs & Labels Section

Photo from Green Solar Technologies

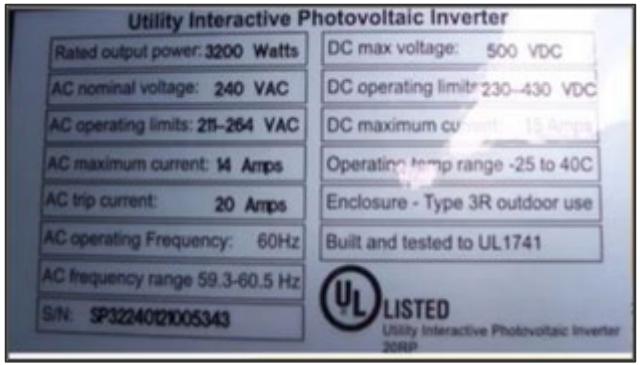


Photo from Green Solar Technologies

Point of Connection, Rapid Shutdown Device (RSD), Grounding, and Labeling:

All Jobs

Point of Utility Interconnection

Inspection	Related Code
Point of connection is either on the supply side of the service disconnecting means or at a dedicated breaker or disconnect on the load side of the service disconnecting means.	2017 NEC 705.12(A) and (B)(1)
For load-side connections, the total rating of the overcurrent protection devices (OCPDs) supplying a panelboard plus **125%** of the inverter output current does not exceed **120%** of the rating of the panelboard busbars.	NEC 705.12 (B)(2)(3)(a)
For load-side connections, the PV interconnect breaker is located at the opposite end of the bus from the feeder connection, unless the bus assembly has ampacity rating equal to or greater than the sum of 125% of the inverter output current and the rating of the overcurrent device protecting the panelboard.	NEC 705.12 (B)(3)
For supply-side connections, the sum of the ratings of all OCPDs connected to the power source must not exceed the rating of the service overcurrent protection. Overcurrent protection for supply-side connected power source conductors must be provided within 3 meters (10 feet) of the point of interconnection to the service.	NEC 705.12(A) and NEC 705.31

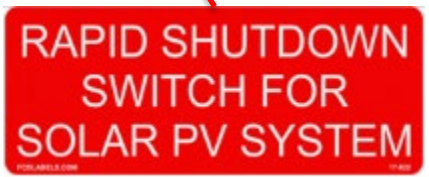
Line-side tap failure

Photo from Tim Brown, City of Shelton

Rapid Shutdown

Inspection	Related Code
Rapid shutdown initiation device installed and located per approved plans. For one- and two-family dwellings, device must be outside at a readily accessible location.	NEC 690.12(C)
Installed rapid shutdown equipment, other than the initiation device, must be listed for the application.	NEC 690.12(D)
Rapid shutdown equipment must control PV system conductors to within the limits of 690.12(B).	NEC 690.12(B)
Required labels per Signage Requirements Table installed.	See Signs & Labels Section

