Wiring Conduit for Solar PV Systems

Last Updated: 08/08/2014

Scope

During construction, add a 1 inch metal conduit from the Photovoltaic array to the designated inverter location, and add a second 1 inch metal conduit from the inverter location to the electrical service panel.

DOE Zero Energy Ready Home Notes

The U.S. Department of Energy [Zero Energy Ready Home National Program Requirements](http://www.energystar.gov/ia/partners/builders/zeroreadyhome/) (Rev. 04) Exhibit 1, Mandatory Requirements, Item 7 Renewable Ready, that all homes must meet the requirements in the Consolidated Renewable Energy Ready Home (RERH) Checklist.

The RERH Checklist requires builders to

- Install a 1-in. metal conduit for the DC wire run from the designated array location to the designated inverter location (cap and label both ends). (RERHPV Guide 3.2)
- Install a 1-in. metal conduit from designated inverter location to electrical service panel (cap and label both ends). (RERHPV Guide 3.3)

See the [Compliance Tab](http://www.energystar.gov/) 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

A conduit is intended to protect the wiring leading from the PV array to the inverter and from the inverter to the electrical service panel. The ends of the conduit should be clearly labeled, particularly if the intent is to install the PV system at a later date. In areas subject to environmental concerns or hazards, the stub outs should be properly sealed and/or capped to prevent contamination.

To meet the requirements of the DOE Zero Energy Ready Home program, install a 1-inch metal conduit from the designated array location to the designated inverter location with the end of the conduit clearly labeled as a Renewable Energy Ready Home component and indicating its purpose and intended use. The conduit run should be identified on electrical and architectural diagrams to be provided to the homeowner.

![Diagram of a house with an inverter and a proposed PV array, showing metal conduit installed from the attic to the 4'x4' plywood area for a future inverter.]

Figure 1. Architectural diagram showing metal conduit.

How to Install a Wiring Conduit for a Future Solar Photovoltaic System:

1. Designate a proposed location for the solar photovoltaic system on the roof.

2. Install a 1-inch metal conduit from the attic to the future location of the inverter.
   a. Begin conduit about 6 inches above the finished insulation depth directly below the designated array location in the attic. Ensure the conduit location in the attic provides at least 18-in. of space below the roof deck and is easily accessible for the future solar installer.
   b. Run the wiring conduit through the home so that the overall length of the conduit is minimized.
   c. Ensure there are three or fewer 90-degree turns from the attic to the designated 4 ft x 4 ft plywood area or provide for accessible pull boxes, as required by the National Electric Code.
   d. Terminate the conduit at the bottom edge of the 4 ft x 4 ft plywood backing for a future inverter. (Optional) For aesthetic reasons, terminate into a flush mount junction or pull box near the bottom edge of the plywood area.

3. Install a 1-inch metal conduit from the designated inverter location to the electrical service panel.

4. To facilitate the wiring of the solar PV system at a later date, the builder may also want to include a pull line in the conduit, particularly if the overall conduit run is lengthy or has multiple bends.

5. Cap and label both ends of both conduit runs so the text is visible and upright (if possible). The label should read, “Renewable Energy Ready Home – Solar Photovoltaic Wiring Conduit.”
Ensuring Success

Ensure adequate utility room size and location for the solar water heating and photovoltaic system components early in the house design process.

Confirm with local code officials early in the design process what steps are needed to guarantee that installation of PV panels will meet with local codes, homeowner's association covenants, and historic district regulations.

Protect the electrical and mechanical components of the solar photovoltaic system from bulk moisture, high temperatures, and direct sunlight. The utility room should be properly ventilated and maintain average indoor temperatures.
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/m^2/day average daily solar radiation based on annual solar insolation using the PVWatts online tool. See map below.
Training

Right and Wrong Images

Display Image: 2018-Health-e-X-InverterReadyCircuit-conduit for PV.JPG
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.

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.

