Installation Instructions

GAF Energy Solar System

Integrated rooftop solar for composition shingle sloped roofs

GAF Energy LLC

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Notices

Copyright

Trademark

The name GAF Energy, DecoTech™, and the GAF Energy logo are all trademarks of GAF Energy LLC.

Warranty

Warranty is void unless product is installed and used in accordance with all written instructions.

Disclaimer

This manual is intended to be a guideline for the installation and use for the product lines manufactured by GAF Energy LLC. The installer is responsible for complying with all applicable regulations.

As the manufacturer, GAF Energy LLC has designed the DecoTech™ system to work in a typical installation as described herein, but cannot guarantee that a typical installation will meet every customer's individual needs.

Homeowners and other building owners should refer to a professional roofing contractor who is trained and certified by GAF Energy for all installation details.

Product Name

The GAF Energy Solar System has been previously referred to under the following names: DecoTech™, DecoTech™ Solar System, and DecoTech™ RI 2000.

Contents

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1. Introduction

The GAF Energy Solar System featuring DecoTech™ is designed by GAF Energy. GAF Energy is a sister company to GAF, North America's largest roofing manufacturer. The sleek, black, low-profile design delivers performance and curb appeal at an affordable price. DecoTech™ was developed with roofing best practices, simplicity of installation, performance, safety, and aesthetics in mind. Its deck-mounting technology coupled with GAF-approved underlayment offers fast installation with high-performance water shedding and a Class A fire rating. Module Level Power Electronics (either AC or DC) are easily integrated in the field.

This Manual contains safety, installation, and troubleshooting instructions for the GAF Energy Solar System.

Read these instructions entirely and thoroughly in order to ensure a problem-free installation.

Save this Manual and keep it in a readily accessible location for future reference. As part of its continuing efforts to improve the performance of its products, GAF Energy periodically makes changes to its products and application specifications. GAF Energy reserves the right to change or modify, at its discretion, any of the information, requirements, specifications, or policies contained herein. Please be sure to check **www.gaf.energy** for the most up-to-date version of this Manual or any technical bulletins for this product.

Abbreviations

AC	Alternating Current
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
DC	Direct Current
OCPD	Overcurrent Protection Device
OSB	Oriented Strand Board
OSHA	Occupational Safety and Health Administration
MLPE	Module Level Power Electronics
NEC	National Electrical Code
NFPA	National Fire Protection Association
MC	Multi-Contact
PPE	Personal Protective Equipment
PV	Photovoltaic
UL	Underwriters Laboratories

Symbol List

CAUTION: Use caution and fully understand the instructions before proceeding.

DANGER: Indicates a hazardous situation. Failure to follow these instructions could lead to serious injury or death.

NOTE: Follow these instructions closely for optimal system operations and best installation practices.

DON'T: An X symbol illustrates an incorrect practice or installation technique.

DO: A check mark illustrates the correct or preferred method of installation.

Definitions

Solar Module Assembly – a GAF Energy solar module combined with:

- Roof attachments (Adjustable Feet)
- MLPE bracket
- MLPE (either a DC optimizer or an AC microinverter)
- Wire clips

The Module Assembly is built in the field with the provided hardware.

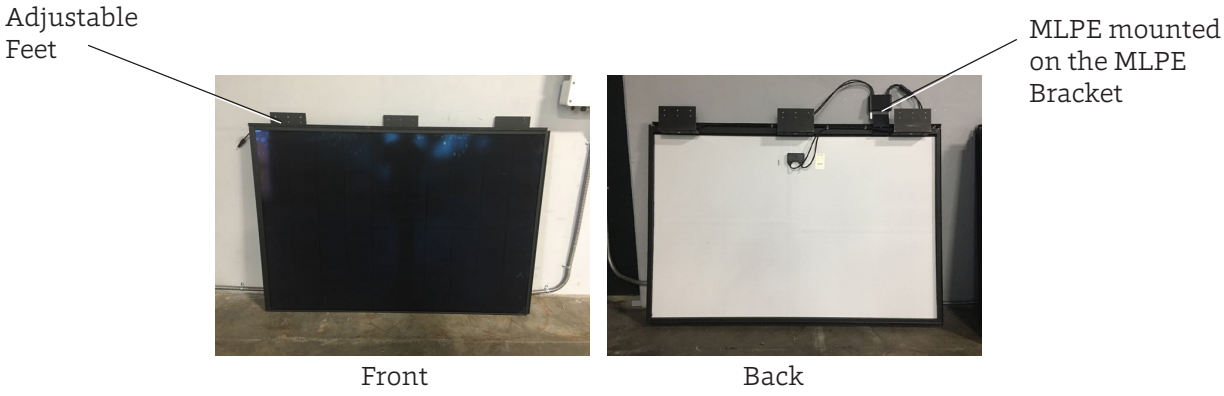


Figure 1. Solar Module Assembly

GAF Energy Solar System — The combination of underlayment, Module Assemblies, Starter Bars, and Flashings make up the GAF Energy Solar System

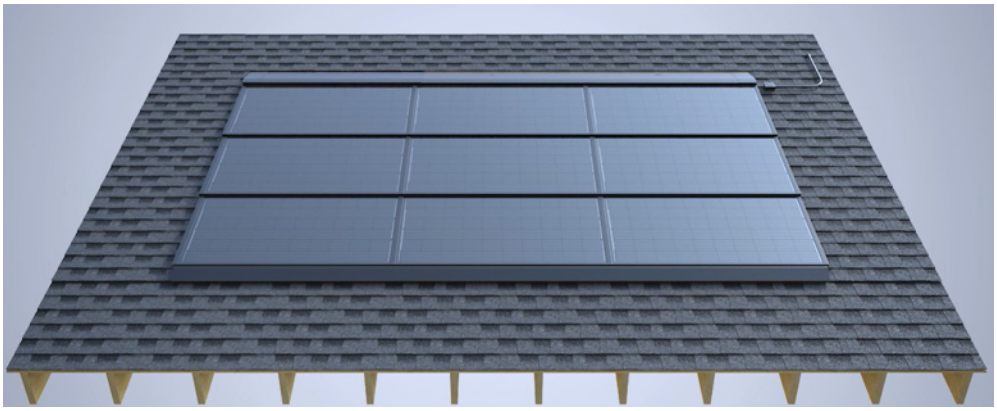


Figure 2. GAF Energy Solar System

General Safety Precautions

- **Must be installed by a qualified person.** The GAF Energy Solar System must be installed by a PROPERLY TRAINED and QUALIFIED INSTALLER. It is the responsibility of every installer to know and follow local code requirements.
- **Follow OSHA.** GAF Energy recommends compliance with OSHA guidelines for Residential Fall Protection.
- **Wear Personal Protective Equipment (PPE).** Use proper PPE and follow safety policies and procedures. Proper PPE when dealing with rooftop solar systems includes, but is not limited to, the following:
  - **Hard hats**. For falling objects, as well as risk of contact with energized conductors. An ANSI Z89 Class A helmet will satisfy this OSHA requirement.
  - **Work gloves.** For slip, abrasion, and thermal resistance. Solar modules tend to get very hot when exposed directly to the sun.
  - **Electrically insulated gloves.** When working on energized circuits.
  - **Appropriate footwear.** Footwear with extra traction and/or heat-resistant soles.
  - **Personal fall arrest system (PFAS).** Consists of an OSHA-approved anchor point, a full-body harness approved for electrical workers, rope or cable, and specific connecting hardware.
  - **Eye protection.** For site-specific hazards.
- **Work only in dry conditions.** Use dry equipment and dry tools. Protect all electrical equipment against weather elements.

Figure 3. Personal Protective Equipment (PPE)

- **Eliminate trip and fall hazards.** Keep work areas on the roof and ground staging areas organized and clean.
- **Beware of "in-between" roof slopes.** A "walkable" roof may not be walkable once the shingles are stripped off. A slope of 6:12 and higher generally becomes unsafe to walk on after being stripped.

General Safety Precautions, continued

- **No stacking of Module Assemblies.** Do not stack or store Module Assemblies on the roof. For general safety of roofing materials, use roof jacks, toe boards, or storage platforms secured to the underlying roof deck to prevent slippage of stored roofing materials.
- **Inspect for damage.** Do not use GAF Energy Solar System components if there are visible signs of damage from transport or handling.
- **Handling the Module Assembly.** Always have two people carry the product by its frame. Do not support the solar modules on your head as a hard hat may damage the PV back sheet.
- **Working Safely with PV systems.** Be aware of the hazards at the jobsite as well as the hazards of working on PV systems. Be alert at all times. Never work alone on PV systems. Always have at least two people installing solar systems on the roof.

Electrical Safety Precautions

- **Must be competent with electrical safety work practices.** The GAF Energy Solar System is an electric-powered generation system. The installer must be qualified according to state and local requirements.
- **De-energize.** All work must be performed on DC or AC circuits only after the circuits have been de-energized.
- **Use proper wire management techniques.** Ensure that none of the AC or DC wires are pinched or damaged during installation. Secure all loose cables with wire ties to the Solar Module Assembly. Do not exceed the minimum bend radius of the cables.
- **Do not modify factory-applied connectors, terminals, or jumper cables.** Do not customize or modify the provided DC or AC cables or connectors in the field.
- **Do not repair.** The GAF Energy Solar System does not contain any user-serviceable parts. Replacement products should be obtained through GAF Energy. Tampering with the GAF Energy Solar System will void the warranty.
- **Thermal and voltage hazard.** Certain parts of the GAF Energy Solar System may become extremely hot due to continued exposure to the sun. It should be installed in a location where it is protected against casual contact. It may also represent an electrical hazard while servicing the system immediately following shutdown.
- **Follow codes.** Perform all electrical installations in accordance with all local codes and the NEC (National Electrical Code) ANSI/NFPA 70 for U.S. installations.
- **Re-inspection.** Regularly re-inspect the solar system to ensure that all fasteners are securely tightened and corrosion free; that wiring is securely connected and free of corrosion; and that cables are free of damage. This is important especially after storms and in areas prone to hail and high winds. Any damaged parts should be replaced immediately.

Electrical Safety Precautions, continued

- **Be aware of ground faults.** Functionally grounded conductors may become ungrounded and energized when a ground fault is indicated, resulting in risk of electric shock. Prior to touching any part of the product, use care to ensure surfaces and equipment are at touch-safe temperatures and voltage potentials (by testing with a multimeter) before proceeding. Anytime the MLPE has been disconnected from the power network, use extreme caution as some components can retain a charge sufficient to create a shock hazard.
- **Licensed Electrician.** Installing AC or DC circuits, switches, tie-in to the PV point of connection, OCPDs, and initial startup of the PV system must be performed by a licensed electrician. Make all electrical connections (e.g., conductor termination, fuses, potential earth connection, etc.) in accordance with the electrical standards prescribed by the applicable NEC wiring methods and/or by other local regulations and codes.
- **Single-use Fasteners.** Unless otherwise specified in this manual, all fasteners are to be considered single-time use only.

2. GAF Energy Solar System Overview

Main Components of the GAF Energy Solar System

The main components of the GAF Energy Solar System are the Module Assembly, the Underlayment System, and the Flashing.

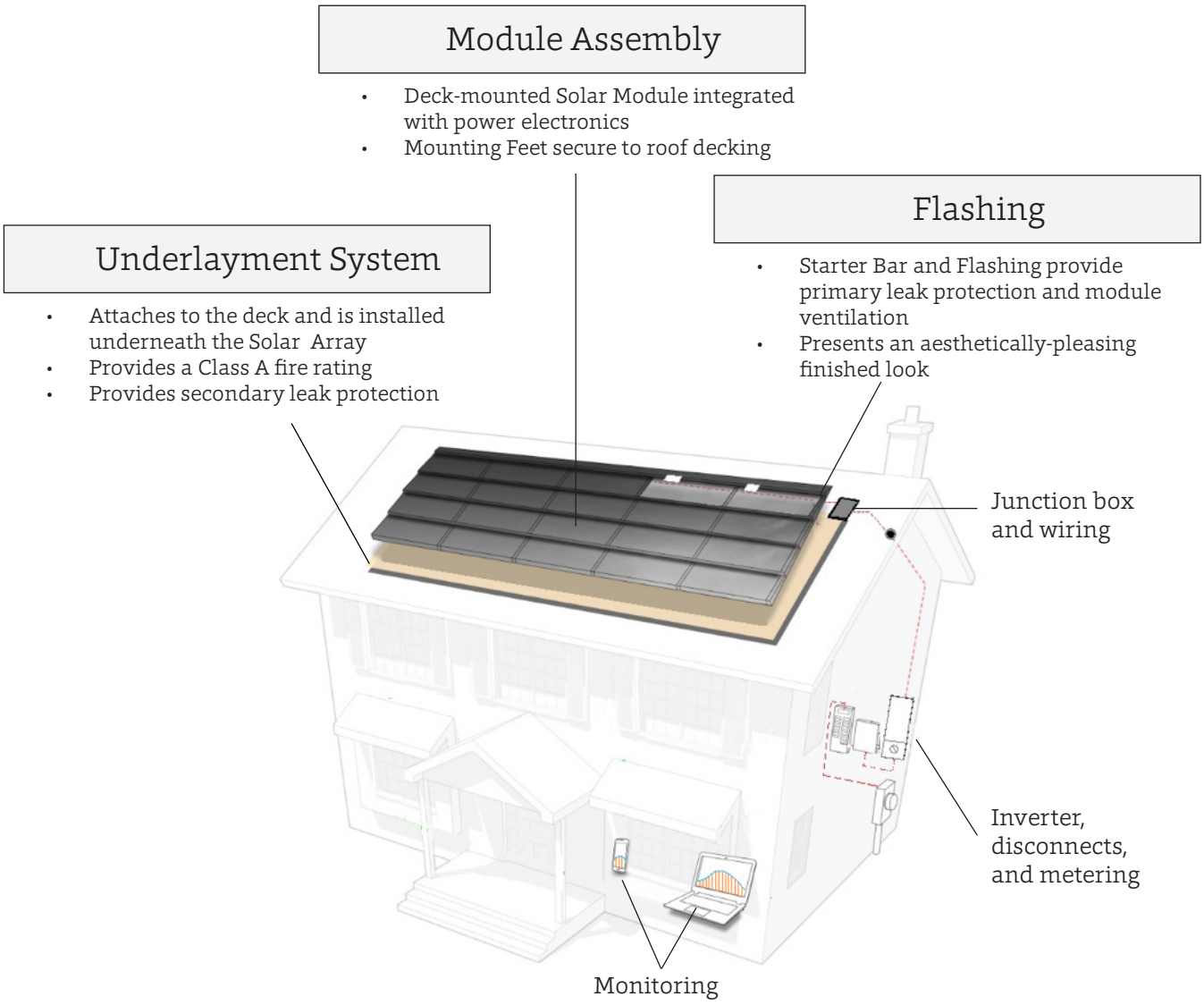


Figure 4. Main components of GAF Energy Solar System installation

The Balance Of System (BoS) components that make up the remainder of the solar installation are outside the scope of this manual. Typical BoS components include: roof-top junction box, conduit and cables, disconnect switch, meter, monitoring system, and inverter. See the Permit Drawings and other site-specific installation drawings for more information.

System Hardware Components

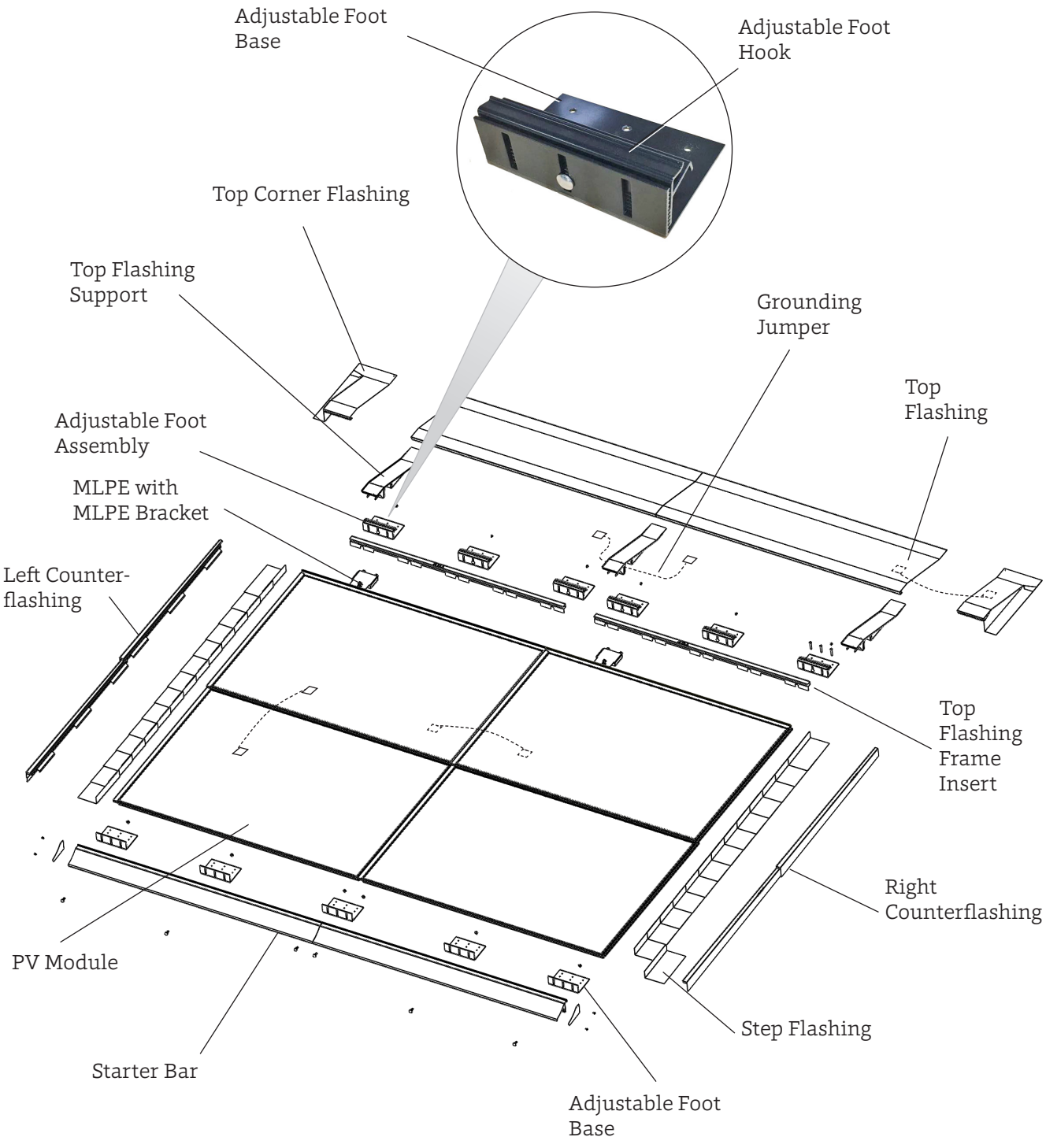


Figure 5. GAF Energy Solar System Hardware Components

Module and Component SKUs

- The DecoTech™ solution supports two PV module types: Silfab and Solaria. Module dimensions are slightly different for each. Each module type has custom sized fittings with its own set of SKUs.
- Separate tables show SKUs for GAF Energy solar, Underlayment, and third-party components. Third-party components include grounding hardware and module-level power electronics (MLPE). Underlayment components are standard roofing materials.

Table 1. GAF Energy SKU Numbers for Solar Array

Component	GAF Energy SKU #	
	SILFAB	SOLARIA
Module	2947401	2947452
Starter Bar	2947405	2947441
Adjustable Foot Base	2947402	2947434
Starter Bar Cover, Left	2947412	2947446 *
Starter Bar Cover, Right	2947413	2947446 *
Step Flashing	2947411	2947447
Counterflashing - Left	2947406	2947448
Counterflashing - Right	2947407	2947449
MLPE Bracket	2947112	2947112
Adjustable Foot Assembly	2947403	2947435
Top Flashing Frame Insert	2947415	2947445
Top Flashing Support	2947414	2947444
Top Flashing	2947408	2947450
Top Corner Flashing - Left	2947409	2947442
Top Corner Flashing - Right	2947410	2947443

* Starter Bar Covers left and right are the same for Solaria.

NOTE: Modules that support the GAF Energy Solar System have different extrusion profiles on each side, and are intended for installation in landscape orientation, in a specific order from left to right, with an up-roof and a down-roof side.

