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7. Solar Ready

§110.10

This chapter of the residential compliance manual addresses residential solar-ready buildings requirements. The intent of the solar-ready requirements is to provide a penetration-free and shade-free portion of the roof, called the *solar zone*. This solar zone helps ensure that future installation of a solar energy system is not precluded by the original design and layout of the building and associated equipment. There are no infrastructure related requirements, such as installation of conduit or piping, inclusion of collateral structural loads, or preinstalled mounting hardware.

The requirements for solar-ready buildings are mandatory measures for newly constructed single-family and low-rise multifamily residential buildings and do not apply to either additions or alterations.

7.1 Overview

All solar ready provisions are mandatory; there are no prescriptive and performance compliance paths. Since the provisions are mandatory, there are no tradeoffs allowed, and applicants must demonstrate compliance with each measure. There are, however, exceptions. Exceptions to mandatory requirements are described in the corresponding sections.

7.2 Covered Occupancies

§110.10(a)

The residential solar-ready requirements apply to single-family residences and low-rise multifamily residential buildings.

A. Single-Family Residential Buildings

The solar-ready requirements are applicable to newly constructed single-family residential buildings located in subdivisions with 10 or more residences...

B. Low-Rise Multifamily Buildings

The solar-ready requirements are applicable to newly constructed low-rise multifamily buildings. By the definition of the Energy Standards, low-rise multifamily buildings have three habitable stories or fewer.

7.3 Solar Zone

§110.10(b)

The solar zone is an allocated space that is unshaded, unpenetrated, and free of obstructions. It serves as a suitable place that solar panels can be installed at a future date.

For single-family residential building the solar zone shall be located on the roof or overhang of the building.

For low-rise multifamily buildings the solar zone can be located at any of the following locations:

1. Roof of building
2. Overhang of the building
3. Roof and overhang of another structure located within 250 feet of the primary building
4. Covered parking installed with the building project
5. Other structures include, but are not limited to, trellises, arbors, patio covers, carports, gazebos, and similar accessory structures.

The solar zone design must comply with the access, pathway, smoke ventilation, and spacing requirements as specified in Title 24, Part 9 or in any requirements adopted by a local jurisdiction. These additional requirements are located in other Parts of Title 24, including Parts 2, 2.5, and 9 that are adopted by the California Building Standards Commission as part of the California Building Standards Code.

7.3.1 Minimum Area

§110.10(b)1

The total area of the solar zone may be composed of multiple subareas. No dimension of a subarea can be less than five feet. If the total roof area is equal to or less than 10,000 square feet, each subarea must be at least 80 square feet. If the total roof area is greater than 10,000 square feet, each subarea must be at least 160 square feet.

7.3.1.1 Single-Family Residential Buildings

The solar zone shall be located on the roof or overhang of the building. The solar zone shall have a total area that is no less than 250 square feet. There are multiple exceptions, as described below, to the required total solar zone area. For Exceptions A, B, and G below, although the language in the Energy Standards implies that these three exceptions apply only to the solar zone requirements, the intent of the Standards is for the exceptions to apply to the solar zone requirement, as well as the interconnection pathway requirements described in §110.10(c), the documentation requirements described in §110.10(d), and the electric service panel requirements described in §110.10(e).

Exceptions:

- A. Single-family residential buildings are exempt from the solar zone, interconnection pathway, and documentation requirements if a solar PV system with a nameplate direct current (DC) power rating of 1000 watts or greater is permanently installed at the time of construction. The nameplate rating must be measured under standard test conditions. The permanently installed solar electric system is not required to be on the roof of the building. To verify compliance with this exception, form *CF2R-SPV-01-E Certificate of Installation: Photovoltaic Systems* must be submitted.
- B. Single-family residential buildings are exempt from the solar zone, interconnection pathway, and documentation requirements if a domestic solar water-heating system is permanently installed at the time of construction. The SWH system must comply with the installation criteria in the Reference Residential Appendix RA4.4.21 and have a minimum solar savings fraction of 0.50 (the fraction of domestic hot water demand provided by a solar water heating systems) permanently installed at the time of construction. This is the equivalent of the prescriptive solar water-heating system requirements when installing an electric-resistance storage or instantaneous water

heater serving a dwelling unit. The permanently installed domestic solar water-heating collectors are not required to be located on the roof of the building. To verify compliance with this exception, form *CF2R-STH-01-E Certificate of Installation: Solar Water Heating System* must be submitted.

