

Solar PV – Permitting and Inspecting

Understanding the solar permitting and inspecting process
for local governments and authorities having jurisdiction (AHJ)



NYSERDA

Solar Guidebook for Local Governments
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Overview

To allow officials to better understand the permitting and inspecting process, and ensure them an efficient, transparent, and safe beginning to their solar development project, this section reviews the solar photovoltaic (PV) permitting and inspection process for local government officials and authorities having jurisdiction (AHJs).

Tools and materials are provided to assist local officials and AHJs on evaluations of solar systems less than 25kW. Solar PV design issues, design reviews of construction documents, and field inspection checklists are among the topics discussed.

Within this chapter, we provide the following supplemental material for government officials and AHJs:

- NY State Unified Solar Permit Application
- Sample construction photos of correctly installed equipment
- Sample installation errors
- Labeling guidelines
- Sample wiring diagrams
- Sample site map for roof mounted solar PV systems

1. Intended Use

NYSERDA developed this tool in collaboration with the New York Department of State, solar contractors, and other stakeholders. It supports NYSERDA's efforts to implement a unified permitting process for residential solar PV systems. Standardizing the permitting and inspecting process across New York State will reduce costs for municipalities and solar customers, create local jobs, and advance New York's clean energy goals.

1.1 What the Tool Is

This tool is a free resource to help code enforcement officials review and evaluate solar electric systems for grid-tied residential solar PV installations of 25 kW or less. Off-grid and commercial-scale solar PV systems are more complex and warrant greater detail than this tool provides.

1.2 What the Tool is Not

This tool is not all-encompassing. Electric construction is a complicated process governed by the NYS Uniform Fire Prevention and Building Code (Uniform Code), which references other codes. This tool highlights many common and important design issues referenced in the National Electrical Code (NEC), but it should not be considered comprehensive.

1.3 Distribution

AHJs and other entities are welcome to use and distribute this tool. AHJs may wish to update the Unified Solar Permit Application itself and Submittal Instructions to reflect any unique requirements that apply to their municipality (such as a schedule of fees). The inspection and design review checklists can also be changed to reflect additional requirements.

AHJs should keep in mind that changing the Unified Solar Permit's contents may diminish consistency and increase the cost of solar energy for their constituents. Changes may not be obvious to contractors working across many local governments, so AHJs should highlight any changes made to the standard documents.

1.3.1 Disclaimer

This document and the New York Unified Solar Permit are provided to support and standardize the solar permitting process. These documents should not be used as a substitute for proper solar PV system design calculations. Users of these documents assume all responsibility for solar PV system design, installation, and permitting, as required by New York State law. NYSERDA and its contractors cannot be held liable for any errors or omissions in these documents.

2. Solar PV System Design Issues

This section provides an overview of issues involved in solar PV system design. It is critical that designers optimize safety and performance because systems have expected lifespans of 20-30 years.

2.1 Array Siting

Designing a solar PV system involves many factors, but the most important is siting the array to maximize sunlight. South-facing roofs are ideal, but PV modules (“panels”) can be located on southwest- or southeast-facing roofs with minimal losses. North-facing roofs and heavily shaded roofs should be avoided. Prior to installation, solar PV contractors measure the amount of sunlight a location receives annually, either with a hand-held tool or aerial imagery software.

Residents planning to remove trees to increase solar access should clearly mark the trees on construction documents submitted with their permit application. The projected growth of vegetation should also be considered when designing a system, especially for ground-mounted arrays.

When a house does not have a clear south-facing roof, contractors can install on garages, outbuildings, or in the ground. Experienced designers will maximize solar access and minimize wire runs, building penetrations, and labor costs. Depending on the layout of a house, conductors can be run on exterior roofs and walls, through attic or basement spaces, or in wall cavities.

2.2 Irradiance and Temperature

Solar electric modules convert solar radiation into electric current. Their power output is variable, based on the intensity of sunlight (irradiance) and the temperature of the cells. All modules have a nameplate capacity, which states the power (Wattage) produced by the module under Standard Test Conditions (STC), defined as 1,000 Watts per square meter at 25 °C. The module’s actual output at a specific point in time is typically lower than the nameplate capacity but can be higher under certain conditions.

Solar electric modules have the greatest power output when exposed to high levels of irradiance (intensity of sunlight) at low temperatures. There is a positive relationship between irradiance and the current (Amperes) solar PV modules produce: as irradiance increases, current increases (with little change in voltage). There is an inverse relationship between temperature and a PV module’s voltage: at temperatures below 25 °C, modules produce voltage higher than during STC. At higher temperatures, voltage decreases (see NEC 690.7), with no significant change to amperage.

In addition to reducing voltage (and therefore Wattage), high temperatures have other detrimental effects on solar PV systems. Prolonged exposure to high temperatures accelerates the rate at which solar PV cells degrade. Therefore, most roof-mounted arrays are located on racking, which places the PV cells 3 to 6 inches above the roof surface and allows airflow under the array. Inverters may be installed outdoors but perform slightly better when not in direct sunlight. High temperatures must be considered when sizing conductors located on hot roofs, as the current carrying capacity of conductors decreases when exposed to heat. Conduit runs must also have expansion fittings (as required by code) to account for thermal expansion and contraction.

Because the output voltage of solar PV modules increases significantly in colder weather, installers must account for the lowest expected ambient temperature when determining the maximum number of solar PV modules per string (NEC 690.7).

2.3 System Sizing and Equipment Selection

Solar electric installations are highly customized. Installers must carefully design systems to meet site-specific conditions and choose equipment that satisfies detailed technical requirements. Solar electric modules have different STC electrical outputs (voltage and current), which vary with temperature and irradiance. At residential sites the NEC limits the maximum DC string voltage to 600 volts, so installers must determine the maximum number of modules per string, based on design low temperatures (i.e. when module voltage is highest). DC strings of modules must also have a minimum voltage (based on design high temperatures) greater than the minimum voltage required to activate the system’s inverter. Certain technologies allow for increased flexibility in system design, such as multiple power point trackers (MPPTs), DC optimizers, and microinverters.

DC array sizes should not exceed an inverter’s maximum input rating. If an inverter is significantly undersized for an array, solar PV production during peak hours will be limited. Generally, a solar PV system’s DC Wattage should not exceed 1.3 times the AC rating of its inverter. Many inverter manufacturers have developed computer programs that assist in string sizing and optimizing system design, such as www.fronius.com/froniusdownload/tool.html

2.4 Grounding

One of the more challenging aspects of solar PV system design and installation is thoroughly grounding and bonding the system in accordance with the NEC.

The grounding electrode conductor (GEC) is the reference ground that establishes the voltage relationships between the ungrounded conductors and earth ground. The GEC must be run with irreversible splices from any separately derived power supply (i.e., inverters that contain transformers) to the grounding electrode. All solar PV systems with a transformer-based inverter will require a GEC from the inverter to the grounding electrode. Table 250.66 in the NEC governs the sizing of the GEC. The GEC must be a minimum of number six American Wire Gauge Building Wire (#6 AWG) when exposed and must be bare or covered with green insulation. When exposed and insulated, the wire must be UV-protected.

The grounded conductor (or “neutral” conductor) is intentionally grounded and carries current under normal conditions. It is always insulated and may be white or gray in color. Current flows out on the ungrounded conductors and returns on the grounded conductor, completing the circuit.

The equipment grounding conductor (EGC) does not carry current under normal conditions. It provides a path back to the grounded conductor (neutral) when a fault occurs. The EGC may include all bonded metal components, such as the racking, boxes, enclosures, building steel, and metal roofing materials. (Bonding is the physical connecting of metal components so that they are at equal potential. They may or may not be grounded. Bonding jumpers may be extensions of the GEC, EGC, or grounded conductor.) Table 250.122 in the NEC governs EGC sizing. The EGC is required on both grounded and ungrounded (transformer-less) systems. The EGC must be a minimum of #6 AWG when exposed and must be bare or insulated green. When exposed and insulated, the wire must be UV-protected.

The GEC, EGC, and grounded conductor must be bonded together at the main service disconnect(s) and at the overcurrent protection/disconnects when performing a supply-side connection.

2.5 Labeling

The NEC provides many unique labeling requirements for solar PV systems, located in Sections 690, 705, 706 and elsewhere. To assist contractors and inspections, NYSERDA has developed an extensive Labeling Guide, located as Section 8 of this document.

2.6 Zoning Considerations

Solar photovoltaic is a relatively new technology. Many municipalities are unsure how solar PV installations fit into their existing zoning and land-use regulations. Large-scale systems in particular raise land use, aesthetic, decommissioning, and disposal concerns.

Municipalities should review their existing zoning requirements to ensure they clearly describe how solar PV systems are classified, and what restrictions are placed upon them. For more information, please reference Chapter 10 - Model Solar Energy Law.

2.7 Wind and Snow Loads

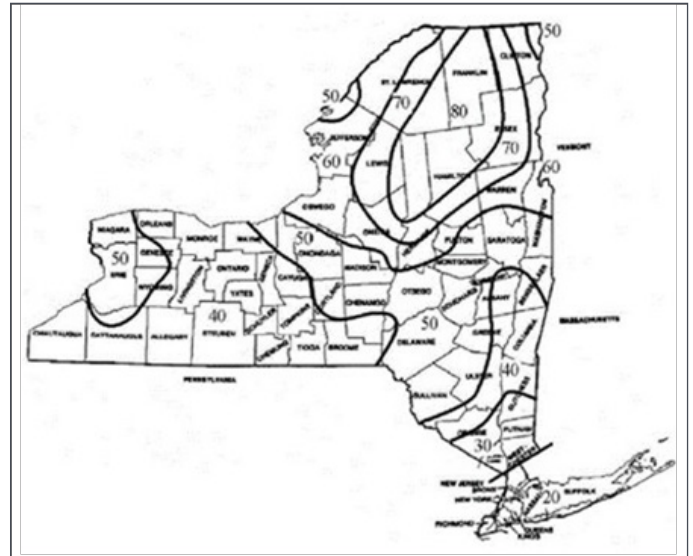
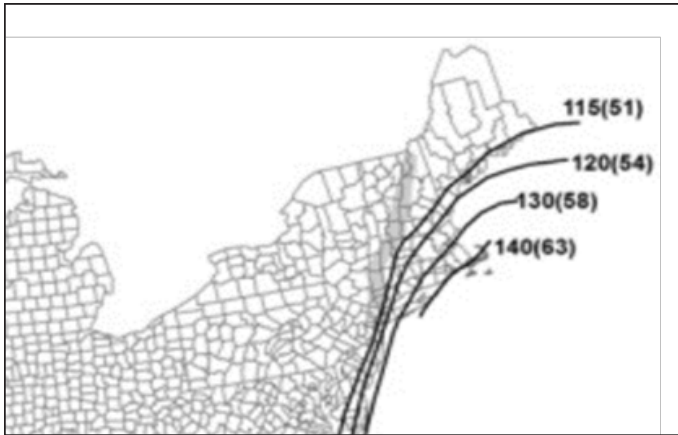
Solar electric contractors are responsible for ensuring that their installations do not jeopardize the structural integrity of the buildings upon which they are mounted. Due to their large surface areas, solar PV arrays can catch updrafts and create significant amounts of uplift during windy conditions. Forces are especially strong when modules are located at the ridge of a roof, when they are mounted a significant distance above the roof surface, or when they are not mounted parallel to the roof surface. Ground-mounted arrays are also subject to large wind forces. Detailed calculations are required to determine the exact amount of pressure for which systems should be designed.

Solar electric arrays, including racking and mounting hardware, typically add 4-6 pounds per square foot of dead load to a structure. Although this amount is modest, it may become significant when combined with a roof's existing dead load and snow load. The International Residential Code provides snow load data, which range from 20-80 pounds per square foot in New York State.

A Professional Engineer or Registered Architect should perform detailed calculations to ensure solar PV designs meet all structural requirements, taking wind load and snow load into account.

Figure R301.2(5)A from the 2020 Residential Code of New York State: Ultimate Design Wind Speeds

Figure R301.2(6) from the 2020 Residential Code of New York State: Ground Snow Loads



3. Design Review of Construction Documents

As part of their permit application, applicants must submit a site plan, an electrical wiring diagram, a structural analysis, and specification sheets for the modules, inverter, and racking system. This section includes a checklist of items for code officials to check as part of their design review.

The construction documents must be stamped by a New York State licensed professional engineer (PE) or registered architect (RA). The local code official will determine the depth of review necessary. The following three-part checklist may be expanded should the code official require examination at greater depth, such as checking wire sizing and other calculations.

3.1 Site Plan

| Yes/No | Site Plan |
|--------|---|
| | Construction document prepared and stamped by a New York State licensed professional engineer or registered architect, who incorporated the following into system design. |
| | <ul style="list-style-type: none"> • Street address and tax map parcel number • All required setbacks, including rooftop access and ventilation requirements as applicable • Location of array, inverter, disconnects, and point of interconnection • Array azimuth and tilt • For ground mounted systems, length and location of trenches • Location and type of rapid shutdown device, if applicable (NEC 690.12) |

3.2 Electrical Diagram

| Yes/No | Electrical Wiring Diagram |
|--------|---|
| | Electrical wiring diagram prepared and stamped by a New York State-licensed Professional Engineer or Registered Architect, who incorporated the following into system design. |
| | <ul style="list-style-type: none"> • Solar electric module array information – number of modules in series, number of strings. • Quantity, make, and model of UL-listed solar PV modules. • All conductor types, ratings, and conduit type (if applicable). Solar electric source circuit conductors are solar PV wire (NEC 690.31(B)). • Max voltage of 600 VDC (NEC 690.7(C)) (1,000 VDC wire may be used on 600 VDC systems). • Rating (voltage and current) for all disconnects. • Voltage drop is minimized (NEC 210.19(A)Informational Note No. 4). • Provision for Rapid Shutdown per NEC 690.12. Using microinverters or string inverters with DC Power optimizers is one way of meeting this requirement. • DC disconnect is present (may be integral to inverter) (NEC 690.13). • Quantity, make, and model of UL-listed inverter provided. • AC disconnect appropriately sized for inverter output (NEC 690.8(A)(3), 690.8(B)(1)). • Conductor type, rating, and conduit type (if applicable) provided for all conductors. • If supply-side connection, meets all requirements of NEC 705.12(A), including: <ul style="list-style-type: none"> - Service-rated AC disconnect specified, at least 60 amps, with appropriate overcurrent protection device. If breaker used, must meet or exceed utility fault current kAIC rating. - Conductors between disconnect and point of interconnection are sized at least 60 amps (#6 or larger). - Supply side connection made between main service panel's main disconnect and utility meter. • If load side connection, meets all requirements of NEC 705.12(B), including: <ul style="list-style-type: none"> - Inverter output connection is made at a dedicated circuit breaker or fusible disconnect. - The sum of 125% of the inverter(s) output current plus the main circuit breaker rating must be less than or equal to 120% of the bus or cable rating (NEC 705.12(B)(3)(b)). - Backfed breaker located at opposite end of busbar from main breaker (NEC 705.12(B)(2)(1)). • Equipment grounding conductor (EGC) present at all components likely to become energized, and sized according to NEC 250.122. • If not using an isolated/ungrounded/transformer-less inverter, grounding electrode conductor (GEC) present and continuous from inverter to service disconnect, sized according to NEC 250.66. |

3.3 Structural Analysis

| Yes/No | Structural Analysis |
|--------|--|
| | Structural analysis prepared and stamped by a New York State licensed professional engineer or registered architect, who incorporated the following into their review. |
| | <ul style="list-style-type: none"> • Weight of the existing roofing (composition shingle, metal, masonry, etc.). • Number of layers of roof covering. • Method of waterproofing penetrations (flashing is required by the 2020 NYS Uniform Code). • Type of racking system (engineered product) and height of solar PV modules from surface of roof. • Location-specific wind load and snow load. • Type, dimensions, and spacing of roof structural framing. • Calculations must be provided if any of the following apply: <ul style="list-style-type: none"> - Roofing is not lightweight, or roof has multiple layers of covering. - Racking system is not engineered for mounting of solar PV modules. - Modules will be mounted more than 18 inches above roof surface. - Modifications must be made to framing to strengthen roof structure. - Solar electric system and racking will add more than 5 pounds per square foot to dead load, or more than 45 pounds per attachment point, calculated as follows: <ul style="list-style-type: none"> • Total weight of solar PV modules, racking, and mounting hardware _____pounds. • Total number of attachment points to roof _____. • Weight per attachment point (A ÷ B) _____pounds. • Total area of solar PV array _____square feet. • Distributed weight of solar PV array on roof (A ÷ D) _____pounds/square foot. |

4. Field Inspection Checklist

The Field Inspection Checklist in this chapter can be used directly by the AHJ or provided to a third-party inspection agency, where applicable. The checklist is intended to highlight key system characteristics and common installation errors. Completing the checklist should take approximately 20 minutes per field inspection. Not all sections may apply to a given installation.

