



IMPACTS ON PHOTOVOLTAIC INSTALLATIONS OF CHANGES TO THE 2012 INTERNATIONAL CODES

A Solar ABCs White Paper

May 2011

Solar America Board for Codes and Standards

www.solarabcs.org



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and 2012 International Residential Code
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EXECUTIVE SUMMARY

The purpose of this white paper is to provide an overview of changes related to photovoltaic (PV) installations in the 2012 International Building Code (IBC) and International Residential Code (IRC). These codes include requirements for building-integrated photovoltaic (BIPV) products and rack-mounted PV products. For each of these products, the codes include requirements for installation, materials, wind resistance, and fire classification. This information is intended to assist code officials, solar installers, and roofing contractors as they interpret and use these codes.

This white paper documents changes found in three sections of the 2012 IBC and two sections of the 2012 IRC:

- IBC Section 1505—Fire Classification,
- IBC Section 1507 and IRC Section R905—Requirements for Roof Coverings, and
- IBC Section 1509 and IRC Section M2302—Rooftop Structures.

Important observations include:

- The requirements are different for BIPV systems and rack-mounted PV systems.
- Until a new PV system fire classification test is finalized and adopted, Section 1509.7.2 of the IBC, as written, may be difficult to apply.
- IBC Section 1509.7.1 prescribes the use of components and cladding requirements of current codes and standards as the basis for calculating wind loads on PV arrays. This provides helpful guidance for wind engineering calculations, but may not provide results consistent with other methods accepted and used today.

You can order the 2012 IBC and 2012 IRC at: www.iccsafe.org/Store/

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Download a copy of the report:

www.solarabcs.org/fireguideline

SOLAR AMERICA BOARD FOR CODES AND STANDARDS

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate wide-spread adoption of safe, reliable, and cost-effective solar technologies.

For more information, visit the Solar ABCs Web site:

www.solarabcs.org

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1. INTRODUCTION AND PURPOSE

The purpose of this white paper is to provide information about changes related to photovoltaic (PV) installations in the 2012 International Building Code (IBC) and the 2012 International Residential Code (IRC). These codes include fire classification, wind resistance, installation, and materials requirements for building-integrated photovoltaic (BIPV) and rack-mounted PV products. This information is intended to assist code officials, solar installers, and roofing contractors as they interpret and use these codes.

This white paper documents changes found in three sections of the 2012 IBC and two sections of the 2012 IRC:

- IBC Section 1505—Fire Classification,
- IBC Section 1507 and IRC Section R905—Requirements for Roof Coverings, and
- IBC Section 1509 and IRC Section M2302—Rooftop Structures.

Solar ABCs has published a separate document on the changes to the International Fire Code (IFC). The 2012 IFC includes requirements for PV installations, and the Solar ABCs report describes the California solar installation guidelines and the similar 2012 IFC requirements. This report is available at: www.solarabcs.org/fireguideline

Section 2 of this document provides background on building codes, and sections 3 and 4 note the relevant sections of the 2012 IBC and IRC codes for BIPV and rack-mounted PV installations. The appendix cites the changes in the 2012 codes related to PV installations. We include the code language in **red**.

2. BACKGROUND ON THE CODES

The International Code Council (ICC) develops a family of model codes, many of which are widely adopted across the United States. The ICC updates its model codes every three years and will publish the 2012 editions of the codes in the spring of 2011. Information about the ICC code development process is available at: www.iccsafe.org/cs/codes/Pages/default.aspx

IBC applies to all buildings and structures except those covered by IRC (see IBC 101.2, which addresses the scope of IBC). IRC applies to detached one- and two-family dwellings and townhouses not more than three stories above grade in height (IRC R101.2). Both IBC and IRC apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal, and demolition of every building or structure or any appurtenance connected or attached to such buildings or structures.

Chapter 27 of the IBC and Part V of the IRC refer to the National Fire Protection Association (NFPA) 70, National Electrical Code. PV systems must comply with Article 690 and other requirements in NFPA 70.