Photo from Roam Solar



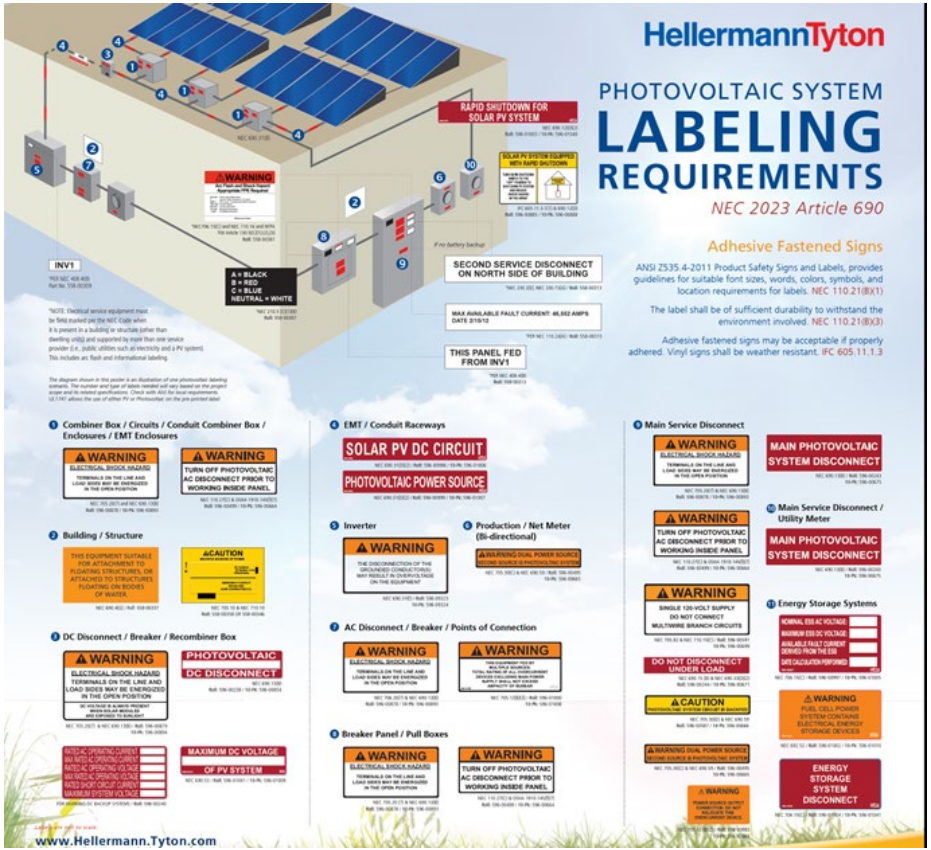
Grounding, Overcurrent Protection, and Disconnects

Inspection	Related Code
Connection from PV system to grounding electrode system made per the approved plans.	NEC 690.47
Overcurrent devices in the PV DC circuits are listed for use in PV system, and ratings match the approved plans.	NEC 110.3(A),(B), 690.9(B)
Disconnects used in PV systems must be rated for the maximum short circuit current and voltage. A DC PV system disconnecting means shall be marked for use in PV systems or be suitable for back feed operation.	NEC 110.3 and 690.13(E) and (F)
Isolating devices or disconnects are installed for the PV equipment, either integrated into the equipment or within 10 feet of the equipment.	NEC 690.15
Connectors that are readily accessible and operating at over 30 volts DC or 15 volts AC require a tool for opening.	NEC 690.33(C)
PV source and output circuits in readily accessible locations and operating over 30 volts must be guarded or in a raceway.	NEC 690.31 (A)

Photos from Brooks Engineering

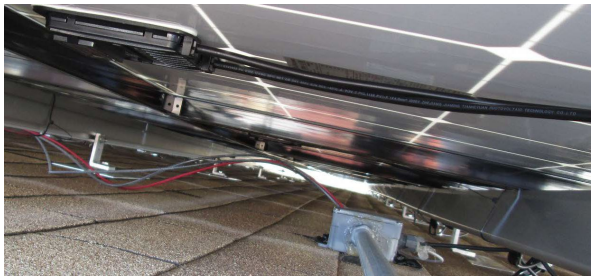
Signs and Labels

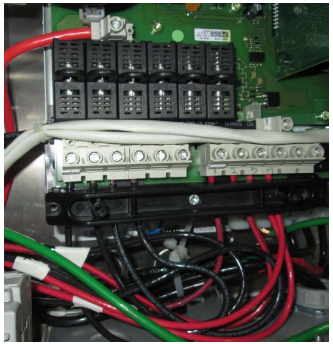
Code Section	Location of Label	Text
NEC 690.13(B)	On the PV system disconnect as Identified in Figure 690.1(B)	PV SYSTEM DISCONNECT
NEC 690.13(B)	Disconnects with power on line and load terminals when in the open position	WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION
NEC 690.53	On the DC disconnects	(1) Maximum voltage Informational Note to (1): See 690.7 for voltage. (2) Maximum circuit current Informational Note to (2): See 690.8(A) for calculation of maximum circuit current. (3) Maximum rated output current of the charge controller or dc-to-dc converter (if installed)
NEC 690.54	At interactive points of interconnection, usually the main service	RATED AC OUTPUT CURRENT ___ AMPS NORMAL OPERATING AC VOLTAGE ___ VOLTS
NEC 690.56(B) 705.10	At the electrical service and at the PV inverter if not at the same location	A directory providing the location of the service disconnecting means and the photovoltaic system disconnecting means
NEC 690.56(C)	At the service disconnecting means	RAPID SHUTDOWN LABELS FOR TYPE OF SYSTEM INSTALLED
NEC 705.12(B)(2)(3)(b)	Inverter output OCPD	WARNING:POWER SOURCE OUT PUT CONNECTION — DO NOT RELOCATE THIS OVERCURRENT DEVICE.
NEC 690.55	Battery enclosure	MAXIMUM OPERATING VOLTAGE, EQUALIZATION VOLTAGE POLARITY OF GROUNDED CONDUCTORS
IFC 605.11.1.4	On conduit, raceways, and enclosures, mark every 10 feet, at turns, above/below penetrations	WARNING: PHOTOVOLTAIC POWER SOURCE
NEC 705.12(B)(3)	Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources.	Dual Power Source. Second source is a solar PV system.