- C. The solar zone may be reduced to no less than 150 square feet for single-family residential buildings with three stories or more and with a total floor area equal to 2,000 square feet or less.
- D. The solar zone may be reduced to no less than 150 square feet for single-family residential buildings with a whole-house fan and where the building is located in Climate Zones 8 through 14 and where the residence is located in the Wildland-Urban Interface Fire Area (as defined in Title 24, Part 2). This exception is to accommodate attic- and roof-venting requirements in these fire areas.
- E. The solar zone may be reduced to 50 percent of the potential solar zone area. For the Energy Standards, the potential solar zone area is the total area of the roof where annual solar access is 70 percent or greater. This exception reduces the required solar zone area when the roof is shaded by objects that are not located on the roof or any other part of the building. If the potential solar zone is smaller than the minimum solar zone area specified in §110.10(b)1A of 250 square feet, then the solar zone can be reduced to half the area of the potential solar zone. If the roof is shaded such that there is no potential solar zone area, then no solar zone is required.

For the solar ready requirements, solar access is the ratio of solar insolation including shading to the solar insolation without shading.

$$\text{Solar Access} = \frac{\text{Solar Insolation Including Shading}}{\text{Solar Insolation Without Shading}}$$

Objects that are excluded from the building project are objects that will not be moved or modified as part of the building project and include existing buildings, telephone poles, communication towers, trees, or other objects. Objects that are included in the building project are objects that will be constructed as part of the building project and include the building itself, HVAC equipment on the building, parking lot lights, and other similar objects. As mentioned, solar access does not take into account shading from objects that are included in the building project as the designer has control of the location of these potential obstructions.

Annual solar access is most easily determined using an instrument equipped with a camera with a fisheye lens and specialized imagery processing software. The instrument can calculate the annual solar access of any point on a proposed site based on the location of the building and information that is captured in the digital photograph. Since this type of instrument relies on photographs, the most appropriate use is to determine solar access on existing buildings. The instruments are not as useful in the design phase for newly constructed buildings, when capturing a digital photograph from the proposed solar zone location is not feasible.

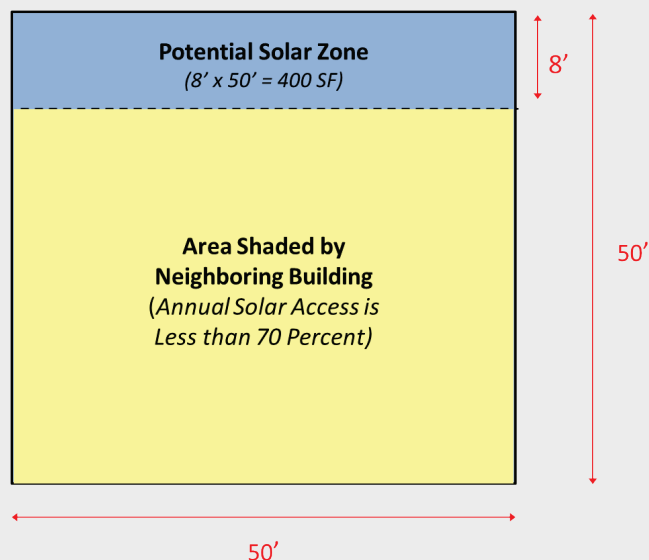
To determine the annual solar access during the design phase, designers will first evaluate whether there are any objects outside the building project that will shade the rooftop (or other prospective solar zone areas such as overhangs or parking shade structures). If an existing object is located north of all potential solar zones, the object will not shade the solar zone. Similarly, if the horizontal distance (“D”) from the object to the solar zone is at least two times the height difference (“H”) between the highest point of the object and the horizontal projection of the nearest point of the solar zone, then the object will not shade the solar zone. (See Figure 7-2.)