Table 2. Third-Party Components

Component	Manufacturer	Provided By
DynoBond™ Grounding Jumper	DynoRaxx	GAF Energy
P320 Solar Optimizer	SolarEdge	GAF Energy
P370 Solar Optimizer	SolarEdge	GAF Energy
IQ 6™ and IQ 6+™ Series Microinverters	Enphase	GAF Energy
IQ 7™ and IQ 7+™ Series Microinverters	Enphase	GAF Energy
QBox® Junction Box for Composition/ Asphalt Shingle Roofs	QuickMount PV ®	GAF Energy
Listed 3/4 inch insulated ground bushing	**Various**	GAF Energy
Listed raintight conduit fittings, array to QBox	**Various**	GAF Energy
Electrical conduit (metal)	**Various**	GAF Energy

Table 3. Underlayment

Component	GAF Energy SKU #	Provided By
VersaShield® SOLO™ Fire-Resistant Slip Sheet (3-foot wide roll)	905500	GAF Energy
QuickStart® Peel & Stick Starter Roll	1122000ST	GAF Energy
StormGuard® Film-Surfaced Leak Barrier	092500MV	GAF Energy

Table 4. Fastener Specifications

Fastener Type	Where Used	Torque	Provided By
Grounding Screw (10-32x3/8 inch, serrated washer, thread cutting type F)	Adjustable Feet to module frame	40 inch-pounds (4.5 Nm)	GAF Energy
Carriage Bolts, (5/16 inch, 18 x 1 inch steel, zinc-plated)	Adjustable Foot Base to Starter Bar		GAF Energy
Serrated Flange Nuts (0.313 inches, #18, steel, zinc-plated)	Adjustable Foot Base to Starter Bar	75 inch-pounds (8.5 Nm)	GAF Energy
Carriage Bolts, (5/16 inch, 18 x 1 inch steel, zinc-plated)	Adjustable Foot Assembly (for module leveling)		GAF Energy
Serrated Flange Nuts (0.313 inches, #18, steel, zinc-plated)	Adjustable Foot Assembly (for module leveling)	125 inch-pounds (14.12 Nm)	GAF Energy
#14 – 1.25 inch (32mm) heavy-duty Roofing Fasteners with EPDM captured washer	Adjustable Feet to roof deck	n/a	GAF Energy
5/16 inch - 18 x 3/4 inch Hex Cap Screw, zinc	MLPE to MLPE Bracket		GAF Energy
5/16 inch External Tooth Washer	MLPE to MLPE Bracket		GAF Energy
5/16 inch - 18 Flange Nut, zinc	MLPE to MLPE Bracket	120 inch-pounds (13.5 Nm)	GAF Energy
Wire Clip, UL 1565-compliant	Wires to module	n/a	GAF Energy
Hex head screws	Starter Bar Cover to Starter Bar		GAF Energy
Roofing Nails	Flashings to roof deck		Installer

Additional Component Notes

- Do not mix Solaria and Silfab GAF Energy components.
- The System can be designed with either a DC power optimizer or an AC microinverter. Follow the MLPE manufacturer's installation instructions. Additional components may be required.
- GAF Energy recommends the use of factory-certified PV cables instead of field-crimping PV wire and connectors.
- Except as noted, no substitutions are allowed without prior written approval from GAF Energy.

Balance of System Components

In addition to the above, the following typical Balance of System items are required. GAF Energy provides the following:

- Wire for homeruns
- Junction box
- Inverter
- Electrical tape
- Conduit and conduit fittings

The roofing and solar system installer provides the remaining typical Balance of System items:

- Roofing materials
  - » Shingles
  - » Roofing Underlayment
  - » Roofing adhesive
  - » Drip edge
  - » Shims
  - » Roofing Fasteners
  - » Cap nails/staples

A licensed electrician must perform final system hookup. Depending on the site-specific array design, the electrician might provide the following additional items:

- Junction box
- AC/DC Disconnect
- Meter

Standard roofing components such as shingles are the responsibility of the installer.

3. System Considerations and Installation Requirements

System Design Considerations

- **Slope limitations:** The GAF Energy Solar System (Solar Array) is intended for use solely on roofs having a slope between 4:12 and 12:12.
- **Deck mounting:** The GAF Energy Solar System must be deck-mounted with prescribed underlayment. It cannot be installed over shingles.
- **Deck thickness and fastening:** The roof deck must be a minimum of 15/32 inches (11.9 mm) thick plywood or 7/16 inches (11.1 mm) OSB decking as recommended by APA – The Engineered Wood Association. Wood plank decking must be well-seasoned and supported having a maximum 1/8 inch (3 mm) spacing at the ends and sides using minimum nominal thickness 1 inch (25 mm) x maximum 6 inches (152 mm) lumber. The decking must have adequate nail-holding capacity and a smooth surface. Boards with a nominal thickness of 1 inch (25 mm) and a maximum width of 6 inches (152 mm) are also acceptable. Installers should ensure that the deck is properly fastened per local building code requirements.
- **Landscape orientation:** The GAF Energy Solar System is designed for landscape module orientation only.
- **Solar Array wiring:** Refer to the Permit Design Drawings for the system wiring details. The system electrical design is outside the scope of this manual.
- **Operating temperature:** The GAF Energy Solar System has an operating temperature range of -40°F to +185°F (-40°C to +85°C).
- **DC electrical output:** Under certain environmental conditions, the GAF Energy Solar System may produce more current and/or voltage than reported at standard test conditions (irradiance of 1000 W/m^2, AM 1.5 spectrum, and a cell temperature of 25°C [77°F]). The solar designer should account for these conditions when designing the solar array.
- **Suitable ambient conditions:** Artificially concentrated sunlight shall not be directed on the Solar Array. The modules must neither be immersed in water nor be exposed to continuous wetting (e.g. by fountains). Exposure to salt or sulfur (sulfur sources, volcanoes) implies a risk of corrosion. The system must not be used for maritime (e.g. boats) or automotive (vehicles) purposes. The system must not be exposed to extraordinary chemical loads (e.g. emissions from manufacturing plants). The GAF Energy Solar System should not be installed on stables.
- **Paint:** Do not apply unapproved paint to any part of the GAF Energy Solar System.
- **Roof Setbacks:** The GAF Energy Solar System requires the installation of a minimum of two full rows of shingles at the eave and the ridge. The minimum allowable offset to the rake is 18 inches (457 mm). Please refer to the local building and fire codes for additional setback and pathway requirements.
- **Mounting hardware:** GAF Energy Solar System is intended to be mounted to a roof using only the listed hardware. Using other unapproved means is a violation of the UL listing and will impact the GAF Energy warranty.

System Design Considerations, continued

- **Design loading:** Refer to the Appendix of this Manual for the allowed mechanical loading of the Solar Module Assembly.
- **Fire classification:** The GAF Energy Solar System has been rated as Class A for resistance to external fire exposure per UL 2703 when used with the following underlayment:
  - » One ply of self-adhered StormGuard® Film-Surfaced Leak Barrier
  - » One ply of VersaShield® SOLO™ Fire-Resistant Slip Sheet, mechanically fastened with plastic cap nails or staples.

  For roof mounting, the acceptability of the completed assembly, including the fire resistance of the underlying components of the roof, shall be evaluated per local fire codes.
- **Solar trackers:** The GAF Energy Solar System has not been evaluated for use on a solar tracker.
- **Nonstructural component:** These products have been evaluated for serving as a nonstructural component of a building only. They are not intended to serve as a primary component of the building's exterior surface. The supporting structure (integrated racking) provided with these systems can only support the solar laminate.
- **PV laminate specific:** The Solar Module Assembly may be used to ground and/or mount a PV laminate complying with UL 1703, or UL 61730-1 and UL 61730-2, only when the specific module has been evaluated for grounding and/or mounting in compliance with the included instructions. The Solaria PowerXT and the Silfab SLA-M laminates have been evaluated for use on the GAF Energy Solar System.
- **Wiring accessibility:** These products and associated wiring must not be accessible from the interior space of the building. NEC procedures for installation of wiring must be followed.
- **Roof obstructions:** Do not install any portion of the solar system over any roof obstructions, plumbing, or attic vents. Do not attempt to cut or modify the Solar Module Assembly to accommodate any roof projections. Roof obstructions must be removed or relocated to another area of the roof.
- **Attic ventilation:** If the GAF Energy Solar System covers a large area of the roof, proper attic ventilation and moisture control must be considered.
- **Ice dams:** Do not install the GAF Energy Solar System near areas of the roof that are prone to ice damming.
- **Shingle mismatch:** When installing a GAF Energy Solar System on an existing roof, all the shingles in the plane of the roof with the solar array must be removed and replaced with new shingles. New shingles used in the plane of the installed solar array may not initially match existing shingles in the other roof planes due to weathering and available colors for new shingles. However, color variation may diminish over time.
- **Safety first:** Follow all of the General Safety Precautions outlined in this manual.
- **Follow roofing best practices:** Follow all related shingle application instructions and industry best practices. Use only shingle products that have been approved by GAF Energy. Special attention is needed when stripping the shingles, installing underlayment, and trim around the GAF Energy Solar System.

Installation Requirements

- **Obtain permits:** The installer must comply with local, regional, and national building codes (IBC, IFC, NEC, etc.) and obtain necessary permits and approvals from the local jurisdiction prior to installing the GAF Energy Solar System.
- **Contact local utility:** Contact your local power provider for grid connection requirements prior to the system design and installation.
- **Deck-height variations:** Repair roof if deck-height variation (either a peak or valley) is greater than 0.75 inches (19 mm) over a 4 foot (1,219 mm) span between trusses.
- **Water damage:** Replace water-damaged sheathing (if any).
- **Relocate obstructions:** Relocate rooftop obstructions that are directly under the planned solar array location.

Grounding

The GAF Energy Solar System grounding requirements are shown below. View is from underneath the solar modules. A listed conduit fitting connects the Top Corner Flashing to the array junction box, and a listed ground bushing inside the junction box connects the ground wire to the system inverter.

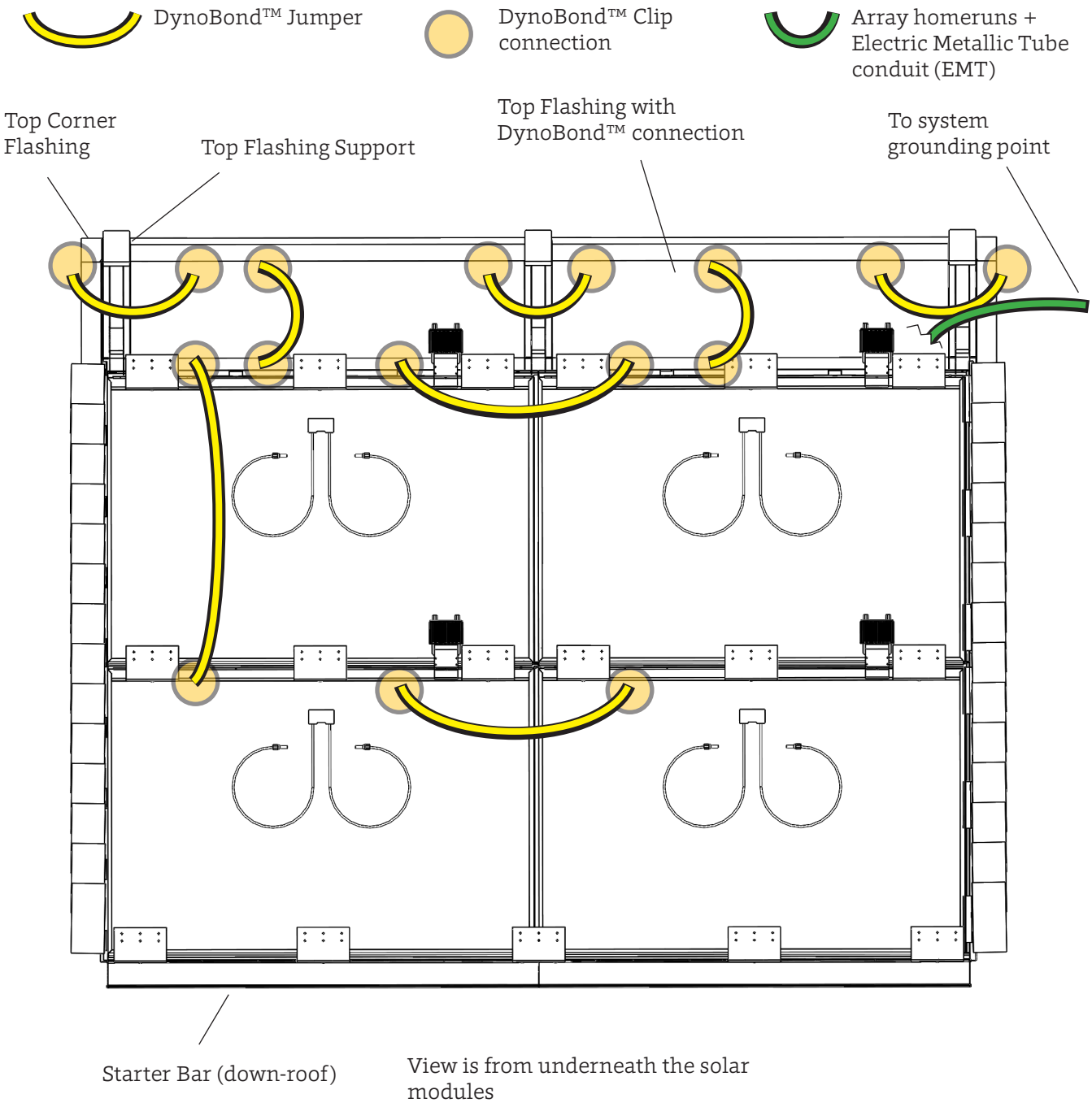


Figure 6. GAF Energy Solar System grounding requirements

Grounding, continued

The adjustable feet and MLPE bracket are bonded to the module frame with the provided Grounding Screw (10-32x3/8 inch, serrated washer, thread cutting type F).

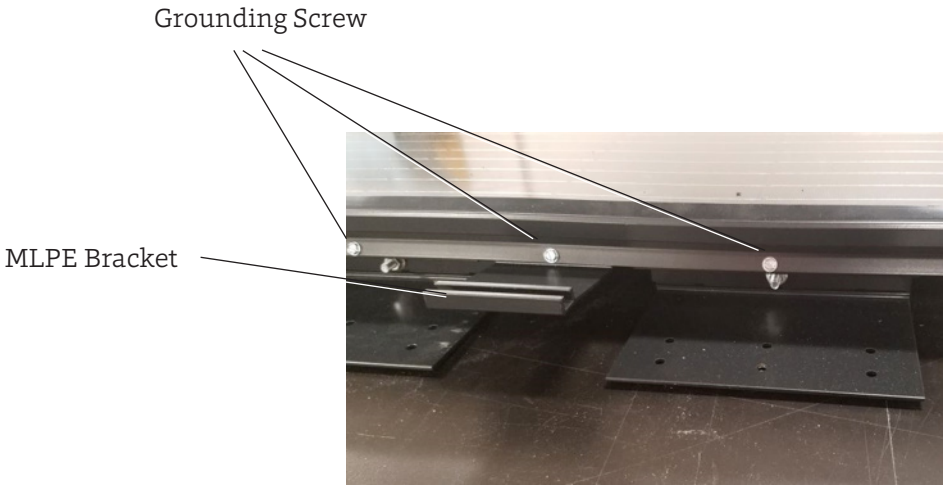


Figure 7. Adjustable Feet and Grounding Screw on module

The two parts of the Adjustable Foot Assembly are bonded together via the provided hardware. This item is shipped pre-assembled.

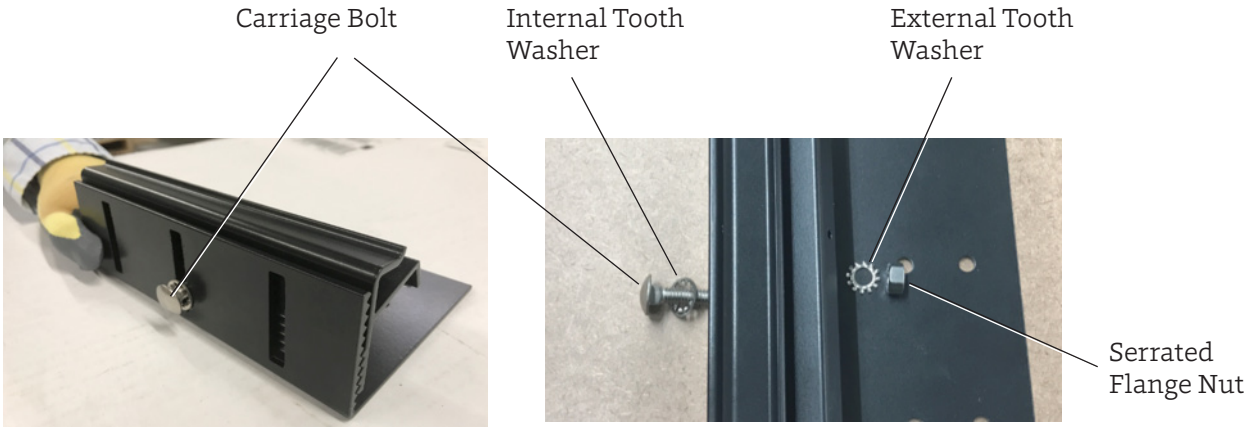


Figure 8. Adjustable Foot bonding hardware

Grounding, continued

The DynoBond™ ground jumpers connect the module frames together.

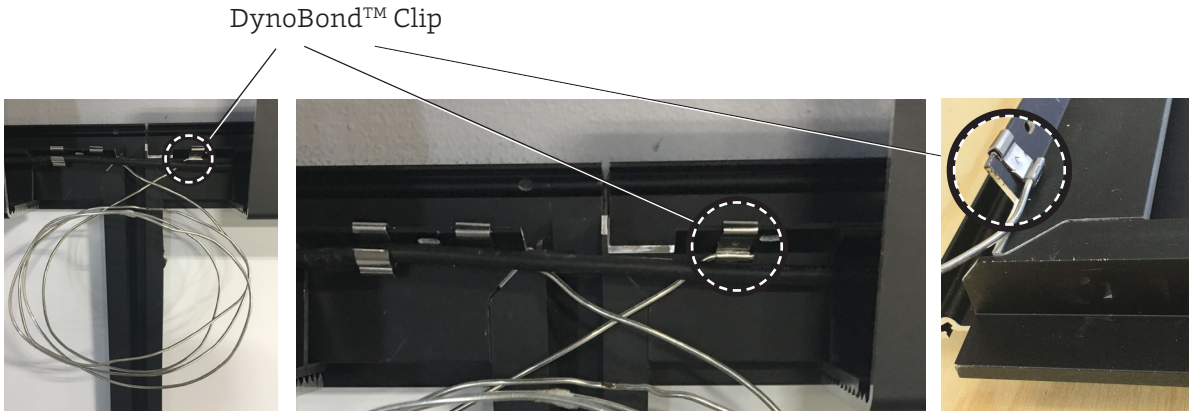


Figure 9. DynoBond™ clip connection to module

DynoBond™ ground jumpers connect the Top Flashing pieces together. Jumpers are passed through the slot in the Top Flashing Support.

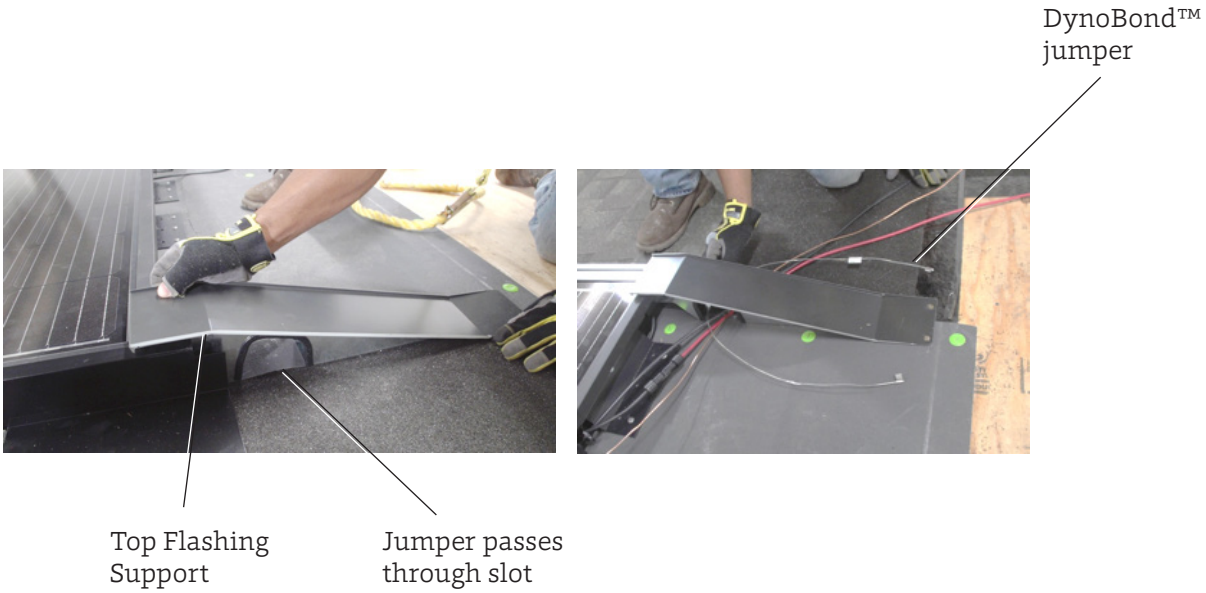


Figure 10. DynoBond™ clip connection, module frame to Debris Guard

System Grounding

System grounding is provided by the conduit fitting and the metallic conduit itself.

The installer pulls an equipment grounding conductor from the inverter into the array junction box and lands this conductor on a listed ground bushing. The ground bushing is bonded to the corner flashing through metallic conduit and listed raintight conduit fittings. Dynobond™ ground jumpers are used to bond inner-array modules, hardware and flashing.