Group Exercise - 1

Question 1: Which locations have the most common and most serious code violations?



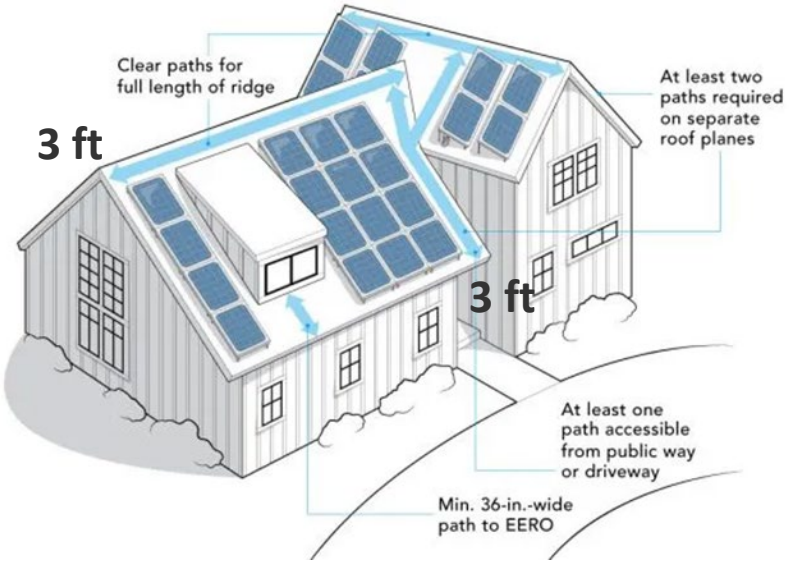


Photos from IREC

Array, inverter, grid connection point, junction box

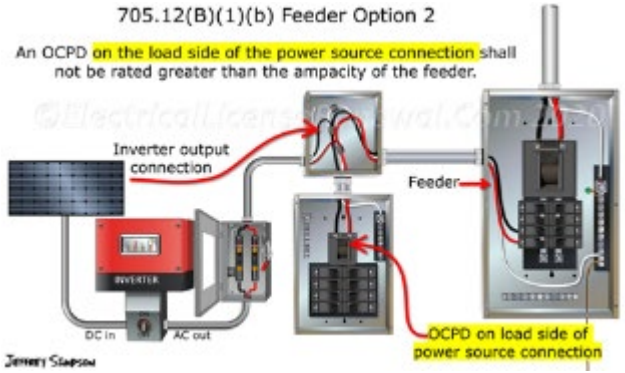
Group Exercise - 1

Question 2: What should be the minimum working clearance for all components that may require service?



Group Exercise - 1

Question 3a: What should be the max current rating of the inverter connected to the overcurrent protection device (OCPD)?
Question 3b: What is the max allowable current for the OCPD?



3a. 125% of the inverter output
3b. 120% of the busbar rating

Group Exercise - 1

Question 4: What type of violations do you see in pictures below?

a

Incorrect The National Electrical Manufacturers Association (NEMA) 3R disconnect on sloped roof. Disconnects are designed for vertical mounting only!

b

Improper cable support with exposure to physical damage

c

Uninstalled flashing

Photos from IREC

Field Inspection Examples for Different PV Systems

Microinverter System

Rooftop Array

- PV modules must be listed to UL 1703.
- Verify that array conductors are not touching the roof surface and that they are properly secured and supported.