The ICC's International Fire Code (IFC) establishes the minimum requirements consistent with nationally recognized good practice for providing a reasonable level of life safety and property protection from the hazards of fire, explosion, or dangerous conditions in new and existing buildings, structures, and premises and to provide safety to fire fighters and emergency responders during emergency operations (IFC 101.2).

State and local jurisdictions have adopted the IBC throughout most of the United States. Many jurisdictions have also adopted the IRC and the IFC. Some jurisdictions adopt the IBC and use that code for residential structures as well. Some jurisdictions adopt one or more of these codes and incorporate local amendments. In addition, jurisdictions take different amounts of time to adopt new editions of the code. To determine the requirements in a specific jurisdiction requires knowledge of which editions of which codes have been adopted and what if any local amendments have been added to the code(s).

3. BUILDING-INTEGRATED PHOTOVOLTAIC REQUIREMENTS

BIPV systems replace conventional materials in a building envelope—typically roof or façade finish materials—with a product that performs the function of the conventional material and generates electricity. IBC references PV shingle roofing products that generate electricity and serve as the roof covering of the structure as well as PV systems that are adhered or attached to the roof covering, such as thin film PV modules permanently adhered to metal roofing.

Installation

IBC Section 1507.17.2 (IRC R905.16.2) details the installation requirements for PV modules/shingles used as roof coverings. For PV systems that are adhered or attached to the roof covering, use the relevant code section from IBC 1507 (IRC R905) for the roof covering.

2012 code language:

IBC 1507.17.2 (IRC R905.16.2) Attachment. Photovoltaic modules/shingles shall be attached in accordance with the manufacturer's installation instructions.

Materials

IBC Section 1507.17.1 (IRC R905.16.1) details the material requirements for PV modules/shingles used as roof coverings. For PV systems that are adhered or attached to the roof covering, use the relevant code section from IBC 1507 (IRC R905) for the roof covering.

2012 code language:

IBC 1507.17.1 (IRC R905.16.2) Material standards. Photovoltaic modules/shingles shall be listed and labeled in accordance with UL1703.

Wind Resistance

IBC Section 1507.17.3 (IRC R905.16.3) details the wind resistance requirements for PV modules/shingles used as roof coverings. For PV systems adhered or attached to the roof covering, use the relevant code section from IBC 1507 (IRC R905) for the roof covering.

2012 code language:

IBC 1507.17.3 (IRC R905.16.3) Wind resistance. Photovoltaic modules/shingles shall be tested in accordance with procedures and acceptance criteria in ASTM D 3161. Photovoltaic modules/shingles shall comply with the classification requirements of Table 1507.2.7.1(2) for the appropriate maximum nominal design wind speed. Photovoltaic modules/shingle packaging shall bear a label to indicate compliance with the procedures in ASTM D 3161 and the required classification from Table 1507.2.7.1(2).

Fire Classification

IBC Section 1505.8 requires that all BIPV modules be tested and labeled as Class A, B, or C in accordance with the methods of ASTM 108 or Underwriters Laboratories® (UL) 790, *Standard Test Methods for Fire Tests of Roof Coverings*. The fire classification rating must meet the requirements in Section 1505.

2012 code language:

IBC 1505.8 Photovoltaic systems. Rooftop installed photovoltaic systems that are adhered or attached to the roof covering or photovoltaic modules/shingles installed as roof coverings shall be labeled to identify their fire classification in accordance with the testing required in Section 1505.1.

4. RACK-MOUNTED PHOTOVOLTAIC REQUIREMENTS

IBC Section 1509 and IRC Section M2302 apply to rooftop structures, and the requirements of these sections apply to PV systems mounted over the roof assembly. PV systems mounted on racks over the roof are a common example of this system.

The requirements in the specific IBC and IRC sections include:

Installation

Code Section	Requirement
IBC Section 1509.7.3	Installation in accordance with manufacturer's installation instructions.
IRC Section M2302.2	Installation in accordance with manufacturer's instructions and NFPA 70 (National Electrical Code).
IRC Section M2302.2.1	The roof shall be constructed to support the loads imposed by the PV modules.
IRC Section M2302.2.2	Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 of the IRC.
IRC Section M2302.2.3	Ground-mounted PV systems shall be installed in accordance with manufacturer's instructions.