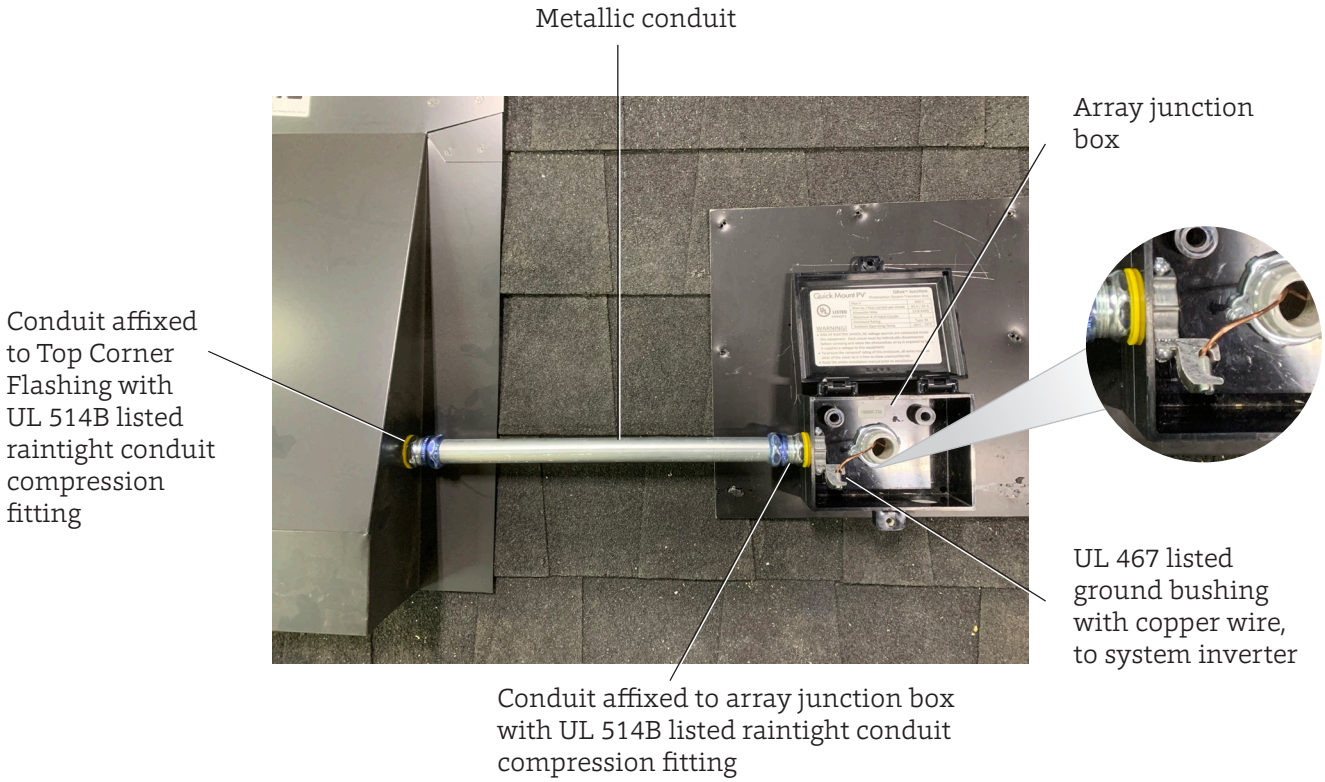


Figure 11. System grounding

The array ground path is created as follows:

1. The array is bonded to the Top Corner Flashing using a DynoBond™ ground jumper that is connected either to the Top Flashing, or to the nearest module frame.
2. A listed raintight conduit compression fitting establishes an electrical bond between the Top Corner Flashing and the electrical conduit that connects the array with the junction box.
3. The conduit connects and bonds to a second listed raintight compression fitting, inside the array junction box.
4. A listed ground bushing inside the junction box connects the electrical conduit to a copper ground wire that runs to the system inverter.

System Grounding, alternate method

An alternative system ground method is to run a continuous bare solid copper ground wire from the MLPE Bracket of the last module to the system inverter ground. Use only a UL Listed WEEB® grounding lug and washer. Connect the MLPE, the WEEB® lug, the bare copper wire,and the DynoBond™ jumper as shown in the figure.

Figure 12. Connection between DynoBond™ jumper and copper ground wire at MLPE

Additional Grounding Notes

- The grounding hardware for the Adjustable Foot Assembly can be reused up to 3 times.
- The grounding screws for the Adjustable Feet and MLPE bracket are single-time use only.
- The DynoBond™ clips are single-time use only.
- Use only UL-approved methods for splicing wire, if splicing is needed.

Recommended Tools for Installation

The following tools are recommended to properly install a GAF Energy Solar System. This list is representative only; additional tools may be required depending on the installation.

- Impact driver
- 5/16 inch (8 mm) Hex driver bit
- 1/2 inch (13 mm) deep socket
- Unibit or graduating drill bit
- Hole saw or paddle bit
- Channel locks
- Chalk line
- Torque wrench
- Sheet metal snips
- Multimeter

Figure 13. Typical grounding tools

Pre-Installation Checklist

The following should be completed prior to the installation of the GAF Energy Solar System:

- **Review documentation:** Review the installation instructions, Permit Drawings, and other site-specific drawings thoroughly.
- **Ensure materials are onsite:** Ensure that all the correct materials in the appropriate quantities are present onsite.
- **Display permits:** Ensure all building/electrical permits are posted in a visible location onsite.
- **Discuss with the building owner:** Confirm access roads, material staging area, and ladder access area (as shown in the Permit Design Drawings). Also discuss work hours, installation noise, and electrical panel shutdown timing with the building owner.
- **Review site:** Review pre-existing site conditions prior to installation. If the installer notices any abnormalities in pre-existing site conditions, do **NOT** proceed with the installation until the matter is resolved with the building owner and with GAF Energy. Typical abnormalities include:
  - » Situations where site conditions do not match planned design
  - » Roof obstructions
  - » Excessive deck-height variations

4. Installation Procedure

The following steps outline the procedure to install the GAF Energy Solar System:

Step 1	Prep the roof
Step 2	Build Starter Bar and Solar Module Assemblies
Step 3	Install the Starter Bar
Step 4	Install first row of Solar Module Assemblies
Step 5	Install remaining module rows
Step 6	Install Step Flashing and Counterflashing
Step 7	Install Top Flashing
Step 8	Install Top Flashing underlayment and shingles

Step 1. Prep the roof

Summary:

a. Prep roof deck and install necessary roofing components, including underlayment.

b. Install initial rows of shingles.

c. Install StormGuard® Film-Surfaced Leak Barrier covering the field of the solar array.

d. Install QuickStart® Peel & Stick Starter Roll over shingle headlap at bottom of array.

e. Install VersaShield® SOLO™ Fire-Resistant Slip Sheet covering the field of the solar array.

Step 1a: **Prep and build the roof up to the start of the array.** Build the roof using standard roofing best practices.

» Clean and inspect the deck, remove protuberances, install any necessary roofing components including drip edges, leak barrier underlayment, and starter roll along eaves and rakes.

» Proceed as for an ordinary shingle roof, referring to the latest version of the *GAF Steep Slope PRO Field Guide* for guidance.

Figure 14. Prep and clean the roof deck

NOTE: StormGuard leak barrier is the required underlayment underneath the solar array. Elsewhere, use your customary underlayment.

Step 1. Prep the roof, continued

Step 1b: **Install initial rows of shingles.** Refer to the latest version of the *GAF Steep Slope PRO Field Guide* for guidance.

» Use the Permit Drawings to determine the number of rows of shingles required between the eave and the Starter Bars.

NOTE: The GAF Energy Solar System requires a minimum of two rows of shingles installed up from the eave, before installing the solar array.

Figure 15. Install initial rows of shingles

Step 1c: **Install StormGuard®.** The StormGuard® Film-Surfaced Leak Barrier covers the field of the solar array.

» Locate and mark the lower-left corner of the solar array. The array starting point must always land within the shingle headlap area.

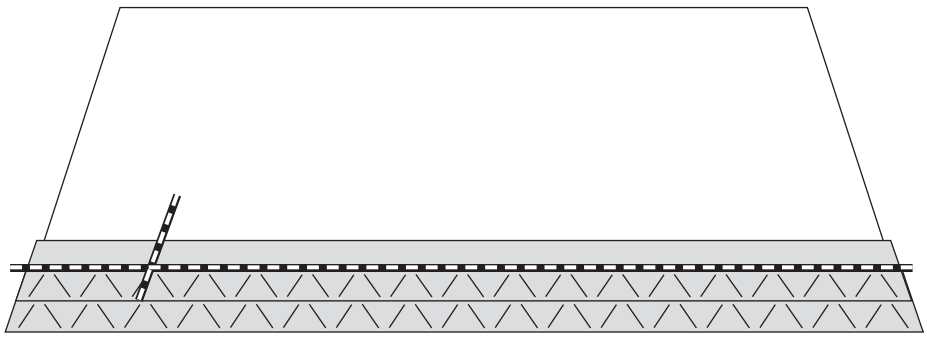


Figure 16. Mark array starting point

Step 1. Prep the roof, continued

» Snap a chalk line 1.5 inches (38mm) above the shingle exposure line of the last row of shingles.

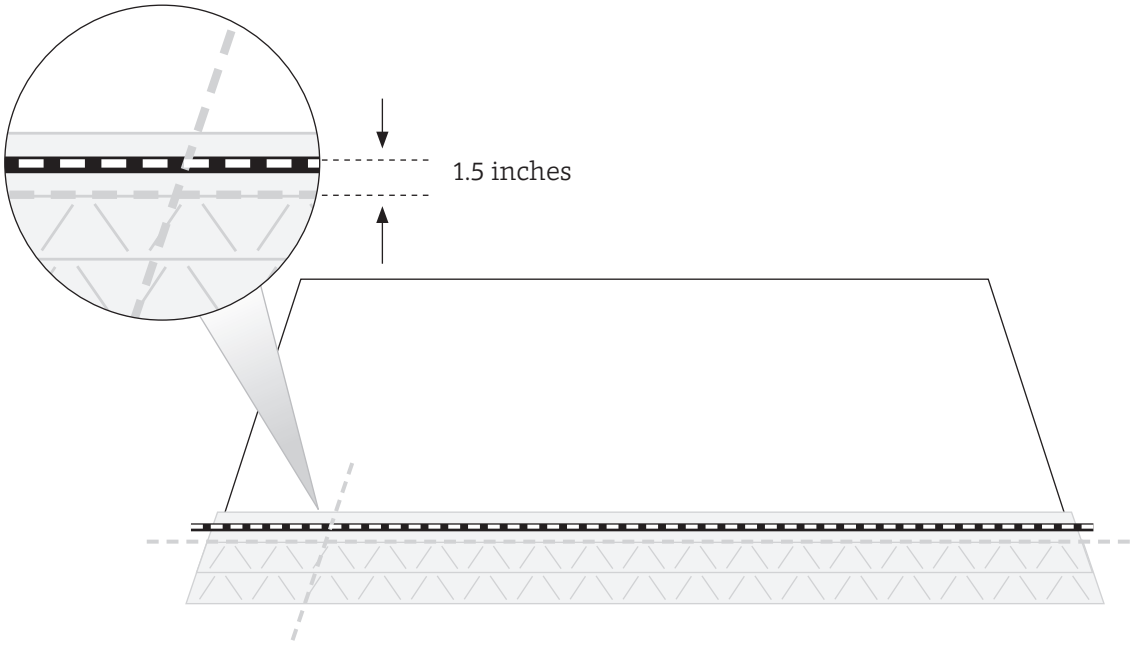


Figure 17. Mark 1.5 inches above shingle exposure line

» Mark the left, right, and top borders of the array.

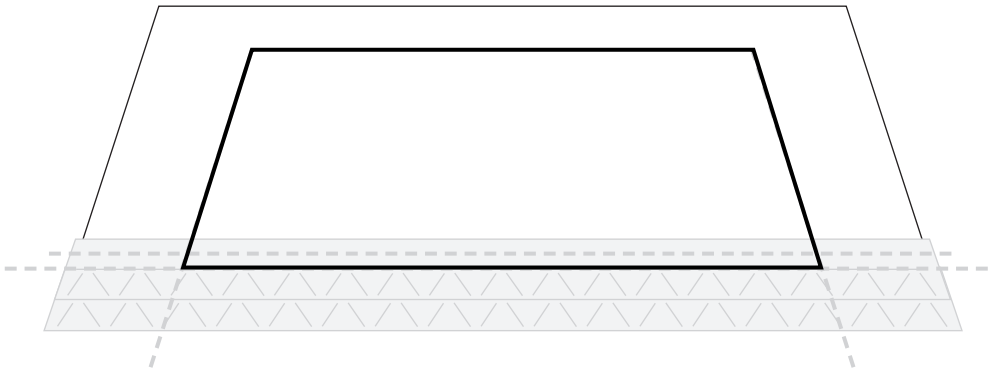


Figure 18. Mark array borders

Step 1. Prep the roof, continued

» Mark 3 feet out from the left and right edges of the array.

Figure 19. Mark 3 feet out from left and right edges of array

» Roll out the StormGuard® leak barrier. Align its lower edge with the chalk line over the shingle headlap, and extend it out 3 feet (914 mm) beyond the left and right sides of the solar array.

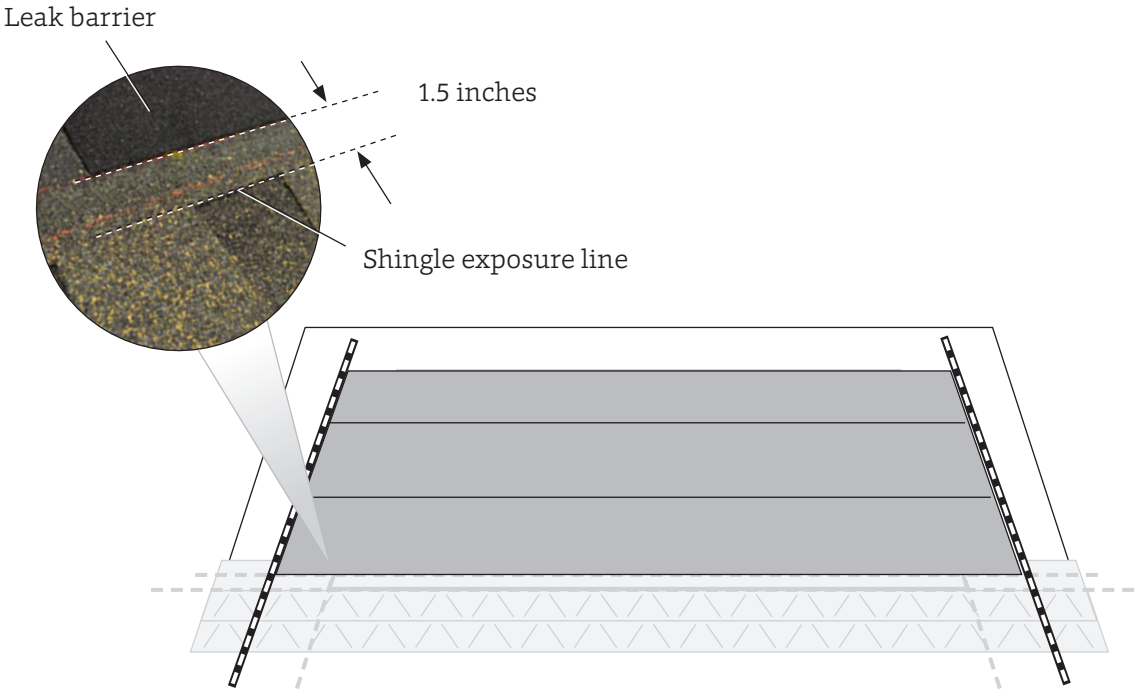


Figure 20. Install StormGuard® leak barrier over field of the array

Step 1. Prep the roof, continued

Step 1d: **Install QuickStart® Peel & Stick Starter Roll.** Install QuickStart® Peel & Stick Starter Roll over the shingle headlap at the bottom of the array, covering the 1.5-inch gap between the StormGuard® leak barrier and the top of the shingle exposure line. The QuickStart® should be the same width as the solar array.

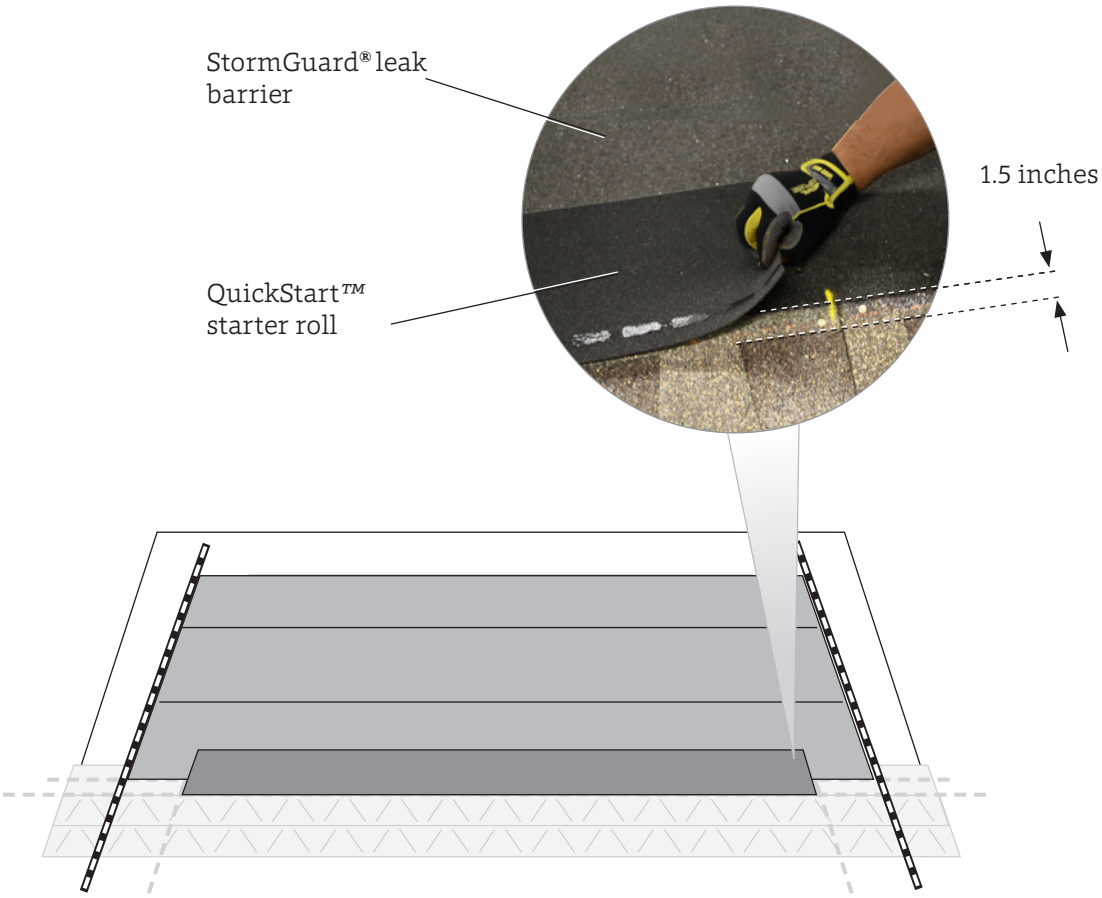


Figure 21. Install QuickStart® Peel & Stick Starter Roll at bottom of array

Step 1. Prep the roof, continued

Step 1e: **Install VersaShield® SOLO™ Fire-Resistant Slip Sheet.** Install VersaShield® over both the StormGuard® Leak Barrier and the QuickStart® Peel and Stick Starter Roll.

- Leave the same 1.5-inch gap between the shingle headlap and the start of the VersaShield® slip sheet.
- To fasten, use corrosion-resistant plastic cap nails or staples with plastic caps.
- The VersaShield® slip sheet should be the same width as the solar array.