Inverter

- Microinverters must be listed to UL 1741.
- Verify that microinverters are attached to the racking system with torque values specified by the manufacturer.
- Verify that roof attachments are securely mounted to the structural members.
- Verify proper weather sealing of all roof attachments.
- Check for wire management; there should be no cables or conductors in contact with the roof.

Photo from AP Systems

Photo from IREC

Microinverter System

Conduit and Junction Box

- Verify that the conductor type and connections in a rooftop junction box and conduit are listed for wet locations.
- Verify that the location of the PV system disconnects match the plan.
- No labeling needed for AC conduits.

AC Disconnect Rapid Shutdown

- Verify that PV system signs and labels are installed per plan (*rapid shutdown sign*).
- Some utility companies require an exterior AC disconnect—"visible activation."
- A system equipped with "rapid shutdown" means that controlled conductors shall be limited to not more than 30 volts and 240 volts-amperes within 10 seconds of rapid-shutdown initiation.

Conduits and Junction Box

Photos from IREC

AC Disconnect

Rapid Shutdown

Microinverter System

Main service panel board

- Verify the bus size of the point of utility interconnection.
- Verify that the main circuit breaker and inverter circuit breakers match the plan.
    - NEC 690.64(B) and 705.12(D)(2) state that the sum of ampere ratings of the device supplying power to a busbar or conductor shall not exceed 120% of the rating of the busbar or conductor.

- Verify:
    - Conductor sizes and type match plan
    - The location of the inverter breaker
    - Additional equipment grounding conductor follows the cable path
    - Racking system and module combination for bonding, grounding, and fire resistance rating
    - Wire management
    - Proper labeling.

Main service panel board and meter. *Photo from IREC*

String Inverter System

Rooftop Array

- Verify attachment points and proper flashing.
- Verify that DC-DC converters are properly attached to mounting structure.
- Check wire management.
- Verify that modules are attached to the racking system with torque values specified by the manufacturer.
- Verify that all roof attachments, including junction boxes, are properly weather sealed.

Attachments

Module

Junction Box

Photos from IREC

String Inverter System

Conduits

- Verify that conduit is properly labeled (every 10 feet) and adequately supported (every 6 feet).
- Verify that conduit boxes that are part of DC circuit are correctly labeled for identification.

Conduit

Conduit Box

Inverter

- Verify proper orientation, mounting, and labeling.
- In some cases, utility requires an external accessible AC disconnect.
  - In that case, verify that the label shows AC operating voltage and max AC current.

String Inverter

AC Disconnect/Rapid Shutdown

Photos from IREC

String Inverter System

Subpanel

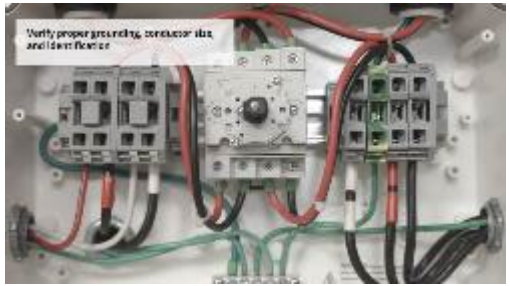
- Subpanel is connected to AC disconnect, and once the AC disconnect is operated, each DC-DC converter is limited to 1 volt.
- NEC requires that there is an AC disconnect means, but the number of disconnects depends on the product in the system and utility requirements.

Grounding, Conductor Size and Type, Overcurrent Protection

- Verify that there is continuity within the grounding system so there is no difference potential.
- Verify the size of the busbar versus the output of the inverter.

Main Meter

- Verify that the bidirectional meter is located near the string inverter.
- Verify that the meter is sealed for weather conditions.



Photos from IREC

But what if the project has battery storage?

Lithium-Ion Energy Storage System

Additional considerations for lithium-ion ESS:

1. Electrical is far more complex
2. Access pathways in and out of dwelling
3. Individual battery capacity rating (20 kWh)
4. Aggregate capacity ratings by installation location
    i. 40 kWh within utility closets, basements, and storage or utility spaces
    ii. 80 kWh in attached or detached garages and detached accessory structures
    iii. 80 kWh on exterior walls
    iv. 80 kWh outdoors on the ground.
5. Structural attachments (Seismic Design Category D or greater)
6. Heat detection.