A “rough inspection” (which occurs when all boxes and wires are installed to the point when walls or trenches are ready to be closed) is not necessary on most small residential installations with existing construction.

When a field inspection is necessary, inspectors should consider bringing the following items:

- Ladder with non-conductive sides.
- Binoculars for surveying inaccessible roof-mounted equipment.
- Screwdriver for opening enclosures.
- A copy of the contractor’s submitted design.

Code enforcement officers should consider asking solar PV contractors for a set of construction photos. Contractors typically document their installation progress with photos, which are sometimes required by their internal quality assurance team or financing partners. NYSERDA also requires construction photos from participating contractors. Code enforcement officers can use such photos to review hard-to-access parts of the installation (such as roof-mounted racking).

4.1 Array

| | | | |
|---|---|---|-----|
| 1. Circuit conductors are properly supported and are not touching the roof surface [NEC 338.30, 350.30, 376.30] | N | Y | N/A |
| 2. Circuit conductors are same conductor type/size as on plan set | N | Y | N/A |
| 3. Module count matches plan set. If no, investigate stringing configuration | N | Y | N/A |
| 4. Module manufacturer/model matches plan set | N | Y | N/A |
| 5. Modules are effectively grounded using lugs, WEEBs, or a racking integrated grounding method [NEC 690.43] | N | Y | N/A |
| 6. Modules and racking are properly secured [NEC 110.3(B), 250.5, 250.8, 250.12, 690.43] | N | Y | N/A |
| 7. DC optimizers or microinverters are properly grounded [NEC 110.3(B), 250.4(A)(5), 250.64(E), 250.97] | N | Y | N/A |
| 8. Wire ties are UV-rated (generally black) | N | Y | N/A |
| 9. All electrical connections are secured to ensure no arcing | N | Y | N/A |
| 10. Racking system is properly grounded (EGC bonding the rails [NEC 690.43]) | N | Y | N/A |
| 11. Conductors are properly identified (ungrounded, grounded, grounding) [NEC 200.7, 200.6, 250.119] | N | Y | N/A |
| 12. Outdoor components are UL-listed for the environment [NEC 110.3(B)] | N | Y | N/A |
| 13. Roof vents are not covered by the modules [2020 NYS Uniform Code] | N | Y | N/A |
| 14. DC conduit is labeled “WARNING: PHOTOVOLTAIC POWER SOURCE” every 10 feet, and is reflective, and meets color and size requirements [NEC 690.31(G)(3) and (4)] | N | Y | N/A |
| 15. Conductors over 30V are guarded, installed in raceways, or otherwise inaccessible [NEC 690.31(G)(3)(4)] | N | Y | N/A |
| 16. Equipment Grounding Conductor (EGC) is protected if smaller than #6 AWG [NEC 690.46, 250.120(C)] | N | Y | N/A |
| 17. Source circuit conductors are not in contact with the roof [NEC 338.10, 334.30] | N | Y | N/A |

4.2 DC Optimizer

| | | | |
|---|---|---|-----|
| 1. DC Optimizer chassis is properly grounded per manufacturer's instructions [NEC 110.3(B), 250.4(A)(5), 250.64(E), 250.97] | N | Y | N/A |
| 2. Rapid Shutdown label is present and meets the requirements of NEC 690.56(C)(1)(a) | N | Y | N/A |

Note 1: Many violations from the "Array" section also apply to the "DC Optimizer" section.

Note 2: DC optimizer can have an integrated ground, or not. Bring the specifications sheet to the inspection for quick reference.

4.3 Structural (Roof-Mounted Only)

| | | | |
|---|---|---|-----|
| 1. All roof penetrations are properly flashed and sealed per 2020 NYS Uniform Code and NEC 110.3(b) | N | Y | N/A |
| 2. Lag bolts are properly installed, not over torqued deforming the flashing | N | Y | N/A |
| 3. Rafter spacing/material matches construction documents | N | Y | N/A |
| 4. Roof appears to be in good condition, with no signs of leaking or damage; Roof is free of debris | N | Y | N/A |
| 5. All racking splices are properly supported per manufacturer requirements (generally splices must be supported on both sides of the joint by a structural attachment) | N | Y | N/A |
| 6. Modules cannot be moved by pushing or pulling with one hand | N | Y | N/A |

4.4 Junction Box

| | | | |
|---|---|---|-----|
| 1. Wire nuts and splices are suitable for the environment [NEC 110.3(B)] | N | Y | N/A |
| 2. Junction box is UL listed for the environment [NEC 110.3(B)] | N | Y | N/A |
| 3. Junction box is properly grounded [NEC 110.3(B), 250.4, 250.8, 250.12, 690.43] | N | Y | N/A |
| 4. Grounding equipment is properly installed [NEC 110.3(B), 250.4, 250.8, 250.12, 690.43] | N | Y | N/A |

4.5 Inverter

| | | | |
|---|---|---|-----|
| 1. The number of strings match the plan set | N | Y | N/A |
| 2. The conductors have sufficient ampacity for each string | N | Y | N/A |
| 3. DC conductors in metal when on or inside a building [NEC 690.31(G)] | N | Y | N/A |
| 4. Conduit penetrations are properly sealed between conditioned and unconditioned space [NEC 300.7(A)] | N | Y | N/A |
| 5. Conduit is properly supported e.g., [LFMC NEC 350.30, EMT NEC 358.30, PVC NEC 352.30] | N | Y | N/A |
| 6. Conduit is not being used as conductor support [NEC 725.143] | N | Y | N/A |
| 7. The enclosure is properly grounded [NEC 690.43, 250.8, 250.12] | N | Y | N/A |
| 8. Grounding equipment is properly installed [NEC 690.43, 250.8, 250.12] | N | Y | N/A |
| 9. Point of interconnection enclosure is labeled as a PV disconnect [NEC 110.21(B) and/or 690.13(B)] | N | Y | N/A |
| 10. DC characteristics label is present [NEC 690.53] | N | Y | N/A |
| 11. The ungrounded DC conductors are properly identified (shall not be white, gray, or white striped) [NEC 200.6(A)(B)] | N | Y | N/A |
| 12. Max string voltage below inverter max [NEC 110.3(B), 690.7] | N | Y | N/A |
| 13. Inverter string fuses are rated for use in application [NEC 110.3(B), 690.9] | N | Y | N/A |
| 14. DC and AC disconnecting means are located within sight of or in each inverter [NEC 690.15] | N | Y | N/A |
| 15. AFCI protection is present and enabled [NEC 690.11] | N | Y | N/A |
| 16. System is equipped with Rapid Shutdown [NEC 690.12] | N | Y | N/A |
| 17. Rapid Shutdown label is present and meets the requirements of NEC 690.56(C)(1)(a) | N | Y | N/A |
| 18. System is marked with a permanent label with the following wording: "PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN" [NEC 690.56(C)] | N | Y | N/A |

4.6 Microinverter

| | | | |
|--|---|---|-----|
| 1. Microinverter chassis is properly grounded per manufacturer's instructions [NEC 690.43(A), 250.4, 110.3(B)] | N | Y | N/A |
| 2. EGC is protected if smaller than #6 AWG [NEC 690.46, 250.120(C)] | N | Y | N/A |
| 3. Rapid Shutdown label is present and meets the requirements of NEC 690.56(C)(1)(a) | N | Y | N/A |

Note 1: Many items from the "Array" section also apply to the "Microinverter" section.

Note 2: Microinverters can have an integrated ground, or not. This information is found on the specification sheet.

Note 3: As long as the microinverters are listed, they are inherently equipped with rapid shutdown, which is required by NEC 690.12. This does not negate the label requirement in NEC 690.56(C)(1)(a).

4.7 AC Combiner

| | | | |
|---|---|---|-----|
| 1. The number of branch circuits match the plan set. | N | Y | N/A |
| 2. The conductors have sufficient ampacity for each branch circuit. | N | Y | N/A |
| 3. The Overcurrent Protective Device (OCPD) for the conductors have a rating sufficient to protect them [NEC 240.4] | N | Y | N/A |
| 4. Conduit penetrations are properly sealed between conditioned and unconditioned space [NEC 300.7(A)] | N | Y | N/A |
| 5. Conduit is properly supported e.g., [LFMC NEC 350.30, EMT NEC 358.30, PVC NEC 352.30] | N | Y | N/A |
| 6. Conduit is not being used as conductor support [NEC 300.11(B), 725.143] | N | Y | N/A |
| 7. The enclosure is properly grounded [NEC 690.43, 250.8, 250.12] | N | Y | N/A |
| 8. Grounding equipment is properly installed [NEC 690.43, 250.8, 250.12] | N | Y | N/A |
| 9. Enclosure is labeled as a disconnect [NEC 690.13] | N | Y | N/A |
| 10. AC characteristics label is present (voltage and amperage), [NEC 690.54] | N | Y | N/A |
| 11. The main breaker is fastened in place [NEC 408.36(D)] | N | Y | N/A |
| 12. Grounded conductors are isolated from enclosure [NEC 250.24(A)(5)] | N | Y | N/A |

4.8 Load-Side Connection

| | | | |
|---|---|---|-----|
| 1. Circuit conductors have sufficient ampacity [NEC 690.8, 310.15] | N | Y | N/A |
| 2. The AC OCPD is properly sized for the expected output current of the PV system. [NEC 690.9] | N | Y | N/A |
| 3. Grounded conductors properly identified [NEC 200.6(A), (B)] | N | Y | N/A |
| 4. The Grounding Electrode Conductor (GEC) is present and sufficiently sized [NEC 690.47(C), 250.66, 250.122, 250.166] | N | Y | N/A |
| 5. The GEC is continuous (or irreversibly spliced) [NEC 250.64(C), 690.47(C)] | N | Y | N/A |
| 6. Ferrous conduit and the enclosure are appropriately bonded to the GEC [NEC 250.4, 250.8, 250.12, 690.43] | N | Y | N/A |
| 7. PV breakers are properly identified [NEC 110.21(B), 705.10] | N | Y | N/A |
| 8. AC characteristics label is present and suitable for the environment (voltage and amperage) [NEC 690.54, 110.21(B)] | N | Y | N/A |
| 9. Dissimilar metals are separated and will not cause a galvanic reaction [(NEC 110.14, RMC NEC 344.14, EMT NEC 358.12(6))] | N | Y | N/A |
| 10. Inverter directory present [NEC 705.10] | N | Y | N/A |
| 11. Backfed breaker or fuse is sized to protect circuits [NEC 690.8(B)(1) and/or NEC 310.15] | N | Y | N/A |
| 12. Source breakers follow 120% rule [NEC 705.12(D)(2)(3)(b)] | N | Y | N/A |
| 13. Backfed breaker properly located in panel [NEC 705.12(B)(3)(b)] | N | Y | N/A |
| 14. Clearances maintained/live parts secured [NEC 110.27(A), 110.26] | N | Y | N/A |

4.9 Supply Side Connection

| | | | |
|---|---|---|-----|
| 1. Disconnect is service-rated and has a current rating of at least 60 Amp [NEC 230.79(D)] | N | Y | N/A |
| 2. Circuit conductors have sufficient ampacity [NEC 690.8, 310.15] | N | Y | N/A |
| 3. New service entrance tap conductors are less than 10 feet [NEC 705.31] | N | Y | N/A |
| 4. The AC OCPD is properly sized for the expected output current of the PV system [NEC 690.9] | N | Y | N/A |
| 5. The disconnect utility conductors are on LINE terminals [NEC 110.3(B), 240.40(if fusible)] | N | Y | N/A |
| 6. There is no OCPD in the grounded conductor [NEC 230.90(B)] | N | Y | N/A |
| 7. The AIC rating on the OCPD meets, or exceeds the rating of other main OCPD on the premises [NEC 110.9, 110.10] | N | Y | N/A |
| 8. The neutral (white or grey grounded conductor) is bonded to the PV disconnect enclosure/GEC [NEC 250.24(C)] | N | Y | N/A |
| 9. The GEC is present and sufficiently sized [NEC 690.47, 250.66] | N | Y | N/A |
| 10. The GEC is continuous (or irreversibly spliced) [NEC 250.64(C), 690.47(C)] | N | Y | N/A |
| 11. Ferrous conduit and the enclosure are appropriately bonded to the GEC [NEC 250.64(E), 250.4(A)(5)] | N | Y | N/A |
| 12. AC characteristics label is present and suitable for the environment (voltage and amperage) [NEC 690.54, 110.21(B)] | N | Y | N/A |
| 13. Power source directory is present, denoting all locations of power sources and disconnects on premises, at each service equipment location [NEC 110.21, 705.10] | N | Y | N/A |
| 14. AC disconnect label is present and suitable for the environment [NEC 690.13(B), 110.21] | N | Y | N/A |
| 15. Dissimilar metals are separated and will not cause a galvanic reaction [NEC 110.14, RMC NEC 344.14, EMT NEC 358.14] | N | Y | N/A |