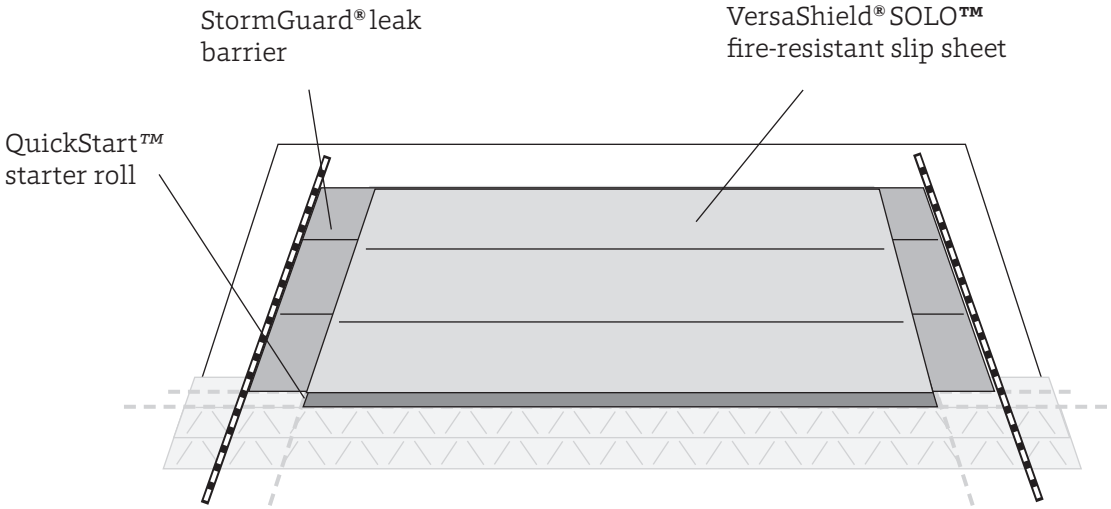


Figure 22. Install VersaShield® SOLO Fire-Resistant Slip Sheet over field of the array

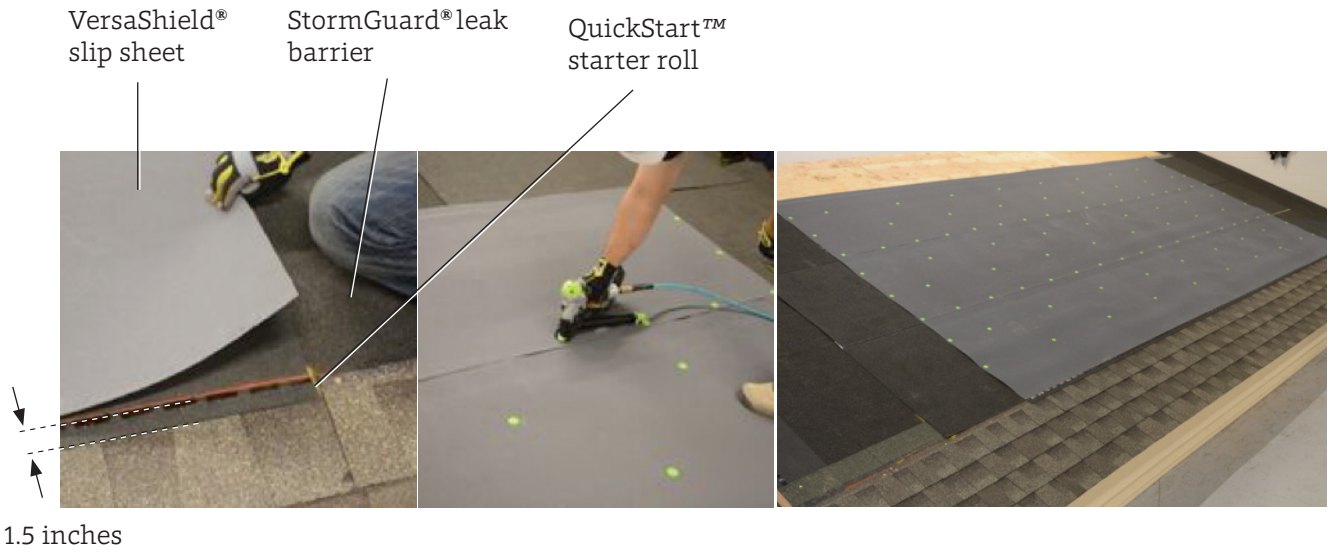


Figure 23. VersaShield® roof example

Step 1. Prep the roof, continued

Notes on VersaShield® Fastener Spacing

- For moderate roof slopes between 4:12 and 6:12:
  - » Along all edges, space the fasteners 12 inches (305 mm) apart. This includes both vertical and horizontal array edges, as well as the VersaShield® side laps and end laps within the field of the array.
  - » For other areas within the field of the array, space the fasteners 24 inches (610 mm) apart horizontally, and stagger these rows.
  - » Nail row vertical spacing is always 12 inches.
  - » Omit the lowest row of fasteners altogether to avoid interference with the Starter Bar.
  - » Allow overlaps between VersaShield® sheets as follows: side laps of 3 inches (76 mm), and end laps of 6 inches (152 mm).
- For steeper roof slopes between 6:12 and 12:12:
  - » Use a spacing of 9 inches on edges (228 mm) and 18 inches (457 mm) elsewhere.
  - » Use the same overlaps as for moderate slope roofs, and omit the lowest row of fasteners.

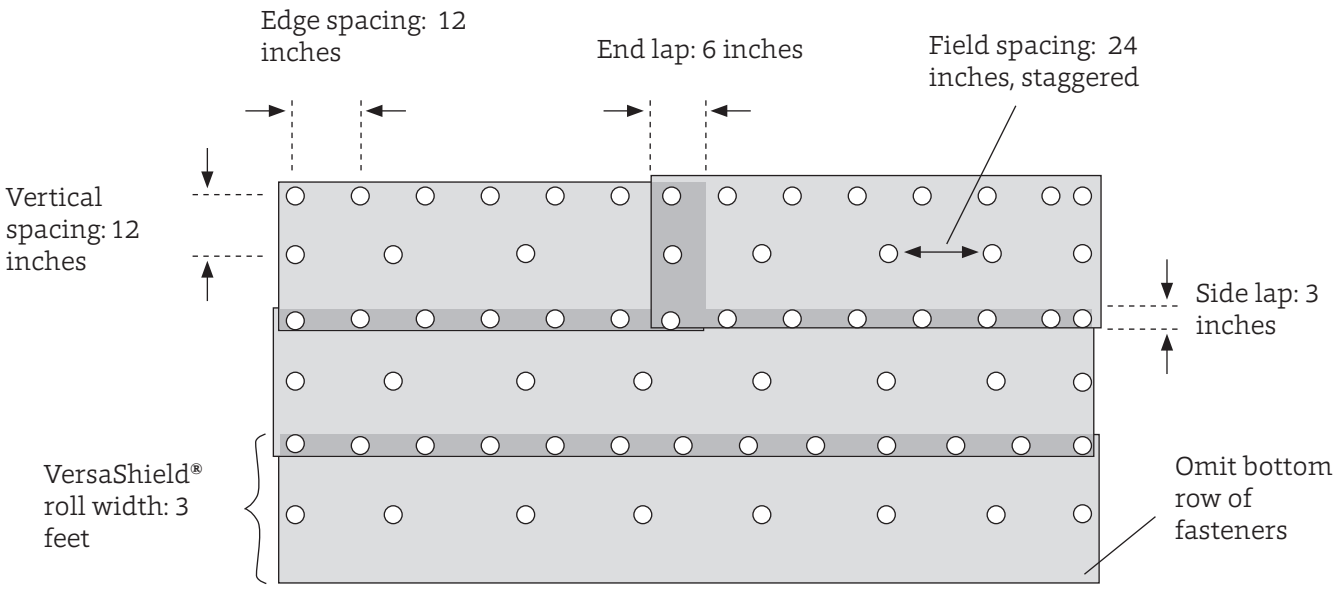


Figure 24. VersaShield® fastener spacing and overlap, slope 4:12 - 6:12

Step 2. Build Starter Bar and Solar Module Assemblies

Summary:

a. Assemble Starter Bar segments and Feet
b. Attach Adjustable Feet to modules
c. Mount MLPEs on MLPE Brackets
d. Attach MLPE Assemblies to modules
e. Connect PV wires
f. Module-level wire management

Step 2a. **Assemble the Starter Bar** by connecting the Bar segments together, and attaching the Adjustable Foot Bases. Each Starter Bar segment receives 3-5 Adjustable Foot Bases as shown in the Permit Drawings. Note that adjacent Starter Bars share a common Foot Base, which splices them together. Attach the Adjustable Foot Bases using the following fasteners, which are provided:

» Carriage Bolts, (5/16 inch, 18 x 1 inch steel, zinc-plated)
» Serrated Flange Nuts (0.313 inches, #18, steel, zinc-plated)

Align the tooth grooves of the Adjustable Foot Base with the tooth grooves on the Starter Bar. Align the grooves as needed to adjust the height of the Adjustable Foot. Insert the Carriage Bolt and fasten with the Nut. Torque the Nut to 75 inch-pounds (8.5 Nm).

Figure 25. Assembling the Starter Bar

Step 2. Build Starter Bar and Solar Module Assemblies, continued

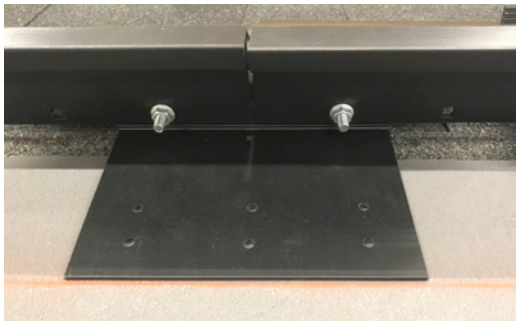


Figure 26. Adjustable Foot splices adjacent Starter Bar segments

NOTE: The next several steps explain how to build the Solar Module Assembly, which is often best performed on the ground before hoisting modules up to the roof. The Module Assembly consists of a PV module with Adjustable Feet, MLPE, with the module leads connected, secured, and ready for drop-in. The figure below shows the components used to build the Module Assembly.

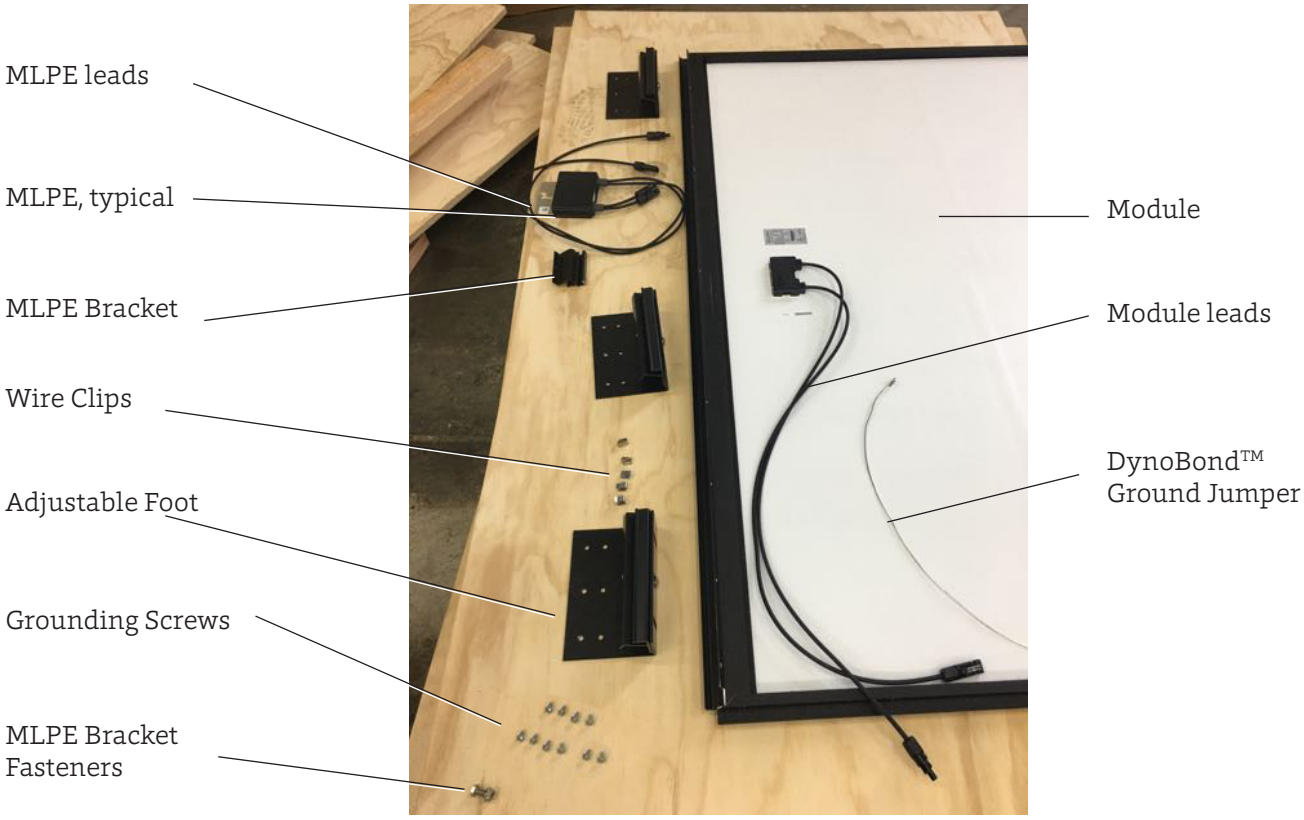


Figure 27. Solar Module Assembly components

Step 2. Build Starter Bar and Solar Module Assemblies, continued

Step 2b. **Attach the Adjustable Feet.** Each Adjustable Foot Assembly consists of the Adjustable Foot Base together with an extruded hook that clips onto the back of the module frame. Each module receives 3-5 Adjustable Feet, depending on local regulations and environmental conditions. Check the approved Permit Drawings for the installation to determine the proper number of Feet.

- Hook the Foot onto the channel along the module frame.
- Rotate the Foot into position and align the pre-drilled holes.
- Attach the Foot using by inserting the Grounding Screw into the pre-drilled hole.
- Torque the Grounding Screw to 40 inch-pounds (4.5 Nm).
- Attach the remaining Adjustable Feet to the module.

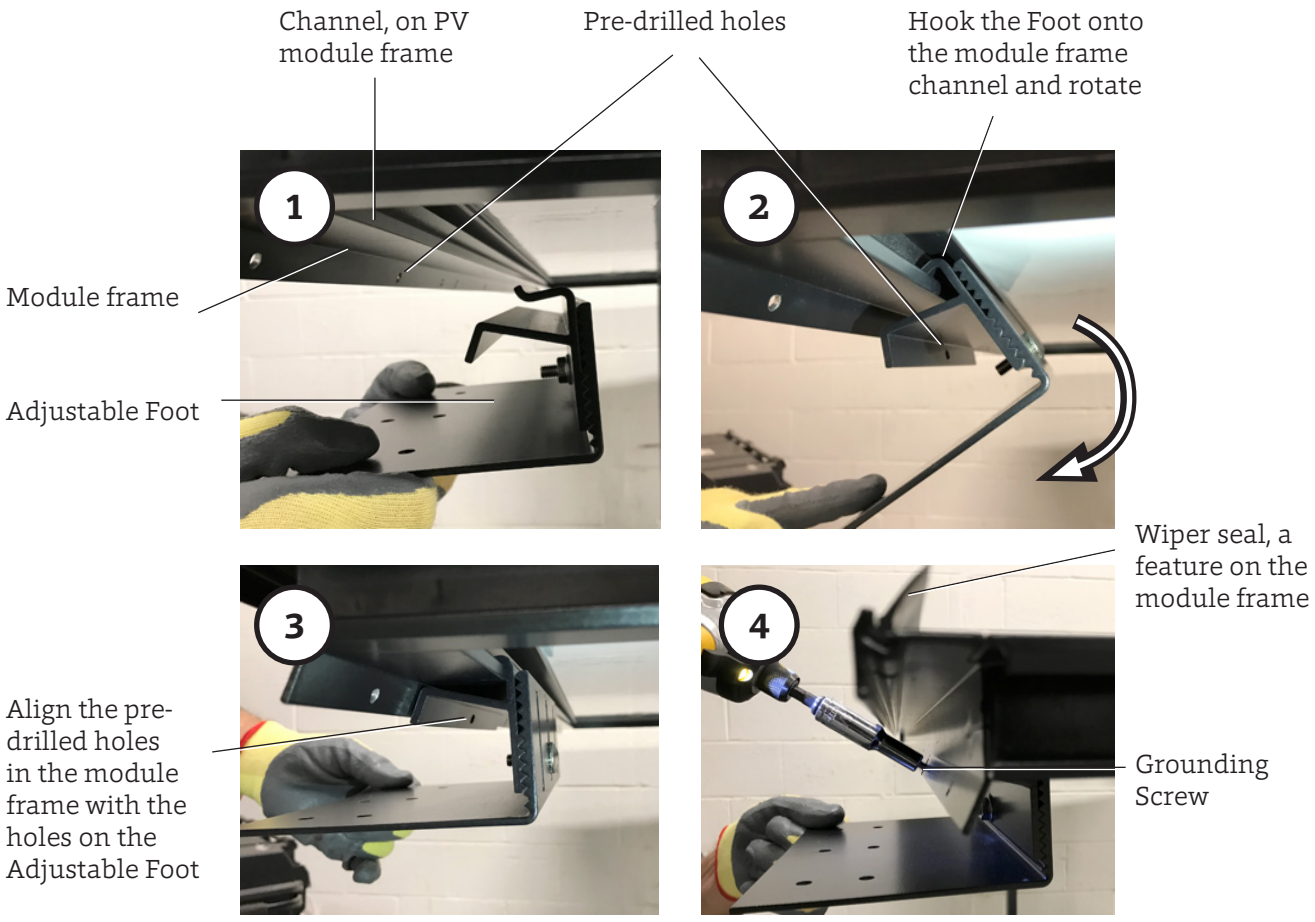


Figure 28. Mounting the Adjustable Feet onto the module frame

Step 2. Build Starter Bar and Solar Module Assemblies, continued

Step 2c. **Mount MLPEs on MLPE Brackets.** Use the following fastener hardware to create the MLPE Assembly. Torque to 120 inch-pounds (13.5 Nm):

- 5/16 inch - 18 x 3/4 inch Hex Cap Screw, zinc
- 5/16 inch External Tooth Washer
- 5/16 inch - 18 Flange Nut, zinc

Figure 29. MLPE Bracket

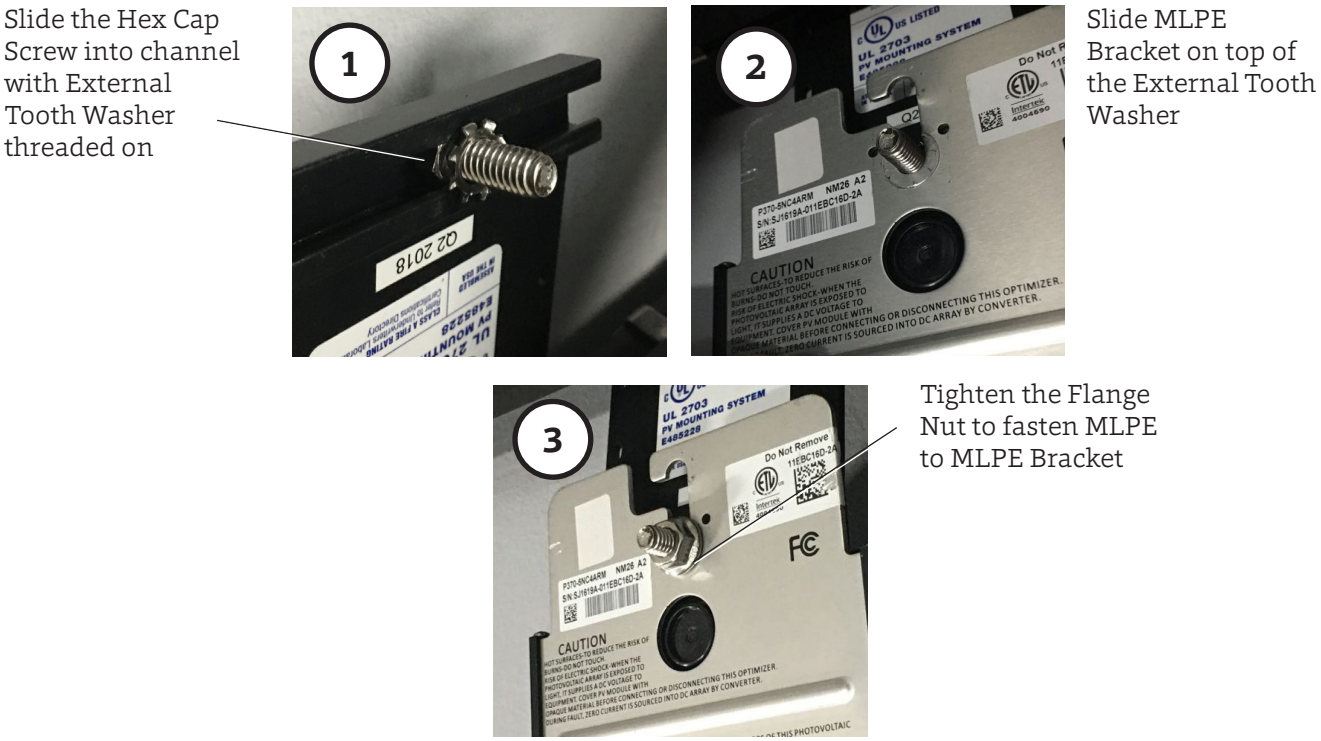


Figure 30. Mounting the MLPE on the MLPE Bracket

Step 2. Build Starter Bar and Solar Module Assemblies, continued

Step 2d. **Attach MLPE Assemblies to modules.** Each module receives one MLPE Assembly.

» Position the MLPE Bracket between the Adjustable Feet near the junction box at the end of the module.

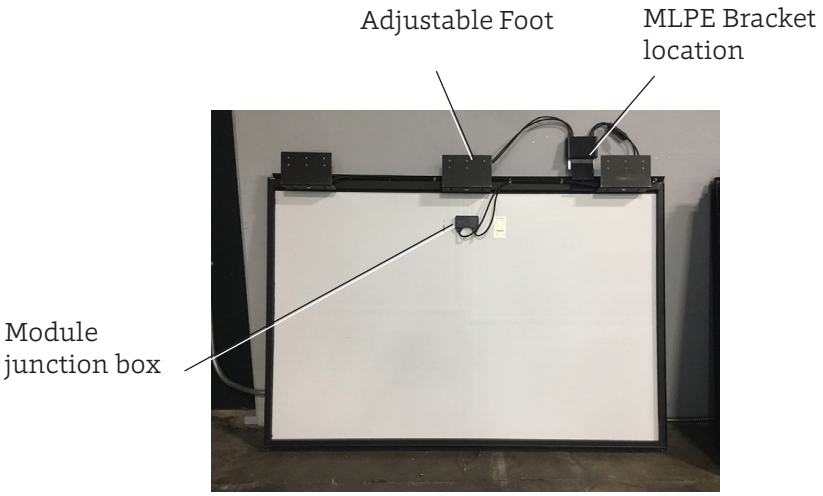


Figure 31. MLPE Bracket location, 3 Feet configuration

» Position the MLPE Bracket, by aligning the pre-drilled hole on the MLPE Bracket with the pre-drilled hole in the module frame.