Figure from Linda Li, Energy Consultant

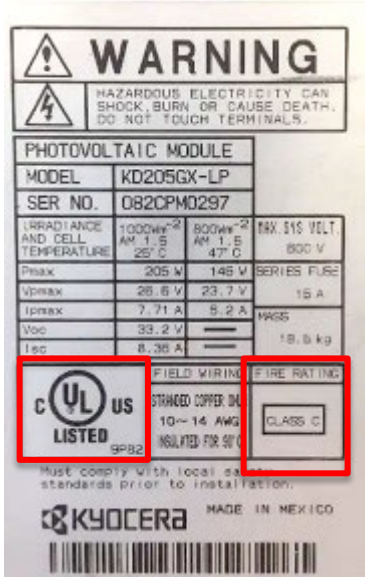
Additional Energy Storage System Considerations

Inspection	Related Code
Flexible battery cables do not leave the battery enclosure.	NEC 400.12
Flexible, fine strand cables are only to be used with terminals, lugs, devices, and connectors that are listed and marked for such use.	NEC 110.3(B) and 110.14
Area is well ventilated, and the batteries are not installed in living areas.	NEC 408.10 and 706.10(A)
Live parts of battery systems are guarded to prevent accidental contact by persons or objects.	NEC 706.10(B)
Working space and illumination are provided around the battery installation.	NEC 706.10 (C), (D) and (E)
Proper diagrams or placards are provided at the building electric service equipment and other power source locations.	NEC 706.11

Photo from Solar Panels Cambs

Group Exercise - 2

Question 1: What should you look for on a PV module label?



UL 1703 listing, fire rating

Group Exercise - 2

Question 2a: At what length/interval does the DC conduit need to be labeled and supported?

Label in every 10 feet
Support in every 6 feet

Question 2b: Do AC conduits also need labeling?

No; only DC conduits should be labeled!

Group Exercise - 2

Question 3: What would be the aggregate capacity rating for a lithium-ion battery if it is located as in the figure?

Figure from Bulletin of Atomic Scientists

40 kWh for batteries located in basement!

Group Exercise - 2

Question 4: If the busbar rating is 200 amps, What is the maximum allowable contribution from the PV system?

40 amps
120% of 200 Amps is 240
minus the busbar load (200) = 40 amps

Field Inspection Best Practices

Major Problem Areas and Related Considerations

1. **Installation quality overall**
   - i. Is the work done in a neat and workmanlike manner (NEC 110.12)?
   - ii. Are roof penetrations flashed/sealed?
   - iii. Are the array exposed cables properly secured, supported, and routed to prevent physical damage?
   - iv. Is the conduit correctly installed and according to CRC R331.3 and NEC 690.4(F)?
   - v. Is there sufficient workspace and access for operation and maintenance of PV equipment?

Photos from Cadmus Group

Major Problem Areas and Related Considerations

2. **Does the installation match the plan?**
   - i. PV module model number, quantity, and locations
   - ii. Array mounting system and structural connections
   - iii. Type and size of overcurrent protection devices (OCPDs)
   - iv. Disconnects and their locations (as required by NEC)
   - v. Grounding and bounding of rack and modules
   - vi. Connection of the PV system to the grounding electrode system
   - vii. Rapid shutdown system (690.12)