4.10 General

| | | | |
|---|---|---|-----|
| 1. Work is done in a neat and workmanlike manner [NEC 110.12] | N | Y | N/A |
| 2. Working clearances are observed per NEC 110.26 | N | Y | N/A |
| 3. Equipment is visibility damaged | N | Y | N/A |

5. Resources

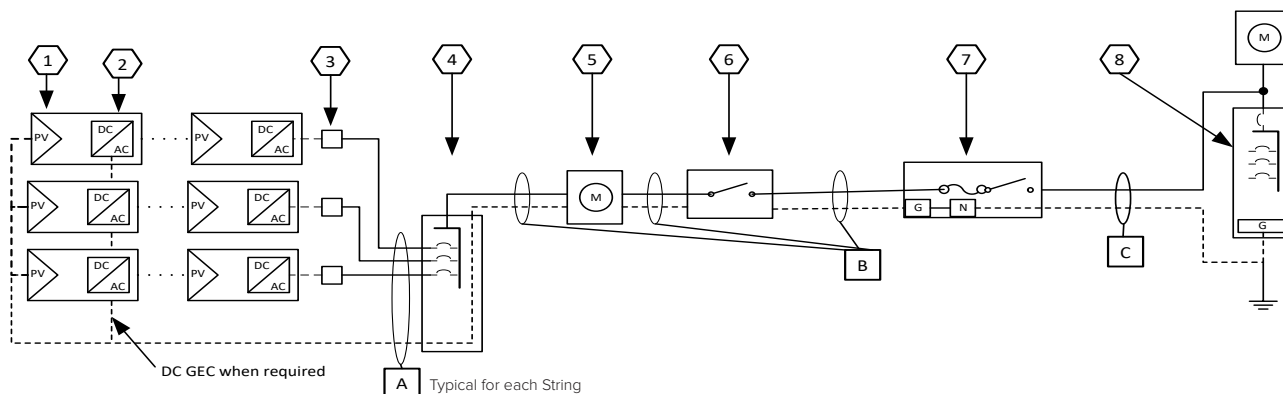
5.1 Sample Wiring Diagram 1: Microinverters with Supply Side Connection

| Equipment Schedule | |
|--------------------|--|
| TAG | DESCRIPTION: (Provide manufacturer and model number if applicable) |
| 1 | Solar PV Module or AC Module: (45) Trina TSM250PA05: (3) strings of (15) |
| 2 | Microinverter (if not ACM): (45) Enphase M250 |
| 3 | Junction Box(es): (3) Soladeck NEMA 3R, on roof |
| 4 | Solar Load Center, Yes / No: YES, 60 amps with (3) 20 amp breakers. |
| 5 | Performance Meter Yes / No: YES, online monitoring through Enphase Envoy unit |
| 6 | *Utility External Disconnect Switch Yes / No: Yes |
| 7 | Supply Side Disconnect with OCPD: Disconnect rating 60 amps. OCPD Rating 60 amps |
| 8 | Main Electrical Service Panel: Cutler-Hammer 200-amp bus, 200-amp main breaker |

Single Line Diagram for Microinverters, Optimizers or AC Modules

Refer to NEC 250.120 for EGC installation & Table 250.122 for sizing.

DC Rapid Disconnect (NEC 690.12) not required for microinverter systems, as DC conductors are under 5 feet.



Conductor, Cable, and Conduit Schedule

| Tag | Description and Conductor Type: (Table 3) | Conductor Size | Number of Conductors | Conductor/Cable Type | Conduit Size and Type |
|-----|--|----------------|----------------------|----------------------|-----------------------|
| A | Current carrying conductors (for each branch circuit): | #10 | 2 | THWN-2 | ½ inch EMT |
| | EGC: | #8AWG Cu | (1) | | |
| | GEC (when required): | n/a | | | |
| B | Current carrying conductors: | #6AWG Cu | (2) plus (1) Neutral | THWN-2 | ¾ inch PVC |
| | EGC: | #8AWG Cu | | | |
| | GEC (when required): | n/a | | | |
| C | Current carrying conductors: | #6AWG Cu | (2) plus (1) Neutral | THWN-2 | ¾ inch EMT |
| | EGC: | #8AWG Cu | (1) | | |
| | GEC (when required): | n/a | | | |

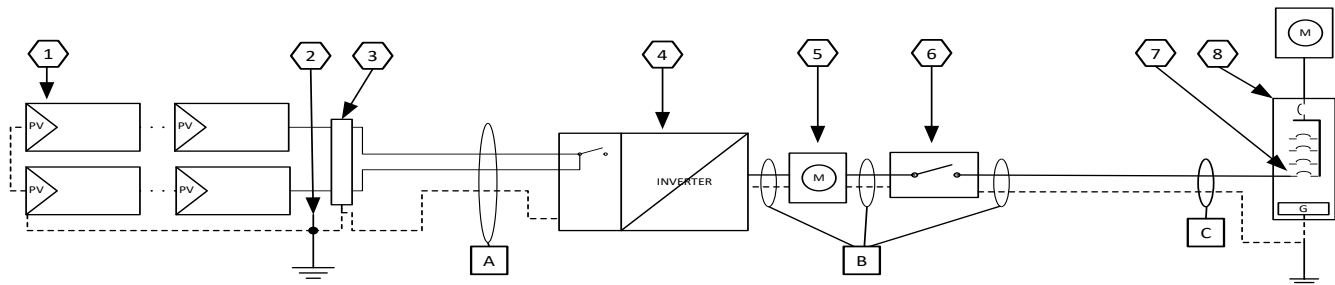
5.2 Sample Wiring Diagram 2: String Inverter with Supply Side Connection

Equipment Schedule

| TAG | DESCRIPTION: (Provide manufacturer and model # if applicable) |
|-----|---|
| 1 | Solar PV Module: (24) SolarWorld SW280 Mono, (2) strings of (12) |
| 2 | Grounding Electrode for Array |
| 3 | Junction Box(es): Soladeck NEMA 3R, on roof |
| 4 | Inverter Model: (1) Fronius Primo 6.0-1, Transformerless |
| 5 | Performance Meter Yes / No |
| 6 | *Utility External Disconnect, or AC disconnect grouped with inverter if not grouped with main service panel |
| 7 | Backfed AC breaker in Main Service Panel rating: 35 amps |
| 8 | Main Service Panel Main Breaker rating:200 amps; Bus Bar rating: 200 amps |

Single Line Diagram for String Inverter

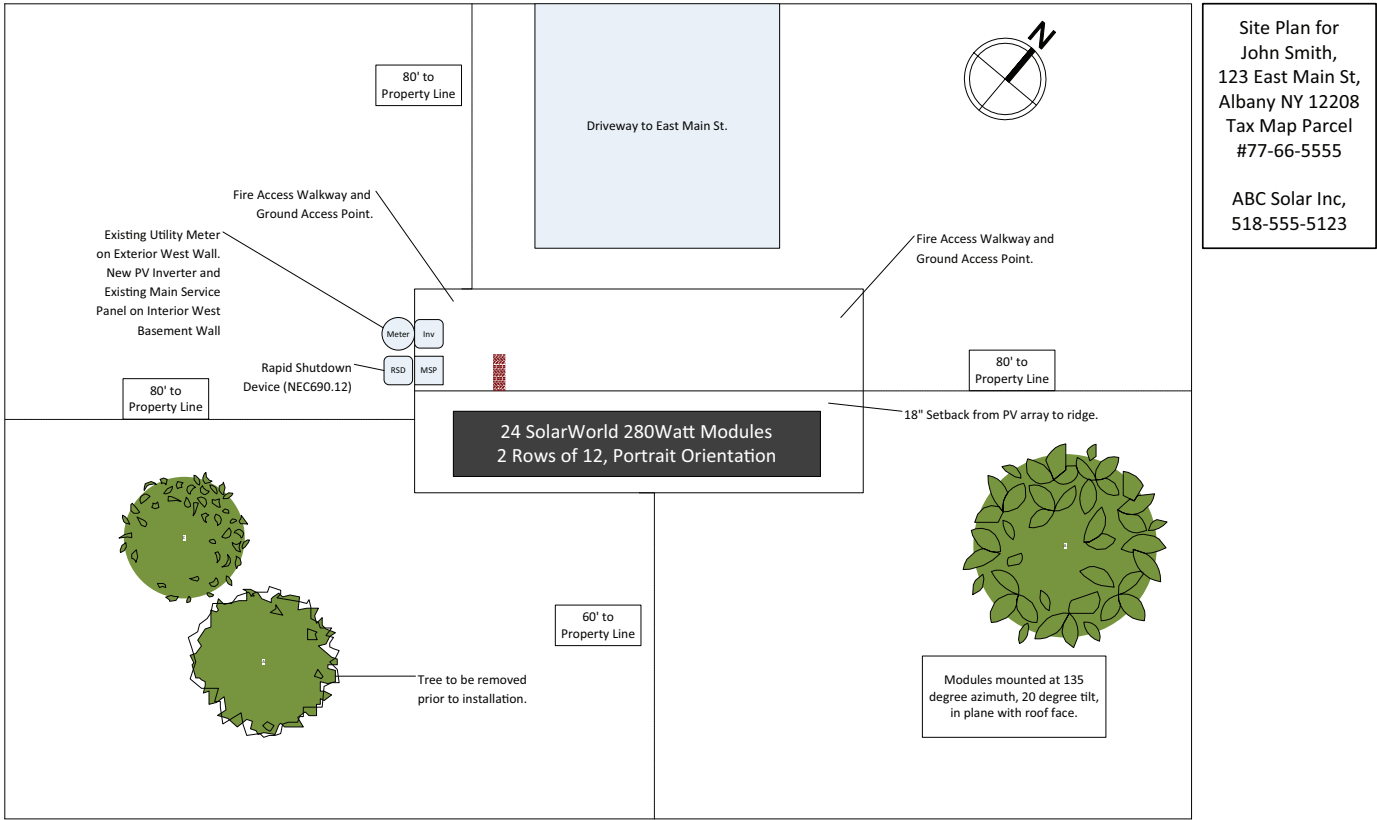
Refer to NEC 250.120 for EGC installation & Table 250.122 for sizing.



Conductor, Cable, and Conduit Schedule

| Tag | Description and Conductor Type: | Conductor Size | Number of Conductors | Conductor/Cable Type | Conduit Size and Type |
|-----|---------------------------------|----------------|----------------------|----------------------|-----------------------|
| A | Current carrying conductors: | #10AWG Cu | 2 | THWN-2 | ½ inch EMT |
| | EGC: | #10AWG Cu | 1 | | |
| | GEC (when required): | n/a | | | |
| B | Current carrying conductors: | #8AWG Cu | (2) plus (1) Neutral | THWN-2 | ¾ inch PVC |
| | EGC: | #10AWG Cu | | | |
| | GEC (when required): | n/a | | | |
| C | Current carrying conductors: | #8AWG Cu | (2) plus (1) Neutral | THWN-2 | ¾ inch EMT |
| | EGC: | #10AWG Cu | (1) | | |
| | GEC (when required): | n/a | | | |

5.3 Sample Site Map



6. Sample Photos

NYSERDA requires contractors participating in the NY-Sun program to provide construction photos. The photos in this chapter are illustrative examples only. Not all photos will apply to a given installation. Code enforcement officers may require construction photos from solar PV contractors to supplement or replace an in-person inspection. These example photos also help give a sense of solar PV system components and installation methods, and how they look when installed correctly.

6.1 Required Construction Photos for NY-Sun Incentive Program

6.1.1 Overview Photos

Home Address Verification

Guidance: Must show street number and be taken from a street view.

Inspection Items: Site address must match site address reported

Example Photos:



South Facing Horizon

Guidance: View of Horizon facing South (or whatever direction an array is facing) taken from behind the array illustrating presence or lack of potential shading issues.

Inspection Items: Site shading must match what was reported

Example Photos:



6.1.2 General Array Photographs

Pull Back Image of Array

Guidance: Wide angle shot or multiple images with clear reference point of each array so module count can be verified.

Inspection Items: Module and array count and must match what was reported

Example Photos:



Module Label Documentation

Guidance: Close up module label with model label legible.

Inspection Items: Module model must match what was reported

Example Photos:



6.1.3 Array Racking Photographs

Module Racking System Documentation

Guidance: Multiple angles of racking being used. Must provide pictures of complete array and sub-arrays. Pictures should be taken just before panels are installed to show all grounding and wire management.

Inspection Items: Racking system mechanical connections must be installed to manufacturer specifications

Example Photos:



Racking Roof Mounting System Documentation

Guidance: Photos must illustrate adequate flashing and sealing of racking attachments, that no vents or pipes are obstructed, and that roof is free of damage. For flat roofs, photos must include example of how vertical posts are secured to roof.

Inspection Items:

- Roof penetrations must be sealed and flashed to prevent moisture problems
- PV module and/or racking system must not obstruct open vent pipe(s) on roof
- No visible roof damage must be present

Example Photos:



Racking End Clip Documentation

Guidance: Photos should demonstrate the end clips are properly installed.

Inspection Items: Modules must be properly secured to the end of the racking system with end clips and sufficient clearance

Example Photos:



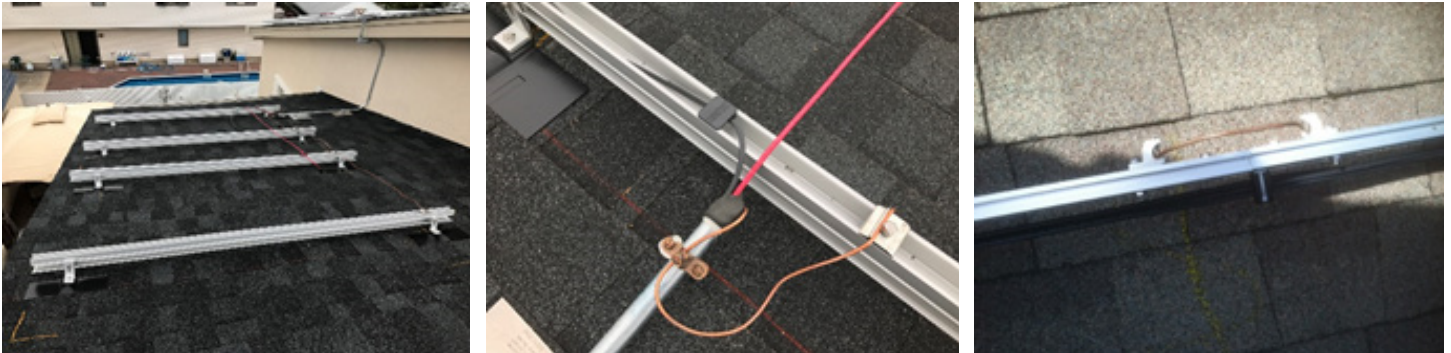
Racking System Grounding

Guidance: Photos should show there is a continuous ground path from all rails, sub-arrays, conduits, etc. Provide documentation for any self bonding rail systems. Provide a close up shot of EGC for size verification.

