**CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)**

# Draft Measure Information Template – Nonresidential Solar-ready Buildings

*2013 California Building Energy Efficiency Standards*

California Utilities Statewide Codes and Standards Team May 2011

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# 1. Purpose

Through Codes and Standards Enhancement (CASE) Studies, the California Investor Owned Utilities (IOUs) provide standards and code-setting bodies with the technical and cost-effectiveness information required to make informed judgments on proposed regulations for promising energy efficiency design practices and technologies.

The IOUs began evaluating potential code change proposals in fall 2009. Throughout 2010, the IOU CASE Team (Team) evaluated costs and savings associated with each code change proposal. The Team engaged industry stakeholders to solicit feedback on the code change proposals, energy savings analyses, and cost estimates. This Draft CASE Report presents the IOU code change proposal for nonresidential solar-ready buildings. The contents of this report, including cost and savings analyses and proposed code language, were developed taking feedback from the solar and building industries and the California Energy Commission (CEC) into account.

This is a draft version of the CASE Report. A final version will be available after the CEC rulemaking procedures conclude.

# 2. Overview

## 2.1 Measure Title

Nonresidential Solar-ready Buildings.

## 2.2 Description

The nonresidential solar-ready buildings measure would require new nonresidential buildings with three or less floors to be designed such that it will be technically feasible to install, at a future date, a photovoltaic (PV) or solar water heating (SWH) system of the size specified in the code. The solar-ready requirements would apply for major retrofits if the retrofit would increase the total roof area by more than 20 percent. The required design features include: 1) an un-shaded and un-obstructed solar zone of a specified area, 2) inclusion of the as-designed maximum dead load and live loads for the solar zone in compliance forms and building drawings; and 3) inclusion of design for interconnecting the PV or SWH to the building electrical or plumbing system in building drawings.

This code change proposal does not require solar equipment to be installed, nor does it propose a means of using renewable energy generation to reach a specified energy budget.

## 2.3 Type of Change

The proposed change could be incorporated into the building code in two ways: as a new mandatory requirement in Part 6 of Title 24, or by replacing the existing voluntary PV-ready requirement in Part 11 of Title 24 with the proposed mandatory solar-ready requirement. Changes to modeling software, calculation procedures or the assumptions used in performance calculations are not necessary. The proposed code would not add a compliance option, nor would it affect the way that trade-offs are made.

If the solar-ready measure is incorporated into Part 6 of Title 24, the proposed language would become a mandatory measure in Subsection 2: All Occupancies—Mandatory Requirements for the Manufacture, Construction, and Installation of Systems, Equipment and Building Components. Subsection 2 applies to all building types, so the language would clearly indicate the measure would only apply to low-rise nonresidential buildings that have three of fewer stories. To implement the proposed measure as a mandatory measure in Part 6, the nonresidential Title 24 envelope compliance forms would also need to be modified. A section would be added to form ENV-1C: Certificate of Compliance and Field Inspection Energy Checklist. A new form, ENV-5C, will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

If the solar-ready measure is incorporated into Part 11 of Title 24, the proposed language would be added as a mandatory measure in Chapter 5 Division 5.2: Nonresidential Mandatory Measures - Energy Efficiency. Alternatively, the proposed language could be added into a new division to Chapter 5, Division 5.6: Nonresidential Mandatory Measures – Renewable Energy. To implement the proposed measure as a mandatory measure in Part 11, a new compliance form would need to be added. The form would likely be called EE-1: SOLAR READY or RE-1: SOLAR READY, depending on whether the proposed language would appear in the energy efficiency (EE) division or the renewable energy (RE) division. The new form will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

While the proposed solar-ready requirement does not expand or modify the scope of Title 24, incorporating a requirement that buildings actually install renewable electricity generation systems could require modifications to the scope of Title 24. Considering California's goal of achieving zero-net energy residential and nonresidential building by 2020 and 2030, respectively, it is reasonable to assume that renewable energy requirements could be incorporated into Title 24 in forthcoming code change cycles. Items pertaining to modifying the scope of Title 24 to incorporate renewable energy requirements are outside of the scope for this CASE Report.

## *2.4 Energy Benefits*

The primary goal of the solar-ready measure is to enable PV and SWH systems to be installed on buildings at a future date. The code would not require PV or SWH systems to be installed, so energy savings from this measure are attributed to an increase in the number of systems that would be voluntarily installed at some point in the life of the building. The code change would provide assurance that all buildings with access to solar resource will allocate space on the building site for solar equipment, thus enabling solar to be installed on buildings that would have otherwise been unsuitable. The energy benefits presented in the Analysis and Results section of this report provide the savings that could be expected if PV systems of the size specified by the code were installed on new buildings.

As discussed in Section 3.3 of this report, it is difficult to predict the number of systems that will be installed on a voluntary basis, and it is therefore difficult to predict how much energy will be saved because of the measure. Section 4 of this report presents the prospective energy and energy cost savings if all buildings install solar systems sized according to the proposed code and extrapolations to show savings if smaller subsets of the building stock install systems.

Time Dependent Valuation (TDV) savings were not calculated because the code change would not lead to direct energy savings because, as mentioned previously, the code does not require PV or SWH installations. Assuming systems are installed, TDV benefits will vary based on system design. Many PV and SWH systems are optimized so the majority of electricity is generated in the afternoon when demand is the highest. Modules generate the most electricity or are most effective at heating water when they have the most direct access. Since western-facing aspects get direct sunlight in the afternoon, modules oriented towards the west or southwest are optimized to offset peak energy demand.

## 2.5 Non-Energy Benefits

This code change will enable solar installations in the future. Surveys of the existing building stock indicate that fewer than 30 percent of existing buildings are suitable locations for PV or SWH installations (Harvey 2010). This code change would enable virtually all low-rise commercial buildings to be suitable.

There are many benefits of distributed renewable energy. Electricity generated from renewable sources produce far fewer greenhouse gas emissions than electricity generated from coal or natural gas power plants. Distributed generation effectively offsets grid electricity demand, thereby alleviating the necessity of building new power plants. Some also argue that a distributed generation provides enhanced system reliability; if there are many small systems generating electricity, the grid is not impacted as severely if one or more large power plants go off-line.

## 2.6 Environmental Impacts

The proposed code change does not have any potential adverse environmental impacts. Water consumption would not increase and there is no impact on water quality. There are no environmental or energy impacts associated with material extraction, manufacture, packaging, shipping to the job site, installation at the job site, or other activities associated with implementing the measure.

## 2.7 Technology Measures

While the measure does aim to enable more PV and SWH installations, the proposed code change does not require the installation of any particular technology or equipment. If a building owner decides to install solar equipment at a future date, they may choose to install any equipment that is available at the time.

## 2.8 Performance Verification of the Proposed Measure

The solar-ready measure will not require performance verification or commissioning. No acceptance tests are recommended.

## 2.9 Cost Effectiveness

As mentioned, the proposed code change does not require equipment installation, so there are no equipment costs associated with the change. A building that is constructed to be solar-ready will remain solar-ready for the lifetime of the building, and there are no costs associated with maintaining the solar-readiness of the building. With no equipment costs and no maintenance costs, the only costs associated with the measure are design costs. Initially designers will need to familiarize themselves with the solar-ready requirement, but over time design will become streamlined and the costs of complying will be minimal. The CEC's Life Cycle Costing (LCC) Methodology does not include design costs in the costs of a measure, so for LCC purposes the measure has no costs. Since the proposed code will enable energy savings and there are no LCC costs, the proposed change is cost-effective.