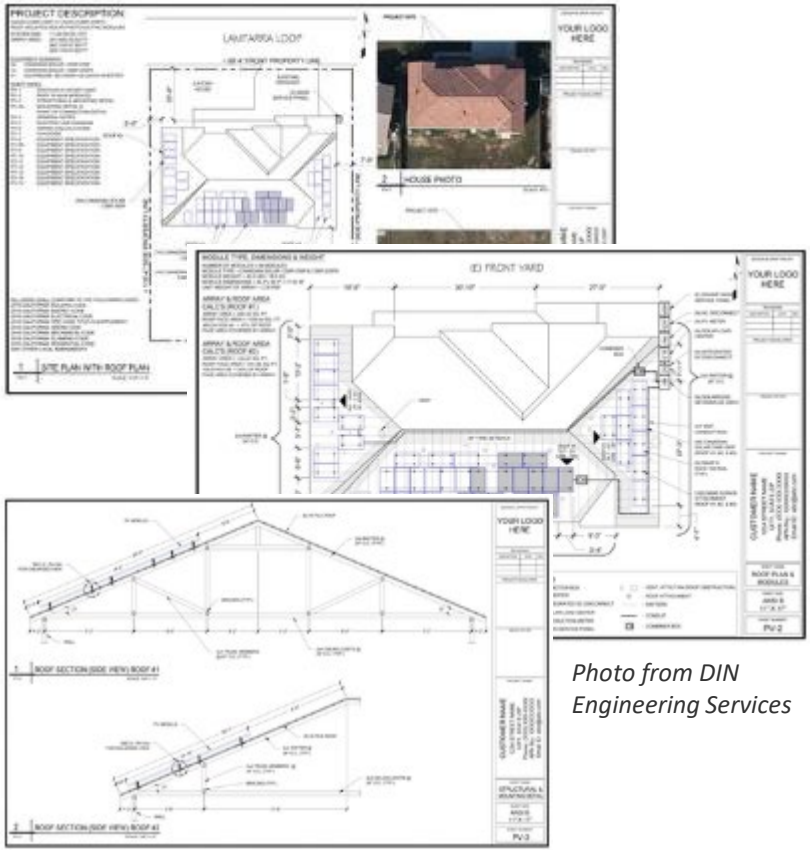
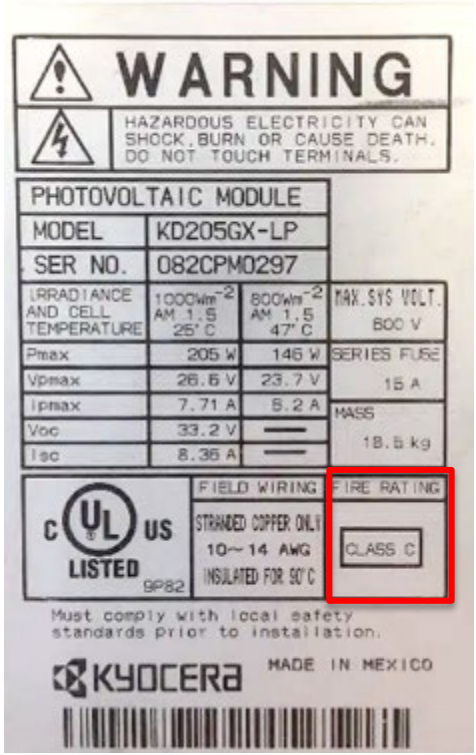


Photo from DIN Engineering Services

Major Problem Areas and Related Considerations

3. **Fire protection and emergency response**
   a. Are the firefighter's access setback inline with the approved plan?
   b. Do roof-mounted PV systems have the required fire classification?