Inspection Items:

- Racking system and support structure must be grounded per manufacturer instructions
- Equipment grounding conductor must be larger than #6AWG or be protected from physical damage
- Electrical bonding means (e.g., bonding jumpers) must be present between rail sections

Example Photos:



6.1.4 Module Installation Photos

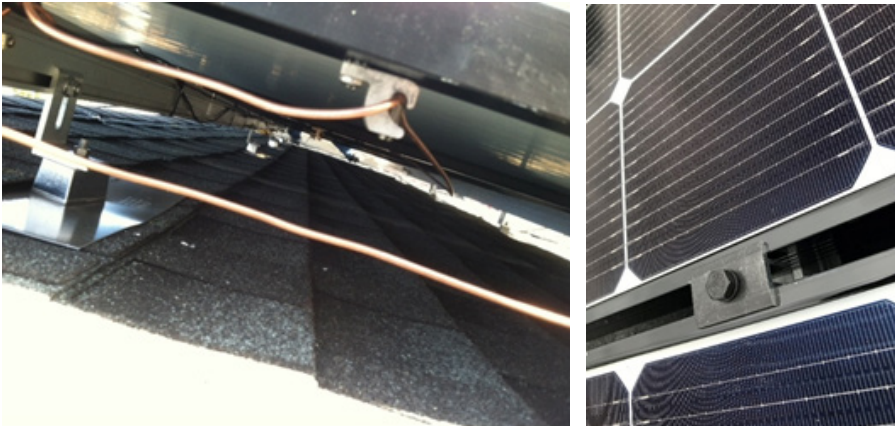
Module Grounding

Guidance: Demonstrate the bond between the module and rails by means of approved rail components or appropriate grounding hardware at each array. Provide documentation if necessary.

Inspection Items:

- Module grounding hardware must be present
- Module grounding hardware must be properly installed to effectively ground module frames; including solid contact between grounding device and metal of the module frames, at designated grounding points

Example Photos:



Wire Management of Modules (Under Array)

Guidance: Supply multiple pictures from all arrays showing proper wire management under arrays and entering conduit or junction boxes. Provide image of wire management device (clips, UV rated zip ties, etc.).

Inspection Items:

- Circuit conductors cannot be in contact with the roof and supported and secured at least every 4.5' and within 12" of every termination
- Wire ties/clips must be UV and/or outdoor rated
- Conductors cannot be installed with a bend radius less than 5 times the conductor diameter

Example Photos:



6.1.5 Conductor Conduit Photos

Conductor Support and Management

Guidance: Take pictures showing all conduit is properly supported. Include photos to illustrate thermal expansion fittings and frost sleeves are used when required. Include close-ups of fittings and connectors.

Inspection Items: Thermal expansion fitting must be present on raceways to compensate for expansion and contraction

- PV circuit conduit or raceway must be properly supported and secured
- Conduit below grade must be installed with provisions for movement (e.g., frost sleeve)
- Conduit fittings and connectors must be designed and listed for use

Example Photos:



Conduit Roof Top Penetrations

Guidance: Include photos that illustrate any roof penetrations for conduit pass through or securing are adequately sealed.

Inspection Items:

- Roof penetrations must be sealed and flashed to prevent moisture problems
- PVSC indoors in metal conduit

Example Photos:



Conduit Penetrations into Conditioned Space

Guidance: Include photos of conduit pass through into building to illustrate it is sealed.

Inspection Items: Conduit must have an approved internal sealant between conditioned and unconditioned spaces

Example Photos:



6.1.6 Junction/Combiner Box Photos

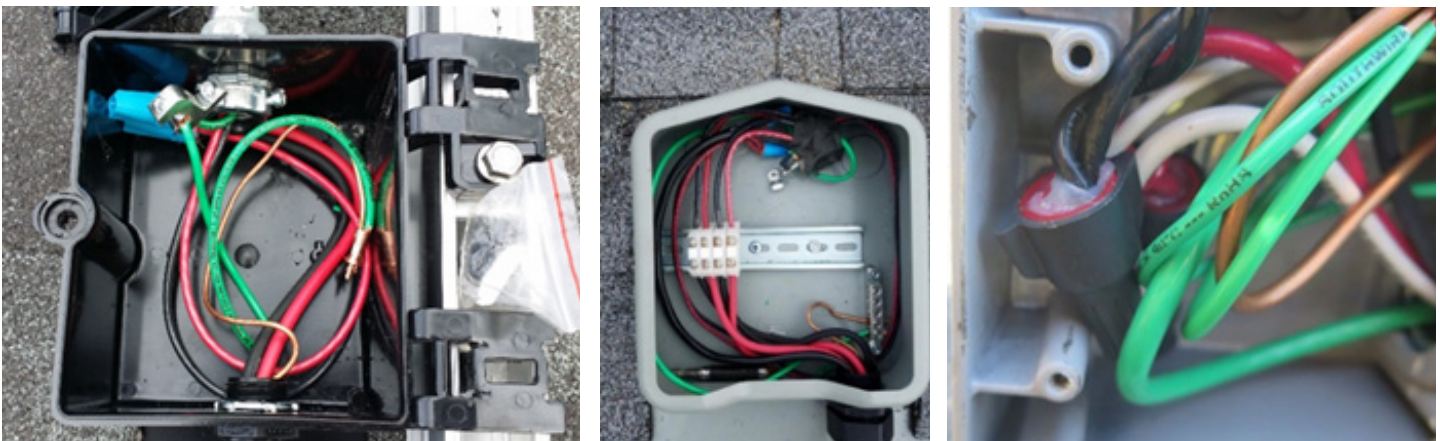
Internal Photo (cover off)

Guidance: Pictures should show proper grounding and components used for splices and transitions (i.e. terminal blocks, wire nuts etc.). Also show proper use of strain relief and submit pics of all Junction boxes on site

Inspection Items:

- Electrochemically dissimilar metals cannot be in direct physical contact
- Ferrous conduit and enclosures containing the grounding electrode conductor (GEC) must be electrically continuous or appropriately bonded to GEC
- Junction Box circuit conductors must be properly sized for expected current load
- Conduit fittings and connectors must be designed and listed for their use
- Thermal expansion fittings must be installed on raceways and conduit
- Grounded conductor must be identified properly as white or gray
- Junction Box splices and connections must be secure and of high integrity
- Junction Box splice components must be rated for environment
- Grounded conductor(s) must be insulated from metal enclosure surfaces and the ground terminal
- Equipment grounding conductor must be properly identified
- Junction Box must be properly grounded

Example Photos:



External Photo (cover on)

Guidance: Pictures should show proper labels close enough to verify language, wires are secured no more than 12” from junction box and should show proper use of strain relief. Include images for all junction/combiner boxes onsite.

Inspection Items:

- Junction Box must be properly guarded against accidental contact and/or physical damage and have proper working clearances
- Junction Box must be properly identified and listed
- Junction Box must be suitable for wet locations
- Junction Box must be properly secured in place

Example Photos:

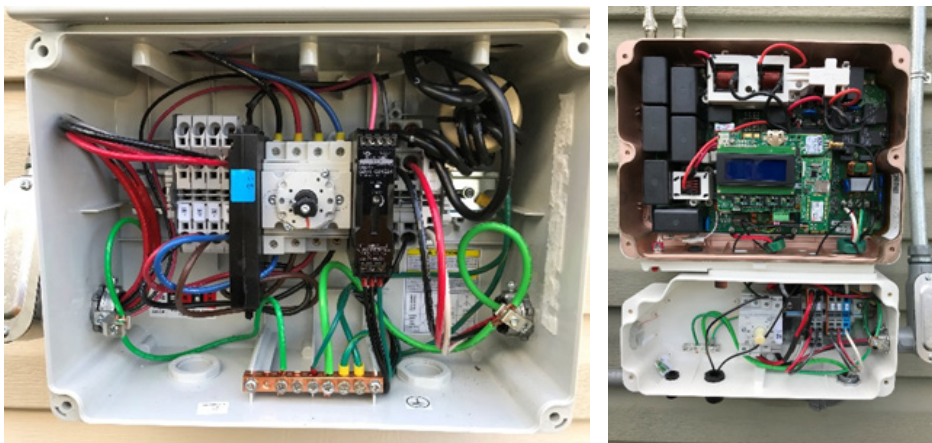


Guidance: Inverter showing correct wiring (AC and DC side) and grounding of inverter as well as conduits.

Inspection Items:

- Electrochemically dissimilar metals cannot be in direct physical contact
- Ferrous conduit and enclosures containing the grounding electrode conductor (GEC) must be electrically continuous or appropriately bonded
- Inverter DC grounded conductors and AC grounded conductors (neutral wires) must be correctly identified
- Conduit fittings and connectors must be designed and listed for use
- Inverter PV source conductors' ampacity must meet or exceed expected current load
- Inverter PV system AC output conductors ampacity must meet or exceed expected current load
- Inverter string fuses must be 600 or 1000 VDC (if applicable)
- Inverter metal enclosure must be properly grounded
- Inverter grounding electrode conductor must be present and sufficiently sized
- Equipment grounding conductor must be properly identified

Example Photos:



6.1.7 Inverter Photos

External Photo (with lid on)

Guidance: Photos showing proper labels installed, and proper working and manufacturer clearances are provided.

Inspection Items:

- Inverter detailed system information label must be present
- The completed installation appears to be neat and of good workmanship
- Inverter must be mounted in accordance with manufacturer instructions and its listing
- Inverter mounting location provides clearance required by the manufacturer
- Inverter Ground Fault warning label must be present

Example Photos:



Inverter Label Picture

Guidance: Close up photo clearly showing all data clearly legible

Inspection Items:

- Inverter model number must match what must be submitted to Salesforce
- PV array maximum DC string voltage complies with inverter maximum input voltage rating

Example Photos:



6.1.8 Balance of System

Balance of System Wall Photos

Guidance: A pulled back shot showing all BOS equipment. Take multiple shots if necessary.

Inspection Items:

- AC disconnect switch must be labeled with AC output information
- AC disconnect switch must be properly labeled as a photovoltaic system disconnect
- The completed installation appears to be neat and of good workmanship
- PV Service Disconnect must be be installed in accordance with its listing and manufacturer instructions
- Installed with appropriate working clearances and guarding from accidental contact
- AC Disconnect must be in a readily accessible location
- Service Disconnects must be properly grouped
- Permanent plaque or directory must be properly installed

Example Photos:



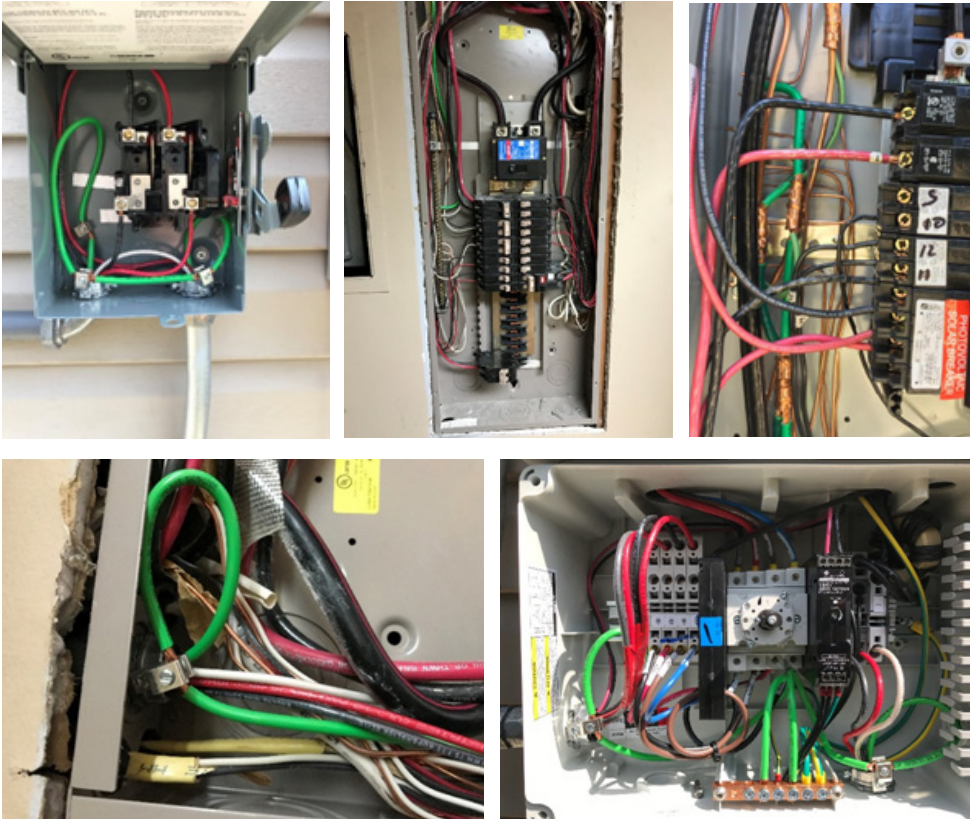
GEC Path Photos

Guidance: Sequence of photos showing the path of the GEC from the inverter(s) to the structure's GEC. Must show use of bond bushings and irreversible splices when used.

Inspection Items:

- Grounding electrode conductor must be present and sufficiently sized
- Grounding electrode conductor must be properly bonded to the main premise grounding electrode system
- Grounded conductor(s) must be bonded to the enclosure of the PV service disconnect through a listed grounding terminal or bus

Example Photos:



6.1.9 A/C Combiner

Internal Photos (cover off)

Guidance: Include photos to show correct wiring and grounding at all terminals. Include close ups of any breakers with rating visible.

Inspection Items:

- Ferrous conduit and enclosures must be either electrically continuous or bonded to the grounding electrode conductor
- Enclosure must be properly grounded using a listed grounding method
- AC Combiner overcurrent protection must be sufficient
- Grounded conductor(s) must be insulated from metal enclosure surfaces and the ground terminal inside combiner box
- Grounded conductor must be properly identified
- Ungrounded conductor must be properly identified
- Equipment grounding conductor must be properly identified
- Conduit or raceway must have adequate support
- AC Combiner circuit conductors must be properly sized for expected current load
- PV backfeed breaker must be sufficiently sized to prevent nuisance tripping
- Electrochemically dissimilar metals must not be in direct physical contact, which may lead to a galvanic reaction

Example Photos:



External Photo

Guidance: Include photos to show all labeling and enclosure ratings, with photos provided to allow wording and value verification.

