Roof Anchor System for Solar Panels

Last Updated: 12/30/2015

Scope

Install a mounting system for solar thermal or solar photovoltaic panels. Understand the type of roof anchor systems for solar thermal and photovoltaic (PV) panels or integrated roof modules that are available on the market and how they are mounted to the roof structure. Consider the roof type (material and slope), weatherproofing, installation convenience, and wind and snow loadings. Choose an appropriate racking and mounting system for the type of PV module, and install the system along with needed flashing and seals.

See the [Compliance Tab](#) for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description

Photovoltaics (PV) are being used more often today on the rooftops of homes to capture and convert solar energy into electricity, thereby reducing total energy costs for the homeowner. These may be large PV panels that are assembled into an array, or PV shingles that are used in place of standard roofing shingles. Solar thermal systems for heating water mount in similar ways.

When adding any type of PV (solar) array on the roof of a newly constructed house, it is important to consider the type of roof anchoring system for the PV modules. Choosing an appropriate and well-designed racking and mounting system for the type of PV module being installed is crucial for the most effective function of the module, as well as the integrity of the roof and house.

Several different types of roof racking and mounting systems are available on the market by various manufacturers. Although each manufacturer has its own uniquely designed mechanisms, the systems generally have the same basic components. For PV modules, the racking and mounting system typically consists of the following: a two-railed track that is bolted into the rafters and onto which the panels are clamped, a flashing component for the weatherproofing of the penetrations, and all required hardware such as bolts and clamps. Some systems eliminate the need for the rails, thereby removing those additional connections. However, if integrated roof modules (e.g., PV shingles) are being installed on a house, it is common that no additional mounting system would be needed. Photovoltaic shingles, for example, typically can be installed as easily as standard roofing shingles by being nailed directly to the roof deck. This installation typically takes place during the normal roofing construction and would require only one roofing contractor that is experienced in installing PV shingles.

Another factor is whether the PV modules will be suitable for the roof slope and orientation or if additional slope needs to be added by the roof mount system. In the past, design strategies such as matching the tilt angle with the latitude of the home were recommended to optimize the annual power generation from the PV system. Given the lower price of PV modules today, the design of the PV system may no longer need to impose additional tilt on the PV array to make the installation economically feasible. This decision also can significantly affect the overall aesthetics of the PV installation.

When choosing a racking and mounting system, factors such as the roof material, roof slope, weatherproofing, installation convenience, and wind and snow loads should be taken into account. Certain mounting systems may be specific to particular roofing materials or slopes or may be able to function with all roof types. Masonry roofs may require additional structural considerations because of the extra weight of the roof tiles.

Weatherproofing is an extremely important element of a PV anchoring system. Because many penetrations will be made in the roof to secure the mounting system, it is critical to ensure that leaks do not develop from those penetrations. In the past, sealants alone were used to waterproof the penetrations, but this became problematic because the sealant often would break down from the impacts of the ultraviolet rays from the sun, oxidation, expansion and contraction, and wind and other vibrations. Therefore, a better practice is to have additional weatherproofing in place, including flashing.

Another important consideration in the choice of a racking and mounting system is the ease of installation. A system that is designed to make installation easy and more efficient could result in cost savings from fewer labor hours and potentially less rework. Reference the manufacturer’s documentation for the exact system being used to better understand all of this information.

Roof Penetrations, Flashing, and Roof Attachments

With the exception of raised-seam metal roofs, most all roof types require penetrations for rack mounts. In the best installations, standoff, lag screws, or bolts tie into structural members. All brackets should have butyl tape or a high-quality caulking such as polyurethane or polysulfide, to seal any bolt penetrations and under struts, brackets, or mounting feet.

If standoff mounts or other brackets can be installed before the roofers install the finished roof, roofers can more easily shingle or tile around the flashing, and may install the flashing for the mounts. This approach helps to ensure that the roof warranty is intact.
Solar installers need to coordinate with roofers prior to the installation to ensure warranty issues are addressed, proper flashing materials are on hand, and installation procedures have been worked out.

**Composition Shingle Roofs**

Many efficiency programs recommend that on existing homes, roofs should have 10 or more years of useful life remaining.