» Attach the MLPE Bracket onto the module frame using the Hex Grounding Screw provided. Torque to 40 inch-pounds (4.5 Nm).

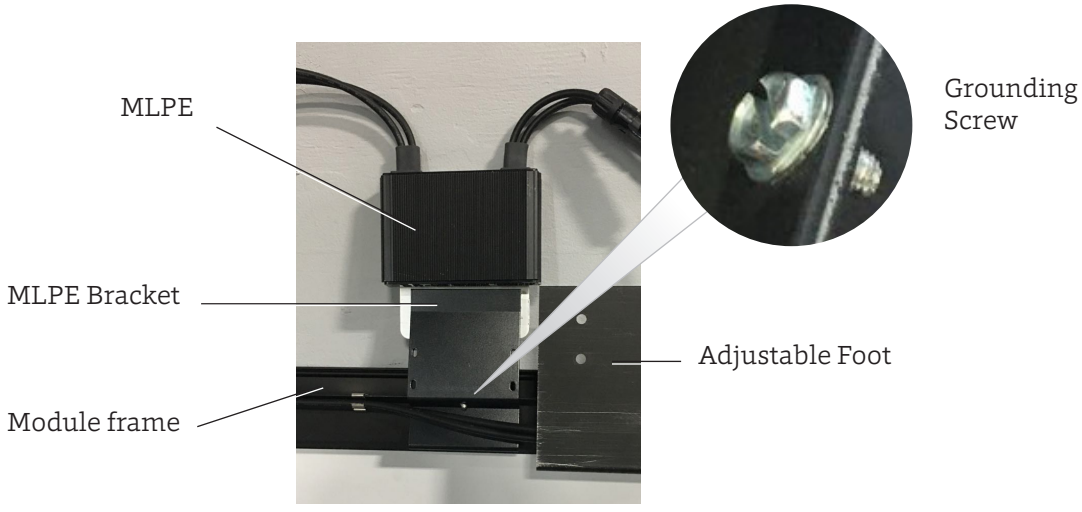


Figure 32. MLPE Bracket installation

Step 2. Build Starter Bar and Solar Module Assemblies, continued

Step 2e. **Connect module wires.** Connect the module leads to the mating connectors on the MLPE. Do not exceed the cables' minimum bend radius, as specified in the ***U.S. National Electrical Code***.

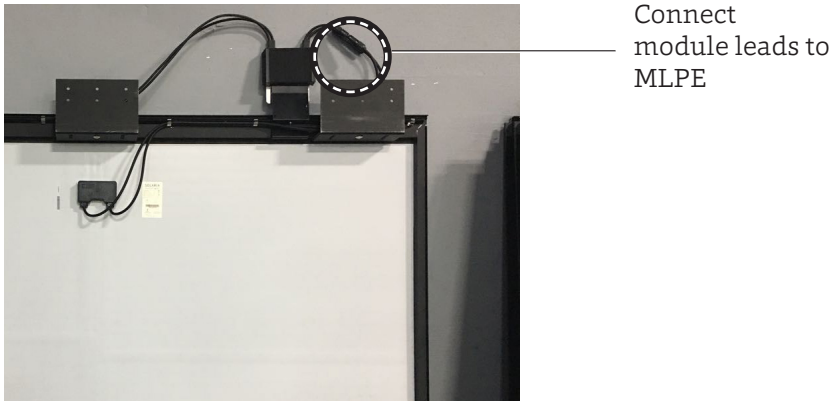


Figure 33. Connect module and MLPE wires

Step 2f. **Module-level wire management.** Secure the wires to the MLPE and module frame as needed, using Wire Clips. Prep the Module Assemblies properly ahead of time, in order to ensure that wires do not come in contact with the Side Flashing later on in the installation.

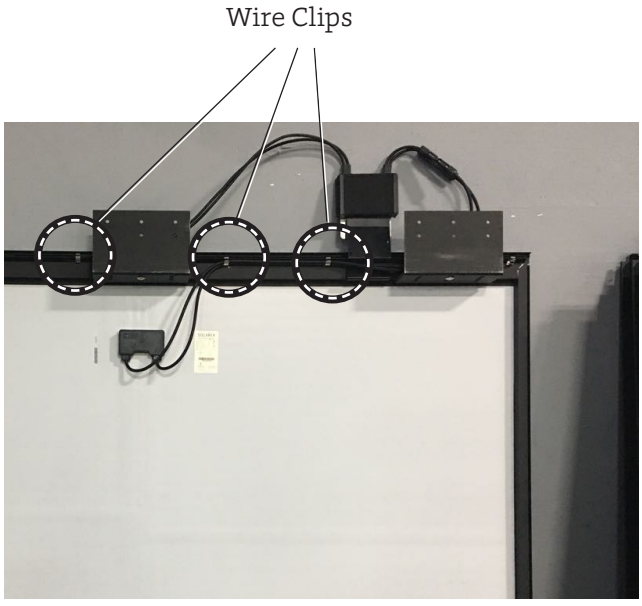


Figure 34. Module-level wire management, example

Step 2. Build Starter Bar and Solar Module Assemblies, continued

The completed Module Assembly appears as shown below, with Adjustable Feet, MLPE, and wire management.

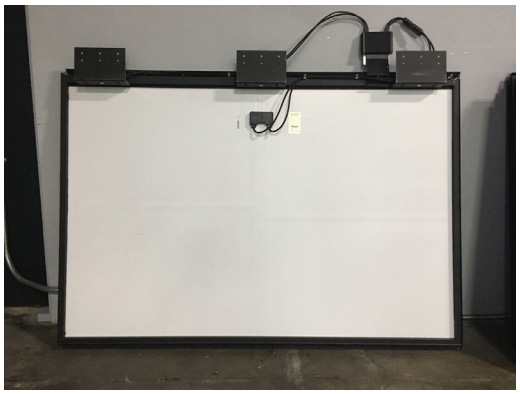


Figure 35. Completed Module Assembly

NOTE: Because adjacent Starter Bar segments are spliced together using a common Adjustable Foot Base, it is strongly recommended that you assemble all of the Starter Bars together before attaching them to the roof deck. Doing so allows alignment of the entire first module row, and subsequently the remainder of array.

Step 3. Install the Starter Bar

Summary:

a. Snap chalk line 5.25 inches above the shingle exposure line.

b. Position and attach Starter Bar to deck

c. Ensure Starter Bar is level, adjust Feet if needed

Step 3a. **Snap chalk line.** Snap a chalk line 5.25 inches (133 mm) from the edge of the shingle exposure line.

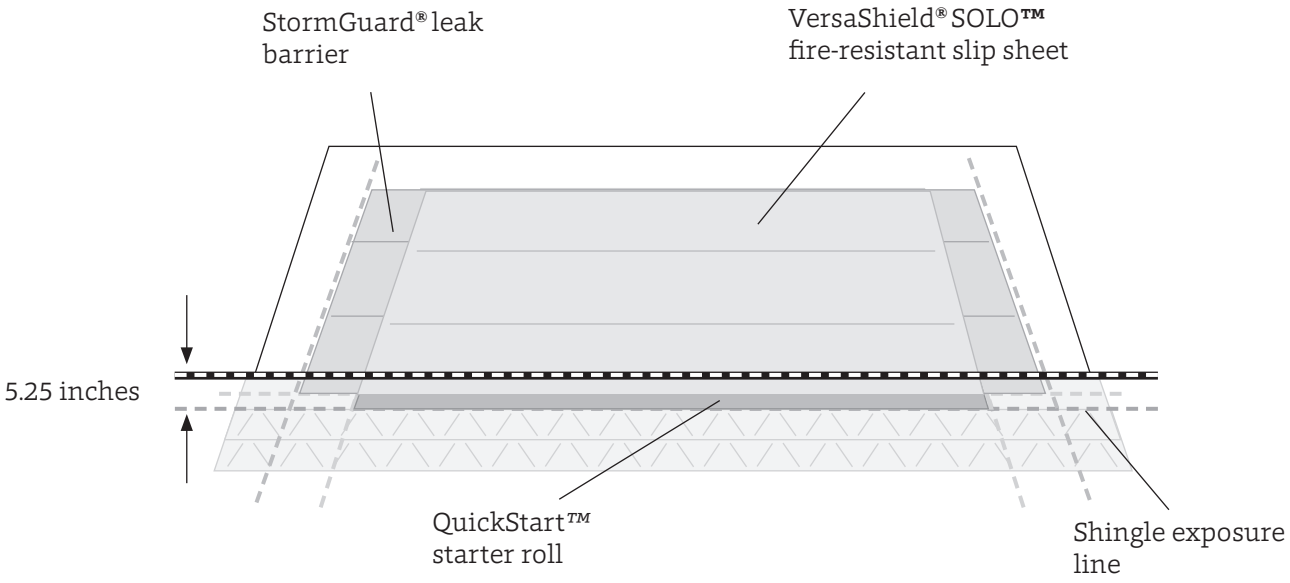


Figure 36. Snap chalk line for Starter Bar Foot positioning

Step 3. Install the Starter Bar, continued

Step 3b. **Position and attach Starter Bar to deck.** The assembled Starter Bar includes multiple Adjustable Foot Bases.

- Align the up-roof edge of the Adjustable Foot Base with the chalk line. Align Starter Bar ends with the left and right edges of the array. Ensure that the Starter Bar is horizontally centered left to right within the array area.
- Each Mounting Foot has two rows of three pre-drilled screw holes. Use either row of screw holes to avoid seams and knots in the roof deck.
- Fasten the Starter Bar to the roof deck using three Roofing Fasteners per Foot. Use the Roofing Fasteners provided. Do not over-tighten.

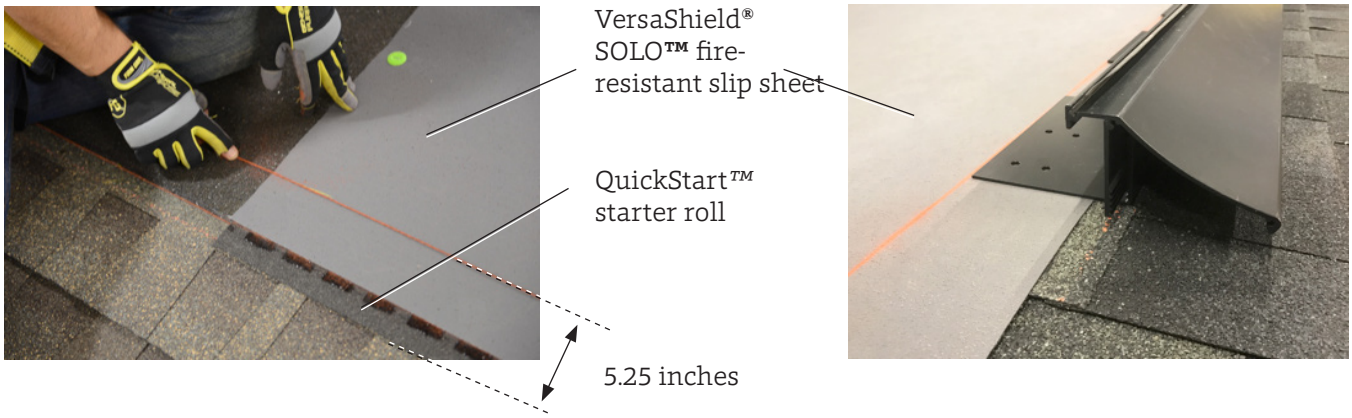


Figure 37. Align toe of Mounting Foot with chalk line and center Starter Bar horizontally within array

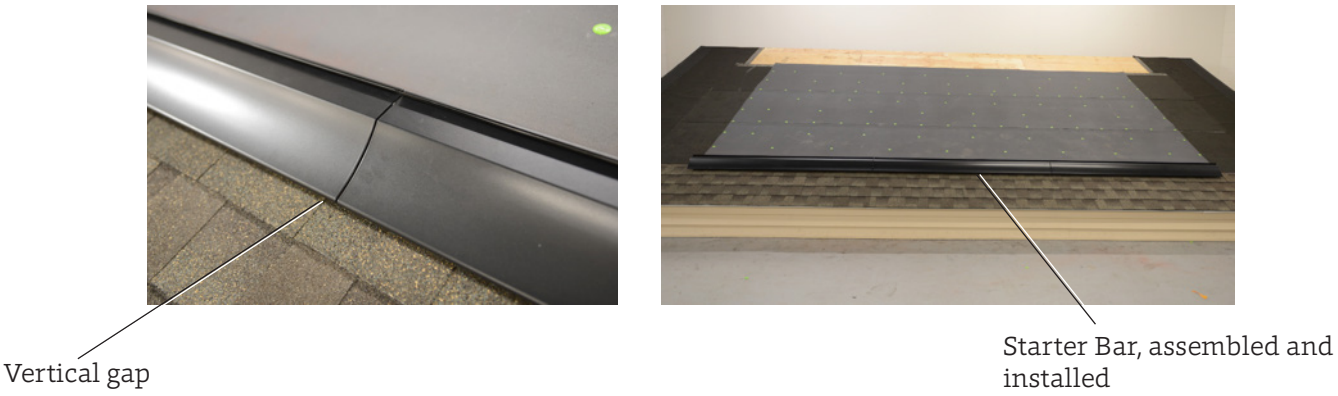


Figure 38. Starter Bar installed on a roof

NOTE: There will be a small vertical gap between the bottom edge of the Starter Bar and the roof surface itself.

Step 3. Install the Starter Bar, continued

Step 3e. **Ensure Starter Bar is level, adjust Feet if needed.** Verify that all portions of the Starter Bar are at the same height. Adjust the Feet as necessary.

Step 4. Install first row of Solar Module Assemblies

Summary:

a. Mount first row of Module Assemblies onto the Starter Bar

b. Connect electrical and grounding components

c. Align and attach Module Assemblies to the roof deck

Notes

- All the substeps in this section apply to a single module row. Some steps will be repeated for subsequent module rows.
- Use the stickers on the MLPEs to create a module map showing the correct installed position of every module in the array. It is recommended that you perform this step either as part of ground prep, or as you go, rather than waiting until the end.

Step 4a. **Mount first row of Solar Module Assemblies onto the Starter Bar.** Place the Module Assemblies into the Starter Bars from left to right. The Adjustable Feet on the Module Assemblies should be pointing up-roof. Each Module Assembly has a channel in the module frame that hooks into a flange on the Starter Bar, and side laps that allow the modules to interlock together.

» Hold the Module Assembly at a low angle and slide it down-roof until the edge of the Module Assembly hooks underneath the Starter Bar.

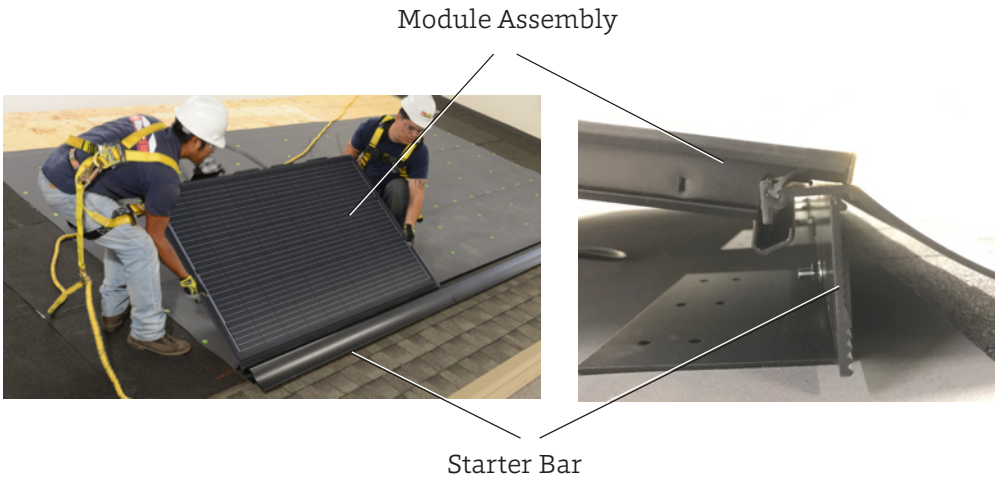


Figure 39. Mount Solar Module Assembly onto the Starter Bar

Step 4. Install first row of Solar Module Assemblies, continued

» Align the left edge of the first Module Assembly with the left edge of the Starter Bar.

» Place the next Module Assembly into the Starter Bar, a few inches to the right of the first Module Assembly, laying flat. Slide it to the left until it interlocks with the first Module Assembly.

» Repeat these steps from left to right until the row of modules is complete.

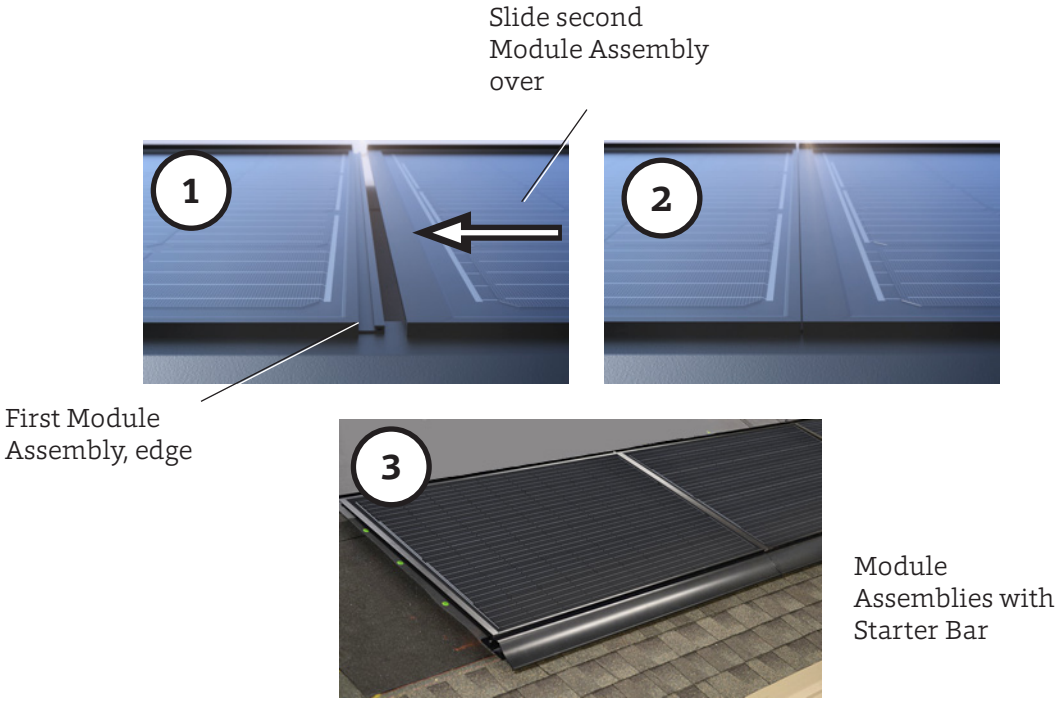


Figure 40. Placing and aligning Solar Module Assemblies

» Stretch a mason line across top edge (up-roof edge) of the row of Module Assemblies to ensure that modules are level. Adjust the Feet as needed to level the modules. Do not fasten the Feet yet.

Figure 41. Check that modules are level

Step 4. Install first row of Solar Module Assemblies, continued

Notes on Leveling with Adjustable Feet

The height of the Adjustable Foot can be adjusted from a minimum of 1.72 inches to a maximum of 3.15 inches. To adjust the height of the Feet:

- Loosen the Carriage Bolt and Flange Nut that secures the Adjustable Foot Hook to the Adjustable Foot Base. The Base attaches to the module and does not need to be detached.
- Align the interface to the correct tooth groove height.
- Re-tighten the Carriage Bolt and Flange Nut torque to 125 inch-pounds (14.12 Nm). The Flange Nut may be re-torqued up to 3 times when adjusting the height.

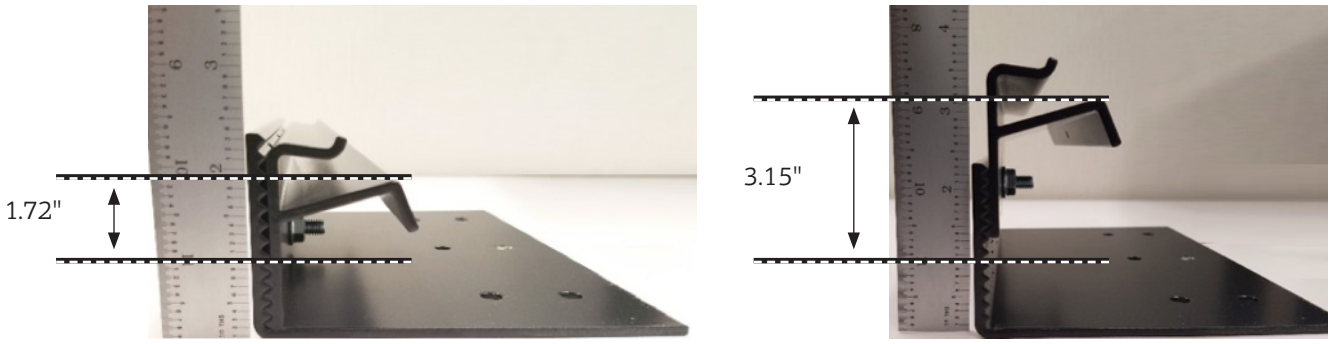


Figure 42. Foot adjustment range

Step 4b. **Connect elecrical and grounding components.** This includes MLPE to MLPE, row-to row (homerun), and ground jumpers. Complete the wiring according to the string diagram on the site-specific drawings. Detailed module connections may not be shown in the Permit Drawings, so refer to other site-specific drawings.