DOE Zero Energy Ready Home PV-Ready Checklist (Revision 07)

- Install a 1” metal conduit for the DC wire run from the designated array location to the designated inverter location (cap and label both ends). (RERHPV Guide 3.2)
- Install a 1” metal conduit from designated inverter location to electrical service panel (cap and label both ends). (RERHPV Guide 3.3)
- Install and label a 4’ x 4’ plywood panel area for mounting an inverter and balance of system components. (RERHPV Guide 3.1) Alternative: Blocking is permitted to be used as an alternative to the 4’ x 4’ panel. The area designated for the future panel to mount PV components shall be clearly noted in the system documentation.
- Install a 70-amp dual pole circuit breaker in the electrical service panel for use by the PV system (label the service panel) (RERHPV Guide 3.4) Alternative: Provide a labeled slot for a double-pole breaker in the electrical service.

DOE Zero Energy Ready Home National Program Requirements Mandatory Requirement 7 (Renewable Ready) shall be met by any home certified under the DOE Zero Energy Ready Home program, only where all of the following conditions are met:

1. Location, based on zip code has at least 5 kWh/m2/day average daily solar radiation based on annual solar insolation using PVWatts online tool, AND;
2. Location does not have significant natural shading (e.g., trees, tall buildings on the south-facing roof, AND;
3. Home as designed has adequate free roof area within +/-45° of true south as noted in the table below.

<table>
<thead>
<tr>
<th>Conditioned Floor Area of the House (sq. ft.)</th>
<th>Minimum Roof Area within +/- 45° of True South for PV-Ready Checklist to Apply (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2000</td>
<td>110</td>
</tr>
<tr>
<td>≤ 4000</td>
<td>220</td>
</tr>
<tr>
<td>≤ 6000</td>
<td>330</td>
</tr>
<tr>
<td>&gt; 6000</td>
<td>440</td>
</tr>
</tbody>
</table>

DOE Zero Energy Ready Home PV-Ready Checklist - Minimum Roof Area (Source: DOE Zero Energy Ready Home PV-Ready Checklist (Revision 07)).

2009, 2012, 2015, and 2018 IECC

Section 401.3 A permanent certificate shall be posted on or near the electrical distribution panel that lists types and efficiencies of water heating, heating, and cooling equipment, as well as insulation R values, and window U and SHGC factors.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)
Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.


Follow the requirements for solar water heating systems found in the IMC, Chapter 14, Solar Systems (Solar Thermal Systems in 2018 IMC).

2014 National Electric Code (NEC)

Follow the requirements for solar photovoltaic (PV) systems found in the 2014 National Electric Code (NEC), Article 690, PV Power Systems, and Article 110, Requirements for Electrical Installations.

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/). 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.


[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/organize 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-by 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 R324.3.5.2, 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.

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[6] installed on or above the roof covering shall be designed and installed in accordance with Section R902.2 this section.

R902.2 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.

R324.4.1.1 Rooftop 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.

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.

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.

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 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 R907.5) is already required by Section R324.3.1.

5. Two separate sections (Sections 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.
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.

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):

More Info.

Access to some references 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.

Case Studies
None Available

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. **2015 IECC - International Energy Conservation Code**
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: May, 2014
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6. **2015 IRC - International Residential Code for One and Two Family Dwellings**
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: May, 2014
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

7.
8. **2018 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** August, 2017
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

9. **DOE Zero Energy Ready Home National Program Requirements (Rev. 07)**
   - **Author(s):** U.S. Department of Energy
   - **Organization(s):** DOE
   - **Publication Date:** May, 2019
   - Standard requirements for DOE’s Zero Energy Ready Home national program certification.

10. **NABCEP Photovoltaic (PV) Installer Resource Guide**
    - **Author(s):** Brooks, Dunlop
    - **Organization(s):** NABCEP
    - **Publication Date:** March, 2012
    - This Photovoltaic (PV) Installer Resource Guide is an informational resource covering basic requirements for PV installations intended for individuals pursuing the Photovoltaic Installer Certification credential offered by the North American Board of Certified Energy Practitioners (NABCEP).

11. **PV Primer**
    - **Author(s):** Building Science Corporation
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** June, 2006
    - Report aiming to “de-mistify” technology and economic considerations of residential PV systems.

12. **Renewable Energy Ready Home Solar Site Assessment Tool**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** May, 2014
    - Website tool intended to guide home builders in assessing whether a new home has the proper physical orientation to support a future installation of a solar energy system.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.*

**Contributors to this Guide**
The following authors and organizations contributed to the content in this Guide.

- **Building Science Corporation**, lead for the Building Science Consortium (BSC), a **DOE Building America Research Team**
- **Pacific Northwest National Laboratory**