Stanchions and hanger bolts can be used with flashing at the mounting points. In new homes, it is best if both the bolt and the stanchion are applied before the roofing is installed. The lag screw end of the hanger bolt is threaded directly into the structure. The stanchion is lag-screwed to the roof structure (into a truss or rafter). After these are placed, a flashing is applied over the bolt or stanchion. Hanger bolts are preferred due to their low cost and quick installation, but should not be used with solar thermal systems that use integrated collector storage for structural reasons. Stanchions may be flashed with roof boot type flashing.

**Flat Roofs**

Curb mounts work well for flat roofs. Elevated racks are often used on flat roofs to provide an appropriate angle for the collector or module. Racks may be mounted on curbs or standoff mounts. Another reason for using racks in colder climates is to place modules and collectors above snow levels. Curb systems are described in the NRCA manual.

**Standing Seam Metal Roofs**

Clips can attach to raised seam metal roofing that do not require a roof penetration and can be used to clamp racks to the seam (Christian 2006).

**Structural Insulated Panel Roofs**

As part of a study of affordable ZEH in Tennessee, a process was worked out for installing racks on roofs made with structural insulated panels (Christian 2006). A more recent article in Home Power describes an approach using a toggle bolt (Sughrue 2013). Follow SIP manufacturers instructions.

**Low-Profile Mount**

Many PV systems come with arrays, racks, and clips that are designed to mount together. One method of reducing the visual effect of a solar array is to make the mounting system as close to the roof, and as small, as possible. All major PV manufacturers produce PV modules that can be mounted in low-profile racks.

**Thin Film**

Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Thin film technology has made it possible for solar cells to now double as these materials:

- Rooftop or solar shingles
- Roof tiles
- Building facades
- Glazing for skylights or atria.

Thin-film rooftop or solar shingles, made with various non-crystalline materials, are just now starting to enter the residential market. These systems replace typical roofing materials and do not require roof anchors or racks.

Some PV systems are designed to be integrated into roof designs. Perhaps the most popular integrated system in the U.S. is made up of PV modules that are sized and mounted to replace. Since these products are replacing roofing material and are the first line of defense against the elements, they should be compliant with local and national roofing requirements.

**How to Choose an Appropriate Roof Racking and Mounting System for the most common PV Modules**

The following provides a general description of the steps that should be taken to choose the most appropriate roof racking and mounting system for the specific type of PV module being installed on the roof of a house. Standardized design packages with preengineered mounting systems and integrated components can substantially reduce installation costs (Ventre, et al., 2001). These systems tend to include documentation such as drawings and instructions that aid with permitting and inspections.

1. **Identify the roofing material and slope.** The first step in choosing a roof-mounted PV anchoring system is to identify the type of roofing material that will be installed and the slope of the roof. These parameters will affect the type of anchoring system because the systems differ, based on these elements.
2. **Identify the type of PV module being installed.** The second step is to determine the exact type of PV module that will be installed. The choice of whether discrete PV modules will be connected as an array or as an integrated roof module (e.g., PV shingles) will greatly impact the type of rooftop anchoring system to be used. Some integrated PV modules do not require any additional mounting hardware, making the following steps irrelevant. Reference the manufacturer’s product documentation to better understand this.

3. **Choose the most appropriate anchoring system for the project.** Once the roof type (material and slope) and the type of PV module have been identified, choose the mounting system. When choosing a system, make sure that it includes the necessary components (as discussed above). Also, consider the efficiency of the installation process and the potential additional loads on the system from wind and snow. Reference the manufacturer’s documentation for the exact product to ensure that the anchoring system will integrate properly with the chosen PV module.
4. **Verify that installation of the PV modules and anchoring system was completed correctly, according to best practices.** When the first row of PV modules has been installed on the anchoring system, check the installation to verify that it was completed to a high standard of quality. This may help to prevent future costs related to weather damage or rework.

![Figure 4. Anchor system installation. (Image courtesy of IBACOS).](image)

![Figure 5. Completion of the first row of PV panels and quality assurance checks. (Image courtesy of IBACOS).](image)
Ensuring Success

Early in the design process, ensure that the correct type of mounting system will be used to integrate the PV modules on the roof, and verify that the chosen mounting and racking system will be compatible with the PV panels. This can be done by considering the roof material, roof slope, weatherproofing, ease of installation, and wind and snow loadings. Closely examine the manufacturer’s product documentation for all of the systems involved, both early in the design process and throughout the installation.