If objects external to the building project could shade the solar zone, annual solar access can be quantitatively determined using several computer-aided design (CAD) software packages that can import a CAD file of the building and perform a shading analysis or several online solar quoting tools can be used that make use of both overhead and orthogonal aerial imagery. Annual solar access can be qualitatively determined using several three-dimensional modeling programs. The method/tools used to quantify that the solar access is less than 70 percent (and reduce the potential solar area) shall be documented in compliance form CF1R-SRA-02-E.

Example 7-1

Question

A house has a total roof area of 2,500 SF. The neighbor's house and trees shade the roof, so 2,100 SF of the roof has less than 70 percent annual solar access. How big does the solar zone have to be?



Answer

If the entire roof were to have an annual solar access of 70 percent or greater, the minimum solar zone would have been 250 SF. Since the potential solar zone is only $2,500 - 2,100 = 400$ SF, however, the minimum solar zone can be reduced to 50 percent of the potential solar zone, or 200 SF.

- F. The solar zone may be reduced to no less than 150 square feet if all thermostats in the residential building are occupant-controlled smart thermostats (OCST) with communications capabilities enabled to receive and respond to demand response signals. An OCST is a setback thermostat with communication capabilities that enable the occupant to receive demand response-related messages and respond to those signals by automatic adjustment of the thermostat setpoint as described in Joint Appendix JA5 (subject to occupant participation). Enabling communications capabilities requires that the OCST has one of the following:
1. onboard communications capabilities,
 2. an installed communications module for OCSTs with removable communications module(s), or

3. an installed communications gateway for an OCST where an external gateway is required for communications.
- G. Single-family residential buildings are exempt from the solar zone, interconnection pathway and documentation requirements if all of the following conditions are met:
1. All thermostats in the buildings are OCST with communications capabilities enabled to receive and respond to demand response signals (subject to occupant participation). Enabling communications capabilities requires that the OCST has one of the following: onboard communications capabilities, an installed communications module for OCSTs with removable communications module(s), or an installed communications gateway for an OCST where an external gateway is required for communications.
 2. One of the following measures shall be met:
 - a. Install a dishwasher that meets or exceeds the ENERGY STAR® program requirements and install either a refrigerator that meets or exceeds the ENERGY STAR program requirements or a whole-house fan driven by an electronically commutated motor; or
 - b. Install a home automation system capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals; or
 - c. Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code; or
 - d. Install a rainwater catchment system designed to comply with the California Plumbing Code and use rainwater flowing from at least 65 percent of the available roof area.

7.3.1.2 Low-Rise Multifamily Residential Buildings

The solar zone shall be located on the roof or overhang of the building or on the roof or overhang of another structure located within 250 feet of the building or on covered parking installed with the building project. Other structures include, but are not limited to, trellises, arbors, patio covers, carports, gazebos, and similar accessory structures. The solar zone shall have a total area that is no less than 15 percent of the total roof area of the building after subtracting any skylight area from the roof area. There are multiple exceptions, as described below, to the required total area. For Exceptions A, B, D, and E below, although the language in the Energy Standards implies that these four exceptions only apply to the solar zone requirements, the intent of the Energy Standards is for the exceptions to apply to the solar zone requirement, as well as the interconnection pathway requirements described in §110.10(c), and the documentation requirements described in §110.10(d).

Exceptions

- A. Buildings are exempt from solar zone, interconnection pathway, and documentation requirements if a solar electric system with a nameplate DC power rating of no less than 1 watt per square foot of roof area is permanently installed at the time of construction. The nameplate rating must be measured under standard test conditions. The permanently installed solar electric system is not required to be located on the roof or overhang of the building or on the roof or overhang of another structure. To verify compliance with this exception, form *CF2R-SPV-01-E Certificate of Installation: Photovoltaic Systems* must be submitted.