- Follow proper wire management techniques to secure the wires. Do not allow wires to be trapped or pinched underneath the modules. Ensure that wires do not come in contact with the Side Flashing, which is installed in a subsequent step.
- Ensure that row-to-row wire management leads and jumpers are free and available.

Step 4. Install first row of Solar Module Assemblies, continued

Figure 43. Typical module-to-module connections

NOTE: Refer to the MLPE manufacturer's installation instructions for any electrical testing and verification steps that may be required before proceeding.

» Attach DynoRaxx® brand DynoBond™ Ground jumpers between modules in accordance with the instructions in DynoRaxx Document No. 070919.

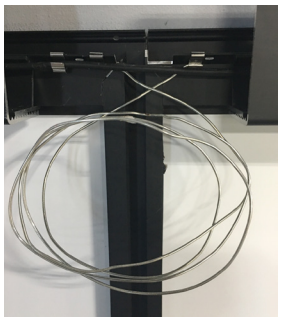


Figure 44. Installing DynoBond™ Jumpers between modules

NOTE: Although the GAF Energy Solar System does not require a separate copper ground wire for a single array, in the event that an installation uses one for conditions like multiple sub-arrays, be sure to neatly manage excess copper under the modules.

Step 4. Install first row of Solar Module Assemblies, continued

» Create an MLPE map showing the location of each module in the array. This step can be done prior to, or during, module installation. Remove MLPE stickers before fastening modules to the roof deck.

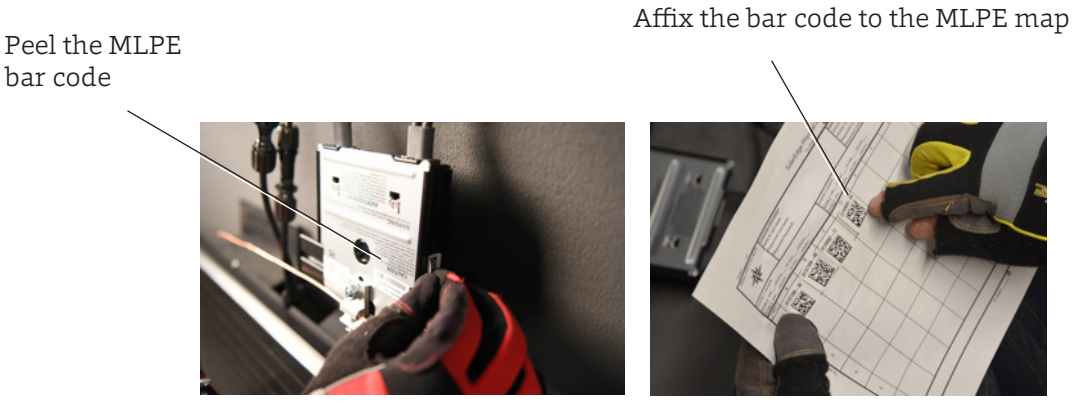


Figure 45. Create MLPE map, example

Step 4c. Align and attach Module Assemblies to the roof deck. Proceed from right to left.

» Starting from the rightmost Module Assembly in the row, align the inner edge of the module with the outer edge of the Starter Bar. The module lap extends beyond the edge of the Starter Bar on the right-hand side of the array. This alignment step is critical to ensure proper installation of the Step Flashing and Counterflashing later on.

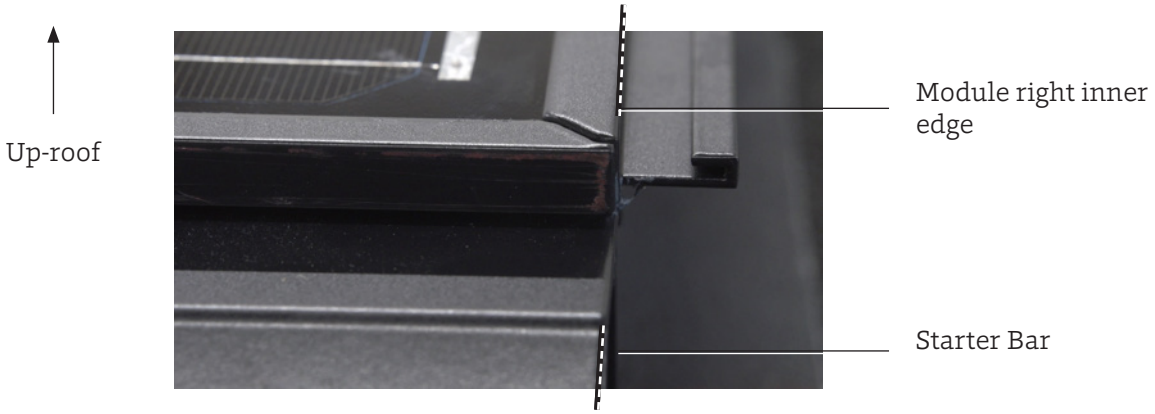


Figure 46. Aligning rightmost module edge with Starter Bar end

Step 4. Install first row of Solar Module Assemblies, continued

» Align both sides of the array. Check the module leveling once more before fastening.

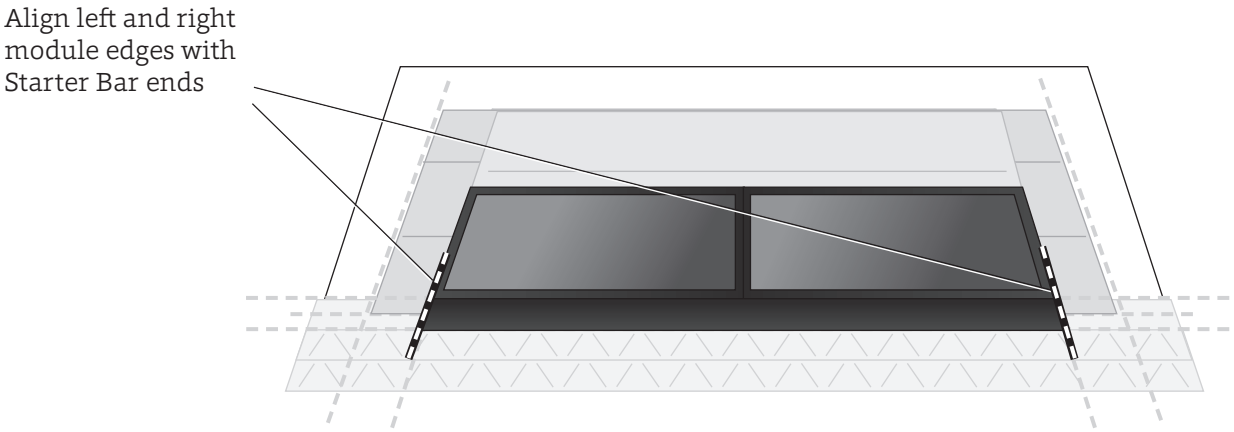


Figure 47. Align array at both sides before securing modules to deck

» If roof deck is plywood, use 3 Roofing Fasteners per Adjustable Foot. If roof deck is 7/16 inch OSB, use 6 Roofing Fasteners per Foot. Follow the Permit Drawings and use the Roofing Fasteners provided. Do not over-tighten the Roofing Fasteners.

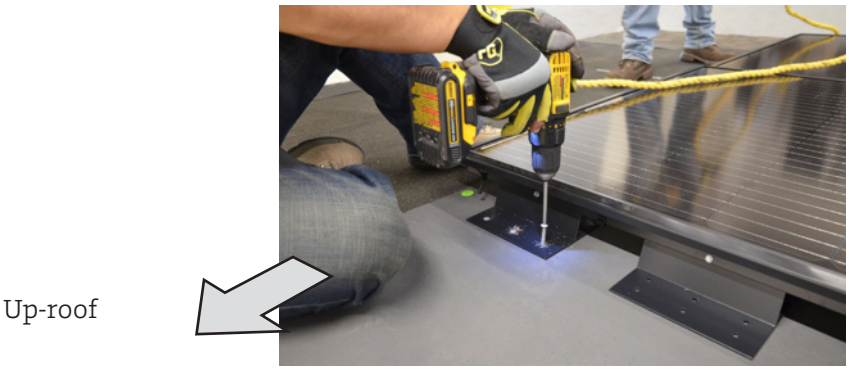


Figure 48. Attach Solar Module Assemblies to roof deck

WARNING: Ensure that no electrical cables or jumpers are stuck underneath the Feet before attaching the Adjustable Feet to the roof deck.

Step 5. Install remaining module rows

Summary:

a. Drop in next module row

b. Connect electrical leads for modules, grounding, and row to row

c. Fasten modules to deck

Step 5a. **Drop in next module row.** Repeat the same sequence as for the first module row, going from left to right. Each Module Assembly must align with the one below it.

Step 5b. Connect electrical leads for modules, grounding, and row to row.

» Connect the modules within the row.

» Connect module leads row-to-row, following the string diagrams in the site-specific installation drawings. Ensure proper wire management incuing the home run and the ground jumpers. Do not allow wires to come in contact with the Side Trim, which is installed for the next module row in a subsequent step.

» Connect DynoBond™ jumpers between modules.

» Connect DynoBond™ jumpers between module rows.

Step 5c. **Fasten modules to deck.** Ensure that no wires are trapped or pinched underneath the modules and that row-to-row connectors are free and available. Route the home run wire and the row-to-row ground jumper between the Adjustable Feet. The existing cables are long enough to extend from one row to the next.

Figure 49. Fasten next row of modules

Step 6. Install Step Flashing and Counterflashing

Summary:

a. Install Starter Bar covers

b. Install Step Flashing

c. Install Counterflashing

Step 6a. **Attach the Left and Right Starter Bar Covers.** Use the screws that are provided.

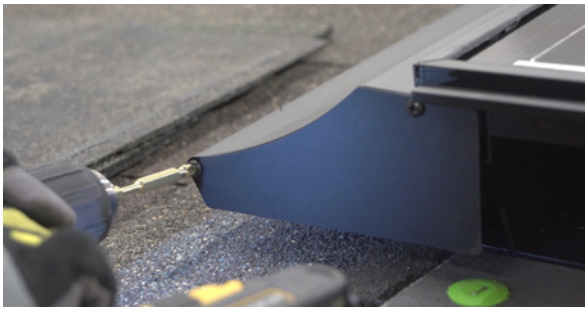


Figure 50. Install Starter Bar covers

NOTE: Optionally, install the first two pieces of Step Flashing before attaching the Starter Bar Covers.

Step 6b. **Install Step Flashing.** Install the Step Flashing and roof shingles the same as for a typical skylight, interleaving Step Flashing under each row of shingles as you go up the roof. Slip the first Step Flashing behind the Starter Bar Cover. Continue installing the Step Flashing and shingles up to th top of the array. Repeat for each side of the array. Refer to the *GAF Steep Slope PRO Field Guide* for assistance.

Figure 51. Completed Step Flashing

Step 6. Install Step Flashing and Counterflashing, continued

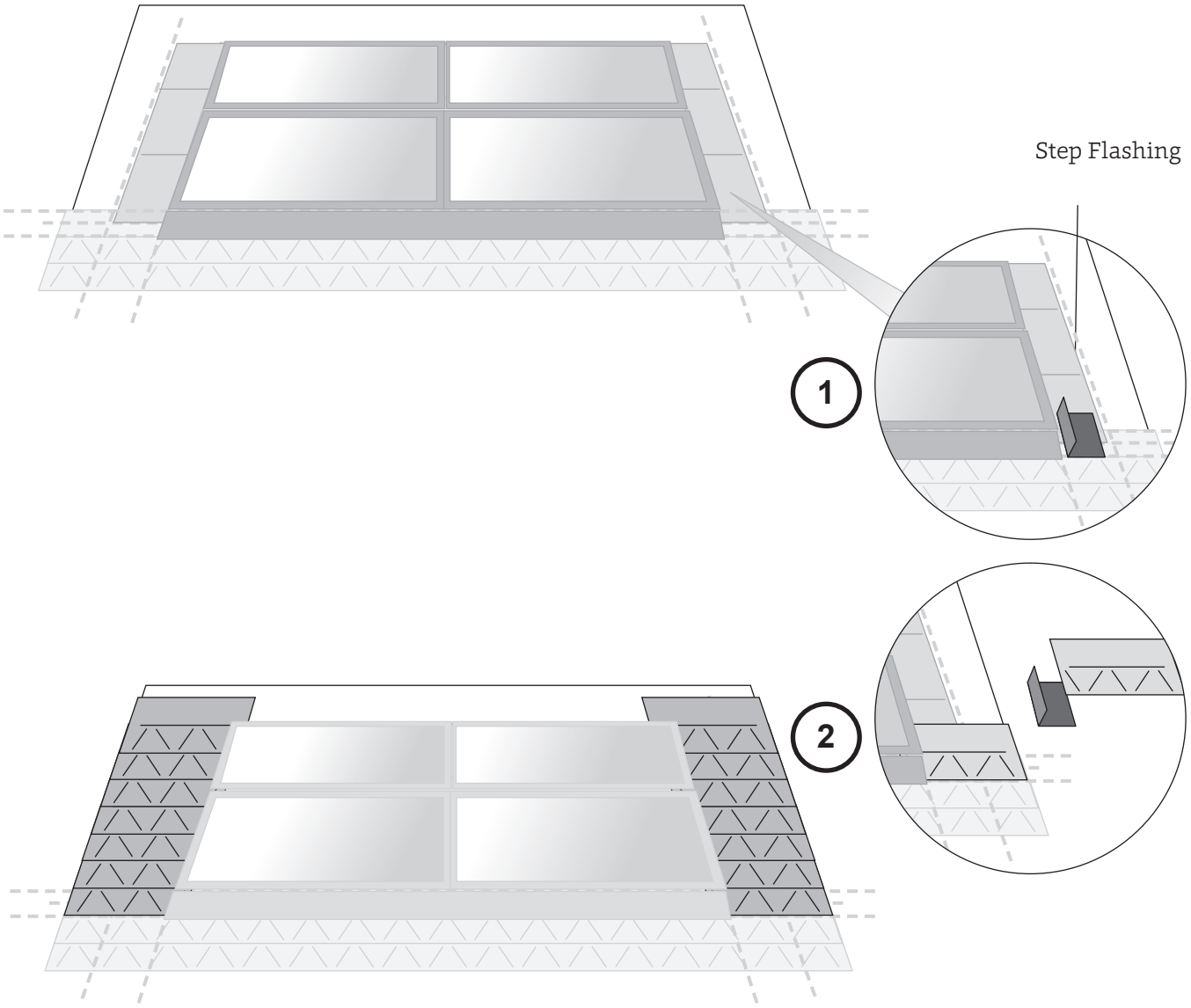


Figure 52. Step Flashing installation sequence

Step 6. Install Step Flashing and Counterflashing, continued

» The final Step Flashing should extend past the top of the array. In additon, make sure that the shingle exposure extends underneath the area where the Top Corner Flashing will land (installed in next step).

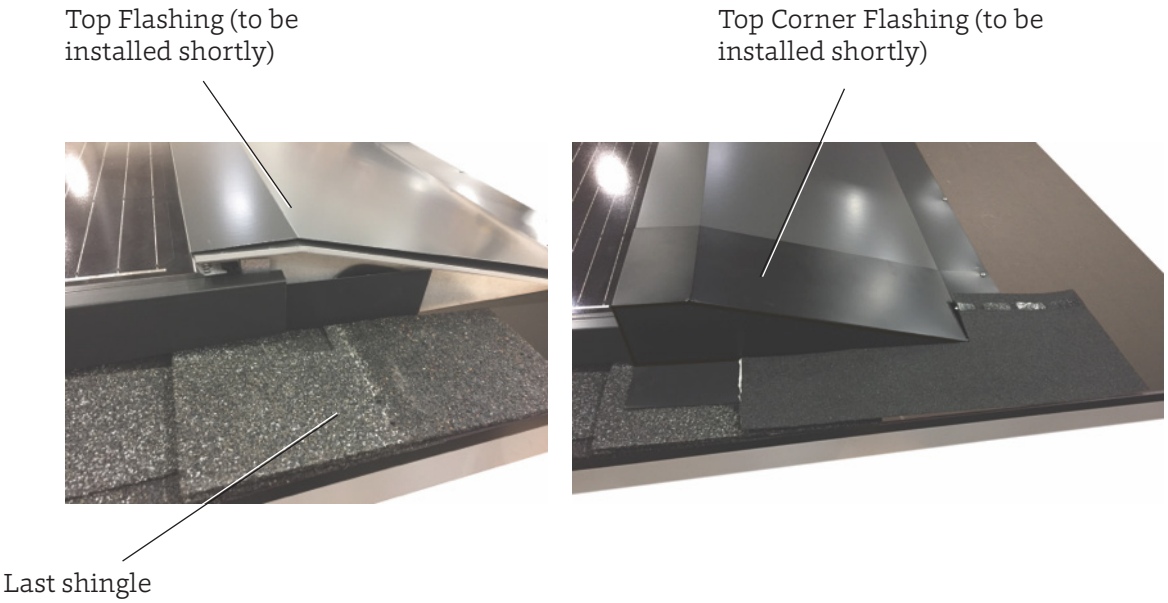


Figure 53. Step Flashing and shingle overlap with Top Corner Flashing

Step 6c. **Install Counterflashing.** Install the Left and Right Counterflashing from bottom to top, on both sides of the array.

» Mount the Counterflashing on a channel within the module frame, and then press Counterflashing firmly until a snap fit is created.

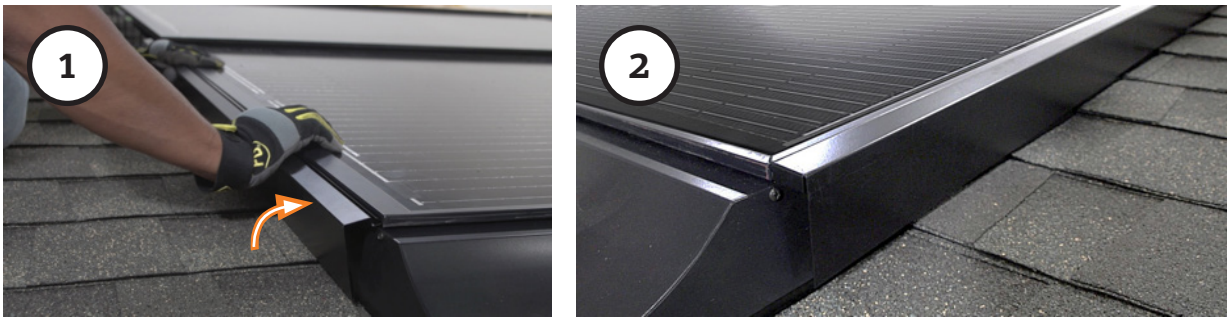


Figure 54. Install Counterflashing

Step 6. Install Step Flashing and Counterflashing, continued

NOTES

- Remove the plastic film covering from the flashing before installation. Leaving the flashing exposed to high outdoor temperatures for prolonged periods may make the film difficult to remove.
- The Left and Right Counterflashing are tapered from bottom (wide) to top (narrow).

Step 7. Install Top Flashing

Summary:

a. Install Top Flashing Frame Inserts
b. Install Top Flashing Supports and DynoBond™ jumpers
c. Position the Top Flashing
d. Install Grounding Clips on Top Flashing
e. Nail Top Flashing in place
f. Install Top Corner Flashings

Step 7a. **Install Top Flashing Frame Inserts.** The Top Flashing Frame Insert snaps onto the top (up-roof) edge of the Solar Module Assembly. Verify that every tab is engaged by pulling back on the Frame Insert. Install one Frame Insert for each Solar Module Assembly along the top row of the array.

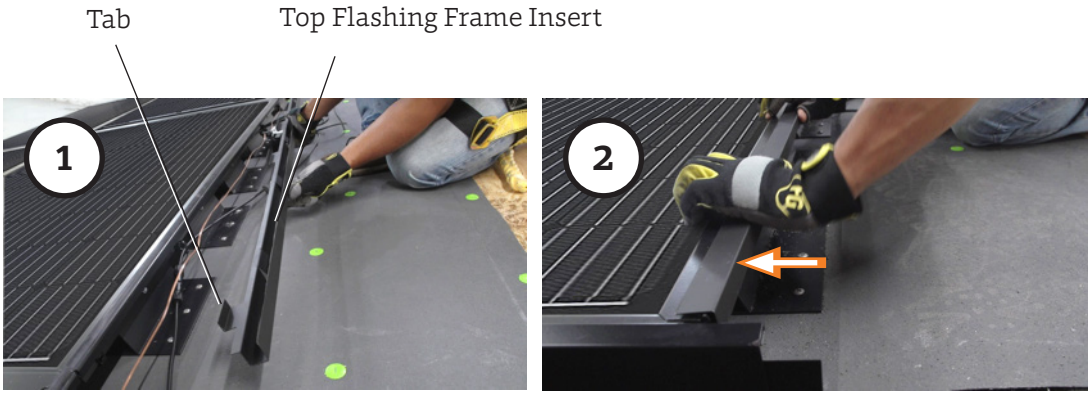


Figure 55. Install Top Flashing Frame Insert

Step 7. Install Top Flashing, continued

Step 7b. **Install Top Flashing Supports and DynoBond™ jumpers.** Place Top Flashing Supports at the corners of the array, and at every module-to-module joint. In high snow load areas, additional Top Flashing Supports may be required.