Installing PV or SWH systems on solar ready buildings (as defined in the recommended code language) could reduce the installed cost of the system by up to 10 percent (C&S Stakeholder Process; Solar Stakeholder Meeting II Follow-up Jan. 11, 2011). Cost savings are realized on buildings where solar equipment is installed voluntarily and the equipment is installed as a retrofit (i.e. the system was not installed as part of the original building construction). The savings will result when equipment is easily interconnected to the buildings electrical or plumbing system.

Both cost savings from equipment installation and energy cost savings apply only when PV or SWH systems are installed voluntarily. None of the cost savings were included in the cost effectiveness calculations because not all buildings will install systems so savings are not universal across the entire building stock.

## *2.10 Analysis Tools*

The proposed measure would be a mandatory requirement that does not include performance trade-offs, so changes to the performance modeling software are not required. However, a compliance method that uses a modeling tool is proposed. The code would require the use of a CEC-approved tool and adherence to CEC guidelines.

## *2.11 Relationship to Other Measures*

This CASE proposes PV and SWH "solar ready" requirements for nonresidential buildings. This CASE is related to three other solar PV and solar water heating measures. The multifamily SWH CASE proposes solar water heating and solar ready requirements for *multifamily* homes. The cross-cutting SWH CASE proposes to increase the existing solar fraction requirement for single family residential buildings with electric water heating, and to add a new solar fraction requirement for restaurants with both electric and natural gas water heating above a certain square footage. The Solar Oriented Development and Solar-ready Homes CASE proposes solar ready requirements for PV and SWH for *single-family* residential buildings and proposes requirements for building orientation. These CASEs were developed collaboratively, with each CASE addressing distinct areas of the code.

The proposed solar-ready requirement would not supersede the cool roofing requirements or the skylight requirements. All buildings would need to comply with cool roofing, daylighting and solar-ready requirements.

# 3. Methodology

## *3.1 Existing Conditions*

### 3.1.1 Buildings Suitable for Solar Installations

Surveys of the existing building stock indicate that less than 30 percent of existing nonresidential buildings are suitable for PV or SWH installations (Harvey 2010). Common features that make buildings unsuitable include:

- Shading both from external sources, such as neighboring buildings, or self-shading (e.g. from HVAC equipment or a taller part of the building);
- Roof obstructions like mechanical equipment, pipes, vents, ducting, antennas, satellite dishes, or weather monitoring equipment;
- Unfavorable roof shape such as domed roofs;
- Unfavorable roof orientation or slope; and
- Insufficient structural integrity to accommodate solar equipment.

Figure 1 shows a building with self-shading and roof obstructions. The tallest portion of the building, which is located on the southern edge of the building site, shades the rest of the site. If the tallest portion of the building were located on the northernmost edge of the site, the remaining area would be un-shaded. If shading were not an issue on this building, it still would not be feasible to place collectors on the roof that is covered with ducting. Even when buildings have an area that is un-shaded and unobstructed and suitable for solar, the area is often not as large as it could have been if the building was designed to optimize solar potential (see Figure 2).

**Roof obstructions.** This section of roof is covered with ducts leaving no space on the roof for solar equipment.

**Self-shading.** The tallest part of the building is situated on the southern edge of the site. As a result, the entire site, including the parking lot, is shaded.

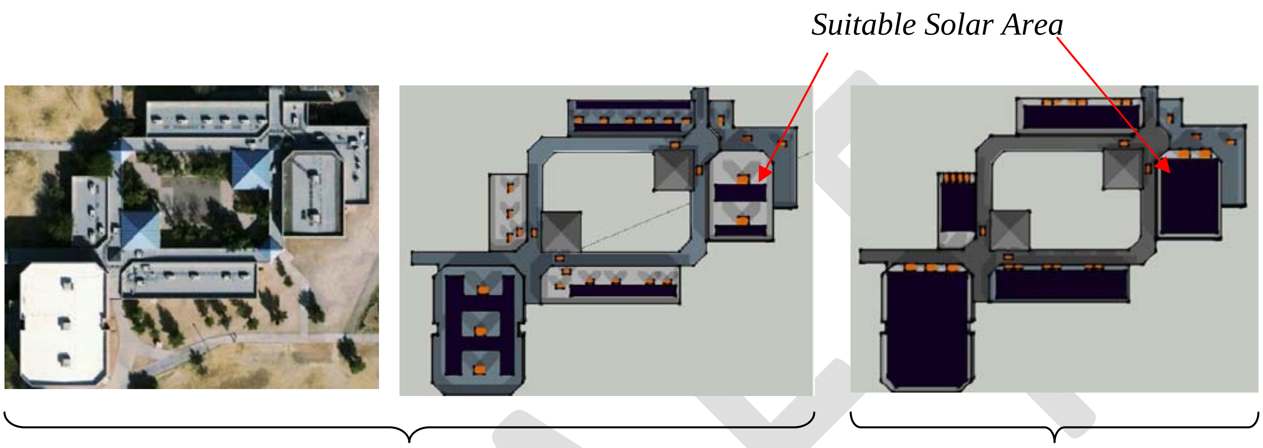
**Figure 1. Example of Building that is Not Suitable for PV or SWH**

Many existing buildings are unsuitable because they lack ample structural integrity to accommodate PV or SWH equipment. This is especially true of older buildings that were constructed before California had stringent structural and seismic building requirements took effect. Structural retrofits are possible, but they are oftentimes costly. After factoring in the cost of the required structural retrofits into the project cost, the project becomes prohibitively expensive.

As structural requirements have become more stringent, buildings have become better suited for solar installations. Researchers have found that, in general, inadequate structural integrity is not a limiting factor for installing solar systems in buildings constructed after the 2007 California Building Standards took effect (Binkley). The 2007 code requires most nonresidential buildings to accommodate a uniform live load of 20 psf and a concentrated load of 300 psf (Part 2, Section 1607A.11), which is strong enough to hold typically 4 - 8 psf crystalline or thin-film PV system or lightweight SWH systems with some remaining strength to account for wind or snow loading. During the second public stakeholder meeting held on November 2, 2010, industry stakeholders confirmed that California's current structural requirements for nonresidential buildings are sufficient to accommodate PV systems. Some jurisdictions have adopted supplemental structural requirements to account for snow loading or excessive wind loads caused by relatively high local wind speeds.

### 3.1.2 Current Solar Ready Design Practices

Figure 2 shows a rooftop designed using current standard design practices and a rooftop where the solar area has been maximized. The standard practice is to locate rooftop equipment in the center of the roof and to install screens or tall parapits to hide equipment. This is not ideal for solar because the shadows from equipment and screens make the areas to the east, west, and north of the obstruction unsuitable. An alternative design, which maximizes the space suitable for PV, is to install rooftop equipment on the north side of the roof. By pulling equipment away from the parameter of the building, equipment becomes less visible from the ground level eliminating the need for tall parapits and/or screens.




**Standard Design Practice.** Rooftop equipment in the center of roof and parapits are high. Limited un-shaded and unobstructed space available for solar.

**Optimized Solar Design.** Rooftop equipment on north side of roof. Significantly more un-shaded and unobstructed space available for solar.

**Figure 2. Standard and Optimized Rooftop Design**

Source: Harvey

### 3.1.3 Current Market Penetration of Solar

Currently, only a small percentage of suitable buildings actually install PV systems. California Solar Initiative (CSI) data indicates that the market penetration of PV installations on newly constructed buildings is low. Between 2007 and 2010, fewer than fifty PV systems were installed on newly constructed nonresidential buildings per year (see Figure 3). CSI program administrators have indicated CSI data may not accurately represent the number of systems that are installed on newly constructed buildings; some systems that are labeled as retrofit installations were installed within months of completing construction. From a practical perspective, installations that occur within the first months of building occupancy should be considered new construction as opposed to retrofits. While this is a valuable insight into discrepancies in the data, even if it is assumed that *all* PV systems installed on nonresidential buildings were installed on newly constructed buildings as opposed to retrofits (a very conservative estimate), still fewer than 5 percent of newly constructed buildings are currently installing PV systems. This is a low overall market penetration rate of PV installations, especially considering California's impending zero-net energy goals. The market penetration of on-site renewable electricity generation needs to increase rapidly if all newly constructed nonresidential buildings in California are going to be zero-net energy by 2030.

