CALIFORNIA
ENERGY
COMMISSION

ELIGIBILITY CRITERIA
AND
CONDITIONS FOR INCENTIVES
FOR SOLAR ENERGY SYSTEMS
SENATE BILL 1

STAFF REPORT

August 2007
CEC-400-2007-014

Arnold Schwarzenegger, *Governor*

CALIFORNIA ENERGY COMMISSION

Claudia Orlando
Smita Gupta
Principal Authors

Sandy Miller
Project Manager

Bill Blackburn
Supervisor

Bill Pennington
Office Manager
BUILDINGS AND APPLIANCES

Mark Hutchinson
Office Manager
RENEWABLE ENERGY PROGRAM

Valerie T. Hall
Deputy Director
EFFICIENCY AND RENEWABLES DIVISION

B.B. Blevins
Executive Director

Cover Photos:
Column 1 and 2 – courtesy US Department of Energy's National Renewable Energy Laboratory
Column 3
Row 1 – courtesy B. A. Wilcox
Row 2 – courtesy SMUD
Row 3 – courtesy Milton H. Smith construction

Table of Contents

Abstract

Senate Bill 1 (Murray, 2006) is the culmination of the Governor's Million Solar Roofs Initiative, expanding upon the California Solar Initiative (CSI) and the New Solar Homes Partnership (NSHP) . The statute requires the California Energy Commission to establish eligibility criteria, conditions for incentives and rating standards for projects applying for ratepayer funded incentives for solar energy (photovoltaic (PV)) systems.

Senate Bill 1 states three specific expectations to be met to qualify for the ratepayer funded incentives made available through the bill:

1. high quality solar energy systems with maximum system performance to promote the highest energy production per ratepayer dollar,
2. optimal system performance during periods of peak demand, and
3. appropriate energy efficiency improvements in the new and existing home or commercial structure where the solar energy system is installed.

The report summarizes principles for developing a successful statewide photovoltaic program delineated in the 2004 and 2005 Integrated Energy Policy Reports, and highlights other energy policy that should be considered from AB 32, the Climate Action Initiative, Energy Efficiency Goals and Procurement statutes, Green Building Initiative, and the New Solar Homes Partnership. The report is organized into sections addressing SB 1 mandates for Solar Energy Component Standards, Solar Energy System Installation Standards, Energy Efficiency, and Other Eligibility Criteria Established in Statute. For each of these sections, the report presents the pertinent SB 1 Provisions, Background, New Solar Homes Partnership Provisions, California Solar Initiative Provisions, and Recommendations for Guidelines. The report recommends that the effective date be January 1, 2009.

Keywords

SB 1, Million Solar Roofs, California Solar Initiative, New Solar Homes Partnership, solar energy systems, PV, photovoltaic, energy efficiency, eligibility criteria, conditions for incentives, rating standards, Energy Commission, NSHP, CSI, publicly owned utilities, PUC, solar, 2030 Challenge, ASHRAE Standard 189, Building America, zero energy, LEED, Portfolio Manager, Green Building Initiative, benchmarking, building commissioning, building performance contractor, HERS rating, energy audit, PV Calculator, expected performance based incentive, PBI, EPBI, IEC, 61215, 61646, Savings By Design

Executive Summary

Senate Bill 1 (Murray, 2006) is the culmination of the Governor's Million Solar Roofs Initiative, and expands upon the California Solar Initiative (CSI) and the New Solar Homes Partnership (NSHP) . The statute requires the California Energy Commission, in consultation with the California Public Utilities Commission (CPUC), local publicly owned utilities and interested members of the public, to establish eligibility criteria, conditions for incentives and rating standards for projects applying for ratepayer funded incentives for solar energy (photovoltaic (PV)) systems.[1]

Senate Bill 1 calls for three specific expectations to be met to qualify for the ratepayer funded incentives made available through the bill:

- high quality solar energy systems with maximum system performance to promote the highest energy production per ratepayer dollar,
- optimal system performance during periods of peak demand, and
- appropriate energy efficiency improvements in the new and existing home or commercial structure where the solar energy system is installed.