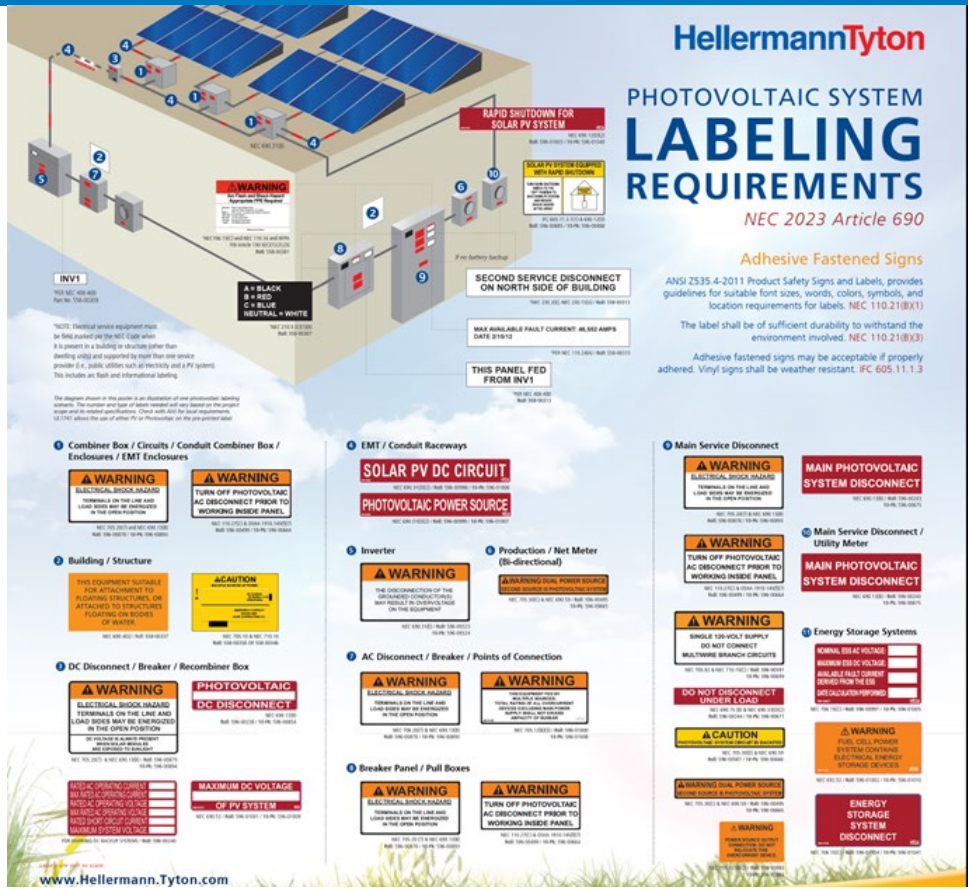


Major Problem Areas and Related Considerations

4. Labeling and Marking

i. Are conductors, cables, conduit types, sizes, and markings installed according to the approved plan?

ii. Are PV system markings, labels, and signs installed according to the approved plan?



Key Takeaways

Key Takeaways

- The field inspection process is key to the development of a healthy and safe PV industry.
  - Inspections verify that an installation is compliant with building and electrical codes and fire safety requirements.
- Many inspection checklists exist that can help inspectors perform their code enforcement obligations.
- Common major code violations are in the array, inverter, grid connection, and junction boxes.
  - Wire management is one of the most important parts of inspection. Conductors that touch the roof are subject to damage which can cause system failures or arcing fires.
  - Electrical grounding is another important consideration for electrical inspection.
  - Fire departments should have a safe path that they can access to the roof.
- Pairing solar with battery storage is likely to grow, and you may see more of these projects in the future.

Q&A Session

www.nrel.gov

Jeff.Cook@nrel.gov
Sertac.Akar@nrel.gov

This work was authored [in part] by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

U.S. DEPARTMENT OF ENERGY

NREL
Transforming ENERGY

References

IREC, 2018, Plan review and Field Inspection Guidelines Model Inspection Checklist for Residential Rooftop PV, https://irecusa.org/blog/local-energy-climate-solutions/new-guide-for-solar-plan-review-and-inspection-checklists/

IREC, 2023, Online Training, Solar PV Field Inspection Basics – Series
- PV Field Inspection 1 - Microinverter System
- PV Field Inspection 2 - DC-DC Converter System
- PV Field Inspection 3 - Lithium-Ion Energy Storage System

https://cleanenergytraining.org/products/solar-pv-field-inspection-basics-series

Jeffrey Cook, Rosalie Yu, Kaifeng Xu, Sushmita Jena, Tim Rivard, and Jessica de la Paz., 2023, SolarAPP+ Performance Review (2022 Data), Golden, CO: National Renewable Energy Laboratory, NREL/TP-6A20-85827 https://www.nrel.gov/docs/fy23osti/85827.pdf

Jesse R. Cruce, Eric O'Shaughnessy, Jenna Harmon, Jesse Geiger, and Jeffrey J. Cook. 2022. Residential Solar Adoption Timelines and Impacts from the COVID-19 Pandemic. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-83529. https://www.nrel.gov/docs/fy22osti/83529.pdf.

O'Shaughnessy, Eric, Shiyuan Dong, Jeffrey J. Cook, Jesse Cruce, Kristen Ardani, Emily Fekete, and Robert Margolis. 2022. "Effects of Local Permitting and Interconnection Requirements on Solar PV Installation Durations." Energy Policy 161 (February): 112734. https://doi.org/10.1016/j.enpol.2021.112734.

Bill Brooks, 2021 , Solar Permitting & Inspection Best Practices for CT Communities Training video https://vimeo.com/showcase/10454075/video/839843041

HellermannTyton, 2023, Photovoltaic System Labeling Requirements NEC 2023 Article 690, https://gp1.wpc.edgecastcdn.net/00AC62/documents/datasheets/SOLARPOSTER2020.pdf