- Place the corner Top Flashing Supports 1/4 to 1/2 inch (6-12 mm) from the edge of the Counterflashing.
- Center the remaining Top Flashing Supports on the joints between the Solar Module Assemblies.
- Fasten each Top Flashing Support using two standard roofing nails. Fasten within 1 inch (25 mm) of the edge of the Flashing Support.

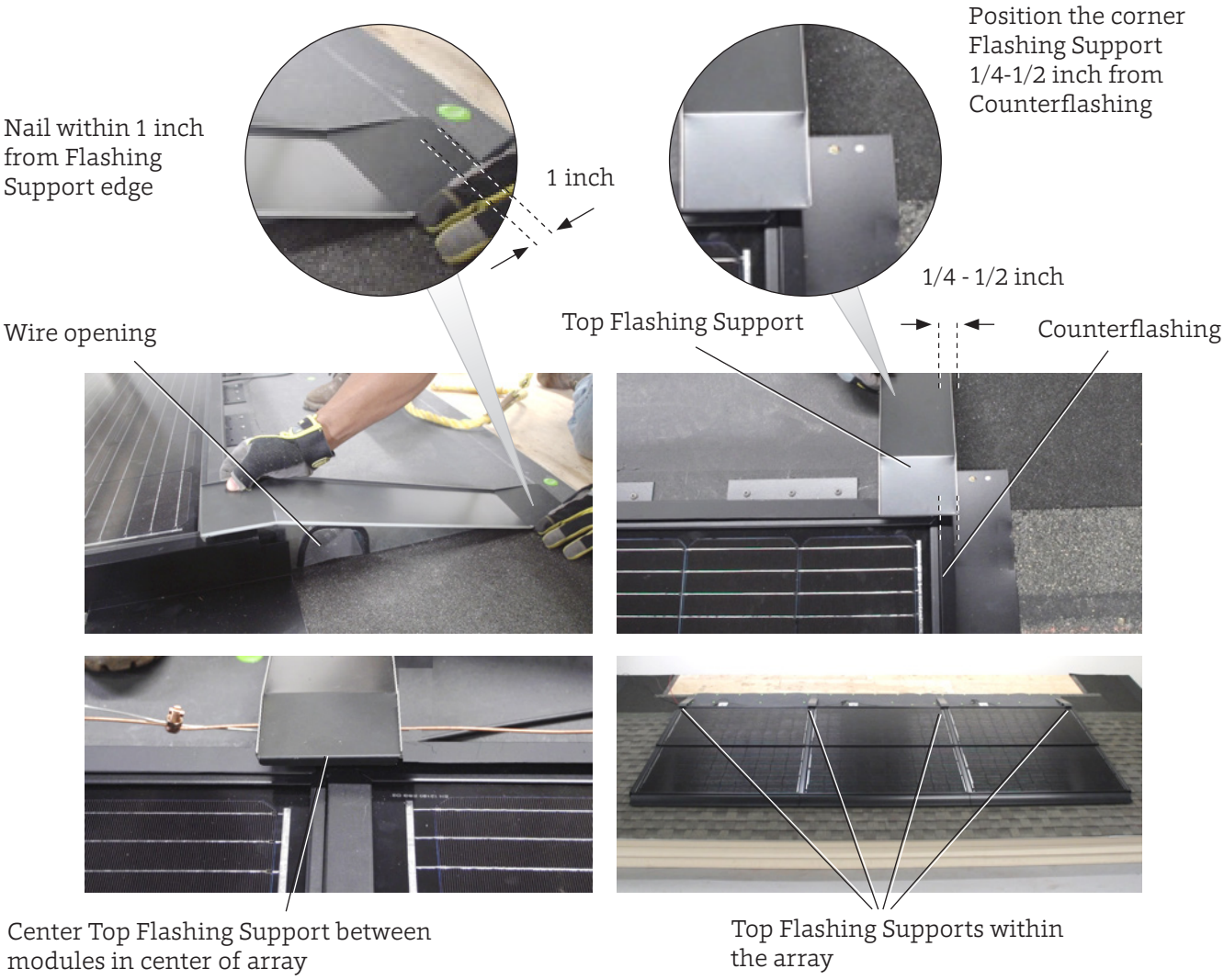


Figure 56. Locating and installing the Top Flashing Supports

Step 7. Install Top Flashing, continued

» Bend each DynoBond™ jumper into a U-shape and pass it through the slot in one of the Top Flashing Supports.

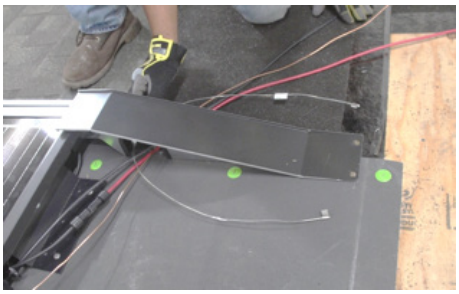


Figure 57. Position DynoBond™ jumpers

Step 7c. **Position Top Flashing.** Position the Top Flashing so that it aligns with the Solar Module Assembly. The Top Flashing hooks into the Top Flashing Frame Insert.

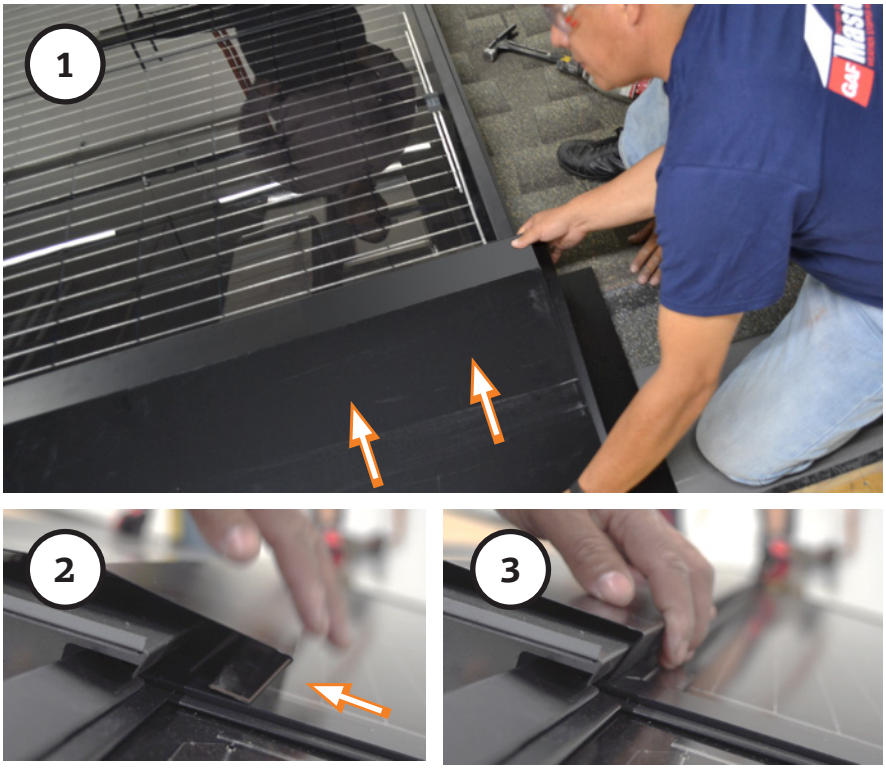


Figure 58. Position the Top Flashing

Step 7. Install Top Flashing, continued

Step 7d. **Install Grounding Clips on Top Flashing.** The DynoBond™ jumper clips are designed to penetrate the finishing coat on the ege of the Top Flashing. Use a hammer to lightly tap the jumper clip into place. Add a jumper for each Top Corner Flashing, leaving one clip free. Add a jumper from one of the modules to the Top Flashing as well.

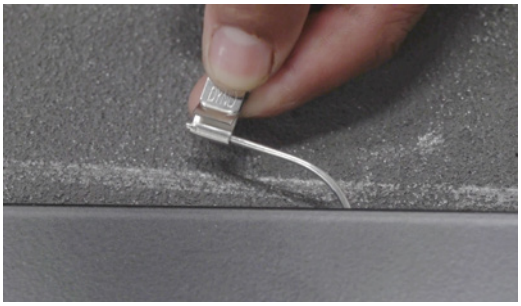


Figure 59. Attaching the DynoBond™ grounding jumper clip to Top Flashing

NOTE: The DynoBond™ jumper clips are designed for 1-time use only.

Step 7e. **Nail Top Flashing in place.** Attach the Top Flashing to the roof deck using a minimum of four evenly spaced standard roofing nails. Trim excess VersaShield ® SOLO™ Fire-Resistant Slip Sheet to within approximately 1 inch of the Top Flashing.

Figure 60. Installing the Top Flashing

Step 7. Install Top Flashing, continued

WARNING: Ensure that no electrical cables are trapped underneath the flat portion of the Top Flashing.

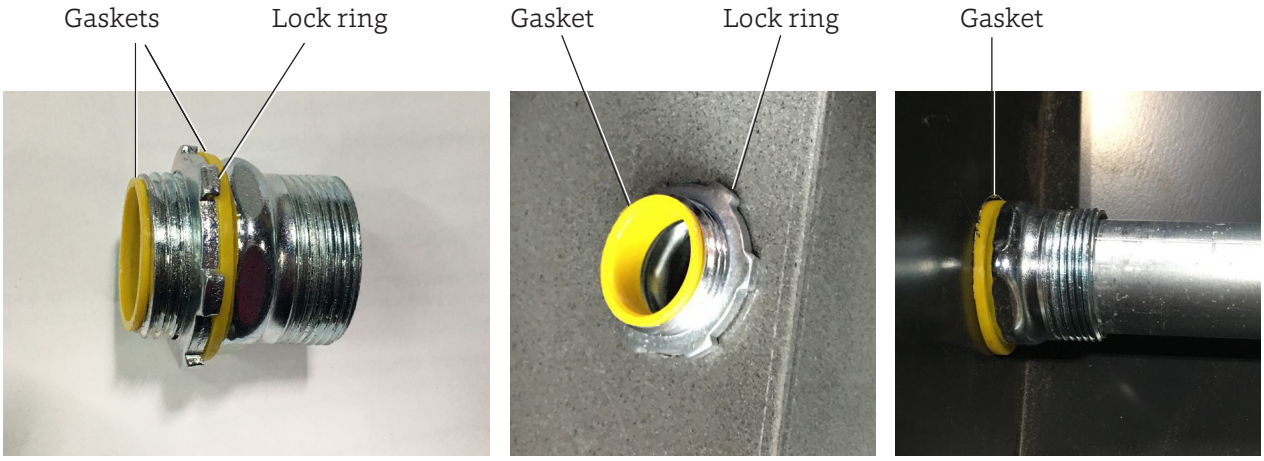
NOTE: Exposed roofing nails will be covered by a leak barrier installed in a subsequent step.

Step 7f. **Install Top Corner Flashings.** Install the Left and Right Top Corner Flashings and run the conduit according to the Permit Drawings.

- Identify the Left or Right Top Corner Flashing that will receive the wire conduit.
- Attach the wire conduit to the Top Corner Flashing.
- Install the Top Corner Flashing over the Top Flashing.
- Attach the DynoBond™ jumper clip to each Top Corner Flashing.
- Connect conduit to the Top Corner Flashing nearest the array junction box. Ensure that conduit lock ring bonds to Corner Flashing. Pull array wires through through Corner Flashing and conduit.
- Fasten the Top Corner Flashing with standard roofing nails along the top edge.

Figure 61. Installing the Top Corner Flashing

Step 7. Install Top Flashing, continued



Raintight conduit assembly

Inside face of Top Corner Flashing

Outside face of Top Corner Flashing

Figure 62. Top Corner Flashing with conduit

Figure 63. Conduit fitting, exploded view

Step 8. Install Top Flashing Underlayment and Shingles

Summary:

a. Install QuickStart® over Top Corner Flashings
b. Install shingles over Top Corner Flashings
c. Install StormGuard® leak barrier over Top Flashing
d. Install QuickStart® over Top Flashing leak barrier
e. Install remaining rows of shingles
f. Install QBox junction box

Step 8a. **Install QuickStart® over Top Corner Flashings.** Install a strip of QuickStart® Peel and Stick Starter Roll over each Top Corner Flashing on the left and right sides of the array. Notch the QuickStart® as needed to fit it snugly around the Top Corner Flashing.

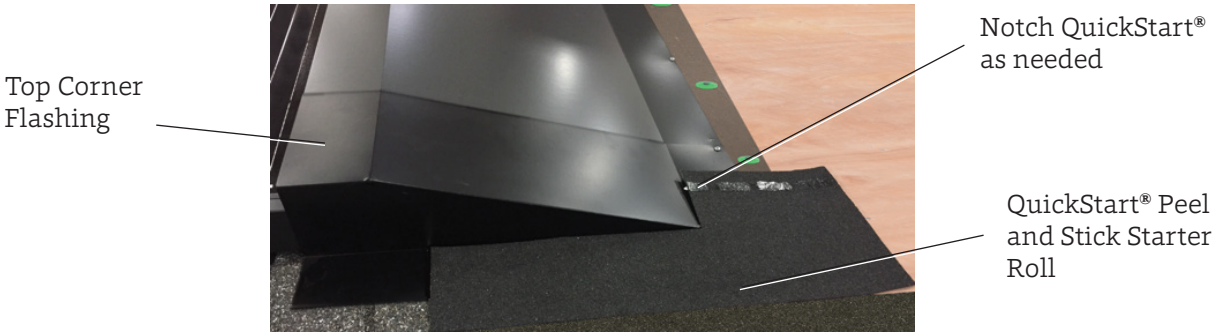


Figure 64. Apply QuickStart® Starter Roll over Top Corner Flashing

Step 8b. **Install shingles over Top Corner Flashings.** Install shingles over each Top Corner Flashing on the left and right sides of the array. Notch as needed to fit it around the Top Corner Flashing.

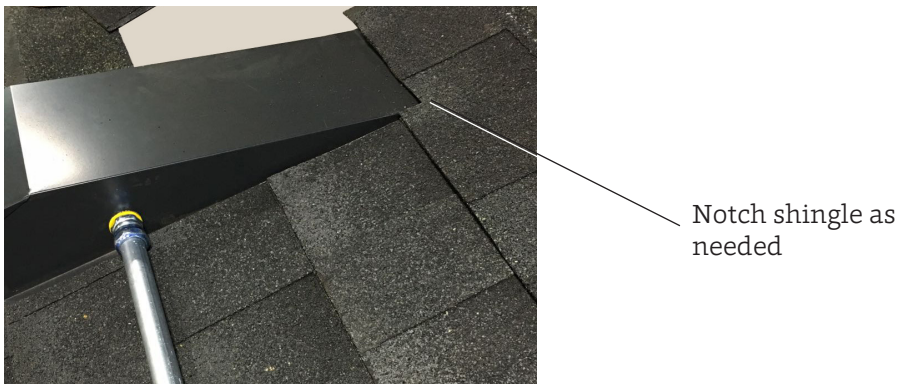


Figure 65. Install shingles over Top Corner Flashing

Step 8. Install Top Flashing Underlayment and Shingles, continued

NOTE: Protect wires from abrasion on the shingles, and from other physical damage, until array installation is complete.

Step 8c. **Install StormGuard® leak barrier over Top Flashing.** Install StormGuard® leak barrier over the nailing area of the Top Flashing across the top of the array. The leak barrier should cover the headlap of the adjacent row of shingles, and extend past the array on either side by approximately 3 feet (914 mm).

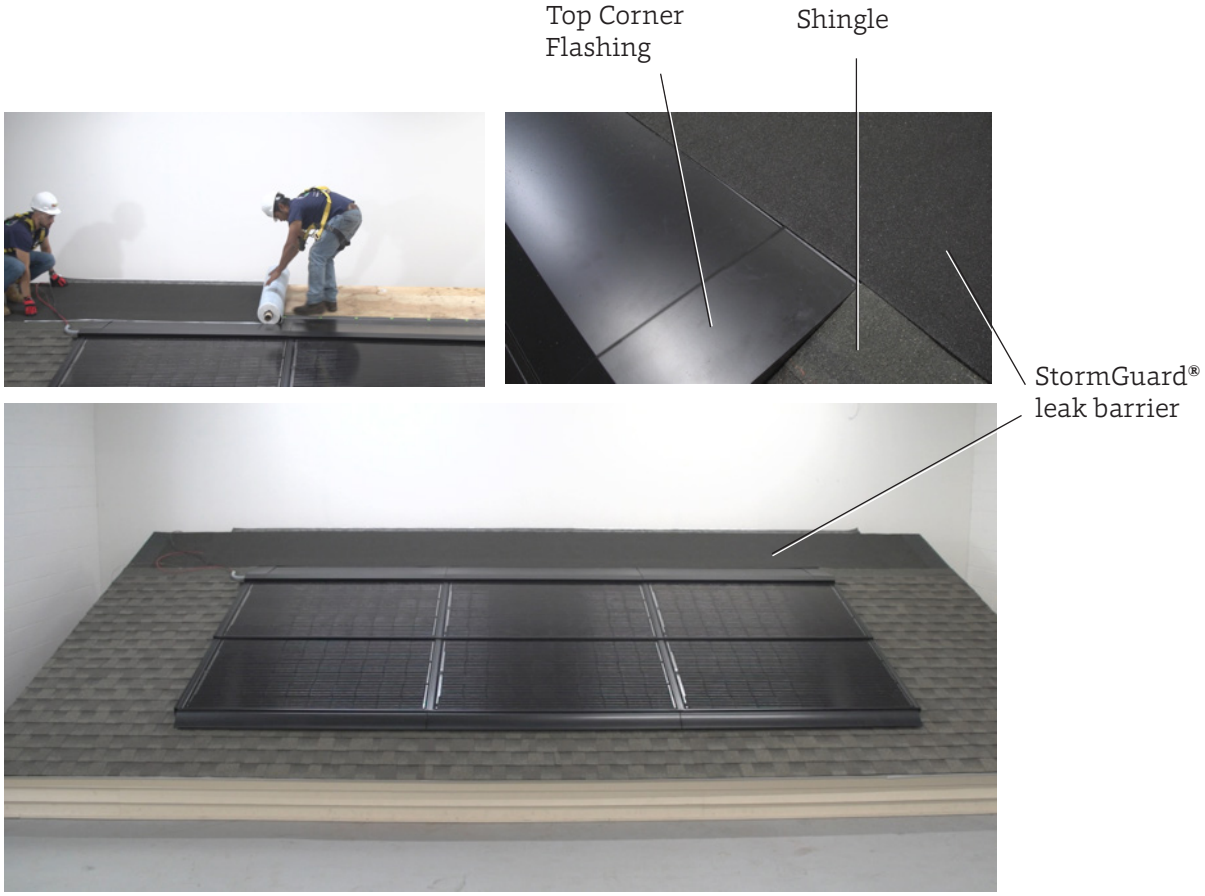


Figure 66. Install StormGuard® leak barrier over Top Flashing and shingles

Step 8. Install Top Flashing Underlayment and Shingles, continued

Step 8d. **Install QuickStart® over Top Flashing leak barrier.** Install QuickStart® Peel and Stick Starter Roll on top of the StormGuard® leak barrier across the top of the array. The QuickStart® is the starter course for the row of shingles to be installed above the array. Extend the QuickStart® to the edges of the leak barrier, 3 feet past the sides of the array.

Figure 67. Install QuickStart® over the StormGuard® leak barrier

Step 8e. **Install remaining rows of shingles.** Continue installing shingles up to the roof peak following roofing best practices.

Figure 68. Install remaining shingles and finish roof

Step 8. Install Top Flashing Underlayment and Shingles, continued

Completed GAF Energy Solar System

Figure 69. Completed GAF Energy Solar System

Step 8. Install Top Flashing Underlayment and Shingles, continued

Step 8f. **Install QBox and run electrical to QBox.** Refer to Permit Drawings and site specific installation drawings for the intended location of the QBox, and refer to the QuickMount QBox Installation Manual for other instructions.