Early in the project, confirm with local code officials that the mounting and racking system will meet all code requirements. Most jurisdictions require that PV installations are properly flashed and waterproofed according to roofing codes.

There are two structural concerns, dead load, the weight of the systems bearing on the roof, and live loads, the intermittent loads created by wind, snow, and maintenance personnel. Collectors should never be supported by roof sheathing between structural members. The project structural engineer or truss designer should be involved early in the design process. Even if not needed to accommodate the load, additional framing may be added as a convenience for easier solar installations even if structural loads are within limits.

Dead loads are typically minimal in PV arrays, no more than 5-10 lbs/ft2. However, the loads are often transferred to the rooftop through mounting devices that concentrate the array dead loads onto small surface areas of the roof or individual load bearing members. These conditions can significantly add to the loading conditions of a single truss, rafter, joist, decking or other roof component. Live loads can be large in magnitude, but are intermittent, and attributed to wind, snow, and maintenance personnel. Most PV modules are rated for dead loading of 50-55 lbs/ft2, or equivalent to the pres­sure of constant 110-120 mph winds (Barkasi and Dunlop, 2001).

Designing mounting systems for wind uplift is more critical in areas subject to hurricanes and excessive wind speeds. Manufacturers of collectors, modules, and mounting systems typically have their mounting systems pre-engineered for worst-case wind loads (DEG 2005). In parts of the world that are vulnerable to hurricanes or extreme wind storms, the collector and its mounting structure need to be able to withstand intermittent wind loads up to 146 miles per hour. This corresponds to a pressure of about 75 pounds per square foot (FSEC 2006). Rudin and Becerra (2006) describe approaches for analyzing severe wind loads.

Wind loads may be greater near the roof ridge. Mounting collectors or arrays near the ridge may increase wind loads on the equipment (FSEC 2006). Similarly, locating collectors and arrays in from eaves may reduce wind loads (Rudin and Becerra 2006).

Good engineering cannot make up for poor instal­lation. It is easy to miss structural members when fastening mounting systems to the roof. Care must be taken to insure that fasteners are correctly positioned. Failure of a bolt to torque down is a clear indication the structural member has been missed. Also, bolts shorter than those recommended by the manufacturer should not be used. Mounting systems can be secured to structural blocking placed between rafters/trusses if the layout of rafters/trusses do not align with the desired collector location. All bolts securing collectors or modules to racks or brackets must be securely tightened.

An overview of mounting systems and manufacturers can be found in an article by Rebekah Hren in Home Power (http://www.homepower.com/articles/solar-electricity/equipment-products/m...).

Check the quality of installation after the mounting system and PV modules have been installed to ensure that future damage will not occur that could have been prevented.

Use a high-quality contractor with experience in PV installation to help ensure that the installation is done correctly. Insist that PV installers meet with other trades to work out equipment compatibility, supply, and installations issues. For example:

- Roofers need to know what types of flashing to use, who will be installing it, and when. Roofers also need to know if BIPV will be used that will replace sections of the roof.
- Trades requiring roof penetrations need to know what areas are off limits for vents or other elements that may shade the PV. This coordination issue was the number one area of difficulty identified by PV installers interviewed for this document.
- PV and solar thermal installers need to know what parts of the roof to use for their systems. Typically the truest southern exposure should go to the PV installation.
- For long-term performance, landscape designers and installers need to keep the southern exposure unobstructed from trees and outbuildings.
- Painters and stucco crews need to take all steps necessary to avoid overspray.

Be sure that the PV panel system is properly grounded.
Climate

The DOE Zero Energy Ready Home PV-Ready Checklist (Revision 07) is required only under the following condition related to climate (See the Compliance Tab for other exceptions):

- Location, based on zip code, has at least 5 kWh/m²/day average daily solar radiation based on annual solar insolation using the PVWatts online tool. See map below.

![Average Daily Solar Radiation Per Month](image)

The spread of average daily PV radiation per month over the United States, with the required and recommended amount of kWh/m² per day.
Training

Right and Wrong Images
None Available
CAD
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)

Complete contract documentation as described in this guide is not required by ENERGY STAR HOMES® Version 3/3.1.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 1, Item 7) Provisions of the DOE Zero Energy Ready Home PV-Ready Checklist are Completed.

IRC

Chapter 15 (Roof Assemblies and Rooftop Structures) discusses waterproofing. See Sections 1503, 1506, and 1507 for details.