Inspection Items:

- Integrated AC combiner/disconnect switch must be labeled with AC output information
- AC Combiner must be labeled to indicate presence of multiple sources
- The completed installation appears to be neat and of good workmanship
- AC Combiner must be suitable for wet locations
- AC Combiner must be properly secured in place
- AC Combiner must be installed with the appropriate clearances

Example Photos:



6.1.10 A/C Disconnect Photos

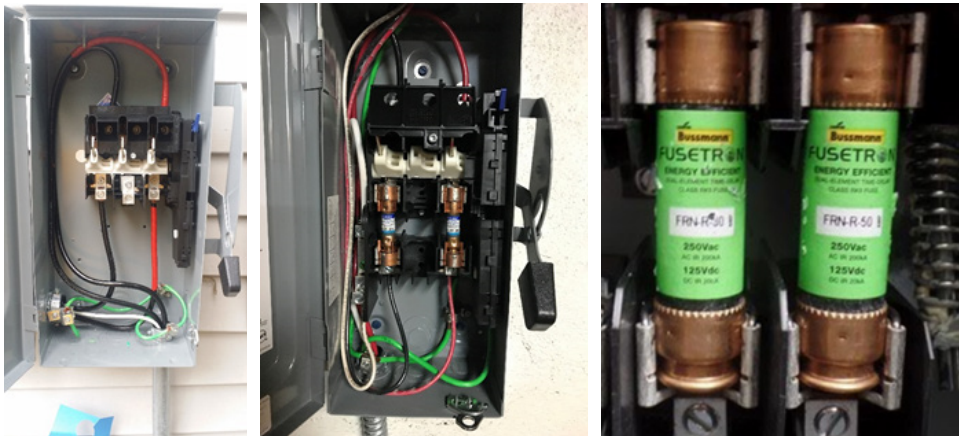
Interior Photo

Guidance: Show correct wiring and grounding. Make sure OCPD rating is clear and readable.

Inspection Items:

- AC Disconnect must be properly rated for expected current load
- Electrochemically dissimilar metals must not be in direct physical contact
- Disconnect terminals must be properly wired
- Ferrous conduit and enclosures must be either electrically continuous or appropriately bonded to GEC
- AC Disconnect Switch must be breaking the ungrounded conductor and keep the grounded conductor properly grounded and unenergized
- Ungrounded conductor must be properly identified
- Outdoor conductor insulation type must be rated for 90C and wet conditions
- Grounded conductor(s) must be insulated from metal enclosure surface and ground terminal inside Disconnect enclosure
- Equipment grounding conductor must be properly identified
- Enclosure must be properly grounded by a listed means
- AC Disconnect must be grounded
- Equipment grounding conductor must be properly sized
- Equipment grounding conductor must be larger than #6AWG or else it must be protected from physical damage
- Grounding electrode conductor must be sufficiently sized
- Grounding electrode conductor must be continuous
- AC Disconnect must be present when required to isolate equipment for service

Example Photos:



Exterior Photo

Guidance: Photos should allow for factory installed listings, and field installed label wording and values to be assessed.

Inspection Items:

- AC Disconnect switch must be properly labeled as a photovoltaic system Disconnect
- AC Disconnect switch must be labeled with AC output information
- The completed installation appears to be neat and of good workmanship
- AC Disconnect must be installed with the appropriate clearances
- AC Disconnect enclosure must be suitable for wet locations

Example Photos:



6.1.11 Main Panel Tie-In Pictures

Interior of Main Service Panel

Guidance: Take both close up and pulled back shots to correct wiring, grounding, and overcurrent protection (solar and main). Include clear shots of all splices for load and line side taps. Include a back-up photo showing circuit run to illustrate interconnection point/method.

Inspection Items:

- Main panel overcurrent protection must be sufficient
- PV system AC output conductors must be appropriately sized for expected current load
- Grounded conductor must be identified properly
- PV back feed breaker rating size must be properly sized to protect circuit conductors
- PV backfeed breaker must be sufficiently sized to prevent nuisance tripping
- Sum of back feed breaker(s) and main breaker must be less than or equal to 120% of busbar rating
- Inverter output connection must be properly located in main panel
- PV system AC output conductors must be appropriately sized for expected current load
- Enclosure must be properly grounded using a listed grounding method
- Equipment grounding conductor must be properly identified
- Grounding electrode conductor must be sufficiently sized
- Grounding electrode conductor must be properly bonded to the main premise's grounding electrode system
- GEC must be continuous/irreversibly spliced
- The completed installation appears to be neat and of good workmanship
- Grounded conductor(s) terminal lug must be properly installed in accordance with its listing

Example Photos:



Busbar label

Guidance: Include a clear photo(s) of the busbar rating of the main service panel or other enclosure where PV is connected.

Inspection Items: Sum of backfeed breaker(s) and main breaker must be less than or equal to 120% of busbar rating

Example Photos:



Exterior of Main Service Panel

Guidance: Include photos to show all labeling (manufacturer enclosure rating and field installed labels). Include photos with cover on, cover off, door open, and door closed.

Inspection Items:

- PV system backfeed breaker must be properly labeled as a photovoltaic system Disconnect
- AC Disconnect switch must be labeled with AC output information
- Main panel busbar must be labeled to indicate presence of multiple sources
- PV backfeed breaker(s) must be correctly labeled
- Permanent plaque or directory must be properly installed
- The completed installation appears to be neat and of good workmanship
- Main Panel must be properly secured in place
- Main Panel must be installed with the appropriate clearances

Example Photos:



6.1.12 If Applicable Photos

Pole Mounted Systems Photo

Inspection Items:

- All array conductors must be properly connected
- Thermal expansion fittings must be installed on raceways
- Conduit below grade must be installed with provisions for movement
- PV source and output circuits operating in readily accessible locations must be installed in a raceway
- Racking system and support structure must be properly grounded per manufacturer instructions
- The completed installation appears to be neat and of good workmanship
- Ground/pole mount support structure, anchor system, and or footings must be installed and used according to manufacturer instructions
- Outdoor wire ties/clips must be UV and outdoor rated

Metal Roof Grounding

Inspection Items: Metal roof beneath PV Array must be properly grounded

Battery Back-Up Photos

Inspection Items:

- Quantity of batteries present must match report quality to Salesforce
- Model of batteries must match model reported to Salesforce
- Working clearance maintained above and around battery bank
- Batteries must be properly ventilated
- Battery backup system voltage must be limited to 50VDC nominal
- Battery DC conductors must be protected from accidental contact
- Battery DC conductors must be properly sized for expected current load
- Battery DC conductor type complies code requirements
- Electrical equipment in all adjacent circuits must be protected from battery bank short circuit current
- Conduit fittings and connectors must be designed and listed for this use
- DC Disconnect must be present for ungrounded conductors of battery banks over 30V
- Batteries must be installed on non-conductive supports
- Grounded conductor must be properly identified

6.1.13 Overall Observation

Program

Inspection Items: Existing Panelboard does not meet Program Compliance

7. Sample Installation Errors

The following photos are examples of common yet serious installation errors. Each item presents a safety concern, a system performance issue, or both. For each of these installations, a certificate of completion had been issued by the AHJ.

Photo 1: Main service panel overloaded per NEC 705.12(B)(3)(b).

(100 amp main circuit breaker + 40 amps of PV) ÷ 100 amp bus rating >120%.



Photo 2: Backfed PV breaker not installed at opposite end of buss bar from main breaker: NEC 705.12(B)(3)(b)

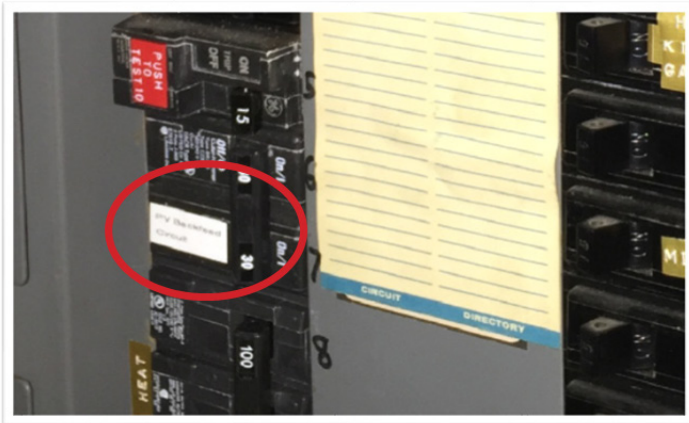


Photo 3: Working clearance not maintained: NEC 110.26



Photo 4: Equipment visibly damaged



Photo 5 - Conductors over 30V not guarded, installed in raceway, or otherwise inaccessible: NEC 690.31(A)



Photo 6: Roof penetrations and anchors not flashed, or improper flashing and sealing: 2020 NYS Uniform Code including applicable 2020 Building Code of NYS and NEC 110.3(B)



Photo 7: Where not protected from physical damage, equipment grounding conductor must be #6 or larger: NEC 690.46, 250.120(C). Conductors laying on asphalt shingles will become damaged and will not last a PV system's expected 30-year lifespan.

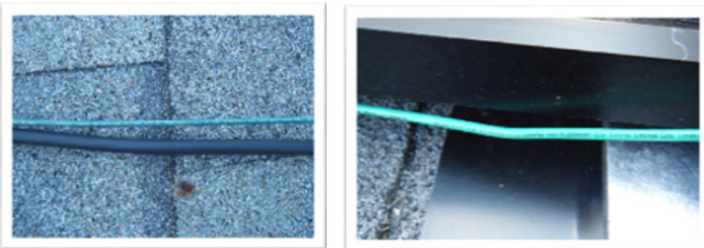


Photo 8: Source circuit conductors in contact with roof: NEC 338.10, 334.30



Photo 9: Equipment is not rated for location. In this case, a non-GFCI outlet for PV monitoring equipment is located in a wet location: NEC 110.3(B), 210.8(A)(3)



Photo 10: DC Conductor in contact with sharp edge: NEC 334.15(B)



Photo 11: AC disconnect/load center manufacturer's label obscured: NEC 110.21



Photo 12: Conductors entering conditioned space must be sealed: NEC 300.7



Photo 13: Two Hole conduit strap, with only one point of attachment, and no strain relief on conductors: NEC 110.3(B)



Photo 14: Failure to torque the lugs to the manufacturers specification: NEC 110.14(D)



8. Solar PV System Labeling Guidelines

Technical Bulletin: NYSERDA Solar Photovoltaic System Labeling Guidelines

8.1 Scope and Purpose

This document was prepared as part of NYSERDA's ongoing quality assurance (QA) for the NY-Sun Solar Photovoltaic (PV) program.

As part of this QA program, NYSERDA and their contractors have performed thousands of inspections on solar PV systems installed in New York State since January 1, 2012. Many of these inspections have found issues related to incorrect, incomplete, or missing labels on installed equipment. The NEC, OSHA and ANSI provide guidelines for required labels. However, these guidelines are not necessarily organized in an easy to use manner and make it difficult for system installers to get a clear understanding of labeling requirements for solar PV systems.

The purpose of this document is to provide participating installers and other stakeholders with a summary of the required labels for the most common PV system configurations.

Unless otherwise noted, this bulletin is based on the 2017 edition of the NEC.

8.2 Overview of Label Locations and Requirements

| System Component | Required Labels |
|--|---|
| Combiner Box / Circuits / Conduit Combiner Box / Enclosures / EMT Enclosures | PV Disconnect [NEC 690.13(B)] |
| | Guarding of Live Parts [NEC 110.27(C)] |
| Building / Structure | Power Source Directory [NEC 705.10, 690.56(B)] |
| EMT / Conduit Raceways | Wiring Methods [NEC 690.13(G)(3)(4)] |
| | Embedded in Building Surfaces [NEC 690.31(G)(1)] |
| Inverter | Bipolar PV Systems [NEC 690.31(I)] |
| | Interactive System Point of Interconnection [NEC 690.54] |
| Production / Net Meter (Bi-directional) | Point of Connection [NEC 690.59] |
| AC Disconnect / Breaker / Points of Connection | PV Disconnect [NEC 690.13(B)] |
| | Identification of terminals [NEC 690.52] |
| | AC Characteristics [NEC 690.54] |
| Break Panel / Pull Boxes | PV Disconnect [NEC 690.13(B)] |
| | Guarding of Live Parts [NEC 110.27(C)] |
| | Interactive System Point of Interconnection [NEC 690.54] |
| Main Service Disconnect | Single 120-Volt Supply / Overcurrent Protection [NEC 710.15(C), 692.9(C)] |
| | Connector Disconnect Warning [NEC 690.15(C), 690.33(E)(2)] |
| | Type of Disconnect [NEC 690.13(F), 705.12(B)(3-4), 690.59] |
| | Dual Power Source [NEC 705.12(B)(3-4), 690.59] |
| | PV Disconnect [NEC 690.13(B)] |
| | Guarding of Live Parts [NEC 110.27(C)] |

8.3 Label Construction, Placement, Color, and Marking

8.3.1 Materials and Construction

Labeling used outdoors must be of durable construction and intended to withstand conditions including high temperatures, UV exposure, and moisture as required by NEC 110.21(B)(3). Heavy duty UV resistant vinyl, metal, or plastic may all be suitable materials, depending on the specific product ratings. Installers should also consider the label attachment method (e.g., adhesive) when considering longevity and are encouraged to review ANSI Z535.4-2011 for guidance on selecting the appropriate labeling and adhesive materials.

8.3.2 Placement

It is a violation of an enclosure's UL listing (and NEC 110.3(B)) to cover any existing manufacturer applied labels with installation specific labels, so this should be avoided. Additionally, it is highly recommended that the installer attaches a label or magnet with the company name and contact information at the inverter or interconnection point for easy reference.

8.3.3 Colors

Label colors are chosen per OSHA 29 CFR 1910.145 direction that the requirements of ANSI Z535.4-2011 be used.

NFPA 70 (NEC) is driven by NFPA 1 (Fire Code) which provides specific colors and characteristics for certain labels as required by the NEC, so these requirements over rule the referenced ANSI standards in these cases, as noted in this Technical Bulletin and the text of the NEC.

8.3.4 Marking

Marking on labels for system specific values, such as short circuit current, shall not be hand-written and must be legible, as required by NEC 110.21(B)(2). Marking may be achieved by means of engraving or use of a long-lasting ink or paint as part of the printing process.

8.4 Label Descriptions and NEC References

There are various articles in the NEC that require labeling for PV systems. Many of the specific requirements are found in Article 690, Solar Photovoltaic Systems. Additional requirements are found in Article 110: Requirements for Electrical Installations; Article 200: Use and Identification of Grounded Conductors; Article 225: Outside Branch Circuits and Feeders; Article 230: Services; and Article 705: Interconnected Electric Power Production Sources.