This report presents the Energy Commission staff's recommendations to accomplish that direction.

To guide the state in developing a successful photovoltaic program consistent with the Governor's *Million Solar Roofs Initiat*ive, the Energy Commission delineated several principles in the 2004 and 2005 *Integrated Energy Policy Reports (IEPR)* that relate directly to the SB 1 mandate to develop eligibility criteria, conditions for incentives and component rating standards. These principles include:

- Leveraging energy efficiency improvements should be a primary consideration in deploying photovoltaics. To participate in the PV program, new buildings should be required to exceed the current building standards, while existing buildings should be required to improve their efficiency. Combining energy efficiency measures with PV will ensure proper sizing of PV systems, contribute to the state's efficiency goals, and provide maximum benefits to PV purchasers and electricity consumers.
- Rational targeting of PV deployment to achieve the greatest cost benefit should be a central feature of a large-scale solar program. Solar installations should be targeted to

[1] Senate Bill 1 is an extensive, multi-faceted legislation that covers many other matters besides the eligibility criteria, conditions for incentives and rating standards addressed in this report. This report does not address those other matters.

climate zones with high peak demands for air conditioning and where solar systems can provide the most benefit.

- Transitioning away from capacity-based incentives to performance-based incentives by integrating energy efficiency and time-of-use energy considerations should be a priority.

The IEPR also recognized the common policy vision referred to as "the loading order" that was also articulated by the state's principal energy agencies in the *Energy Action Plan:*

> The Action Plan envisions a "loading order" of energy resources that will guide decisions made by the agencies jointly and singly. First, the agencies want to optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand. Second, recognizing that new generation is both necessary and desirable, the agencies would like to see these needs met first by renewable energy resources and distributed generation. Third, because the preferred resources require both sufficient investment and adequate time to "get to scale," the agencies also will support additional clean, fossil fuel, central-station generation. Simultaneously, the agencies intend to improve the bulk electricity transmission grid and distribution facility infrastructure to support growing demand centers and the interconnection of new generation.

In the Governor's endorsement of the IEPR, he highlighted the importance of his *Million Solar Roofs Initiative* and the aggressive pursuit of all cost effective energy efficiency, consistent with the loading order.

There are several other Energy Policy directives that are important to consider as the Energy Commission responds to the SB 1 mandates.

- AB 32 and the Climate Action Initiative – Governor Schwarzenegger's Executive Order S-3-05 placed California in a global leadership position by establishing aggressive greenhouse gas emissions reduction targets. The Climate Action Team's 2006 Report to the Legislature highlighted the need for expansion of energy efficiency, coupled with increased penetration of photovoltaic systems. These policies were reinforced by Assembly Bill 32 (Nunez, 2006).

- Energy Efficiency Goals and Resource Procurement – SB 1037 (Kehoe, 2005) and AB 2021 (Levine, 2006) directed electricity corporations subject to the CPUC's authority and local publicly owned electricity utilities, respectively, to first meet their unmet resource needs through all available energy efficiency and demand response resources that are cost effective, reliable and feasible.

- Green Building Initiative – Governor Schwarzenegger's Executive Order S-20-04 took his first concrete step in pursuing the loading order. The Green Building Initiative committed to aggressive action to reduce state building electricity use by 20 percent by 2015 by taking all cost-effective measures described in the Green Building Action Plan, and strongly encouraged commercial building owners to take aggressive action to reduce electricity usage in the same manner. The GBI urged the PUC to apply its energy

efficiency authority to improve commercial building energy efficiency by the 20 percent goal.