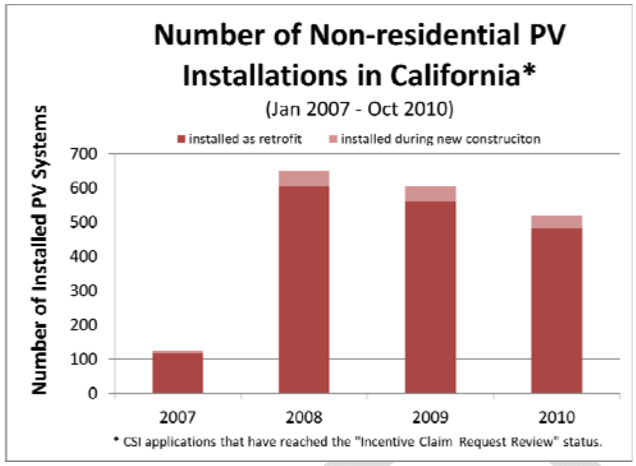



**Figure 3. Number of Installed PV Systems on Nonresidential Buildings, 2007-2010**

Source: CSI 2010

As shown in Figure 4, the capacity of installed PV systems varies significantly. The smallest systems are under 1kW and the largest systems are larger than 1 MW.[1] It is not possible to determine whether the PV systems are typically offsetting 1 percent of the electricity demand or 100 percent of the electricity demand, however CSI data indicates that some customers are installing relatively large systems that are likely offsetting most or all of their electricity demand.

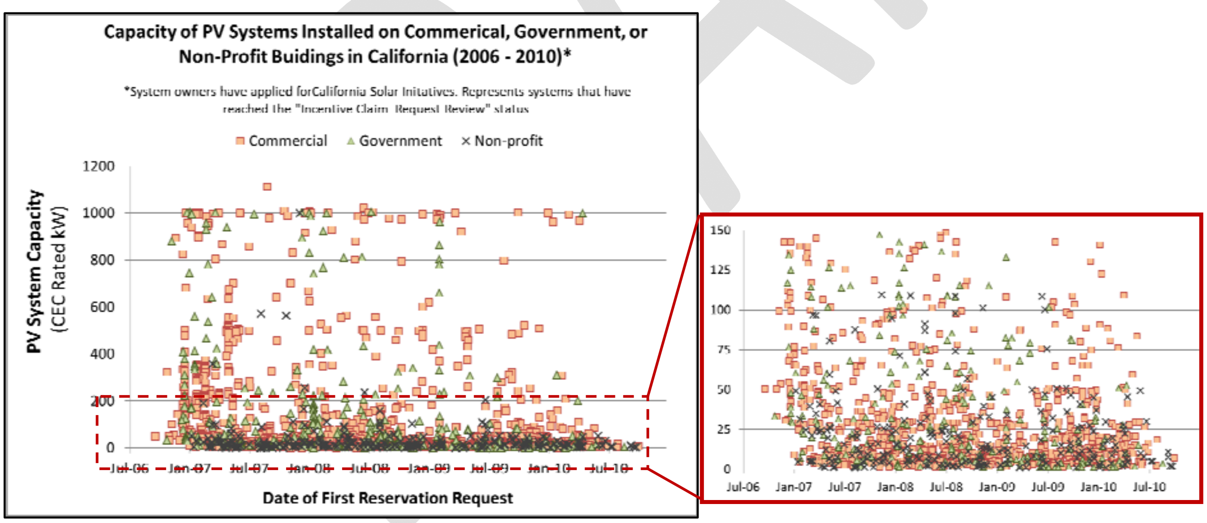



**Figure 4. Capacity of PV Systems Installed in California (2007 - 2010)**

Source: CSI 2010

[1] CSI does not provide incentives for systems over 3 MW, and it only provides rebates for up to 1MW of a system. There are other incentive programs available for larger system sizes, so in general the CSI database does not capture data on systems larger than 1 MW in capacity

### 3.1.4 PV and SWH Market Trends

The current cost of PV or SWH systems does not have a direct impact on the cost of the solar-ready measure because the code would not require systems to be installed, but system costs will have an impact on the number systems that are installed at some point during the life of the building. As shown in Figure 5, the installed cost of solar PV has decreased steadily over the past decade. With rapid technology advances, it is practical that costs could fall to $2/Watt within the decade (McKinsey). As the cost of solar falls and the cost of grid electricity increases, building owners are going have a growing incentive to install solar systems.

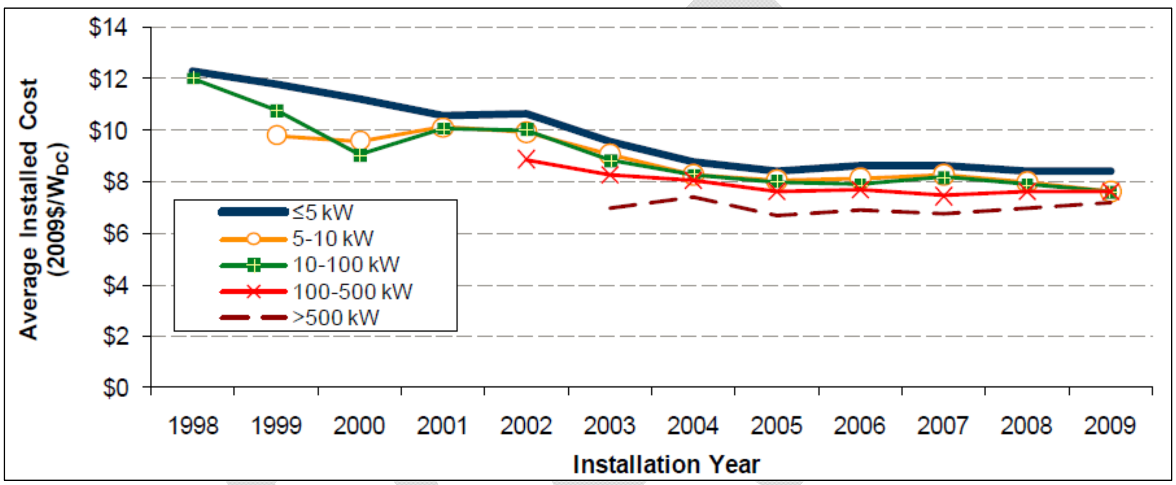



**Figure 5. Installed Cost Trends of PV Systems of Various Sizes (1998 - 2009)**

Source: Barbose, Darghouth & Wiser. 2010.

## *3.2 Proposed Code Change*

### 3.2.1 Summary of Proposed Change

By addressing the common limitations that render solar infeasible or excessively costly, the proposed code change would enabling a larger number of solar installations in the future. The code change will ensure that buildings that have access to solar resource are able to accommodate PV or SWH systems. It would also encourage building designers to provide a larger un-shaded and unobstructed area thereby enabling the installation of larger PV and/or SWH systems. As discussed in the previous section, key factors that make buildings unsuitable for solar include external shading, shading by features of the building project itself, obstructions like pipes and ducts, and inadequate structural integrity. Requiring designers to consider how PV or SWH systems would be integrated into the building will help eliminate some of the common constraints. Incorporating solar readiness as a primary design consideration may also will encourage building owners to consider the option of installing PV or SWH systems more seriously.