2012 IBC code language:

1509.7.3 Installation. Rooftop mounted photovoltaic systems shall be installed in accordance with the manufacturer's installation instructions.

2012 IRC code language:

M2302.2 Requirements. The installation, inspection, maintenance, repair and replacement of photovoltaic systems and all system components shall comply with the manufacturer's instructions, Sections M2302.2.1 through M2302.2.3 and NFPA 70.

M2302.2.1 Roof-mounted panels and modules. Where photovoltaic panels and modules are installed on roofs, the roof shall be constructed to support the loads imposed by such modules. Roof-mounted photovoltaic panels and modules that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9. Where mounted on or above the roof coverings, the photovoltaic panels and modules and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction.

M2302.2.2 Roof and wall penetrations. Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 to prevent entry of water, rodents and insects.

M2302.2.3 Ground-mounted panels and modules. Ground-mounted panels and modules shall be installed in accordance with the manufacturer's installation instructions.

Materials

IBC Section 1509.7.4 and IRC Section M2302.3 require PV panels and modules to be listed and labeled in accordance with UL 1703. IRC Section M2302.4 requires inverters to be listed and labeled in accordance with UL 1741.

2012 IBC Code language:

1509.7.4 Photovoltaic panels and modules. Photovoltaic panels and modules mounted on top of a roof shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer's installation instructions.

2012 IRC Code language:

M2302.3 Photovoltaic panels and modules. Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703.

M2302.4 Inverters. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

Wind Resistance

IBC Section 1509.7.1 establishes criteria for calculating the minimum design loads for rack-mounted PV systems on roofs. The code specifies that the wind loads shall be calculated using the method prescribed for components and cladding (C&C) using an effective wind area based on the dimensions of a single unit. This provides guidance for wind load engineering calculations, which were not available previously for PV systems on roofs.

The procedure called for by Section 1509.7.1 is different from the procedure described in Solar ABCs report, *Wind Load Calculations for PV Arrays*, which recommends using the main wind-force resisting systems (MWFRS) as the design parameter. The Solar ABCs report is available to download at:

www.solarabcs.org/about/publications/reports/wind-load/index.html

There are pros and cons associated with the use of each of these methods. By definition, MWFRS is an assemblage of structural elements assigned to provide support and stability for the overall structure and receive and transmit wind loading forces from more than one surface. In the American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures* (ASCE-7), C&C are defined as elements of the building envelope that do not qualify as part of the MWFRS.

Although many BIPV or flush-mounted modules meet the C&C criteria, the Solar ABCs task team determined that the common method of mounting PV arrays on roofs using a racking system meets the definition of MWFRS. Specifically, the modules and mounting hardware are considered to be a structural system because all the hardware is above the roof surface and forces are applied to more than one surface of the system. Rack-mounted PV array modules and hardware are more than a surface-covering element such as a shingle or siding.

The IBC language states that the effective wind area should be based on the dimensions of a single unit frame. For a large rack, this method may be very conservative, and result in over-estimated wind forces. This small effective area may be appropriate for modules mounted at the perimeter of an array field, but interior modules can be subject to significantly lower forces. Using the single unit as the effective wind area may be appropriate until testing can establish the distribution of wind forces.

The IBC method and the Solar ABCs method each recommend using a different, existing element of current codes and standards as the basis for the wind load calculations. In the long term, the preferred solution to this discrepancy is not to analyze PV systems in the same way as other dissimilar components, but rather to develop wind load guidelines specifically for PV modules and arrays. Solar ABCs is currently conducting wind tunnel testing to develop performance-related design parameters for PV systems. Once developed, these design requirements can be incorporated into the IBC and ASCE standards.

The IRC does not include wind resistance requirements.

2012 IBC Code language:

1509.7.1 Wind resistance. Rooftop mounted photovoltaic systems shall be designed for wind loads for component and cladding in accordance with Chapter 16 using an effective wind area based on the dimensions of a single unit frame.