- New Solar Homes Partnership – The Energy Commission took steps to implement the IEPR policy through the New Solar Homes Partnership. The goal of the NSHP is to create a self-sustaining market for solar homes where builders incorporate high levels of energy efficiency and high performing solar systems. The Energy Commission did so through an expected performance based incentive structure that focuses on the key performance factors that are subject to the builder's control at the time of construction. The Energy Commission developed specific tools to enable high performing solar homes, including independent testing and certification of the performance characteristics of key solar system components, computer analysis of the key characteristics of component efficiency, system design and installation to accurately determine and incent high performance, and installer and third party field verification protocols to insure the system is installed consistent with the performance simulation and performs as expected. The NSHP established two levels (Tiers) of energy efficiency targets. In setting these Tiers, the Commission aimed to "co-brand" each Tier so that it coincides with the level of efficiency needed to participate in existing, well established, energy efficiency programs in which California builders are motivated to participate. Tier I is the minimum level necessary to qualify for solar system incentives – it is set at the 15 percent beyond Title 24 Standards level required to qualify for existing IOU residential new construction incentives. Tier II is the Energy Commission's preferred level set to match the energy efficiency levels achieved by California builders participating in the U.S. Department of Energy's Building America program (35 percent beyond Title 24 Standards for total energy and 40 percent for cooling energy). Both Tiers require appliances installed by builders to meet Energy Star requirements. The Energy Commission expects the IOUs to provide cost effective Public Goods Charge PGC funded incentives to assist and encourage builders to meet the energy efficiency requirements of each Tier.

This report is organized into sections addressing SB 1 mandates for Solar Energy Component Standards, Solar Energy System Installation Standards, Energy Efficiency, and Other Eligibility Criteria Established in Statute. For each of these sections, the report presents the pertinent SB 1 Provisions, Background, New Solar Homes Partnership Provisions, California Solar Initiative Provisions, and Recommendations for Guidelines. The report closes by presenting the schedule that is planned for developing and adopting the Guidelines, the need for a transition period between the adoption of the Guidelines and their effective date, and makes the recommendation that the effective date be January 1, 2009.

The report makes the following recommendations:

Solar Energy Component Standards

- Modules - Staff recommends that the test requirements developed under the NSHP for PV modules be used for all modules. In addition to UL 1703 safety testing and certification, module performance characteristics should be measured using the

International Electrotechnical Commission (IEC) 61215 or 61646 standards by independent accredited laboratories. The reliability of this detailed performance data is critical to determine the expected performance of systems.

- Inverters – Staff recommends that the existing test protocol in use to list eligible equipment by the Energy Commission be continued, enabling the use of detailed performance curves for determining expected system performance rather than just the single weighted inverter efficiency numbers. This testing requirement is already in use with both the NSHP and CSI programs.
- Meters – Staff recommends that the performance meter requirements as described and in development under the CSI program be used to ensure the accuracy and quality of meters. The requirements include display and monitoring of the long term and instantaneous production from systems to assist in diagnosing and mitigating any faults which affect performance.

Solar Energy System Installation Standards

- Performance Based Incentives – Staff recommends discontinuation of the payment of incentives based on capacity. Incentives should be paid either through an actual or an expected performance based incentive mechanism. Staff recommends the CSI approach for determining what solar energy systems are paid incentives under an actual performance based incentives (PBI) approach. Staff recommends the NSHP approach for determination of expected performance based incentives (EPBI).
- PV Calculator - Staff recommends that SB 1 expected performance based incentives be based on the NSHP PV Calculator, which uses an hourly calculation engine to determine expected system performance (in Time-of-Use weighted kWh) based on detailed tested and certified module and inverter performance characteristics to estimate performance in each hour. The PV Calculator accounts for the unique hourly output of that specific module/inverter combination as a function of power, current and voltage conditions and matching, and cell temperatures as a function of module engineering, ambient temperature and wind at the project location, and the consequences of installation characteristics, including azimuth, tilt, and shading obstructions in each hour.
- Shading – Staff recommends SB 1 installation standards that encourage a purposeful avoidance of shading based on the NSHP methodology. This approach should be reflected in EPBI calculations, and existing and future shading obstructions should be accounted for in the hourly determination of expected system output, as determined by the PV Calculator.
- Peak Load – Staff recommends use of the Time Dependent Valuation (TDV) multipliers established by the Energy Commission to weight the hourly kWh system performance to account for time-of-use production and provide incentive for component engineering, system design and installation that reduce peak demand.