The proposed code would apply to newly constructed low-rise nonresidential buildings. It would also apply to major retrofits to low-rise nonresidential buildings if the planned retrofit would increase the total roof area by more than 20 percent. Buildings would be required to have an allocated solar zone on the roof or elsewhere on the building site. The solar zone would be sized according to the code requirements. The zone also needs to be un-shaded by objects on the building site (e.g. HVAC equipment, trees, other sections of the building), and free of obstructions (e.g. pipes, vents). The code would require designers to plan for the interconnection of the PV or SWH system to the buildings electrical or plumbing system. The interconnection point to the building electrical or plumbing system would need to be identified as would space for key equipment such as inverters, metering equipment, and storage tanks. Pathways for running conduit or piping to connect the system components would also be need to be established during the building design phase. To address structural integrity issues, the proposed code would require that the as-designed maximum dead load and live load for the solar zone be clearly labeled on the record drawings, and Title 24 compliance forms. Each of the components of the proposed solar-ready code is discussed in more detail in the following sections.

### 3.2.2 Allocated Solar Zone

The CASE Team took a number of factors into consideration when defining the requirements for the allocated solar zone. The various factors are discussed below. The methodology used to calculate the area of the solar zone is described in the section 3.2.6.

**Desired System Capacity**: The solar zone needs to be large enough to accommodate a system that could offset a reasonable portion of the building's electricity or hot water demand. Initially, the Team based the target capacity on the existing voluntary reach code requirement (Title 24, Part 11, section A5.211) that calls for buildings to generate 1 percent of electricity demand from a renewable source. After calculating the area of the solar zone such that it could provide 1 percent of the building’s demand, stakeholders provided feedback that the solar zone was too small and would not result in changes to current design practices. Taking this feedback into account, the target system capacity was increased to 20 percent of the expected electricity demand.

Low energy density buildings like warehouses have enough space to generate much more than 20 percent of expected demand. These types of buildings will be required to have a larger solar zone, in order to maximize the space available for future solar installations.[2] The code requires the solar zone to be the larger of either: a) 50 percent of the roof area (net of the area skylights), or b) an area large enough to accommodate a PV system capable of generating 20 percent of the electricity demand (as discussed in section 3.2.6, there are two methods for calculating the area described in option b).

**Available Space:** Not all buildings have enough roof space (or space on the building site) to accommodate a system large enough to offset a meaningful amount of demand. High energy density buildings, such as restaurants, refrigerated warehouses, and grocery stores may not be able to provide

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[2] Maximizing the space available for future installations could mean a system covering the entire solar zone area could generate more than 100 percent of the building’s electricity or hot water demand. There is little reason to install SWH systems that produce more hot water than there is on-site demand, but if a PV system generates more electricity than there is on-site demand, the remaining electricity generated can offset demand from another building.

enough space on the building site to accommodate a system capable generating 20 percent of building's electrical demand. In high-rise buildings, which are particularly space constrained, even if 50 percent of the roof area were available for PV, the amount of electricity the system could generate would not make a dent in offsetting the building's annual consumption. High-rise buildings tend to be in high density areas where the building occupies much of the total building site so the rooftop is the only feasible location on the building site to install solar collectors. In part because of constraints about available roof space, the proposed code change excludes high-rise buildings. High-rise buildings tend to encounter more shading constraints than low-rise buildings, which also contributed to the decision to exclude high-rise building from the code requirement.[3]

There may also be instances among low rise buildings where a solar zone sized to provide 20 percent of the electricity demand would be unrealistic, and might be larger than 100 percent of the roof space, or might not allow for other essential roof top equipment. To guard against this scenario, the proposed requirement will have a cap such that the solar zone is never required to exceed 75 percent of the total roof area (net of the area covered by skylights).

**Shading:** Shading of solar modules and arrays can cause disproportional reductions in power output: in extreme cases, 10 percent shading can reduce power output by as much as 90 percent. As mentioned, typical shading constraints include rooftop equipment, trees, and sections of the building shading the lower roofs. To address shading constraints, the code requires that the solar zone be set back two times the height of any obstruction to the south, east or west of the zone. Using Solar Pathfinder or a similar tool to determine the shading constraints was not recommended because the tools are better suited for evaluating the shading on existing buildings. Using the rule-of-thumb 2:1 ratio will simplify the design process.

**Contiguous Area:** It is more favorable to have a solar array cover a contiguous area as opposed to many smaller discontinuous areas. The code language specifies that the solar zone can be comprised of up to five smaller sub-areas. However, no area can be smaller than 250SF unless the total required solar zone area is less than 250SF. In order to count towards the building's total solar zone requirement, all individual solar zone areas have to be at least 5 feet wide in the narrowest dimension so that solar modules can easily fit within the zone.

**Architectural Leeway:** The solar-ready requirement is not intended to limit the flexibility designers have to use architectural footprints that enhance natural ventilation, windows, and daylighting. Nor does it intend to preclude architectural elements such as sloped roofs or domed roofs. To help assure that buildings with unique architectural features can comply with the solar-ready requirements, designers would have the option of using a CEC-approved PV modeling software to design a PV system that is capable of generating 20 percent of the expected electricity use. If designers decide to use the design approach, they have the option of modeling more complex PV systems that may

[3] ASHRAE has received feedback that due to space constraints it is challenging or impossible for high-rise buildings to adhere to the renewable-energy-ready measure in ASHRAE 189. Stakeholders have also provided feedback that rooftops in dense urban areas are often shaded by neighboring buildings, so solar resource is very limited.

incorporate less common products such as PV glazings and laminates or less traditional array orientations or tilts. As long as the PV system modeled according to CEC guidelines is shown to be capable of generating the minimum amount of electricity, the solar zone requirement would be fulfilled.

**Fire Marshal Guidelines:** Fire safety was an important consideration when developing the code change proposal. The solar industry has been presented with the challenge of designing systems that are compatible with current fire suppression techniques and that provide enough space on the roof for fire fighters to move around the roof safely. The 2012 International Fire Code (IFC) includes a new solar PV provision (section 605.11), which will be used as the basis for a solar PV provision in the 2013 revision of the California Fire Code (Title 24, Part 9).[4] At the time of writing, the 2013 revisions to the California Fire Code had not been adopted, so the CASE Team used the IFC provision and the California Office of the State Fire Marshal guidelines to inform decisions about the impact of future fire codes on the amount of space that would be available for solar equipment (CDFFP 2008). Key considerations include setting the solar zone back from the edges of the roof, from ventilation hatches and from skylights.

**Skylighting:** The preferred strategy for achieving zero-net energy buildings is to first conserve energy, then to use energy efficiently and finally use renewable energy sources to meet the buildings energy demand. Skylighting helps achieve energy conservation objectives, and it is important that the solar-ready requirement does not encourage designers to sacrifice installing skylights, and the immediate energy savings they will enable, in order to provide space for future solar panels. To avoid incorporating a disincentive for installing skylights, the compliance options calls for that the solar zone to cover 50 percent of the roof area net of area covered by skylights. Designers can install as many skylights as desired and no more than 75 percent of the *remaining* roof space would need to be allocated to the solar zone.

**Mixed Occupancy:** The calculated method for determining the size of the solar zone depends on the building end use (e.g. office, retail, etc.). If one end-use constitutes at least 80 percent of the floorspace, the solar zone multiplier for the predominant end-use should be used in calculations. Otherwise, the mixed use multiplier should be used. The calculation methods for determining the multipliers are discussed in section 3.2.6.

### 3.2.3 Allocated Space for System Equipment

The proposed code change requires designers to allocate a space for key system components such as inverters, metering equipment and storage tanks. The amount of space the equipment requires will depend on the building size and the building end use. The compliance manual could provide additional guidance on how to size equipment appropriately.