Parts of Chapter 9 (Roof Assemblies) and Chapter 23 (Solar Energy Systems) discuss the installation of PV panels and the associated details, including waterproofing.

National Electric Code

Although the code does not impose specific regulations for roof mounting of PV systems, grounding and other electrical requirements are outlined. Each roof mounting system must be properly grounded.

Standards

Several associations are involved in standards development and best practices for roofing, including roofing systems for PV modules:

- **The National Roofing Contractors Association (NRCA)** produces manuals that discuss best practice guidelines for all aspects of roofing systems, including PV module installation.
- **The Center for Environmental Innovation in Roofing (CEIR)** attempts to improve communication between the roofing and PV industries. To do this, it created the Center PV Taskforce, which has developed best practices and guidelines for PV roof installation.
- The Tile Roofing Institute (TRI) is well known for its best practice guidelines for tile roofing systems and is a major player in the development of legislation and codes.
- **The Sheet Metal and Air-Conditioning Contractors National Association (SMACNA)** focuses on flashing details and building envelope metals. It produces manuals about flashing, with the focus on preventing building moisture intrusion.

Installation of Photovoltaic Systems - Code Compliance Brief

Overview:

_The intent of this brief is to provide code-related information about photovoltaic systems to help ensure that what is proposed regarding the photovoltaic ‘product’ itself, including accessories such as inverters and controls, as well as their individual and collective installation can be verified as being in compliance with safety-related codes and standards for residential construction. Providing consistent information to document compliance with codes and standards to all relevant parties responsible for verifying compliance with those codes and standards (e.g., code officials, builders, contractors, designers, utilities, fire officials, etc.) is expected to result in increased compliance and more timely, less challenging and more uniform plan review and field inspections._

Photovoltaic systems can provide power for a single use or building, be connected to the utility grid, or could be a hybrid of the two. They can be mounted on building roofs or walls, integrated as an actual component of roof or wall construction, or simply mounted at grade or elevated above grade on a supporting framework. Codes that are relevant to such systems when installed on, as part of, or adjacent to a home include the National Electric Code (NEC), the structural sections of the International Residential Code (IRC), and the renewable-energy sections of the International Energy Conservation Code (IECC) as well as a number of safety standards that area referenced in these documents and address portions of the photovoltaic system (e.g., IEEE[1] or Underwriters Laboratory [UL standards] as referenced in these documents and applicable to the photovoltaic system and its components). The installation of photovoltaic panels on a building roof or integral with a building roof also raises other code issues (e.g., roof loading, wind loading, fire ratings, weather tightness, mounting systems, roof penetrations, etc.), which may also be relevant for systems mounted on or integral to a wall.

An increased number of photovoltaic systems are being deployed to help meet household energy needs. For a home to qualify as a U.S. Department of Energy Zero Energy Ready Home,[2] it must be constructed, at a minimum, as “solar
energy ready." [3] Any initiative focused on the application and use of wind, photovoltaic, or other renewable resources will likely require the installation of a system to store excess energy for subsequent use (refer to the referenced Code Brief on Design and Installation of Electrical Energy Storage Systems for additional information and the Database of State Incentives for Renewables and Efficiency at http://www.dsireusa.org/). Beyond this DOE initiative, some builders and homeowners choose to install photovoltaic systems—whether they are participating in a program or not—simply to have power from non-utility sources to reduce their monthly electric bills as well as to enhance the value and appeal of the home. This brief provides further clarification and resources to assist with designing, constructing, and installing these type of systems and/or system components and verifying that they are safe and meet code.

The following sections list the applicable code and standard requirements and details helpful for Plan Review. The Field Inspection section then provides details for inspecting “… photovoltaic systems.” For resources on technical validation, best practices, and measure guidelines, refer to the Technical Validation/Reference Materials section of this brief.

The lists and provisions provided below in each section are intended to target the primary code sections and provisions. There may be other references, code sections, standards, testing methods, etc., that affect the technology or other assemblies or functions of the building.