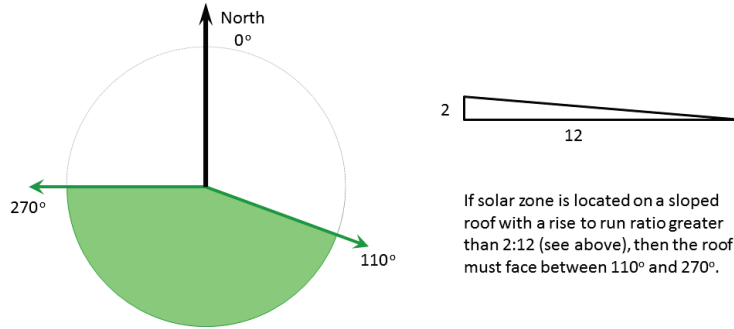
- B. Buildings are exempt from solar zone, interconnection pathway, and documentation requirements if a domestic solar water-heating system complying with §150.1(c)8Biii is permanently installed at the time of construction. This is the equivalent of the prescriptive solar water-heating system requirements when installing a water-heating system serving multiple dwelling units. The permanently installed domestic solar water-heating collectors are not required to be located on the roof or overhang of the building or on the roof or overhang of another structure. To verify compliance with this exception, form *CF2R-STH-01-E Certificate of Installation: Solar Water Heating System* must be submitted.
- C. The solar zone may be reduced to 50 percent of the potential solar zone area. The potential solar zone area is the total area of the roof where annual solar access is 70 percent or greater. This exception reduces the required solar zone area when the roof is shaded by objects that are not on the roof or any other part of the building. If the roof is shaded such that there is no potential solar zone area, then no solar zone is required.
- D. Low-rise multifamily buildings that comply with items 1 and 2 below are exempt from solar zone, interconnection pathway, and documentation requirements.
1. All thermostats in each dwelling unit are occupant controlled smart thermostats (OCST) with communications capabilities enabled to receive and respond to demand response signals. An OCST is a setback thermostat with communication capabilities that enable the occupant to receive Demand Response related messages and respond to those signals by automatic adjustment of the thermostat setpoint as described in Joint Appendix JA5 (subject to occupant participation). Enabling communications capabilities requires that the OCST has one of the following: onboard communications capabilities, an installed communications module for OCSTs with removable communications module(s), or an installed communications gateway for an OCST where an external gateway is required for communications. OCST must be certified by the Energy Commission to meet the requirements described in the Joint Appendix JA5.
 2. For each dwelling unit, one of the following measures shall be met:
 - a. Install a dishwasher that meets or exceeds the ENERGY STAR program requirements and install either a refrigerator that meets or exceeds the ENERGY STAR program requirements or a whole-house fan driven by an electronically commutated motor; or
 - b. Install a home automation system capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals; or
 - c. Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code; or
 - d. Install a rainwater catchment system designed to comply with the California Plumbing Code and use rainwater flowing from at least 65 percent of the available roof area.
- E. Buildings are exempt from solar zone interconnection pathway and documentation requirements if the roof is designed for vehicle traffic (parking lot) or if the roof is designed as a helicopter landing zone.

7.3.2 Orientation

§110.10(b)2

For both single-family residential and low-rise multifamily buildings, all sections of the solar zone on steep-sloped roofs (ratio of rise to run of greater than 2:12) shall be oriented between 110 degrees and 270 degrees of true north. The orientation is important because it ensures a reasonable solar exposure if a solar energy system is installed in the future.

Figure 7-1: Orientation of roof if solar zone is located on steep-sloped roof



If a solar zone is located on a low-sloped roof (ratio of rise to run of 2:12 or less), the orientation requirement does not apply.