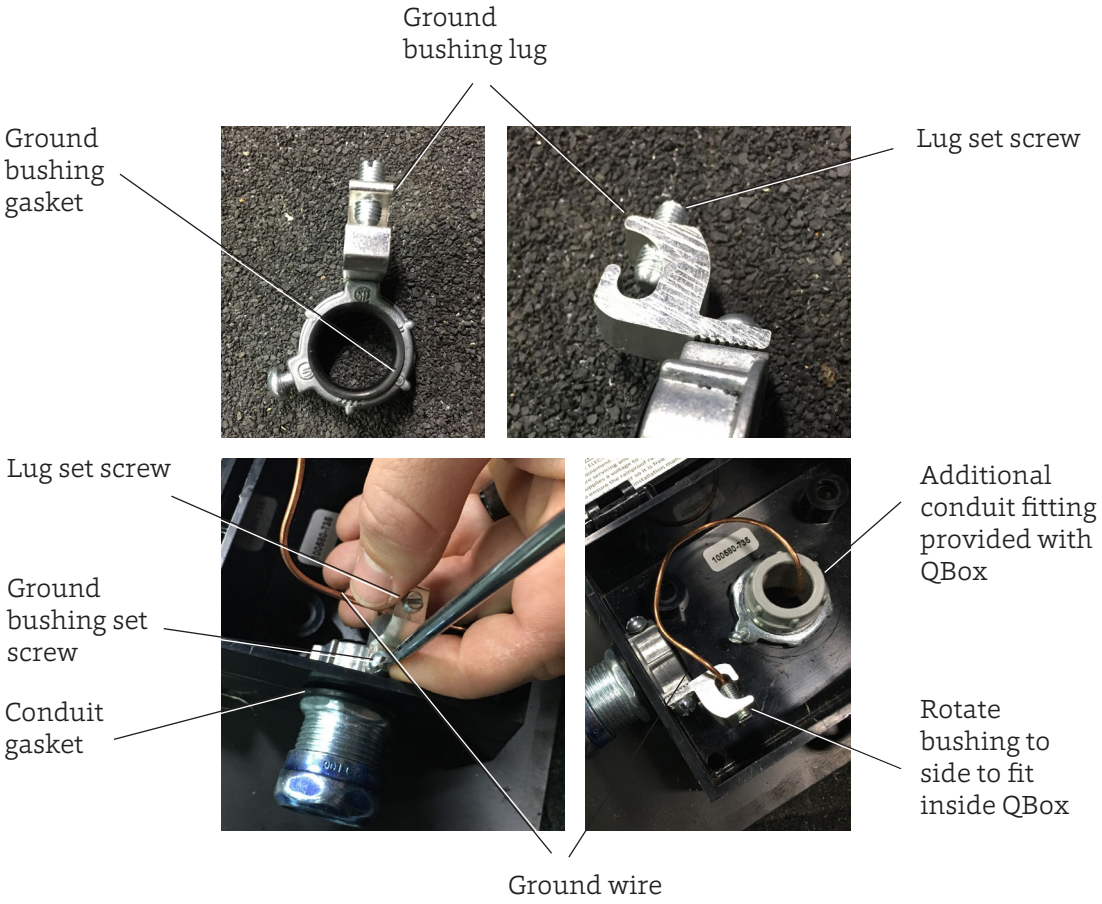


Figure 70. Connect home runs and ground conductor to QBox

Wire Management

Module-level power electronics (MLPE) are integrated into the Solar Module Assembly. Following are typical example schematics showing how the MLPEs are wired in the field. Refer to the string diagram in the site-specific installation drawings for the exact details of each installation. Schematics show MPLEs above module for clarity. Actual MLPE position is underneath the module.

DC Optimizer, Schematic

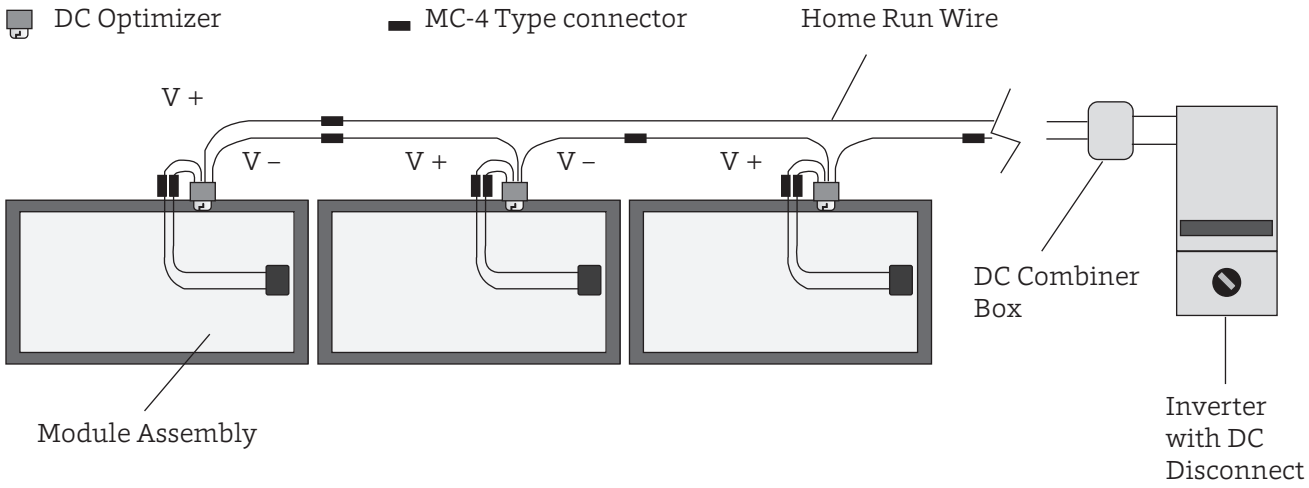


Figure 71. Typical DC Optimizer Wiring

AC Microinverter, Schematic

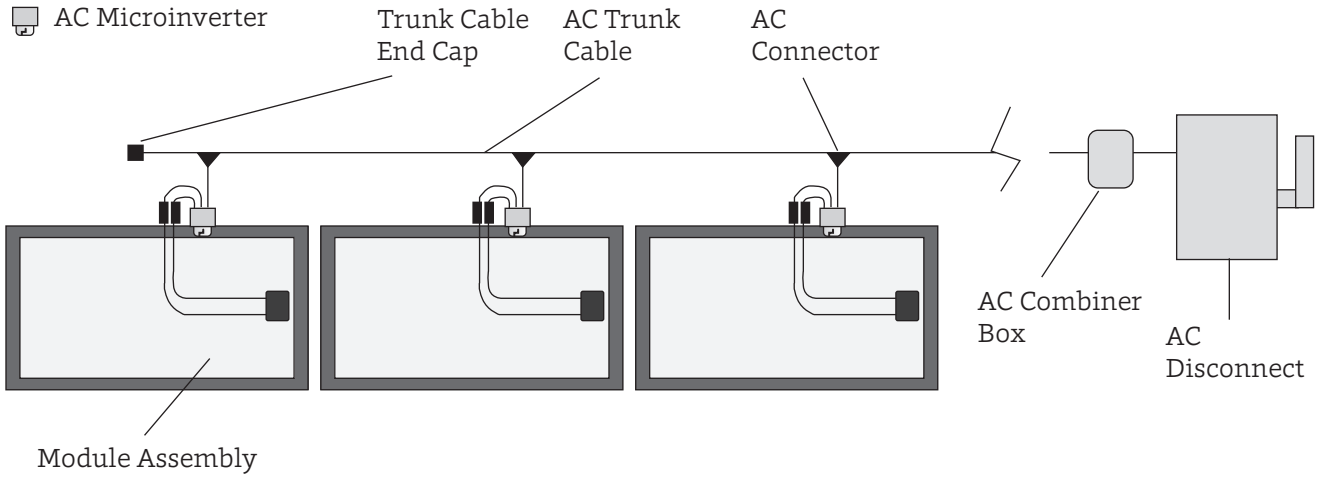


Figure 72. Typical AC Microinverter Wiring

Wire Management, continued

The installing contractor must ensure that none of the wiring comes in contact with any of the Side Trim or Debris Guard. Use Wire Clips wherever necessary.

- Always obey the cables' minimum bend radius.
- Do not over-tension the wires.

Physical Wire Management Diagram

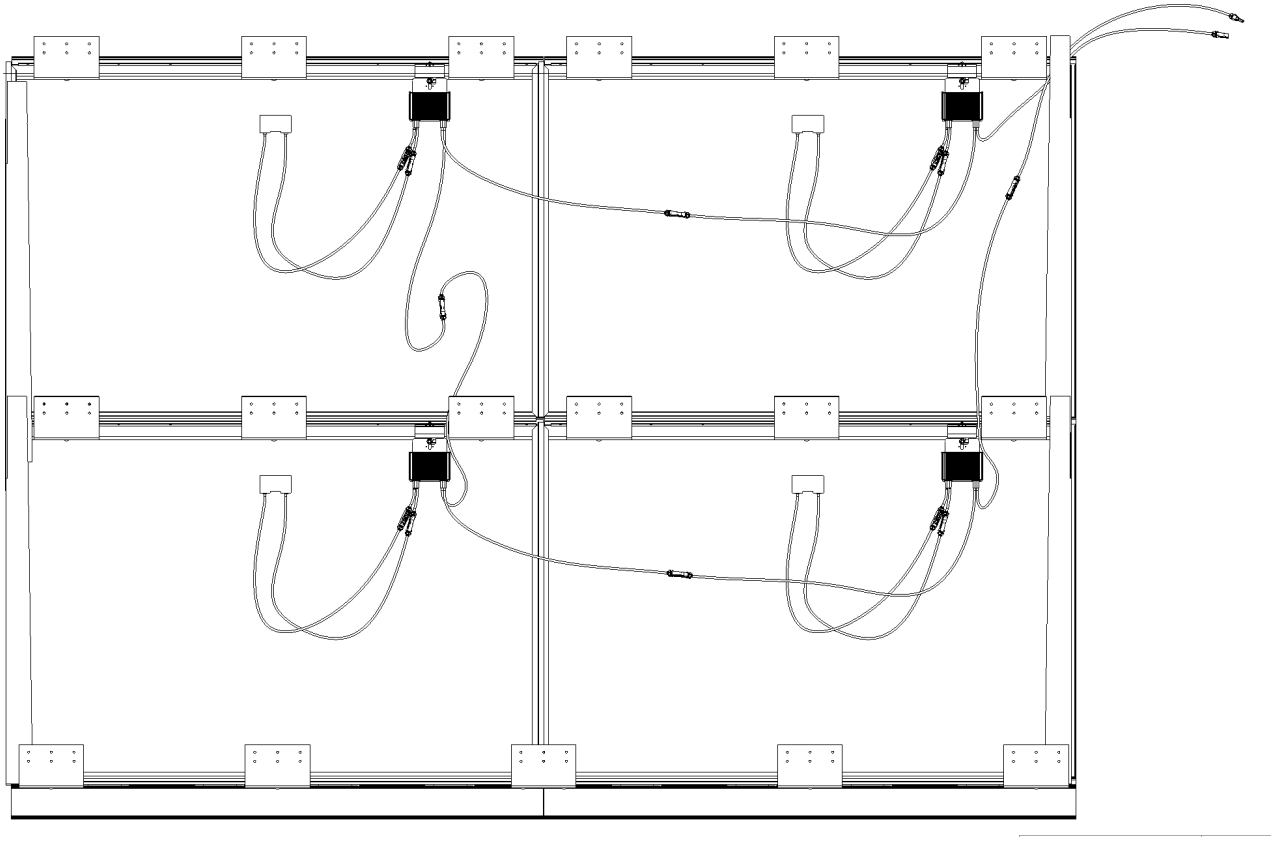


Figure 73. Physical wire management diagram

System Maintenance

- The GAF Energy Solar System has no user-serviceable parts and requires no routine maintenance. However, periodic re-inspection of the PV installation for loose components, loose fasteners, and any corrosion of components is required. If any issues are found, the affected components must be immediately replaced by the installer.
- Do NOT attempt to dismantle the equipment or make any internal repairs. Any attempt to open the equipment could compromise the integrity of the system and void the warranty on the system.
- Do NOT attempt to clean soiled solar module assemblies. The Module Assembly is naturally cleaned by seasonal rains. In the unlikely event that cleaning is required, contact your installer.
- Direct all inquiries to GAF Energy Technical Support at 1-800-ROOF-411.
- For more information on GAF Energy solar products and services for solar applications, visit **www.gaf.energy**.

Appendix

DecoTech™ Solar Module Technical Data

Solaria Laminate Specifications

SOLARIA

Performance at STC (1000W/m², 25° C, AM 1.5)					
Solaria PowerXT-		**345R-PD**	**350R-PD**	**355R-PD**	**360R-PD**
Max Power (P_{max})	[W]	345	350	355	360
Efficiency	[%]	19.1	19.4	19.6	19.9
Open Circuit Voltage (V_{oc})	[V]	46.9	47.1	47.4	47.7
Short Circuit Current (I_{sc})	[A]	9.46	9.49	9.53	9.56
Max Power Voltage (V_{mp})	[V]	38.5	38.8	39.1	39.5
Max Power Current (I_{mp})	[A]	8.93	9.02	9.09	9.13
Power Tolerance	[%]	-0/+3	-0/+3	-0/+3	-0/+3

Performance at NOCT (800W/m², 20°C Amb, Wind 1 m/s, AM 1.5)					
Max Power (Pmax)	[W]	255	259	261	265
Open Circuit Voltage (V_{oc})	[V]	44.1	44.3	44.6	44.8
Short Circuit Current (I_{sc})	[A]	7.66	7.69	7.68	7.71
Max Power Voltage (V_{mp})	[V]	35.4	35.7	36.0	36.3
Max Power Current (I_{mp})	[A]	7.15	7.22	7.27	7.30

Temperature Characteristics		
NOCT	[°C]	45 +/-2
Temp. Coeff. of P_{max}	[% / °C]	-0.39
Temp. Coeff. of V_{oc}	[% / °C]	-0.29
Temp. Coeff. of Isc	[% / °C]	0.04

Design Parameters		
Operating temperature	[°C]	-40 to +85
Max System Voltage	[V]	1000
Max Fuse Rating	[A]	15
Bypass Diodes	[#]	4

Mechanical Characteristics	
Cell Type	Monocrystalline Silicon
Dimensions (L x W x H)	1621mm x 1116mm x 40mm
Weight	21 kg / 46 lbs
Glass Type / Thickness	AR Coated, Tempered / 3.2mm
Frame Type	Anodized Aluminum
Cable Type / Length	12 AWG PV Wire (UL) / 1000mm
Connector Type	Amphenol H4 (MC4 compatible)
Junction Box	IP67 / 4 diodes
Front Load (UL 1703)	5400 Pa / 113 psf*
Rear Load (UL 1703)	2400 Pa / 50 psf*

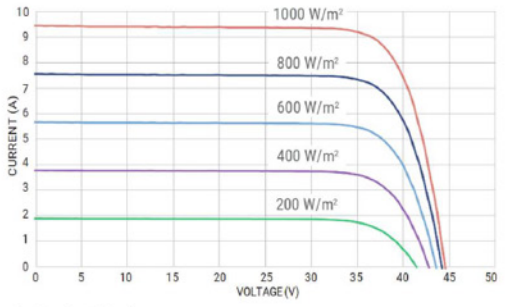
*Refer to Solaria Installation Manual for details

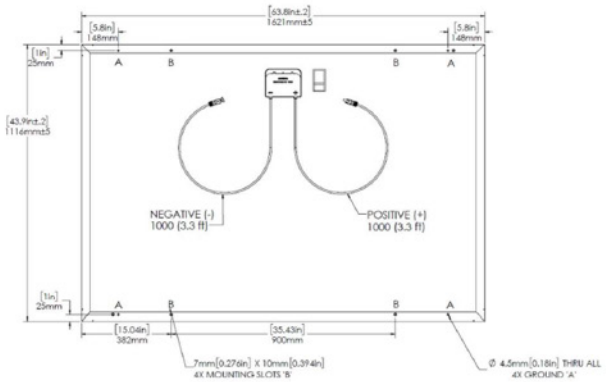
Certifications / Warranty	
Certifications	UL 1703/IEC 61215/IEC 61730/CEC CAN/CSA-C22.2
Fire Type (UL 1703)	1
Power & Product Warranty	25 years*

* Warranty details at www.solaria.com

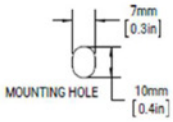
Packaging	
Stacking Method	Horizontal / Palletized
Pcs / Pallet	25
Pallet Dims	1668 x 1150 x 1230 mm
Pallet Weight	590 kg / 1300 lbs
Pallets / 40-ft Container	28
Pcs / 40-ft Container	700

IV Curves vs. Irradiance (350W Module)





Authorized Dealer



Silfab Laminate Specifications

Electrical Specifications		SILFAB SLA Monocrystalline	
Test Conditions		STC	NOCT
Module Power (Pmax)	Wp	310	234
Maximum power voltage (Vpmax)	V	33.05	29.7
Maximum power current (Ipmax)	A	9.38	7.88
Open circuit voltage (Voc)	V	40.25	37.2
Short circuit current (Isc)	A	9.93	8.14
Module efficiency	%	19.0	17.9
Maximum system voltage (VDC)	V	1000	
Series fuse rating	A	15	
Power Tolerance	Wp	-0/+5	

Measurement conditions: STC 1000 W/m2 • AM 1.5 • Temperature 25 °C • NOCT 800 W/m² • AM 1.5 • Measurement uncertainty ≤ 3%
• Sun simulator calibration reference modules from Fraunhofer Institute. Electrical characteristics may vary by ±5% and power by -0/+5W.

Temperature Ratings		SILFAB SLA Monocrystalline
Temperature Coefficient Isc	%/K	0.03
Temperature Coefficient Voc	%/K	-0.30
Temperature Coefficient Pmax	%/K	-0.38
NOCT (± 2°C)	°C	45
Operating temperature	°C	-40/+85

Mechanical Properties and Components	SILFAB SLA Monocrystalline
Hail impact resistance	ø 25 mm at 83 km/h
Cells	60 - Si monocrystalline - 3 or 4 busbar - 156.75 x 156.75 mm
Glass	3.2 mm high transmittance, tempered, antireflective coating
Backsheet	Multilayer polyester-based
Bypass diodes	3 diodes-45V/12A, IP67/IP68
Cables and connectors (See installation manual)	1200 mm ø 5.7 mm (4 mm2), MC4 compatible

Certifications	SILFAB SLA Monocrystalline
Product	ULC ORD C1703, UL 1703, IEC 61215, IEC 61730, IEC 61701, CEC listed
	UL Fire Rating: Type 2 (Type 1 on request)
Factory	ISO 9001:2008

Warning: Read the installation and User Manual before handling, installing and operating modules.

Third-party generated pan files from PV Evolution Labs available for download at:
www.silfab.ca/downloads

TOP PERFORMER 2017 DNV·GL PV MODULE RELIABILITY SCORECARD

Silfab SOLAR

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Mechanical Properties

Table 5. Mechanical Properties of the GAF Energy Solar System

	Solaria Laminates	Silfab Laminates
Weight (Framed Module + 5 Mounting Feet + MLPE Bracket)	55 lb. (53 kg)	51 lb. (23 kg)
Width	45.0 inches (1,143 mm)	40 inches (1,016 mm)
Length	65.3 inches (1,659 mm)	66.5 inches (1,689 mm)
Depth, Front	1.67 inches (42 mm)	
Depth, Back	Adjustable	
Frame	Black anodized aluminum	Black powder-coated aluminum
Mechanical Loading	50 lb./ft2 (244 kg/m2) positive design load 40 lb./ft2 (195 kg/m2) negative design load	50 lb./ft2 (244 kg/m2) positive design load 50 lb./ft2 (244 kg/m2) negative design load
Fire Rating	Class A per UL 2703	
To achieve a Class A fire rating, the solar array must be installed with one ply of StormGuard® Film-Surfaced Leak Barrier followed by one ply of VersaShield® SOLO™ Fire-Resistant Slip Sheet over minimum 15/32 inches (11.9 mm) thick plywood or 7/16 inches (11.1 mm) OSB roof deck. Please refer to Underwriters Laboratories Certifications Directory for actual assemblies.		

Codes and Standards

PV Laminate (Frameless)

- The PV laminates are certified to UL 1703.

Module Assembly and Side Trim

- The Module Assembly and Side Trim are certified to UL 2703.
- The certification includes the MLPE Mounting Bracket.

GAF Energy Solar System

The GAF Energy Solar System was tested to comply with the following roofing standards:

- UL 1897 – Uplift Tests for Roof-Covering Systems
- TAS 100 – Test Procedure for Wind and Wind-Driven Rain Resistance of Discontinuous Roof Systems

Fire Rating

The GAF Energy Solar System, in combination with the underlayment system, is classified as a Class A fire rated system per UL 2703

Underlayment System

The Underlayment System described in this manual is tested and certified for installation with the GAF Energy Solar System described herein.

Notes on Codes and Standards

- Refer to the UL Online Certification Directory for actual assemblies.
- Follow all instructions in this document to assure the system is installed as certified.

Document Version Control

Document Revision Number	Date	Notes
1.0.0	May, 2017	Added: • Alignment Pins • Document Version Control Table • Custom Step Flashing • Lab-tested design load values
1.0.1	July, 2017	Added: • Alternate array configurations • 2-wire WEEB lug
1.1.0	November, 2017	Added or updated • Added Silfab laminate • Added Adjustable feet • Updated SKU numbers and right counterflashing install • Updated wire management techniques and grounding methods for the Adjustable Feet
2.0	March, 2018	Edited for clarity
3.0	April, 2019	Changes • Updated product name • Updated SKUs • Added Solaria laminate • Removed SolarWorld laminate
3.1	August, 2019	Changes • Three-feet mounting option • Dynobond™ grounding options
4.0	October, 2019	Changes • Side Trim replaces Step Flashing • Debris Guard replaces Top Flashing • Changes to underlayments • SKU change for MLPE Bracket
4.1	January, 2020	Changes • Remove Side Trim and Debris Guard • Restore Step Flashing, Top Flashing, Corner Flashing, Top Flashing Support, Top Flashing Frame Insert, and Counterflashing • Revert to previous version of MLPE Bracket
4.2	February, 2020	Changes • Revert 4.0 changes to underlayments • New system grounding method
4.3	August, 2020	Changes • Clarified specs on third-party components

Document References

The following supplemental references include other system manuals, code references, and other documentation.

1. DynoBond™ installation manual, DynoRaxx® Document No. 070919.
2. GAF Steep Slope PRO Field Guide
3. Permit Drawings
4. Site-specific installation drawings
5. U.S. National Electrical Code (NEC)
6. QuickMount QBox Installation Manual