Plan Review:

This section provides details in the 2015 IRC and IECC, and the language (underscored and struck-through) from code change proposals being considered for the 2018 IRC. The language underlined and struck-through could change during the final code hearings that occur in late October 2016. The intent of these proposals is to address redundant code requirements and consolidate/reorganize requirements that were also included in Chapter 9 of the IRC during the last code cycle. These changes will help to address any confusion regarding the installation of photovoltaic systems. Go to http://www.iccsafe.org/codes-tech-support/codes/code-development-process/20152017-code-development-group-b/ for additional information on the code proposals and hearings. This Code Compliance Brief will be updated accordingly after the hearings and final online Governmental Consensus voting period in November 2016.

2015 IRC, Section R104 Duties and Powers of the Building Official

2015 IECC/IRC, Section R104.1 General. The building official has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code.

R102.1/R104.11 Alternative Materials, Design and Method of Construction and Equipment. The provisions of this code are not intended to prevent the installation of any material or prohibit any design or method of construction not specifically prescribed in the 2015 IECC/IRC, provided that any such alternative has been approved. The building official is permitted to approve an alternative material, design, or method of construction where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method, or work offered is for the purpose intended, not less than the equivalent of that prescribed in the code. Compliance with the specific performance-based provisions of the International Codes is an alternative to the specific requirements of this code.

R104.11.1 Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official has authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.

Per the 2015 IECC/IRC, Section R103.3/R106.3 Examination of Documents, the code official/building official must examine or cause to be examined construction documents for code compliance.

Construction Documentation. Review the construction documents for details describing photovoltaic system and/or components construction techniques.

2015 IECC/IRC, Section R103.2/N1101.5 Information on construction documents. Construction documents should include:

- Design, size, and location
- System ratings, testing, and labeling
- Conduit, wiring, and electrical layout design
Mounting specifications

Inverter location and listing.

2015 IRC, Section 324 Solar Energy Systems

R324.3 Photovoltaic systems. Photovoltaic systems shall be designed and installed in accordance with Sections R324.3.1 through R324.5.2.5, NFPA 70. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction, manufacturers installation instructions.

R324.3.1 Equipment listings. Photovoltaic panels[4] and modules[5] shall be listed and labeled in accordance with UL 1703. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

R324.4 Roof-upon-mounted photovoltaic systems. Roof-top-mounted photovoltaic panel systems installed on or above the roof covering shall be designed and installed in accordance with Section R907 this section.

R909.2 R324.4.1 Structural requirements. Rooftop-mounted photovoltaic panel systems shall be designed to structurally support the system and withstand applicable gravity loads in accordance with Chapter 3. The roof upon which these systems are installed shall be designed and constructed to support the loads imposed by such systems in accordance with Chapter 8.

R324.4.1.1 Roof live load. Roof structures that provide support for photovoltaic panel systems shall be designed for applicable roof live load. The design of roof structures need not include roof live load in the areas covered by photovoltaic panel systems. Portions of roof structures not covered by photovoltaic panels shall be designed for roof live load. Roof structures that provide support for photovoltaic panel systems shall be designed for live load, LR, for the load case where the photovoltaic panel system is not present. Portions of roof structures not covered with photovoltaic panel systems shall be designed for dead loads and roof loads in accordance with Section R301.4 and R301.6. Portions of roof structures covered with photovoltaic panel systems shall be designed for the following load cases:

1. Dead load (including photovoltaic panel weight) plus snow load in accordance with Table R301.2(1).
2. Dead load (excluding photovoltaic panel weight) plus roof live load or snow load, whichever is greater, in accordance with Section R301.6.

The intent of the changes is to clarify and correct the requirement for design loads for roofs with photovoltaic panels.

R907.2 R324.4.1.2 Wind resistance. Rooftop-mounted photovoltaic panel or modules systems shall be installed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3).

Language for wind resistance is taken from R907.2.

R907.3 R324.4.2 Fire classification. Rooftop-mounted photovoltaic panel or modules photovoltaic panel systems shall have the same fire classification as the roof assembly required in Section R902.

R909.3 R324.4.3 Installation Roof penetrations. Rooftop mounted photovoltaic systems shall be installed in accordance with the manufacturer's instructions.

Roof penetrations shall be flashed and sealed in accordance with this chapter Chapter 9.

R324.5 Building-integrated photovoltaic systems. Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section R905.

R324.5.1 Photovoltaic shingles. Photovoltaic shingles[7] shall comply with Section R905.16.

R324.5.2 Fire classification. Building-integrated photovoltaic systems shall have a fire classification in accordance with Section 902.3.