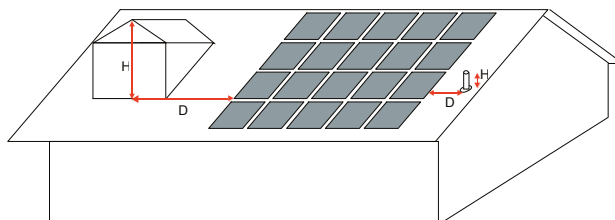
7.3.3 Shading

§110.10(b)3

For both single-family residential and low-rise multifamily buildings, the solar zone shall be free from roof penetrations and shall not have any obstructions such as vents, chimneys, architectural features, or roof-mounted equipment located in the solar zone. This requirement ensures that the solar zone remains clear and open for the future installation of a solar energy system.

For both single-family residential and low-rise multifamily buildings, any obstruction located on the roof or any other part of the building that projects above the solar zone shall be located at a sufficient horizontal distance away from the solar zone in order to reduce the resulting shading of the solar zone. For each obstruction, the horizontal distance (“D”) from the obstruction to the solar zone shall be at least two times the height difference (“H”) between the highest point of the obstruction and the horizontal projection of the nearest point of the solar zone (see following equation).

$$\text{Equation 7.1} \quad D \geq 2 \times H$$

Figure 7-2: Schematic of Allowable Setback From Rooftop Obstructions

Source: California Energy Commission

Any obstruction oriented north of all points of the solar zone is not subject to these requirements. Any obstruction that is not located on the roof or another part of the building, such as landscaping or a neighboring building, is not subject to these requirements.

7.4 Construction Documents

Construction documents must include information about the as-designed structural loads and plans for interconnecting a photovoltaic (PV) and SWH system to the electrical or plumbing system of the building.

These requirements apply to both single-family residential and low-rise multifamily buildings.

7.4.1 Structural Design Loads

§110.10(b)4

For the areas of the roof designated as the solar zone, the structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents. This is required so that the structural loads are known if a solar energy system is installed in the future. There are no requirements for the inclusion of any collateral loads for future solar energy systems.

7.4.2 Interconnection Pathways

§110.10(c)

All buildings that comply with the solar-ready requirements with a solar zone must also include a plan for connecting a PV and SWH system to the electrical or plumbing system of a building. The construction documents shall indicate:

1. A location for inverters and metering equipment for future solar electric systems.
2. A pathway for routing conduit from the solar zone to the point of interconnection with the electrical service. There is no requirement to install any conduit.
3. A pathway for routing of plumbing from the solar zone to the water-heating system. There is no requirement to install any piping.

7.4.3 Documentation

§110.10(d)

A copy of the construction documents or a document containing the required solar-ready information shall be provided to the occupant. The building occupant must also receive a copy of compliance forms number CF1R-SRA-01-E and CF1R-SRA-02-E. Providing this information to the building occupant is required so that the solar-ready information is available if a solar energy system is installed in the future.

7.5 Main Electrical Service Panel

§110.10(e)

This requirement applies only to single-family residential buildings. The main electrical service panel shall have a minimum busbar rating of 200 amps and shall have a reserved space to allow for the installation of a double-pole circuit breaker. The reserved circuit breaker space shall be on the opposite (load) end from the input feeder or main circuit location. The reserved circuit breaker space shall be permanently marked as “For Future Solar Electric”. These items are required to simplify the possible future installation of a solar electric system.

7.6 California Fire Code Solar Access Requirements

Under regulations established by the Office of the State Fire Marshal, the 2016 version of Parts 2, 2.5, and 9 of Title 24 include requirements for the installation of rooftop solar photovoltaic systems. These regulations cover the marking, location of DC conductors, and access and pathways for photovoltaic systems. They apply to residential and nonresidential buildings regulated by Title 24 of the California Building Standards Codes. Provided below is a brief summary of the fire code requirements for residential buildings.

PV arrays shall not have dimensions in either axis greater than 150 feet. Residential buildings with hip, ridge/valley roof features shall provide a 3-foot access pathway away from applicable eave to hip/ridge/valley features. To provide adequate smoke ventilation, PV arrays shall not be located higher than 3 feet below the ridge. Builders shall refer directly to the relevant sections of Title 24 (most currently Part 2: Section 3111, Part 2.5 Section R331, and Part 9 Section 903.3) for detailed requirements.