- Field Verification – Staff recommends that a sample of systems be required to have third party field verification for visually checking components, installation characteristics and shading, and verifying performance using the NSHP protocol.

- Installation – Staff recommends the use of the current CSI/NSHP installer requirements for valid license and the encouragement of NABCEP installer certification (not required). Installers should carryout the field verification protocol for each of their jobs to avoid installation problems.

Energy Efficiency

- Newly Constructed Residential Buildings – Staff recommends that the NSHP Tier I and Tier II criteria apply to all newly constructed residential buildings. Staff recommends PGC funded energy efficiency incentives be made available for each Tier. The Tier II level is consistent with the current CPUC Big/Bold Energy Efficiency Strategies.

- Newly Constructed Commercial Buildings – Staff recommends a Tier structure for newly constructed commercial buildings, similar to the NSHP to achieve co-branding with prominent energy efficiency programs in California. Staff recommends that Tier I be the minimum requirement for qualifying for solar incentives and be set at 15 percent beyond the Title 24 Standards requirements, in line with the energy efficiency requirements of LEED New Construction and Savings By Design. Staff recommends that Tier II be the preferred level and be set at 30 percent beyond the Title 24 Standards, in line with the 2030 Challenge, ASHRAE Standard 189, and the federal tax credit. Staff recommends PGC funded energy efficiency incentives be made available for each Tier. The Tier II level is consistent with the current CPUC Big/Bold Energy Efficiency Strategies.

- Existing Commercial Buildings – Staff recommends that existing commercial buildings meet the expectations of the Governor's Green Building Initiative (GBI). All commercial buildings should be benchmarked, using Energy Star's *Portfolio Manager*. If the rating is at 75 or above and the building is equal to or smaller than 50,000 square feet, no further action should be required. If the rating is less than 75 or the building is larger than 50,000 square feet, commissioning of the building should be required, and the project should implement equipment repairs and adjustments and install all cost effective measures or achieve a minimum benchmarking rating level of 75. Utilities should provide incentives for using a building commissioning agent and for installing cost effective measures identified through building commissioning.

- Existing Residential Buildings – Staff recommends that the CPUC's current requirement for an online energy audit be continued for existing residential buildings at this point in time. Staff recommends that the CPUC sponsor an investigation to determine what measures have been installed by applicants as a result of the online audit.

  Staff recommends that the following concepts be further developed for a future update of the SB 1 guidelines. Staff recommends the development of an approach similar to that for existing commercial buildings. Utilities should establish a targeting system

(benchmarking) that compares the home's energy use per square foot to the range of energy use of the utility's residential customers, to identify which quartile of energy use per square foot the home falls into. The quartile for the individual home would determine what level of investigation would be appropriate to determine energy efficiency measures that would be cost effective for the home. Homes that fall into the best quartile of energy use per square foot, 75 percent to 100 percent, would continue to follow the use of an online energy audit and should be encouraged to implement those measures which are determined to be cost effective for which the utility offers measure-specific incentives. Homes in the lower quartiles are prime candidates for further onsite investigation (onsite energy audit, HERS rating, or building performance contractor assessment) to determine cost effective measures. Homes that are in the bottom three quartiles should install cost effective measures or improve their energy use per square foot to the point that the home falls into the 75 percent quartile. Utilities should provide incentives for using an energy auditor, home energy rater or building performance contractor and for installing cost effective measures identified in the audit, HERS rating or building performance contractor assessment.