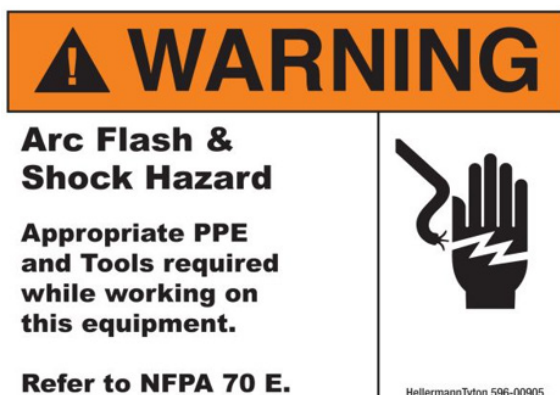
8.4.1 Arc-Flash Hazard Warning

NEC 110.16 Flash Protection

Electrical equipment such as switchboards, panel boards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked or factory marked to warn qualified persons of potential electric arc flash hazards. The marking shall meet the requirements in 110.21(B) and be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

Figure 1

Note: does not apply to residential PV systems



Directory / Identification of Power Sources

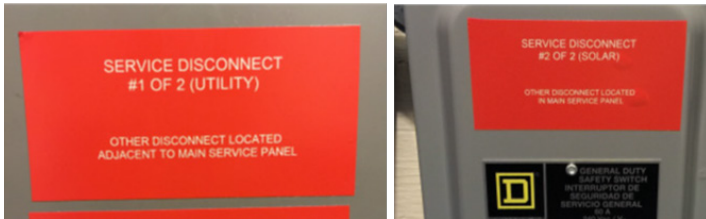
A directory identifying the solar system and other power sources on site should be placed at service equipment and state the location of system disconnecting means. The NEC stipulates this requirement in the following articles:

NEC 705.10 Directory

A permanent plaque or directory, denoting all electric power sources on or in the premises, shall be installed at each service equipment location and at locations of all electric power production sources capable of being interconnected.

Exception: installations with large numbers of power production sources shall be permitted to be designated by groups.

Figure 2



NEC 230.2(E) Identification

Where a building or structure is supplied by more than one service, or any combination of branch circuits, feeders, and services, a permanent plaque or directory shall be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building or structure and the area served by each. Note that NEC 225.37 has similar requirements.

Figure 3



NEC 705.70 Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations

Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. In these cases, inverter location must be noted in the directory required by NEC 705.10, described above.

8.4.2 Conductor Identification and Grouping

NEC 310.110 Conductor Identification

This Article specifies the acceptable conductor marking methods for:

- Grounded conductors: NEC 200.6 (see below)
- Equipment grounding conductors: NEC 250.119 (see below)
- Ungrounded conductors: Shall be distinguishable from grounded and grounding conductors, with reference to NEC 310.120 for manufacturer-applied markings

NEC 690.31(B) Identification and Grouping

PV system conductors shall be identified and grouped as required by 690.31(B). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

1. **PV Source Circuits.** PV source circuits shall be identified at all points of termination, connection, and splices.
2. **Grouping.** Where the conductors of more than one PV system occupy the same junction box or raceway with a removable cover(s), the AC and DC conductors of each system shall be grouped separately by wire ties or similar means at least once, and then shall be grouped at intervals not to exceed 1.8 m (6 feet).

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious.

NEC 690.31 (G) (1) Embedded in Building Surfaces

Where 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 using a marking protocol that is approved as being suitable for continuous exposure to sunlight and weather.

NEC 200.6 Means of Identifying Grounded Conductors

(A) **Sizes 6 AWG or Smaller.** An insulated grounded conductor 6 AWG or smaller shall be identified by one of the following means:

1. A continuous white outer finish.
2. A continuous gray outer finish.
3. Three continuous white stripes along the conductor's entire length on other than green insulation.
4. Wires that have their outer covering finished to show a white or gray color but have colored tracer threads in the braid identifying the source of manufacture shall be considered as meeting the provisions of this section.

(B) **Sizes 4 AWG or Larger.** An insulated grounded conductor 4 AWG or larger shall be identified by one of the following means:

1. A continuous white outer finish.
2. A continuous gray outer finish.
3. Three continuous white stripes along the conductor's entire length on other than green insulation.
4. At the time of installation, by a distinctive white or gray marking at its terminations. This marking shall encircle the conductor or insulation.

Note: Tape or similar marking means are only code-compliant on large (4 AWG or larger) conductors. Smaller diameter conductors cannot be field-identified in this way.

NEC 200.7 Use of Insulation of a White or Gray Color or with Three Continuous White or Gray Stripes

The following shall be used only for the grounded circuit conductor, unless otherwise permitted in 200.7(B) and (C):

1. A conductor with continuous white or gray covering
2. A conductor with three continuous white or gray stripes on other than green insulation
3. A marking of white or gray color at the termination

Note: PV systems utilizing transformerless (ungrounded) inverters do not ground either polarity of the PV array conductors. Therefore, conductors in these circuits cannot have insulation colored white or gray.

Figure 4



NEC 250.119 Identification of Equipment Grounding Conductors

Unless otherwise required, equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes. Conductors with these color schemes shall not be used for grounded or ungrounded circuit conductors.

8.4.3 Identification of PV Disconnects

NEC 690.13(B) Marking

Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked “PV SYSTEM DISCONNECT” or equivalent.

Note: This requirement applies to both AC and DC disconnects. The International Fire Code (IFC) recommends labels that identify the main service disconnect or critical disconnects with reflective, red and white labels (IFC 605.11).

Figures 5



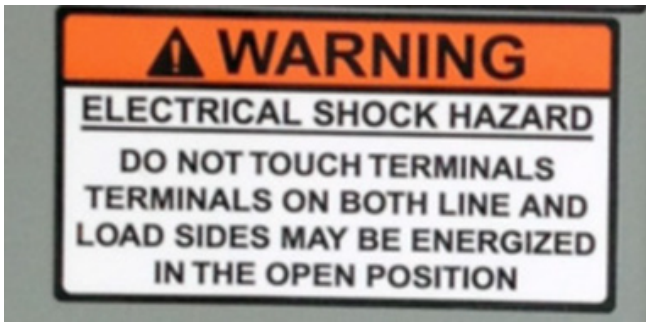
8.4.4 Terminals Energized on Line and Load Sides of Disconnect in Open Position

NEC 690.13(B) Switch or Circuit Breaker

Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked “PV SYSTEM DISCONNECT” or equivalent. Additional markings shall be permitted based upon the specific system configuration. For PV system disconnecting means where the line and load terminals may be the open position, the device shall be marked with the following words or equivalent:

WARNING
ELECTRIC SHOCK HAZARD.
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE AND LOAD SIDES
MAY BE ENERGIZED IN THE OPEN POSITION.

Figure 6



Note: This requirement does not apply to AC disconnects for any inverter Listed to UL 1741

8.4.5 DC PV Source and Output Circuits Inside a Building

NEC 690.31(G) (3) Marking and Labeling Required

The following wiring methods and enclosures that contain PV system dc circuit shall be marked with the wording “WARNING: PHOTOVOLTAIC SOURCE” by means of permanently affixed labels or other approved permanent marking:

1. Exposed raceways, cable trays, and other wiring methods
2. Covers or enclosures of pull boxes and junction boxes
3. Conduit bodies in which any of the available conduit opening are unused

Figure 7



NEC 690.31 (G) (4) Marking and Labeling Methods and Locations

The labels or markings shall be visible after installation. The labels shall be reflective, and all letters shall be capitalized and shall be minimum height of 9.5mm (3/8in) in white on a red background. PV system dc circuit labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 3 m (10 feet). Labels required by this section shall be suitable for the environment where they are installed.

Note: Although the ANSI standard directs that these types of labels have different coloring, the NEC has been driven by fire codes and thus specifies characteristics explicitly for these applications.

Figure 8



8.4.6 DC Photovoltaic Power Source

NEC 690.53 Direct-Current Photovoltaic Power Source

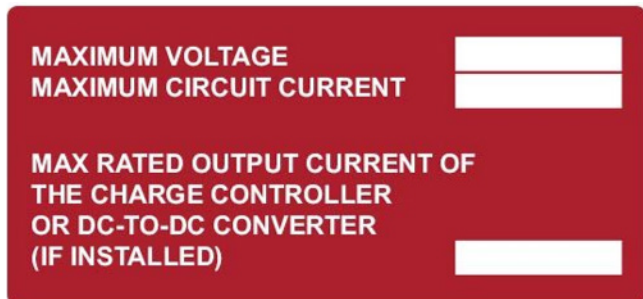
A permanent label for the dc PV power source indicating the information in (1) through (3) shall be provided by the installer at dc PV system disconnecting means and at each dc equipment disconnect means required by NEC 690.15. Where disconnecting means has more than one dc PV power source, the values in NEC 690.53(1) through (3) shall be specified for each source.

- (1) Maximum voltage
- (2) Maximum circuit current
- (3) Maximum rated output current of the charge controller or dc-to-dc converter (if installed)

Informational Note to (1): See 690.7 for voltage

Informational Note to (2): See 690.8(A) for calculation of maximum circuit current

Figure 9



8.4.7 Identification of PV System Interconnection

NEC 690.54 Interactive System Point of Interconnection

All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated AC output current and the nominal operating AC voltage.

Note: Examples of points of interconnection are AC combining panels, AC disconnects, backfed breakers at point of utility interconnection, etc. This requirement does not apply only to the point of common coupling for the PV system and the utility grid.

Figure 10



8.4.8 Identification of Power Sources

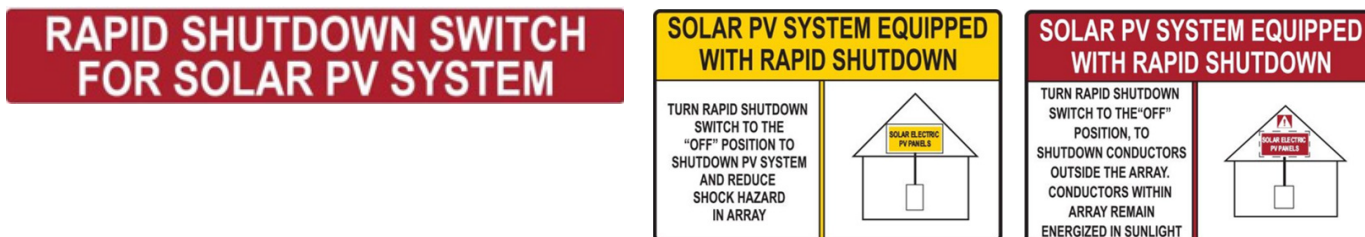
NEC 690.56 Identification of Power Sources

(A) Facilities with Stand-Alone Systems. Any structure or building with a PV power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location acceptable to the authority having jurisdiction. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system.

(B) Facilities with Utility Services and PV Systems. Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory in accordance with NEC 705.

(C) Buildings with Rapid Shutdown. Buildings with PV systems shall have permanent labels as described in 690.56 (C)(1) through (C)(3).

Figure 11



The plaque or directory shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm (3/8 inch), in white on red background.

Note: Although the NEC does not explicitly define a location for this labeling, it is suggested that one be located at the main service disconnect for the utility, and one at the inverter location, or the location of the 'rapid shutdown' initiator if different.

8.4.9 Point of Connection Identification

NEC 705.12(A) or (B)

The output of an interconnected electric power source shall be connected as specified in NEC 705.12(A) or (B).

Figure 12



8.4.10 NEC 408 Switchboards, Switchgear, and Panelboards

408.4 Field Identification Required

(A) Circuit Directory or Circuit Identification.

It is important to properly complete the circuit directory, as required by NEC 408.4(A). These directories are generally found on the inside of panelboard cover doors and if there is not one present prior to the PV installation, it is the installer's responsibility to add one and properly document the relevant PV system-associated breakers.

Figure 13



8.5 Common Labeling Mistakes to Avoid

Do not cover manufacturer's labeling with other labels (NEC 690.13(B), 110.21(B)).

Figure 14



Figure 15



Make sure labels are permanent and suitable for use in the environment to which it will be exposed. In this example, these light duty adhesive labels will not withstand 20+ years of wind, sun and rain, and are in violation of NEC 110.21.

Figure 16



Label Not of Permanent Construction, nor conforming with NEC 690.31(G)(4).

Figure 17



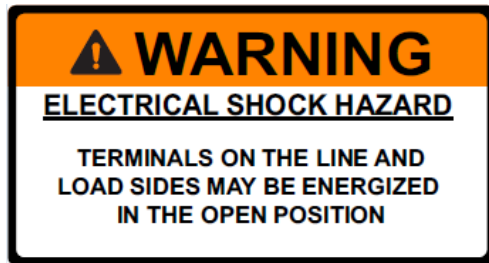
9. Example Labels

The following pages provide example NEC-compliant labels based on NEC required/recommended text as well as their related code articles.

While the use of these labels on NY-Sun-funded solar PV projects is encouraged; final selection, preparation, and placement of labels in compliance with the NEC and other relevant codes is the responsibility of the installer.