Fire Classification

IBC Section 1509.7.2 includes requirements for fire classification of rooftop mounted PV *systems*. IRC Section M2302.2.1 includes requirements for noncombustible or fire-retardant materials. A key objective of the code requirement is that the installation of PV does not diminish the minimum fire safety requirements for the roof. Roof systems have long received fire classification ratings. These ratings are based on the ability to prevent a fire from penetrating through the roof and the ability to minimize the spread of a fire along the roof surface.

The requirements of the 2012 IBC 1509.7.2 will need careful examination in their application. The language of this section states that the fire classification of PV *systems* must match the minimum fire classification of the roof assembly over which they are mounted as required in Section 1505. With any rooftop structure, the structure should not degrade the fire resistance properties of the roof, so as not to place the structure and its inhabitants at an unanticipated risk. However, straightforward implementation of this requirement is not possible.

PV *modules* are a component of a rooftop mounted PV system and, although PV *modules* can receive a fire classification rating (in accordance with ANSI/UL 1703), there is presently no American National Standard Institute (ANSI) fire classification test or rating for a PV *system*. Similarly, there is no ANSI fire classification test for systems that include the PV array and the roof assembly. Thus, as currently written, Section 1509.7.2 refers to the fire classification rating of a system, and this exact approach is not yet available.

In the absence of a PV *system* rating, it may seem appropriate to use the PV *module* fire classification rating in order to ensure the desired result, which is the preservation of the roof assembly's original fire classification. However, simply using the PV module fire classification rating may not provide the desired result in all cases.

In 2008 and 2009, rigorous testing by UL and Solar ABCs revealed that the performance of a *system*—which includes PV modules on standoff mounted racks—exposed to fire or flame is not the same as that of a *module* alone. Currently, modules receive a fire classification rating based on testing the module alone, not as part of a PV system. The results of these tests show that actual performance of a rack-mounted PV system exposed to fire or flame is strongly dependent on the mounting geometry of the PV array and properties of the components that make up the specific module type. (A summary of this research is published in a Solar ABCs report available at: www.solarabcs.org/about/publications/reports/flammability-testing/index.html)

As a result of this testing and in consideration of the current requirements of IBC Section 1509.7.2, Solar ABCs, UL, and an ANSI/UL 1703 Standards Technical Panel (STP) working group are actively developing a new test methodology. This is being done in close association with a working group composed of representatives from the PV industry, the roofing industry, standards development, the building and fire enforcement community, and government laboratory experts. The work product of this effort will be presented immediately to the full STP for UL 1703 for vetting and, ultimately, adoption. If adopted, this new test will be applicable to PV *systems* and will provide the valid, ANSI standard fire classification rating needed for compliance in the execution of the requirements of Section 1509.7.2.

Until a PV system fire classification test is finalized and adopted, Section 1509.7.2, as written, cannot be easily applied. Expert stakeholders are actively working on this issue, Solar ABCs and UL are conducting further research, and UL STPs are revising UL 1703.

2012 IBC Code language:

1509.7.2 Fire classification. Rooftop mounted photovoltaic systems shall have the same fire classification as the roof assembly required by Section 1505.

2012 IRC Code language:

M2302.2.1 Roof-mounted panels and modules. Where photovoltaic panels and modules are installed on roofs, the roof shall be constructed to support the loads imposed by such modules. Roof-mounted photovoltaic panels and modules that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9. Where mounted on or above the roof coverings, the photovoltaic panels and modules and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction.

5. ABOUT THE ORGANIZATIONS

Solar America Board for Codes and Standards

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar PV stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate widespread adoption of safe, reliable, and cost-effective solar technologies.

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International Code Council

The International Code Council (ICC) is a membership association dedicated to building safety and fire prevention. ICC develops the codes and standards used to construct residential and commercial buildings, including homes and schools.