In addition to the requirements in the fire code, the California Department of Forestry and Fire Protection – Office of the State Fire Marshal (CAL FIRE-OSFM), local fire departments (FD), and the solar photovoltaic industry previously developed a *Solar Photovoltaic Installation Guideline* to increase public safety for all structures equipped with solar photovoltaic systems. The intent of this guideline is to provide the solar photovoltaic industry with information that will aid in the designing, building, and installation of solar photovoltaic systems in a manner that should meet the objectives of both the solar photovoltaic industry and the requirements now set forth in the California Fire Code.

The entire Solar Photovoltaic Installation Guideline can be accessed at <http://osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf>

The following illustrations from this guideline demonstrate some acceptable solar access techniques.

Figure 7-3: Cross Gable Roof

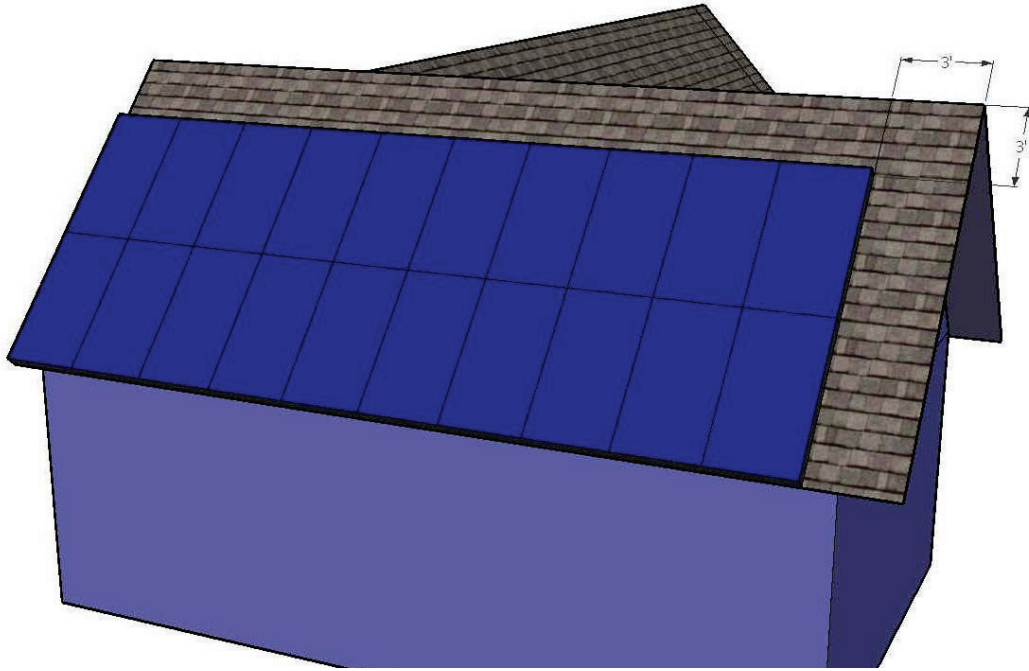


Figure 7-4: Cross Gable with Valley

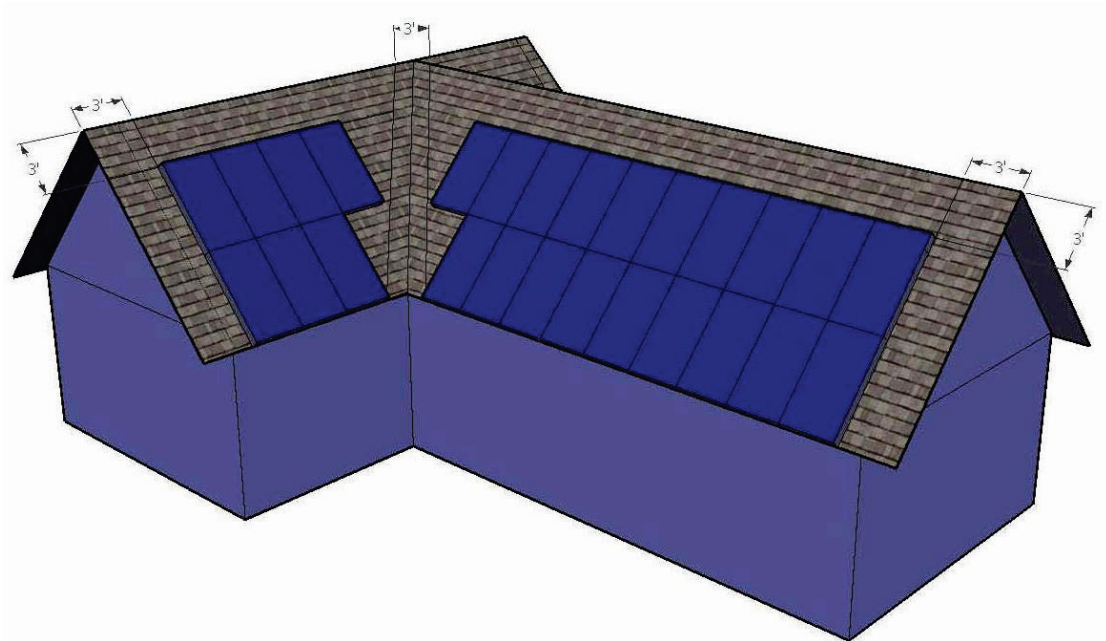


Figure 7-5: Full Gable

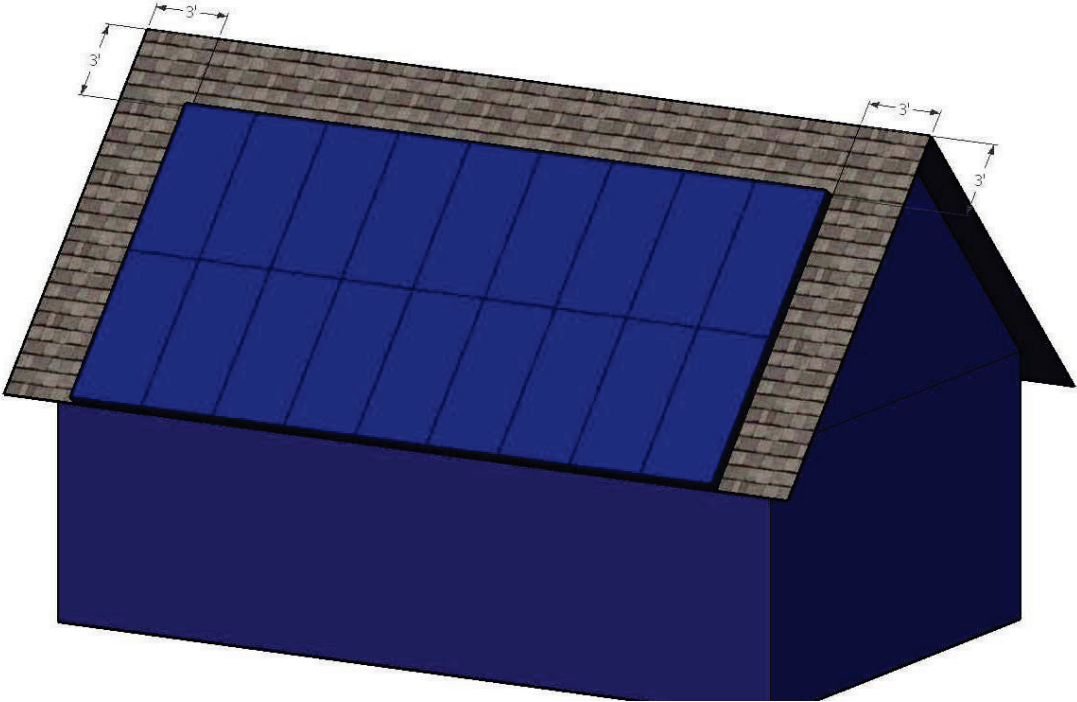
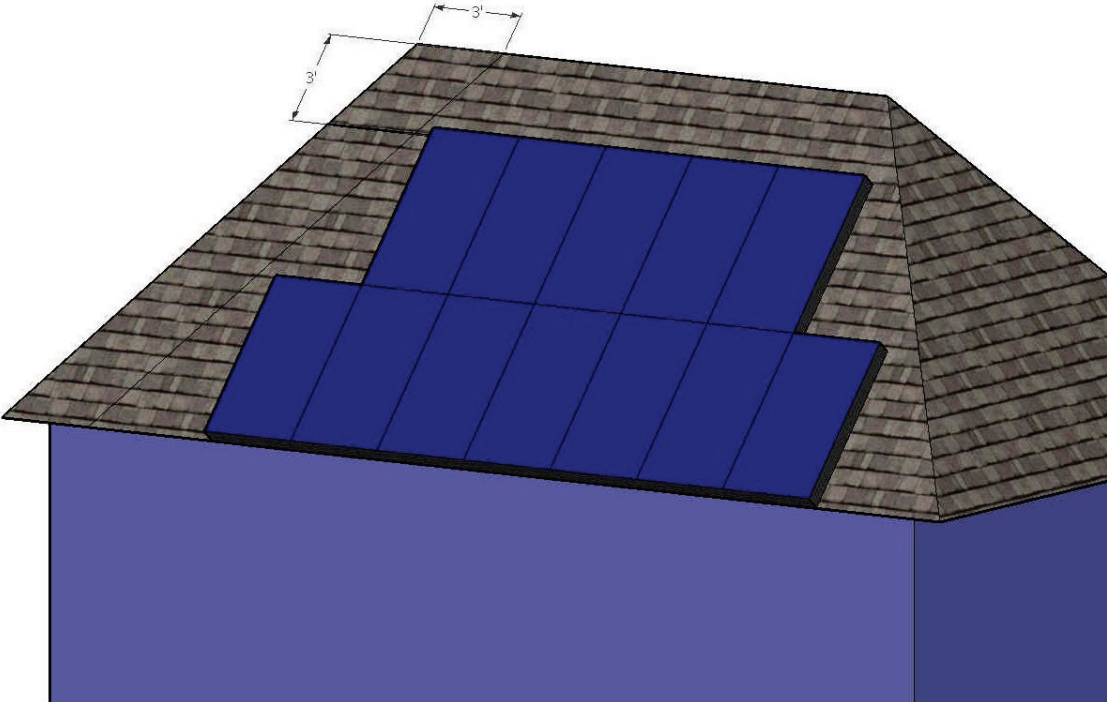