- 1) All labeling used outdoors must be engraved metal, UV stabilized engraved plastic or of a material sufficiently durable to withstand the environment involved. Values hand written or in written in marker are not acceptable per NEC.
- 2) Labels used indoors may be made of durable vinyl or paper
- 3) Do not cover any existing manufacturer applied labels with installation specific labels
- 4) Label colors chosen per NEC directs that ANSI Z535-2011 be used
- 5) Requirements comply with the NEC
- 6) Additionally, it is highly recommended that the installer attach a label with the company name and contact information at the inverter
- 7) All warning signs or labels shall comply with NEC 110.21(B)

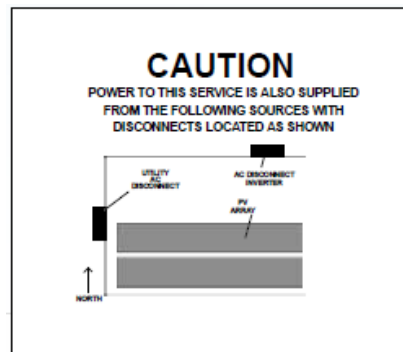
Label #1
NEC 690.13(B)



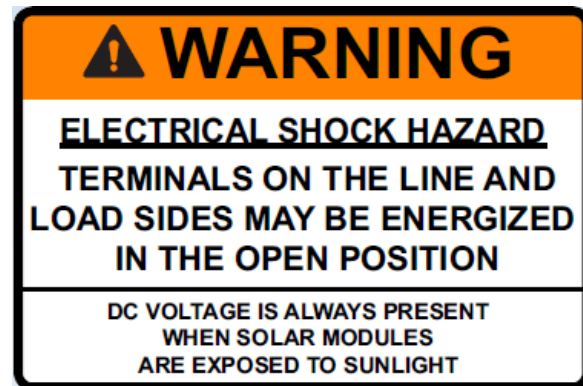
Label #2
NEC 110.27(C)



Label #3
NEC 705.10 & 690.56(B)



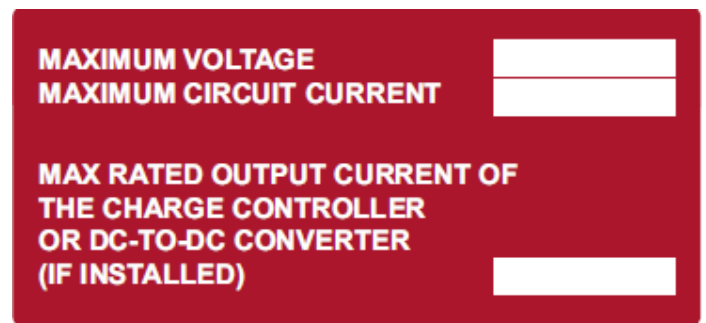
Label #4
NEC 690.13(B)



Label #5
NEC 690.13(B)



Label #6
NEC 690.53



Label #7

NEC 690.31(G)(3)(4)

**WARNING: PHOTOVOLTAIC
POWER SOURCE**

Label #8

NEC 705.12(D)(3) & 690.59

**⚠ WARNING DUAL POWER SOURCE
SECOND SOURCE IS PHOTOVOLTAIC SYSTEM**

Label #9

NEC 690.13(B)

**PHOTOVOLTAIC
AC DISCONNECT**

Label #10

NEC 690.13(B)

⚠ WARNING
ELECTRICAL SHOCK HAZARD
**TERMINALS ON THE LINE AND
LOAD SIDES MAY BE ENERGIZED
IN THE OPEN POSITION**

Label #11

NEC 690.52

NOMINAL OPERATING AC VOLTAGE
NOMINAL OPERATING AC FREQUENCY
MAXIMUM AC POWER
MAXIMUM AC CURRENT
MAX OVERCURRENT DEVICE RATING
FOR AC MODULE PROTECTION

Label #12

NEC 690.54

PHOTOVOLTAIC AC DISCONNECT
RATED AC OUTPUT CURRENT:
NOMINAL OPERATING AC VOLTAGE

Label #13

NEC 690.3(I)

⚠ WARNING
**THE DISCONNECTION OF THE
GROUNDED CONDUCTOR(S)
MAY RESULT IN OVERVOLTAGE
ON THE EQUIPMENT**

Label #14

NEC 710.15(C) & 692.9(C)

⚠ WARNING
**SINGLE 120-VOLT SUPPLY
DO NOT CONNECT
MULTIWIRE BRANCH CIRCUITS**

Label #15

NEC 690.15(C) & 690.33(E)(2)

**DO NOT DISCONNECT
UNDER LOAD**

Label #16

NEC 690.13(F), 705.12(B)(3-4), & 690.59

⚠ CAUTION
PHOTOVOLTAIC SYSTEM CIRCUIT IS BACKFED

Label #17

NEC 705.12(B)(3-4) & 690.59

**⚠ WARNING DUAL POWER SOURCE
SECOND SOURCE IS PHOTOVOLTAIC SYSTEM**

Label #18

NEC 705.12(B)(2)(c)



Label #19

NEC 690.13(B)



10. Top Deficiencies in Solar Electric Systems

In order to provide a summary of common PV system installation issues and help the New York solar industry prioritize education and process improvement, the NY-Sun program has compiled the results of 287 recent PV system inspections. The summaries below are generated from PV installations within a three-month time period based on the 2014 National Electrical Code (NEC). The chart shows that the most frequent violation is Labeling. The table provides an overview of the 9 most common deficiencies found with the top five categories being, Labeling, Grounding, Conductors, Conduit, and Structural. For each category, the list shows the most prevalent violations.

10.1 Likelihood of Finding Installation Issues

In order to prioritize inspection issues, we have calculated what percent of sites have one or more issues in each of the categories below. For example, 78% of inspected sites had at least one Labeling issue.

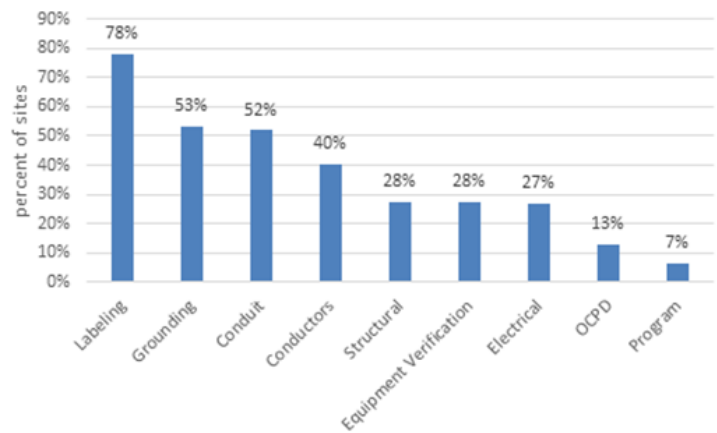
10.2 Deficiency Description

In order to prioritize efforts to improve quality, we have categorized the types of installation deficiencies found into several descriptive categories. As shown in Figure 1, labeling violations are by far the most common deficiency. This is most likely due to the complexity of the NEC, changing code articles, and new requirements (cannot be hand-written, exact size/coloring of certain labels, reflectivity, etc.). Grounding issues were the next most common violation. After the labeling and grounding issues, conduit and conductor violations are the most prevalent.

Table 1. Deficiency Description Categories

| Deficiency | Includes |
|------------------------|--|
| Labeling | Methods and materials for marking PV system components to provide nearby personnel with pertinent system information and warnings |
| Grounding | Portions of the installation used to reference system components to earth potential, including metallic components such as racking |
| Conduit | Methods and materials related to installation of conduit |
| Conductors | Methods and materials related to conductor installation |
| Structural | Non-electrical installation issues related to mechanical execution of work on equipment mounting, building penetrations |
| Equipment Verification | Confirmation that equipment installed matches equipment included in project application materials to NYSERDA |
| Electrical | Uncategorized electrical installation issues |
| OCPD | Installation issues related to overcurrent devices, such as fuses and circuit breakers |
| Program | Installation methods and materials that are not compliant with NY-SUN program requirements but not necessarily non-compliant with pertinent codes or standards |






Figure 1. Likelihood of PV System Installation Issues by Category



10.2.1 Labeling Deficiencies: 78% of Systems Inspected

Below, we have summarized the top 5 deficiencies found related to labeling.


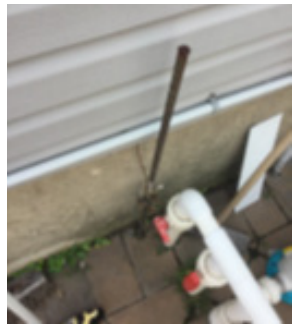
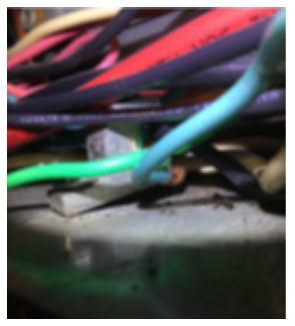
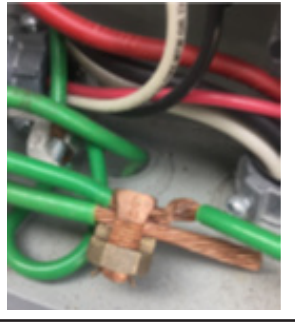

Table 2. Top Labeling Deficiencies

| Rank | System Component | Deficiency Description | Example |
|------|------------------------|---|---|
| 1 | Supply Side Connection | Service Disconnect label with AC output information is missing, incomplete, or not suitable for the environment, in violation of NEC Article 690.54 and/or 110.21. Label: Rated AC output current: ____AAC Nominal operating AC voltage: ____VAC |  |
| 2 | Inverter | Inverter information label is missing, incomplete, or unsuitable for the environment, in violation of NEC Article 690.53. Label: Rated maximum power-point current (Imp): ____ADC Rated maximum power-point voltage (Vmp): ____VDC Maximum system voltage (Voc): ____VDC Short-circuit current (Isc): ____ADC Maximum rated output current of charge controller (if installed): ____ADC |  |
| 3 | AC Combiner | Integrated AC combiner/disconnect switch label with AC output information is missing, incomplete, or not suitable for the environment in violation of NEC Article NEC 690.54. Label: Rated AC output current: ____AAC Nominal operating voltage: ____VAC |  |
| 4 | Supply Side Connection | Permanent plaque or directory denoting location of all power sources and location of disconnects on premise at each service equipment location is missing, incomplete, or unsuitable for the environment, in violation of NEC Articles 705.10, 690.56 and/or 110.21. |  |
| 5 | AC Disconnect | AC Disconnect label with AC output information is missing, incomplete, or not suitable for the environment, in violation of NEC Article 690.54. Label: Rated AC output current: ____AAC Nominal operating voltage: ____VAC |  |

10.2.2 Grounding Deficiencies: 53% of Systems Inspected

Below, we have summarized the top 5 deficiencies found related to Grounding.



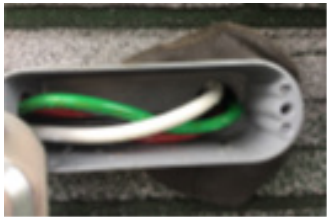


Table 3. Top Grounding Deficiencies

| Rank | System Component | Deficiency Description | Example |
|------|------------------------|--|---|
| 1 | Supply Side Connection | Grounded (neutral) conductor is not properly bonded to PV service disconnect enclosure using a listed grounding bus or terminal, or the grounded conductors are not properly bonded to the Grounding Electrode Conductor (GEC), in violation of NEC Article 250.24(C). |  |
| 2 | Supply Side Connection | The top of the grounding electrode is not flush with, or below, ground level in violation of NEC Article 250.53(G). |  |
| 3 | AC Disconnect | Enclosure is not properly grounded using a listed grounding method, in violation of NEC Articles 690.43, 250.8, and 250.12. Enclosure must be grounded with equipment listed for the purpose and that is solidly connected to the enclosure body. |  |
| 4 | Supply Side Connection | The GEC is not continuous or irreversibly spliced, in violation of NEC Articles 250.64(C) and 690.47(C). Allowable means of splicing the GEC include compression crimp and exothermic welding processes. |  |
| 5 | AC Combiner | Enclosure is not properly grounded using a listed grounding method, in violation of NEC Articles 690.43, 250.8, and 250.12. Enclosure must be grounded with equipment listed for the purpose and that is solidly connected to the enclosure body. |  |

10.2.3 Conduit Deficiencies: 52% of Systems Inspected

Below, we have summarized the top 5 deficiencies found related to Conduits.



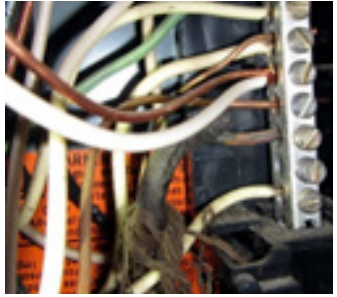


Table 4. Top Conduit Deficiencies

| Rank | System Component | Deficiency Description | Example |
|------|------------------------|---|---|
| 1 | Supply Side Connection | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation, in violation of NEC Article 300.7(A). |  |
| 2 | Inverter | Conduit is improperly used to support conductors, in violation of NEC Article 300.11(B). |  |
| 3 | AC Disconnect | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation in violation of NEC Article 300.7(A). |  |
| 4 | Supply Side Connection | Circuit conduit or raceway lacks adequate support, in violation of NEC (LFMC-350.30, EMT-358.30, Metal Trough-376.30). |  |
| 5 | Array | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation, in violation of NEC Article 300.7(A). |  |

10.2.4 Conductor Deficiencies: 40% of Systems Inspected

Below, we have summarized the top 5 deficiencies found related to Conductors.

Table 5. Top Conductor Deficiencies

| Rank | System Component | Deficiency Description | Example |
|------|------------------------|---|---|
| 1 | Supply Side Connection | Service Entrance conductor splice is not installed in accordance with its listing, in violation of NEC Article 110.3(B) and 110.14. |  |
| 2 | Junction Box | The receptacle is not GFCI-WR rated or listed for use in wet locations in violation of NEC Article 210.8(A)(2) & (A)(3). |  |
| 3 | Supply Side Connection | The neutral conductor is terminated at an individual terminal that already contains another conductor in violation of NEC Article 408.41. |  |
| 4 | Array | Ungrounded conductors are not properly identified, in violation of NEC Article 200.7. |  |
| 5 | Feeder Tap Connection | Feeder tap conductor splice is not installed in accordance with its listing, in violation of NEC Article 110.3(B) and 110.14. |  |

10.2.5 Structural Deficiencies: 28% of Systems Inspected

Below, we have summarized the top 5 deficiencies found related to Structural issues.