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4 Section 605.11 of the 2012 International Fire Code provision was based on guidelines the California Office of the State Fire Marshal published in 2008 (CDFFP 2008).

### 3.2.4 Pathway for Wiring or Piping

The CASE Team considered requiring buildings to be pre-wired or pre-plumbed, which would allow solar equipment to be connected to the building electrical or plumbing system easily. However, after stakeholders expressed concerns about this option, this option was taken off the table. One concern stakeholders had was that to pre-plumb or pre-wire a building, the designers would need to decide on the capacity of the system that would be installed. If the system that is installed at a future date is a different capacity than was originally planned, the wiring or plumbing may not be appropriately sized and new wires or pipes would need to be reinstalled. In this case, the code change could result in an increased installed system cost, which is counterproductive.

Another concern stakeholders expressed is the company that installs the solar equipment bares the liability of ensuring the entire system functions properly. They may not feel comfortable using wiring or piping they did not design and install. Finally, every building owner would incur the cost of pre-wiring or pre-piping the building, but only a portion of building owners who voluntarily install systems would benefit from the potential cost savings of easily connecting equipment to the building electrical or plumbing system. The discrepancy in the number of people that would incur the cost of pre-wiring or pre-plumbing and the number of people who would benefit from the cost savings is large enough that a pre-wiring requirement would not be a cost effective.

The proposed code change language specifies that designers have to identify the path that conduit or piping would follow if a solar system were installed. Wiring or piping would need to take the most direct route from the solar zone to the inverter and from the inverter to the electrical interconnection or from the solar zone to the storage tanks and plumping interconnection. Requiring designers to establish the direct path for wiring or piping encourages the building designer to consider the practical implications of designing a building that is well suited for solar generation. For example, the designer may locate the solar zone directly above the electrical room, which would minimize the length of DC wiring required and would thus result in a simplified and lower cost PV system. Stakeholders indicated that installing a system on a building with direct pathways for wiring and piping could reduce the installed cost of a PV system by as much as 10 percent.

### 3.2.5 Disclosure of Structural Specifications

To address structural integrity issues, the proposed code would require that the as-designed maximum dead load and live load for the solar zone be clearly labeled on the record drawings, and Title 24 compliance forms. One challenge PV and SWH companies face is that the roof's structural capacity is not always known, and it is challenging to get a structural engineer to sign off on the structural condition if they were not involved in the initial design process or if they do not know how the building was modified after construction was complete. Requiring structural engineers to provide the maximum as-designed load for the solar zone will enhance communication about the future solar system amongst the design team and may encourage designers to add structural capacity on the solar zone.

### 3.2.6 Methodology for Calculating Area of Solar Zone

The Team deliberated whether a design method or a calculated method for determining the area of the solar zone would be favorable. Each approach has its benefits and drawbacks and both approaches will lead to the same end result: space available for future solar. The proposed language would allow designers to choose to use either the design method or the calculated method.

For the design method, the code would specify the percentage of the building's expected electricity or hot water demand that would need to be supplied by the future system. The designer would then design the system and provide documentation to show the solar zone was appropriately sized. The design method would require a more comprehensive design effort than the calculated method, but it allows more aesthetics freedom. It would also allow the system to be specifically modeled for the building and will also yield more accurate energy savings estimates.

For the calculated method, the code would specify the size of the solar zone based on the total square footage of the building and the building type. The solar zone multipliers are set so the solar zone will be capable of generating about 20 percent of the building's total electricity demand. The calculated method would likely be more restrictive than the design method but the design effort would not be as involved.

***Design Method***

The design method would require building designers to use a CEC-approved modeling software and follow CEC guidelines to demonstrate that a PV system installed in the allocated solar zone would be capable of generating the minimum amount of electricity. The modeling software and the modeling guidelines would be established after the code is adopted.

***Calculated Method: Solar Zone Multipliers***

The objective of the calculated method is to provide a straight-forward calculation that designers can use to determine the size of the solar zone. As mentioned above, the multipliers are set so the solar zone will be large enough to accommodate a PV system that is capable of generating about 20 percent of the total estimated electricity demand. The multipliers provide a reasonable estimate of the area needed to generate 20 percent of demand, but due to variation in building design and expected electricity demand in each building, the multipliers cannot provide an accurate area requirement for every building in California. The exact area requirement depends on a number of factors including the climate and available solar resource, both of which vary significantly throughout the state. The area the system will occupy also depends on system efficiency, which in turn depends on the type, orientation, and tilt of PV modules, inverter efficiency, length of wiring, and other external factors like temperature and dust factor. If a designer wants a more accurate estimation of the area required to accommodate a PV system, they can use the design method and develop a custom PV system for the building.

To determine the solar zone multipliers, the CASE Team relied on California Commercial Energy-use Survey (CEUS) data to determine the statewide average energy intensity per square foot (kWh/SF floorspace). As shown in Table 1, there are different energy intensity values for various building types. CEUS data was collected in 2002 and is based on electricity use in existing buildings. Newly constructed buildings in 2014 or later will likely consume less energy than the existing building stock in 2002. The implication is the solar zone may be oversized and the zones might be able to generate more than 20 percent of the building load.

**Table 1. Statewide Average Electricity Use and Target Electricity Generation from PV System**

| Building Type | Statewide Average Energy Intensity (kWh/SF floorspace)* | Target Electricity Generation from PV System (kWh/ SF floorspace) |
|---|---|---|
| Small Office | 13.10 | 2.62 |
| Large Office | 17.70 | 3.54 |
| Restaurant | 40.20 | 8.04 |
| Retail | 14.06 | 2.81 |
| Grocery | 40.99 | 8.20 |
| Warehouse | 4.45 | 0.89 |
| Refrigerated Warehouse | 20.02 | 4.00 |
| School | 7.46 | 1.49 |
| Colleges | 12.26 | 2.45 |
| Lodging | 12.13 | 2.43 |
| Other | 9.84 | 1.97 |

* Source: CEC 2006, CEUS Data



After determining the energy intensity of each building the target electricity generation was established by multiplied by annual energy intensity by 20 percent (kWh/SF floorspace). Next Team calculated a statewide average PV system efficiency value. Two representative systems, a high efficiency and a low efficiency system, were selected. For each system, the Team modeled the annual electricity generation per kW (kWh/kW) in all 16 climate zones. Using data from the nonresidential construction forecast, the forecast used in all cost effectiveness calculations for code changes proposed for the 2013 code cycle,[5] the Team weighted the high and low kWh/kW values by the percentage of new nonresidential construction forecasted for each climate zone the year the code would take effect (2014). The result is two statewide values kWh/kW values weighted by the forecasted building SF constructed in each climate zone in 2014. Table 2 presents the findings from modeling representative systems.