R905.16 Photovoltaic shingles. The installation of photovoltaic shingles shall comply with the provisions of Section R905.16, Section R324 and NFPA 70.

This section provides requirements for decks, deck slope, underlayment, underlayment application (including ice barriers and underlayment and high winds), material standards (in accordance with UL 1703), attachments, and wind resistance.

R324.7 Access and pathways. Roof access, pathways, and spacing requirements shall be provided in accordance with Sections R324.7 through R324.7.2.5

Exceptions:
1. Detached garages and accessory structures to one- and two-family dwellings and townhouses, such as parking shade structures, carports, solar trellises, and similar structures.

2. Roof access, pathways and spacing requirements need not be provided where an alternative ventilation method approved by the code official has been provided or where the code official has determined that vertical ventilation techniques will not be employed.

**R324.7.1 Roof access points.** Roof access points shall be located in areas that do not require the placement of ground ladders over openings such as windows or doors, and located at strong points of building construction in locations where the access point does not conflict with overhead obstructions such as tree limbs, wires, or signs.

**R324.7.2 Solar photovoltaic systems.** Solar photovoltaic systems shall comply with Section R324.7.2.1 through R324.7.2.5

**R324.7.2.1 Size of solar photovoltaic array.** Each photovoltaic array shall be limited to 150 feet by 150 feet (45,720 mm by 45,720 mm). Multiple arrays shall be separated by a clear access pathway not less than 3 feet (914 mm) in width.

**R324.7.2.2 Hip roof layouts.** Panels and modules installed on dwellings with hip roof layouts shall be located in a manner that provides a clear access pathway not less than 3 feet (914 mm) in width from the eave to the ridge on each roof slope where panels and modules are located. The access pathway shall be located at a structurally strong location on the building capable of supporting the live load of fire fighters accessing the roof.

**Exception:** These requirements shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

**R324.7.2.3 Single ridge roofs.** Panels and modules installed on dwellings with a single ridge shall be located in a manner that provides two, 3-foot-wide (914-mm) access pathways from the eave to the ridge on each roof slope where panels or modules are located.

**Exception:** This requirement shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

**R324.7.2.4 Roofs with hips and valleys.** Panels and modules installed on dwellings with roof hips or valleys shall not be located less than 18 inches (457 mm) from a hip or valley where panels or modules are to be placed on both sides of a hip or valley. Where panels are to be located on one side only of a hip or valley that is of equal length, the 18-inch (457 mm) clearance does not apply.

**Exception:** These requirements shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

**R324.7.2.5 Allowance for smoke ventilation operations.** Panels and modules installed on dwellings shall not be located less than 3 feet (914 mm) below the roof ridge to allow for fire department smoke ventilation operations.

**Exception:** Where an alternative ventilation method approved by the code official has been provided or where the code official has determined that vertical ventilation techniques will not be employed, clearance from the roof ridge is not required.

**Section R907 Rooftop-Mounted Photovoltaic Panel System**

**R907.1 Rooftop-mounted photovoltaic panel systems.** Rooftop-mounted photovoltaic panels or modules shall be designed and installed in accordance with this section, Section R324 and NFPA 70.

**R907.2 Wind resistance.** Rooftop-mounted photovoltaic panel or modules systems shall be installed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3).

**R907.3 Fire classification.** Rooftop-mounted photovoltaic panels or modules shall have the same fire classification as the roof assembly required in Section R902.

The fire classification of any rooftop-mounted photovoltaic panels or modules must have the same fire classification as required by the IRC for the roof assembly itself (R907.3 and R902).

**R907.4 Installation.** Rooftop-mounted photovoltaic panels or modules shall be installed in accordance with the manufacturer's instructions.

**R907.5 Photovoltaic panels and modules.** Rooftop-mounted photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer's printed instructions.

**SECTION R909 ROOFTOP-MOUNTED PHOTOVOLTAIC PANEL SYSTEMS R909.1 General.** The installation of photovoltaic panel systems that are mounted on or above the roof covering shall comply with this section, Section R324 and NFPA 70.

The following explains the changes proposed:
1. Load requirements for rooftop-mounted photovoltaic system installations are partially covered in R907.2 and R324.4.1. Relocating R907.2 to be a subsection of R324.4 consolidates the load requirements. The structural requirements (Section R909.2) are relocated to be a subsection of R324.4.