Table 6. Top Structural Deficiencies

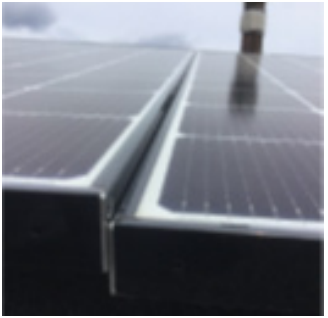




| Rank | System Component | Deficiency Description | Example |
|------|------------------|--|---|
| 1 | Array | Racking system mechanical connections not made correctly and/or racking not installed per manufacturer instructions, in violation of NEC Article 110.3(B). |  |
| 2 | Inverter | Inverter is not mounted in accordance with manufacturer instructions, in violation of NEC Article 110.3(B). |  |
| 3 | Inverter | Moisture or evidence of moisture was found inside the inverter, an approved method of moisture accumulation prevention appears to be missing in violation of NEC Article 314.15. |  |
| 4 | Array | Roof penetrations are not properly sealed and flashed to prevent moisture ingress. |  |
| 5 | AC Combiner | AC Combiner does not have sufficient working clearances as required by NEC Article 110.26. |  |

Table 7. Deficiency as a Percent of All Deficiencies Found

| Frequency | System Component | Defect Category | Deficiency Description |
|-----------|------------------------|-----------------|--|
| 44% | All | Labeling | This deficiency includes all labeling violations found within all the Regions. |
| 2.3% | Supply Side Connection | Grounding | Grounded (neutral) conductor is not properly bonded to PV service disconnect enclosure using a listed grounding bus or terminal, or the grounded conductors are not properly bonded to the Grounding Electrode Conductor (GEC), in violation of NEC Article 250.24(C). |
| 2.2% | Supply Side Connection | Grounding | The top of the grounding electrode is not flush with, or below, ground level in violation of NEC Article 250.53(G). |
| 1.8% | AC Disconnect | Grounding | Enclosure is not properly grounded using a listed grounding method, in violation of NEC Articles 690.43, 250.8, and 250.12. Enclosure must be grounded with equipment listed for the purpose and that is solidly connected to the enclosure body. |
| 1.6% | Supply Side Connection | Conduit | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation, in violation of NEC Article 300.7(A). |
| 1.5% | Supply Side Connection | Conductors | Service Entrance conductor splice is not installed in accordance with its listing, in violation of NEC Article 110.3(B) and 110.14. |
| 1.4% | Supply Side Connection | Grounding | The GEC is not continuous or irreversibly spliced, in violation of NEC Articles 250.64(C) and 690.47(C). Allowable means of splicing the GEC include compression crimp and exothermic welding processes. |
| 1.1% | Array | Structural | Racking system mechanical connections not made correctly and/or racking not installed per manufacturer instructions, in violation of NEC Article 110.3(B). |
| 1.1% | AC Combiner | Grounding | Enclosure is not properly grounded using a listed grounding method, in violation of NEC Articles 690.43, 250.8, and 250.12. Enclosure must be grounded with equipment listed for the purpose and that is solidly connected to the enclosure body. |
| 1.0% | Array | Electrical | Electrochemically dissimilar metals are in direct physical contact, which may lead to a galvanic reaction, in violation of NEC Article 110.14 (for conductors/splice components) and/or RMC-NEC 344.14, EMT-NEC 358.12(6) (for conduit and surrounding materials). |
| 1.0% | Inverter | Conduit | Conduit is improperly used to support conductors, in violation of NEC Article 300.11(B). |
| 0.9% | AC Disconnect | Conduit | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation in violation of NEC Article 300.7(A). |
| 0.9% | Supply Side Connection | Conduit | Circuit conduit or raceway lacks adequate support, in violation of NEC (LFMC-350.30, EMT-358.30, Metal Trough-376.30). |
| 0.9% | Supply Side Connection | Grounding | Enclosure is not properly grounded using a listed grounding method, in violation of NEC Articles 690.43, 250.8, and 250.12. Enclosure must be grounded with equipment listed for the purpose and that is solidly connected to the enclosure body. |
| 0.9% | Array | Conduit | Conduit is missing an approved internal sealant at penetrations between conditioned and unconditioned spaces to prevent condensation, in violation of NEC Article 300.7(A). |

11. Unified Residential Solar PV Permit Application

The workable version of this document can be found at nyserdera.ny.gov/SolarGuidebook, under the Solar Permitting and Inspecting tab.

PERMIT APPLICATION

NY State Unified Solar Permit

Unified solar permitting is available statewide for eligible solar photovoltaic (PV) installations. Municipal authorities that adopt the unified permit streamline their process while providing consistent and thorough review of solar PV permitting applications and installations. Upon approval of this application and supporting documentation, the authority having jurisdiction (AHJ) will issue a building and/or electrical permit for the solar PV installation described herein.

PROJECT ELIGIBILITY FOR UNIFIED PERMITTING PROCESS

By submitting this application, the applicant attests that the proposed project meets the established eligibility criteria for the unified permitting process (subject to verification by the AHJ). The proposed solar PV system installation:

- Yes No 1. Has a rated DC capacity of 25 kW or less.
- Yes No 2. Is not subject to review by an Architectural or Historical Review Board. (If review has already been issued answer YES and attach a copy)
- Yes No 3. Does not need a zoning variance or special use permit. (If variance or permit has already been issued answer YES and attach a copy)
- Yes No 4. Is mounted on a permitted roof structure, on a legal accessory structure, or ground mounted on the applicant's property. If on a legal accessory structure, a diagram showing existing electrical connection to structure is attached.
- Yes No 5. The Solar Installation Contractor complies with all licensing and other requirements of the jurisdiction and the State.
- Yes No 6. If the structure is a sloped roof, solar panels are mounted parallel to the roof surface.

For solar PV systems not meeting these eligibility criteria, the applicant is not eligible for the Unified Solar Permit and must submit conventional permit applications. Permit applications may be downloaded here: [BUILDING DEPARTMENT WEBSITE] or obtained in person at [BUILDING DEPARTMENT ADDRESS] during business hours [INDICATE BUSINESS HOURS].

SUBMITTAL INSTRUCTIONS

For projects meeting the eligibility criteria, this application and the following attachments will constitute the Unified Solar Permitting package.

- This application form, with all fields completed and bearing relevant signatures.
- Permitting fee of \$[ENTER FEE HERE], payable by [ENTER VALID PAYMENT METHODS, If checks are allowed INCLUDING WHO CHECKS SHOULD BE MADE PAYABLE TO]
- Required Construction Documents for the solar PV system type being installed, including required attachments.

Completed permit applications can be submitted electronically to [EMAIL ADDRESS] or in person at [BUILDING DEPARTMENT ADDRESS] during business hours [INDICATE BUSINESS HOURS].

APPLICATION REVIEW TIMELINE

Permit determinations will be issued within [TIMELINE] calendar days upon receipt of complete and accurate applications. The municipality will provide feedback within [TIMELINE] calendar days of receiving incomplete or inaccurate applications.

FOR FURTHER INFORMATION

Questions about this permitting process may be directed to [MUNICIPAL CONTACT INFORMATION].

PROPERTY OWNER

Property Owner's First Name Last Name Title

Property Address

City State Zip

Section Block Lot Number

EXISTING USE

Single Family 2-4 Family Commercial Other

PROVIDE THE TOTAL SYSTEM CAPACITY RATING (SUM OF ALL PANELS)

Solar PV System: _____ kW DC

SELECT SYSTEM CONFIGURATION

Make sure your selection matches the Construction Documents included with this application.

Supply side connection with microinverters Load side connection with DC optimizers
 Supply side connection with DC optimizers Load side connection with microinverters
 Supply side connection with string inverter Load side connection with string inverter

SOLAR INSTALLATION CONTRACTOR

Contractor Business Name

Contractor Business Address City State Zip

Contractor Contact Name Phone Number

Contractor License Number(s) Contractor Email

Electrician Business Name

Electrician Business Address City State Zip

Electrician Contact Name Phone Number

Electrician License Number(s) Electrician Email

Please sign below to affirm that all answers are correct and that you have met all the conditions and requirements to submit a unified solar permit.

Property Owner's Signature Date

Solar Installation Company Representative Signature Date

SUBMITTAL REQUIREMENTS SOLAR PV 25KW OR LESS (ATTACHMENTS)

NY State Unified Solar Permit

This information bulletin is published to guide applicants through the unified solar PV permitting process for solar photovoltaic (PV) projects 25 kW in size or smaller. This bulletin provides information about submittal requirements for plan review, required fees, and inspections.

Note: Language in [ALL CAPS] below indicates where local jurisdictions need to provide information specific to the jurisdiction. Language in italics indicates explanatory notes from the authors of this document that may be deleted from the distributed version.

PERMITS AND APPROVALS REQUIRED

The following permits are required to install a solar PV system with a nameplate DC power output of 25 kW or less:

a) Unified Solar Permit

b) [LIST TYPE OF PERMIT(S) REQUIRED BY THE LOCAL JURISDICTION, i.e., ELECTRICAL OR BUILDING PERMIT]. Planning review [IS/IS NOT] required for solar PV installations of this size.

Fire Department approval [IS/IS NOT] required for solar PV installations of this size.

SUBMITTAL REQUIREMENTS

In order to submit a complete permit application for a new solar PV system, the applicant must include:

- a) Completed Standard Permit Application form which includes confirmed eligibility for the Unified Solar Permitting process. This permit application form can be downloaded at [WEBSITE ADDRESS].
- b) Construction Documents, with listed attachments [SAMPLES ARE AVAILABLE IN Understanding Solar PV Permitting and Inspecting in New York State AT WEBSITE ADDRESS]. Construction Documents must be by stamped and signed by a New York State Registered Architect or New York State Licensed Professional Engineer.

[MUNICIPALITY NAME], through adopting the Unified Solar Permitting process, requires contractors to provide construction documents, such as the examples included in the Understanding Solar PV Permitting and Inspecting in New York State document. Should the applicant wish to submit Construction Documents in another format, ensure that the submittal includes the following information:

- Manufacturer/model number/quantity of solar PV modules and inverter(s).
- String configuration for solar PV array, clearly indicating the number of modules in series and strings in parallel (if applicable).
- Combiner boxes: Manufacturer, model number, NEMA rating.
- From array to the point of interconnection with existing (or new) electrical distribution equipment: identification of all raceways (conduit, boxes, fittings, etc.), conductors and cable assemblies, including size and type of raceways, conductors, and cable assemblies.
- Sizing and location of the EGC (equipment grounding conductor).
- Sizing and location of GEC (grounding electrode conductor, if applicable).
- Disconnecting means of both AC and DC including indication of voltage, ampere, and NEMA rating.
- Interconnection type/location (supply side or load side connection)
- For supply side connections only, indication that breaker or disconnect meets or exceeds available utility fault current rating kAIC (amps interrupting capacity in thousands).
- Ratings of service entrance conductors (size insulation type AL or CU), proposed service disconnect, and overcurrent protection device for new supply side connected solar PV system (reference NEC 230.82, 230.70).
- Rapid shutdown device location/method and relevant labeling.

c) (For Roof Mounted Systems) A roof plan showing roof layout, solar PV panels and the following fire safety items: approximate location of roof access point, location of code-compliant access pathways, code exemptions, solar PV system fire classification, and the locations of all required labels and markings.

d) Provide construction drawings with the following information:

- The type of roof covering and the number of roof coverings installed.
- Type of roof framing, size of members, and spacing.
- Weight of panels, support locations, and method of attachment.
- Framing plan and details for any work necessary to strengthen the existing roof structure.
- Site-specific structural calculations.

e) Where an approved racking system is used, provide documentation showing manufacturer of the racking system, maximum allowable weight the system can support, attachment method to roof or ground, and product evaluation information or structural design for the rack.

PLAN REVIEW

Permit applications can be submitted to [DEPARTMENT NAME] in person at [ADDRESS] and [IF APPLICABLE] electronically through: [WEBSITE/EMAIL/FAX].

FEES

[PROVIDE CLEAR FEE SCHEDULE]

INSPECTIONS

Once all permits to construct the solar PV installation have been issued and the system has been installed, it must be inspected before final approval is granted for the solar PV system. On-site inspections can be scheduled by contacting [DEPARTMENT] by telephone at [PHONE NUMBER] or electronically at [WEBSITE OR EMAIL ADDRESS]. Inspection requests received within business hours are typically scheduled for the next business day. If next business day is not available, inspection should happen within a five-day window. [IF MUNICIPALITY ACCEPTS THIRD PARTY INSPECTIONS, INDICATE THIS AND PROVIDE A LIST OF APPROVED INSPECTORS].

In order to receive final approval, the following inspections are required:

Delete Rough/Final inspection descriptions if not applicable in your jurisdiction

[ROUGH INSPECTION, IF REQUIRED] During a rough inspection, the applicant must demonstrate that the work in progress complies with relevant codes and standards. The purpose of the rough inspection is to allow the inspector to view aspects of the system that may be concealed once the system is complete, such as:

- Wiring concealed by new construction.
- Portions of the system that are contained in trenches or foundations that will be buried upon completion of the system.

It is the responsibility of the applicant to notify [ENTER CONTACT INFORMATION] before the components are buried or concealed and to provide safe access (including necessary climbing and fall arrest equipment) to the inspector. The inspector will attempt, if possible, to accommodate requests for rough inspections in a timely manner.

[FINAL INSPECTION] The applicant must contact [INSERT CONTACT INFORMATION] when ready for a final inspection. During this inspection, the inspector will review the complete installation to ensure compliance with codes and standards, as well as confirming that the installation matches the records included with the permit application. The applicant must have ready, at the time of inspection, the following materials and make them available to the inspector:

- Copies of as-built drawings and equipment specifications, if different than the materials provided with the application.
- Photographs of key hard to access equipment, including;
 - Example of array attachment point and flashing/sealing methods used.
 - Opened rooftop enclosures, combiners, and junction boxes.
 - Bonding point with premises grounding electrode system.
 - Supply side connection tap method/device.
 - Module and microinverter/DC optimizer nameplates.
 - Microinverter/DC optimizer attachment.

[MUNICIPALITY NAME] has adopted a standardized inspection checklist, which can be found in the Understanding Solar PV Permitting and Inspecting in New York State document, found here: [WEBSITE ADDRESS].

The inspection checklist provides an overview of common points of inspection that the applicant should be prepared to show compliance. If not available, common checks include the following:

- Number of solar PV modules and model number match plans and specification sheets number match plans and specification sheets.
- Array conductors and components are installed in a neat and workman-like manner.
- Solar PV array is properly grounded.
- Electrical boxes and connections are suitable for environment.
- Array is fastened and sealed according to attachment detail.
- Conductor's ratings and sizes match plans.
- Appropriate signs are property constructed, installed and displayed, including the following:
 - Sign identifying PV power source system attributes at DC disconnect.
 - Sign identifying AC point of connection.
 - Rapid shutdown device meets applicable requirements of NEC 690.12.
- Equipment ratings are consistent with application and installed signs on the installation, including the following:
 - Inverter has a rating as high as max voltage on PV power source sign.
 - DC-side overcurrent circuit protection devices (OCPDs) are DC rated at least as high as max voltage on sign.
 - Inverter is rated for the site AC voltage supplied and shown on the AC point of connection sign.
 - OCPD connected to the AC output of the inverter is rated at least 125% of maximum current on sign and is no larger than the maximum OCPD on the inverter listing label.
 - Sum of the main OCPD and the inverter OCPD is rated for not more than 120% of the buss bar rating.

UNIFIED SOLAR PERMITTING RESOURCES

The jurisdiction has adopted the following documents from the New York Unified Solar Permit process:

Delete any documents not adopted by the jurisdiction.

- Standard Application [WEB ADDRESS]
- Understanding Solar PV Permitting and Inspecting in New York State document, which includes sample construction documents, inspection checklist, design review checklist, and labelling guide [WEB ADDRESS]

DEPARTMENTAL CONTACT INFORMATION

For additional information regarding this permit process, please consult our departmental website at [WEBSITE] or contact [DIVISION NAME] at [PHONE NUMBER].

Questions?

If you have any questions regarding the solar permitting and inspecting process, please email questions to cleanenergyhelp@nyserderda.ny.gov or request free technical assistance at nyserderda.ny.gov/siting.

The NYSERDA team looks forward to partnering with communities across the state to help them meet their solar energy goals.