To be conservative about the size of the solar zone, the Team used the weighted average system efficiency for the lower efficiency system (1,587 kWh/kW) to estimate the capacity (kW) of the systems required to generate the target electricity generation goal. Finally, the industry rule-of-thumb

[5] Nonresidential construction forecast data is provided by the Demand Forecast office at the California Energy Commission. Moshen Abrishami compiled total construction floor space (in $ft^2$) for 1964 – 2020 in the following nonresidential space types: off-small (offices less than 30,000 $ft^2$), off-large (offices larger than 30,000 $ft^2$), restaurants, retail, food service, non-refrigerated warehouse, refrigerated warehouse, schools (K-12), colleges, hospitals, hotel and lodging, and miscellaneous. In addition, the CEC provides estimates in each space type category for additional floor space each year, indicating the total new construction added annually. The data was provided to the CASE Team on August 23, 2010.

sizing factor of 100 kW/SF was used to arrive at the solar zone multiplier in units of square feet of solar zone per total building floorspace (SF solar zone /SF floorspace) (see Table 3). The calculation method is summarized in Equation 1. The mixed use multiplier is the average of the small office, large office, retail, restaurant, and other multipliers weighted by the 2014 forecasted floorspace of each end use. The forecasted floorspace is presented in Table 4.

$$\underset{\text{(SF solar zone / SF total building)}}{\textbf{Solar Zone Multiplier}} = \underset{\text{(kWh/SF)}}{\textbf{Statewide Avg. Energy Intensity}} \times \underset{\text{20\%}}{\textbf{Target kWh Generation}} \times \underset{\text{(1,587 kW/ kWh)}}{\textbf{Avg. PV System Efficiency}} \times \underset{\text{(SF solar zone/ kW)}}{\textbf{Typical PV Area}} \quad \text{[Equ. 1]}$$

**Table 2. Representative PV System Annual Electricity Generation per kW: 16 Climate Zones**

| Building Type | Representative Systems: Electricity Generation per kW Capacity (kWh/kW) | | Percent of Nonresidential Buildings Forecasted for Construction in 2014 |
|---|---|---|---|
| | Low Result | High Result | |
| Climate Zone 1 | 1,220 | 1,475 | 0.2% |
| Climate Zone 2 | 1,420 | 1,660 | 2.2% |
| Climate Zone 3 | 1,515 | 1,885 | 8.7% |
| Climate Zone 4 | 1,560 | 1,920 | 5.5% |
| Climate Zone 5 | 1,570 | 1,965 | 1.1% |
| Climate Zone 6 | 1,590 | 1,980 | 8.2% |
| Climate Zone 7 | 1,545 | 1,940 | 10.7% |
| Climate Zone 8 | 1,565 | 1,965 | 9.9% |
| Climate Zone 9 | 1,570 | 1,870 | 19.7% |
| Climate Zone 10 | 1,560 | 1,880 | 5.7% |
| Climate Zone 11 | 1,595 | 1,905 | 2.9% |
| Climate Zone 12 | 1,670 | 1,975 | 15.0% |
| Climate Zone 13 | 1,705 | 2,000 | 6.8% |
| Climate Zone 14 | 1,790 | 2,140 | 1.3% |
| Climate Zone 15 | 1,755 | 2,085 | 0.5% |
| Climate Zone 16 | 1,560 | 1,860 | 1.6% |
| **Statewide Weighted Average** | **1,587** | **1,926** | --- |

**Table 3. Target System Capacity (kW/1000 SF floorspace) and Solar Zone Multipliers**

| Building Type | Target System Capacity (kW/ 1000 SF floorspace) | Solar Zone Multiplier (SF Solar Zone / SF floorspace) |
|---|---|---|
| Small Office | 1.65 | 0.165 |
| Large Office | 2.23 | 0.225 |
| Restaurant | 5.07 | 0.507 |
| Retail | 1.77 | 0.177 |
| Grocery | 5.17 | 0.517 |
| Warehouse | 0.56 | 0.056 |
| Refrigerated Warehouse | 2.52 | 0.252 |
| School | 0.94 | 0.094 |
| Colleges | 1.55 | 0.155 |
| Lodging | 1.53 | 0.153 |
| Other | 1.24 | 0.124 |
| Mixed Use | | 0.187 |

### 3.2.7 Interaction with Existing Code Language

The solar-ready requirement would not supersede or be superseded by the cool roofing requirements or the skylight requirements. All buildings would need to comply with cool roofing, daylighting and solar-ready requirements.

## *3.3 Energy Savings Methodology*

The primary goal of the solar-ready measure is to enable PV and SWH systems to be installed at a future date. The code would not require PV or SWH systems to be installed, so energy savings from this measure are attributed to systems that are voluntarily installed at some point in the life of the building. The energy benefits presented in Section 4 of this report provide a reference point for the savings that could be achieved if solar PV systems of the recommended size were actually installed. PV or SWH systems effectively offset demand for electricity at the building site. For the energy savings estimates, it is assumed that the electricity generated from a PV system is equivalent to site energy savings.

To determine the maximum potential first year energy savings, the CASE Team used California Commercial End Use Survey (CEUS) data to determine the average energy intensities (kWh/SF) of various building types. Energy intensities are presented in Table 1. Energy intensities were multiplied by the forecasted low-rise nonresidential construction forecast to arrive at the expected energy use for all new non-residential buildings constructed in 2014, the year the code would take effect. The CASE Team used the data from the Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS) to estimate the portion of non-residential buildings constructed in 2014 that would be three stories or fewer. CBECS data shows that 98% of the commercial buildings in the western region have fewer than stories, but since high-rise buildings have large floorspaces than low-rise buildings, only 79% of the total floorspace is found in low-rise buildings (EIA 2006). By using CBECS data, the analysis assumes the distribution of low-rise and high-rise buildings in

California is the same as the nation-wide distribution. The construction forecast is presented in Table 4.

**Table 4. Forecasted Low-rise Nonresidential Construction in 2014**

| **Building Type** | **Forecasted New Nonresidential Construction in 2014** [a] (million SF) | **Percent Low Rise SF** [b] | **Forecasted New LOWRISE Nonresidential Construction in 2014** (million SF) |
|---|---|---|---|
| Small Office | 9.1 | 54% | 4.9 |
| Large Office | 27.7 | 54% | 14.8 |
| Restaurant | 5.1 | 90% | 4.6 |
| Retail | 32.4 | 95% | 30.7 |
| Grocery | 8.5 | 98% | 8.3 |
| Warehouse | 32.1 | 92% | 29.7 |
| Refrigerated Warehouse | 1.8 | 92% | 1.6 |
| School | 10.0 | 84% | 8.3 |
| Colleges | 7.4 | 84% | 6.2 |
| Lodging | 9.1 | 43% | 4.0 |
| Other | 31.6 | 79% | 25.1 |
| **TOTAL** | **174.7** | | **138.2** |

a) Source: Nonresidential construction forecast data provided by the Demand Forecast office at the California Energy Commission for use in 2013 code change cycle.

b) Source: EIA 2006 (CBECS). Table B10. Number of Floors, Number of Buildings and Floorspace for Non-Mall Buildings

Since the solar-ready code language was developed such that if a PV system that covered the entire solar zone would be capable of generating 20 percent of the expected electricity demand, if all new buildings installed a PV system of the recommended size, the systems would offset 20 percent of the estimated electricity demand from all low-rise nonresidential building constructed in 2014.

The maximum potential lifetime savings were calculated by multiplying the first year saving by the 20 year system life. This calculation does not account for the fact that systems will degrade and generate less electricity over time. With the installed cost of PV expected to drop and uncertainty about whether state and federal incentives for solar will remain over time, it is difficult to predict how many buildings will install PV systems at some point during the building life. The margin of error in predicting the percentage of buildings that will install systems far outweighs other assumptions used in the analysis, including the degradation of the PV system resulting in reduced electricity generation over time.

Since it is difficult to predict the percentage of buildings that will install solar at some point, the analysis section of this report (section 4.1) provides a range of savings assuming between 1 and 100 percent of buildings install the appropriately sized PV system.

## 3.4 Cost Savings Methodology

Cost savings associated with the code change are realized on buildings where solar equipment is installed voluntarily and the equipment is installed as a retrofit (i.e. the system was not installed as part of the original building construction). There are no cost savings expected when systems are installed during initial construction because it is assumed that if designers know the PV or SWH system is going to be installed before or shortly after the building is first occupied, the designers will have already planned for easy (and inexpensive) installation. Cost savings from retrofits will result when PV or SWH equipment is easily interconnected with the building electrical or plumbing systems. Installing PV or SWH systems on solar ready buildings (as defined in the recommended code language) could reduce the installed cost of the system by as much as 10 percent (C&S Stakeholder Process, January 11, 2011). Energy cost savings will result when PV or SWH equipment is installed. Energy cost savings are presented in Table 5.