2. Fire classification requirements (Section R907.3) are for rooftop-mounted photovoltaic systems, not rooftop-mounted photovoltaic panels and modules, and are referenced in Section R324.4.2. The fire classification requirements for building-integrated photovoltaic systems are not linked in Section R324 or R905.16 (see new Section R324.5.2).

3. Installation in accordance with the manufacturer's installation instructions (Sections R907.4 and R907.5 and R909.3) is consolidated into Section R324.3.

4. Listed and labeled rooftop-mounted panels and modules (Section 907.5) is already required by Section R324.3.1.

5. Two separate sections (Section 907 and 909) are not needed for rooftop-mounted photovoltaic panel systems.

6. Flashing of roof penetrations for rooftop-mounted photovoltaic systems (Section R909.3) is addressed in Section R324.4.3.

7. Equipment listing requirements relocated from Section R324.3 to R324.3.1 to consolidate in one location these requirements.

[4] Definition of a photovoltaic panel in the IRC is a collection of photovoltaic modules mechanically fastened together, wired, and designed to provide a field-installable unit.

[5] Definition of a photovoltaic module in the IRC is a complete, environmentally protected unit consisting of solar cells, optics and other components, exclusive of a tracker, designed to generate DC power where exposed to sunlight.

[6] Definition of a photovoltaic panel system in the IRC is a system that incorporates discrete photovoltaic panels that convert solar radiation into electricity, including rack support systems.

[7] Definition of photovoltaic shingles in the IRC is a roof covering that resembles shingles and that incorporates photovoltaic modules.

Field Inspection:

Per the 2015 IECC, Section R104 Inspections, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required inspections include footings and the foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the 2015 IRC, Section R109 Inspections, for onsite construction, from time to time the building official, upon notification from the permit holder or his agent, can make or cause to be made any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for design and installation of photovoltaic systems where one or more specific types of inspection called for by the IECC or IRC may be necessary to confirm compliance. To confirm code compliance, the electrical and/or final inspection would be the typical types of inspections performed.

- Confirm the type of photovoltaic system, design, size and location per the approved construction documentation
- Confirm system ratings, testing and labeling
- Confirm electrical design installation and specifications
- Confirm the inverter installation location and listing
- Confirm rooftop-mounting components are installed per manufacturer specifications and approved construction documents.

Technical Validation(s):

References and Resources*

   **Author(s):** Baechler, Gilbride, Ruiz, Stewart, Love  
   **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory  
   **Publication Date:** June, 2007  
   Report providing an introduction to current photovoltaic and solar thermal building practices.

2. **General PV Specification**  
   **Author(s):** Aldrich  
   **Organization(s):** CARB, Steven Winter Associates, SWA  
   **Publication Date:** March, 2013  
   Brochure on specifications for PV systems.

   **Author(s):** Baechler, Gilbride, Ruiz, Steward, Love  
   **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory  
   **Publication Date:** June, 2007  
   Best Practices document providing an introduction to current photovoltaic and solar thermal building practices.

   **Author(s):** U.S. Environmental Protection Agency  
   **Organization(s):** EPA  
   **Publication Date:** January, 2011  
   The RERH specifications and checklists take a builder and a project design team through the steps of assessing a home’s solar resource potential and defining the minimum structural and system components needed to support a solar energy system.

5. **Solar on Sips**  
   **Author(s):** Sughrue  
   **Organization(s):** Home Power  
   **Publication Date:** September, 2013  
   A structural insulated panel (SIP) roof has no embedded lumber in the structure, and therefore nothing substantial for attaching PV array and solar hot water mounts. Single or double lumber splines could be put into the panels, or I-joists at 4-foot intervals could be added.

6. **Solar Water Heaters**  
   **Author(s):** Department of Energy  
   **Organization(s):** DOE  
   **Publication Date:** May, 2012  
   Website describing how solar water heaters -- also called solar domestic hot water systems -- can be a cost-effective way to generate hot water for your home.

   **Author(s):** National Roofing Contractors Association  
   **Organization(s):** National Roofing Contractors Association  
   **Publication Date:** December, 2006  
   NRCA's premier technical publication gives you the most current and useful technical information in the roofing industry.
Contributors to this Guide
The following authors and organizations contributed to the content in this Guide.

IBACOS, lead for IBACOS, a DOE Building America Research Team