The International Codes, or I-Codes, published by ICC, provide minimum safeguards for people at home, at school, and in the workplace. The I-Codes are a complete set of comprehensive, coordinated building safety and fire prevention codes. Building codes benefit public safety and support the industry’s need for one set of codes without regional limitations.

Website: www.iccsafe.org

Underwriters Laboratories

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Website: www.ul.com

APPENDIX: 2012 CODE CHANGES

Changes to IBC Section 1505

The 2012 IBC contains one change in Section 1505 that impacts PV installations. The modified provisions read:

1505.8 Photovoltaic systems. Rooftop installed photovoltaic systems that are adhered or attached to the roof covering or photovoltaic modules/shingles installed as roof coverings shall be labeled to identify their fire classification in accordance with the testing required in Section 1505.1.

Changes to IBC Section 1507

The 2012 IBC contains several changes in Section 1507 that impact PV installations. The same language is used in IRC Section R905.16. The modified provisions read:

1507.17 Photovoltaic modules/shingles. The installation of photovoltaic modules/shingles shall comply with the provisions of this section.

1507.17.1 Material standards. Photovoltaic modules/shingles shall be listed and labeled in accordance with UL 1703.

1507.17.2 Attachment. Photovoltaic modules/shingles shall be attached in accordance with the manufacturer's installation instructions.

1507.17.3 Wind resistance. Photovoltaic modules/shingles shall be tested in accordance with procedures and acceptance criteria in ASTM D 3161. Photovoltaic modules/shingles shall comply with the classification requirements of Table 1507.2.7.1(2) for the appropriate maximum nominal design wind speed. Photovoltaic modules/shingle packaging shall bear a label to indicate compliance with the procedures in ASTM D 3161 and the required classification from Table 1507.2.7.1(2).

Changes to IBC Section 1509

The 2012 IBC contains several changes in Section 1509 that impact PV installations. The modified provisions read:

1509.7 Photovoltaic systems. Rooftop mounted photovoltaic systems shall be designed in accordance with this section.

1509.7.1 Wind resistance. Rooftop mounted photovoltaic systems shall be designed for wind loads for component and cladding in accordance with Chapter 16 using an effective wind area based on the dimensions of a single unit frame.

1509.7.2 Fire classification. Rooftop mounted photovoltaic systems shall have the same fire classification as the roof assembly required by Section 1505.

1509.7.3 Installation. Rooftop mounted photovoltaic systems shall be installed in accordance with the manufacturer's installation instructions.

1509.7.4 Photovoltaic panels and modules. Photovoltaic panels and modules mounted on top of a roof shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer's installation instructions.

Changes to IRC Section M2302

The 2012 IRC contains a new Section M2302 that impacts PV installations.

Photovoltaic Solar Energy Systems

M2302.1 General. This section provides for the design, construction, installation, alteration and repair of photovoltaic equipment and systems.

M2302.2 Requirements. The installation, inspection, maintenance, repair and replacement of photovoltaic systems and all system components shall comply with the manufacturer's instructions, Sections M2302.2.1 through M2302.2.3 and NFPA 70.

M2302.2.1 Roof-mounted panels and modules. Where photovoltaic panels and modules are installed on roofs, the roof shall be constructed to support the loads imposed by such modules. Roof-mounted photovoltaic panels and modules that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9. Where mounted on or above the roof coverings, the photovoltaic panels and modules and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction.

M2302.2.2 Roof and wall penetrations. Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 to prevent entry of water, rodents and insects.

M2302.2.3 Ground-mounted panels and modules. Ground-mounted panels and modules shall be installed in accordance with the manufacturer's installation instructions.

M2302.3 Photovoltaic panels and modules. Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703

M2302.4 Inverters. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

ACRONYMS

ANSI	American National Standard Institute
ASCE	American Society of Civil Engineers
BIPV	building-integrated photovoltaic
C&C	components and cladding
IBC	International Building Code
IFC	International Fire Code
IRC	International Residential Code
MWFRS	main wind-force resisting systems
NFPA	National Fire Protection Association
PV	photovoltaic
Solar ABCs	Solar America Board for Codes and Standards
STP	Standards Technical Panel