Figure 7-6: Full Hip Roof



7.7 Compliance and Enforcement

At the time a building permit application is submitted to the enforcement agency, the applicant also submits plans and energy compliance documentation. This section describes the forms and procedures for documenting compliance with the solar ready requirements of the Energy Standards. The following discussion is addressed to the designer preparing construction and compliance documents, and to the enforcement agency plan checkers who are examining those documents for compliance with the Standards.

There are four forms associated with the nonresidential solar-ready requirements. Each form is briefly described below.

1. CF1R-SRA-01-E: Certificate of Compliance: Residential Solar Ready Areas

This form is required for every project where the solar-ready requirements apply: newly constructed single-family residential and low-rise multifamily buildings.

2. CF1R-SRA-02-E: Certificate of Compliance: Minimum Solar Zone Area Worksheet

This form is required when buildings comply with the solar-ready requirement by including a solar zone. That is, an appropriately sized solar PV system is not installed, an appropriately sized solar water heating system is not installed, the building does not comply with all the OCST and high-efficacy lighting requirements or the roof is not designed for vehicle traffic or a heliport.

3. CF2R-SPV-01-E: Certificate of Installation – Solar Photovoltaic System

This form is required when the building is exempt from the solar zone requirements because an appropriately sized solar PV system has been installed.

4. CF2R-STH-01-E: Certificate of Installation – Solar Water Heating System

This form is required when the building is exempt from the solar zone requirements because an appropriately sized solar water heating system has been installed.