

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 are 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/>. [1] 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.

[1] Institute of Electronics and Electrical Engineers, Standards Association, <https://standards.ieee.org/> [2]

[2] DOE Solar Energy Ready Program Requirements, http://www.energy.gov/sites/prod/files/2014/04/f15/doe_zero_energy_ready...[3]

[3] The intent of solar energy ready requirements is to provide a penetration free and shade free portion of the roof, called the solar zone. This helps ensure future installation of a solar energy system is not precluded by the original design and layout of the building and its associated equipment.

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/> [4] 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 R324.6.1 and 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 Rooftop-mounted photovoltaic systems. Rooftop-mounted photovoltaic panel systems *photovoltaic panel systems*^[6] 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 *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 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 panels 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 *photovoltaic panel systems* 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):

- Architectural Drawings for Solar Photovoltaic Systems, <https://basc.pnnl.gov/resource-guides/architectural-drawings-solar-photo...> [5]
- Inverter Meter and Shut-Off Mounting Surface for Solar PV Systems, <https://basc.pnnl.gov/resource-guides/inverter-meter-and-shut-mounting-s...> [6]
- Solar Plumbing and Wiring Chase, <https://basc.pnnl.gov/resource-guides/solar-plumbing-and-wiring-chase> [7]
- 70-Amp Dual-Pole Circuit Breaker for PV Systems, <https://basc.pnnl.gov/resource-guides/70-amp-dual-pole-circuit-breaker-p...> [8]
- Design and Installation of Electrical Energy Storage Systems, <https://basc.pnnl.gov/code-compliance/design-and-installation-electrical-energy-storage-systems-code-compliance-brief> [9]
- Roof Anchor System for Solar Panels, <https://basc.pnnl.gov/resource-guides/roof-anchor-system-solar-panels> [10]
- Solar Orientation for Solar Arrays and Panels, <https://basc.pnnl.gov/resource-guides/solar-orientation-solar-arrays-and-panels> [11]
- Water Managed Existing Roof Penetrations, <https://basc.pnnl.gov/resource-guides/water-managed-existing-roof-penetrations> [12]
- Wiring Conduit for Solar PV Systems, <https://basc.pnnl.gov/resource-guides/wiring-conduit-solar-pv-systems> [13]