Both cost savings from equipment installation and energy cost savings apply only when PV or SWH systems are installed voluntarily. None of the cost savings were included in the cost effectiveness calculations because not all buildings will install systems so savings are not universal across the entire building stock.

## 3.5 Cost Effectiveness Methodology

The proposed code change does not require equipment installation nor does it have any incremental maintenance costs. The only costs associated with the measure are design costs. Initially designers will need to familiarize themselves with the solar-ready requirement, but over time design will become streamlined and the costs will be minimal. The LCC Methodology does not include design costs in the costs of a measure, so for LCC purposes the measure has no costs.

# 4. Analysis and Results

## *4.1 Energy Savings*

Table 5 presents the maximum potential savings if all nonresidential low-rise buildings constructed in 2014 install PV systems that are capable of generating 20 percent of the building's expected demand. Demand savings would be about 248 MW and annual electricity savings would be approximately 383 GWh. Throughout the 20-year equipment lifetime, PV systems installed on 2014 vintage buildings would save on the order of 7,870 GWh.

**Table 5. Electricity Savings and Demand Reduction if All New Nonresidential Buildings Built in 2014 Install PV System of Recommended Size during Initial Construction**

| **Building Occupancy** | **All New Buildings Install PV System of Recommended Size** | | |
|---|---|---|---|
| | **Annual Electricity Savings** (MWh) | **Lifetime Electricity Savings*** (GWh) | **Demand Reduction** (MW) |
| Small Offices | 12,755 | 255 | 8.0 |
| Large Offices | 52,513 | 1,050 | 33.1 |
| Restaurants | 36,851 | 737 | 23.2 |
| Retail | 86,427 | 1,729 | 54.5 |
| Food | 68,035 | 1,361 | 42.9 |
| Warehouse | 26,400 | 528 | 16.6 |
| Refrigerated Warehouse | 6,490 | 130 | 4.1 |
| School | 12,429 | 249 | 7.8 |
| College | 15,112 | 302 | 9.5 |
| Hotel | 15,503 | 310 | 9.8 |
| Other | 60,981 | 1,220 | 38.4 |
| **Total** | **383,496** | **7,870** | **248.0** |

* assumes 20-year lifetime

The actual savings resulting from the code change will be much lower than the values presented in Table 5. At least 10 percent of new buildings will likely still be unsuitable for PV due to external shading constraints including shading from nearby topography or permanent structures. Additionally, only some portion of new buildings that are suitable for PV will elect to install.

Table 6 presents a range of energy savings if only a portion of the buildings install PV systems. The lower end of the range represents the current market trends of ~1 percent of newly constructed buildings installing PV.[6]

[6] About 1 percent of newly constructed nonresidential buildings install PV systems, but the system capacity – as a percentage of total building electricity demand – is not known. In this case, the assumption is that buildings will install systems capable of offsetting 20 percent of demand.

**Table 6. Electricity Savings and Demand Reduction if Subset of Nonresidential Buildings Built l in 2014 Install PV System of Recommended Size during Initial Construction**

| Percentage of Buildings that Install PV Systems | Maximum Annual Electricity Savings (MWh) | Maximum PV Capacity Installed (MW) | 20-year Electicity Savings (GWh) | Annual Energy Cost Savings ($million/yr) assumes $0.12/kWh | 20-year Energy Cost Savings ($million) assumes $0.12/kWh |
|---|---|---|---|---|---|
| 1% | 3,935 | 2.5 | 79 | $0.47 | $9.44 |
| 5% | 19,675 | 12.4 | 393 | $2.36 | $47.22 |
| 10% | 39,350 | 24.8 | 787 | $4.72 | $94.44 |
| 25% | 98,374 | 62.0 | 1,967 | $11.80 | $236.10 |
| 40% | 157,398 | 99.2 | 3,148 | $18.89 | $377.76 |
| 50% | 196,748 | 124.0 | 3,935 | $23.61 | $472.20 |
| 100% | 393,496 | 248.0 | 7,870 | $47.22 | $944.39 |

Time Dependent Valuation (TDV) savings were not calculated because the code change would not lead to direct energy savings because, as mentioned previously, the code does not require PV or SWH installations. Assuming systems are installed, TDV benefits will vary based on system design. Many PV and SWH systems are optimized so the majority of electricity is generated in the afternoon when demand is the highest. Modules generate the most electricity or are most effective at heating water when they have the most direct access. Since western-facing aspects get direct sunlight in the afternoon, modules oriented towards the west or southwest are optimized to offset peak energy demand.

## *4.2 Cost Savings*

Industry stakeholders estimated the installed cost of PV or SWH, if installed as a retrofit, could be reduced by 10 percent if installed on a solar-ready building, as defined. The cost savings result from a more simple design process and a more straight forward installation, which reduces labor costs. For example, the pathway to rough wires from the solar zone to the electrical interconnect has already been designed in a solar-ready building. Instead of starting from square one, the system designer will only need to verify that the pre-designed pathway is suitable for the planned system. Provided the pathway has not been obstructed between the time of initial construction and the time the system is installed, there will be clear pathway to install conduit and run wires, which will minimize the cost of installing the wiring.

Figure 6 provides a breakdown of the installed costs of PV systems. Currently, about 50 percent of the installed cost is associated with the PV modules and 50 percent is associated with the balance-of-system (BOS). Module costs are projected to be cut in half, dropping below $1/watt in the coming years. The BOS costs (inverters, wiring, electrical installation, site prep, racking, structural installations, design and overhead) account for half of the installed cost of PV. Looking more closely at the BOS costs, the cost of wiring fluctuates with the market price of raw materials and industry dictates the cost of inverters and racking. The solar-ready measure will address the remaining BOS costs including the cost of the electrical installation, site prep, structural alterations, and the "Business Process" including design costs.

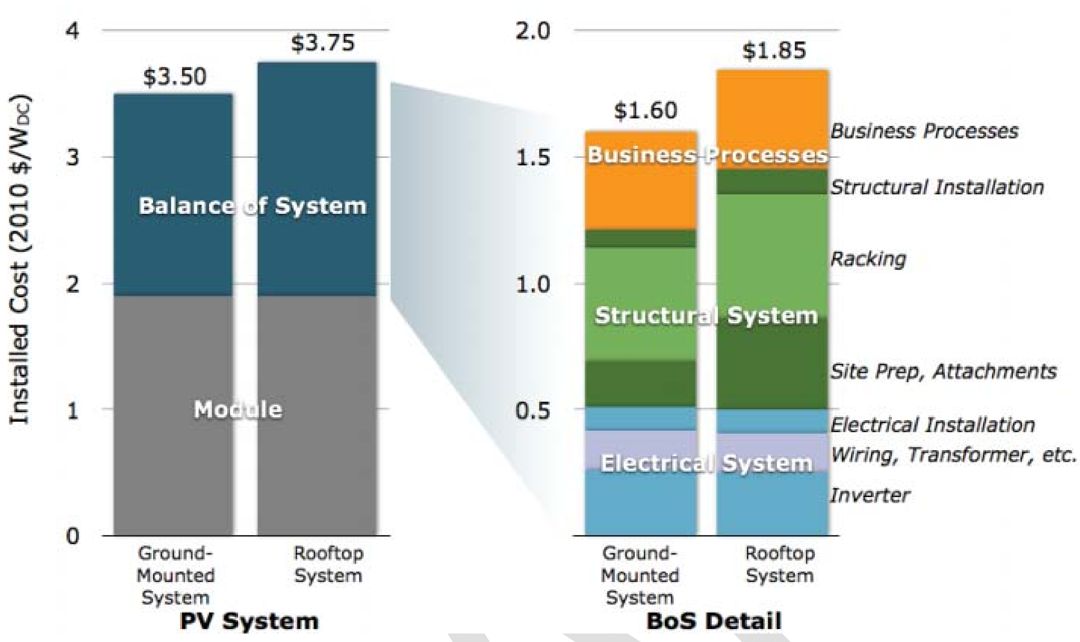


**Figure 6. Cost Breakdown of PV System (2010$/Wdc)**

Source: Boney et al. 2010

## *4.3 Cost Effectiveness*

The proposed code will result in energy savings and there are no LCC costs associated with it, so the proposed change is cost effective.

# 5. Proposed Code Change Language

## *5.1 Where Code Language Would Appear*

The language presented in this section is formatted in two ways: 1) for inclusion in Part 6 of Title 24, and 2) for inclusion in Part 11 of Title 24. The language is the same but the section numbers and formatting vary to accommodate the formats of the two documents. The section numbers in the code language presented in section 5.2 correspond to the sections in Part 11 of Title 24. If the language ends up in Part 6 of Title 24, the section headings and references to compliance form would be modified accordingly.

If the solar-ready measure is incorporated into Part 6 of Title 24, the proposed language would be a mandatory measure in Subsection 2: All Occupancies—Mandatory Requirements for the Manufacture, Construction, and Installation of Systems, Equipment and Building Components. Subsection 2 applies to all building types, so the language would clearly indicate the measure would only apply to nonresidential buildings. To implement the proposed measure as a mandatory measure in Part 6, the nonresidential Title 24 envelope compliance forms would also need to be modified. A section would be added to form ENV-1C: Certificate of Compliance and Field Inspection Energy Checklist. A new form, ENV-5C, will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

If the solar-ready measure is incorporated into Part 11 of Title 24, the proposed language would be added as a mandatory measure in Chapter 5 Division 5.2: Nonresidential Mandatory Measures - Energy Efficiency. Alternatively, the proposed language could be added into a new division to Chapter 5, Division 5.6: Nonresidential Mandatory Measures – Renewable Energy. To implement the proposed measure as a mandatory measure in Part 11, a new compliance form would need to be added. The form would likely be called EE-1: SOLAR READY or RE-1: SOLAR READY, depending on whether the proposed language would appear in the energy efficiency (EE) division or the renewable energy (RE) division. The new form will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

## *5.2 Draft Code Change Language*

**SECTION 5.202: DEFINITIONS**

**BUILDING SITE.** ***To come***

**SECTION 5.203: SOLAR READINESS**

**Low-rise nonresidential buildings with three stories or fewer shall provide for the future installation of on-site solar photovoltaic (PV) or solar water heating (SWH). Record drawings shall show allocated solar zone and the designs for interconnecting the PV or SWH system with the building electrical or plumbing system. Section 5.203 applies to major retrofits of low-rise nonresidential buildings that would increase the total roof area by more than 20 percent.**

> **EXCEPTION: If a PV system that covers 50 percent of the available space on the building site is not capable of generating at least 1 percent of electrical contribution to the estimated annual building energy budget, the building does not need to comply with section 5.203.**

**5.203.1 Allocated Solar Zone.**

**The building must have an allocated solar zone located on the roof of the building or elsewhere on the building site. The solar zone must be clearly marked on the record mechanical and electrical drawings and total area of the solar zone must be documented and on the EE-1 SOLAR READY compliance form.[7] The solar zone must comply with the following:**

1. **Minimum Area. The minimum area of the solar zone shall be the larger of (a) or (b)**
   - a. **Minimum area of solar zone = (total roof area in SF) – (area covered by skylights) x 50%**
   - b. **An area determined by one of the following methods:**
     - i. **Calculated Method. use equation (1) and the solar zone multipliers provided in Table 5.203.1 to calculate the area of the solar zone**

**Equation 1: area of solar zone = (total building SF) x (solar zone multiplier) (1)**

[7] If code change is added as a mandatory measure in Part 6, the nonresidential Title 24 envelope compliance forms would also need to be modified. A section would be added to form ENV-1C: Certificate of Compliance and Field Inspection Energy Checklist. A new form, ENV-5C, will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

**Table 5.203.1**

| Building Type | Solar Zone Multiplier (SF Solar Zone / Total Building SF) |
|---|---|
| Small Office | 0.165 |
| Large Office | 0.223 |
| Restaurant | 0.507 |
| Retail | 0.177 |
| Grocery | 0.517 |
| Warehouse | 0.056 |
| Refrigerated Warehouse | 0.252 |
| School | 0.094 |
| Colleges | 0.155 |
| Lodging | 0.153 |
| Other | 0.124 |
| Mixed Use | 0.187 |

ii. **Design Method. Use a CEC approved calculator tool to determine the area required to generate at least 20 percent of the electrical contribution to the estimated annual building energy budget, as defined by Section 101 of Title 24 Part 6. Calculations must be completed according to CEC guidelines.**

2. **Maximum Area. No solar zone is required to be larger than the maximum area defined by:**

    **Maximum area of solar zone = (total roof area in SF) – (area covered by skylights) x 75%**

3. **Obstructions. The solar zone must be free of pipes, vents, ducts, HVAC equipment and other similar obstructions.**

4. **Shading. The solar zone must be set back a distance of at least two times the height of any objects (including features of the building itself, parapets, rooftop equipment, vegetation, or any other feature) located south, east, or west of the solar zone.**

5. **Contiguous Area. The solar zone may be comprised of up to five smaller sub-areas. No sub-area can be smaller than 250SF unless the total area of the solar zone is less than 250SF. All areas must be at least 5 feet wide in the narrowest dimension.**

6. **Fire Code. The solar zone should be designed in accordance with current Fire Code Requirements (see Title 24, Part 11).[8]**

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[8] When the 2013 revisions to the fire code have been adopted, the reference to Title 24 Part 9 will be updated with the section of the fire code that addresses solar installations.

7. **Structural Integrity. The as-designed dead load and live load for the solar zone must be clearly marked on the record drawings and on EE-1 SOLAR READY compliance form.**[9]

**EXCEPTION to 5.203.1:**

1. **Buildings that have PV or SWH systems installed may count the area the installed system occupies towards the solar zone requirement.**

**5.203.2 Designed PV or SWH Interconnection.**

**Buildings must design for the interconnection of a PV system or a solar water heating system, as specified by (1) and (2) below:**

1. **PV System Interconnection Design. The building electrical drawings must indicate the plan for connecting the PV system of the specified capacity to building's electrical system. The interconnection must be designed such that the sum of the supply feeders from inverter(s) serving the busbar is no more than 20 percent of the busbar rating and wiring follows the shortest feasible pathway between the solar zone to the inverter location and from the inverter location the dedicated electrical interconnection point. D Drawings must clearly label the:**
   a. **solar zone**
   b. **location for inverters and metering equipment**
   c. **electrical interconnection**
   d. **pathway for wiring**
2. **SWH System Interconnection Design. The building plumbing drawings must indicate the plan for connecting the SWH system of the specified capacity to building's plumbing system. The interconnection must be designed such that piping follows the shortest feasible pathway between the solar zone and the plumbing interconnection point. Drawings must clearly label the:**
   a. **solar zone**
   b. **location for hot water storage tanks**
   c. **plumbing interconnection**
   d. **pathway for piping**

[9] If code change is added as a mandatory measure in Part 6, the nonresidential Title 24 envelope compliance forms would also need to be modified. A section would be added to form ENV-1C: Certificate of Compliance and Field Inspection Energy Checklist. A new form, ENV-5C, will be used to ensure the area of the solar zone has been calculated correctly and to ensure the interconnection plan and the solar zone have been designed according to code.

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