Other Eligibility Criteria Established in Statute

- Several eligibility criteria were spelled out fairly specifically, directly in the statute. For most of those the requirements are already covered in both the NSHP and CSI programs. The report clarifies the provisions for those items. Related to performance monitoring and maintenance, staff recommends that the CSI approach of requiring a Performance Monitoring and Reporting System (PMRS) be used. The CSI requires PMRS as long as it is economically reasonable, by setting a PMRS cost cap for systems not installed under a PBI mechanism. Staff also recommends a maintenance plan, as specified by the NSHP, for all systems installed on newly constructed affordable housing and for all other systems that are over 10 kW.

For each section of the report after the Recommendations for Guidelines for that section, there are Other Issues for Further Consideration that discuss matters that require more attention related to the recommendations. Also, there are Questions for Further Consideration. **Commission staff requests that interested persons respond to these questions when commenting on the report.**

CHAPTER 1: Introduction

Senate Bill 1 (SB 1, Murray, Statutes of 2006) is the culmination of the Governor's Million Solar Roofs Initiative, and expands upon the current California Solar Initiative (CSI) program and the New Solar Homes Partnership (NSHP). This Statute adds sections to the Public Resources Code that require the Energy Commission to establish eligibility criteria, conditions for incentives and rating standards for projects applying for ratepayer funded incentives for solar photovoltaic (PV) systems[2]. This staff report presents the status and options for the development of the eligibility criteria, conditions for incentives and rating standards required by Senate Bill 1. These eligibility criteria and conditions for incentives must be developed and adopted by the Energy Commission by January 1, 2008. The Energy Commission will consult with the California Public Utilities Commission (CPUC), local publicly owned electric utilities and members of the public in the development of these program components.

This staff report discusses current energy policy related to the SB 1 directives, current component, installation and energy efficiency requirements under both the NSHP and CSI programs, and Energy Commission staff recommendations for eligibility criteria, conditions for incentives and rating standards as required by SB 1. The Guidelines development and adoption schedule and recommendations for implementation are also discussed.

[2] Senate Bill 1 is an extensive, multi-faceted legislation that covers many other matters besides the eligibility criteria, conditions for incentives and rating standards addressed in this report. This report does not address those other matters.

CHAPTER 2: California Energy Policy Considerations

Integrated Energy Policy Report

Senate Bill 1 calls for three specific expectations to be met to qualify for the ratepayer funded incentives made available through the bill:

1. high quality solar energy systems with maximum system performance to promote the highest energy production per ratepayer dollar,
2. optimal system performance during periods of peak demand, and
3. appropriate energy efficiency improvements in the new and existing home or commercial structure where the solar energy system is installed.

To guide the state in developing a successful photovoltaic program consistent with the Governor's Million Solar Roofs Initiative, the Energy Commission delineated several principles in the 2004 and 2005 Integrated Energy Policy Reports (IEPR) that relate directly to the SB 1 mandate to develop eligibility criteria, conditions for incentives and component rating standards. These principles include:

- Leveraging energy efficiency improvements should be a primary consideration in deploying photovoltaics. To participate in the PV program, new buildings should be required to exceed the current building standards, while existing buildings should be required to improve or certify their efficiency. Combining energy efficiency measures with PV will ensure proper sizing of PV systems, contribute to the state's efficiency goals, and provide maximum benefits to PV purchasers and electricity consumers.
- Rational targeting of PV deployment to achieve the greatest cost benefit should be a central feature of a large-scale solar program. Solar installations should be targeted to climate zones with high peak demands for air conditioning and where solar systems can provide the most benefit.
- Transitioning away from capacity-based incentives to performance-based incentives by integrating energy efficiency and time-of-use energy considerations should be priority.

The IEPR also recognized the common policy vision referred to as "the loading order" that was also articulated by the state's principal energy agencies in the *Energy Action Plan:*

> The Action Plan envisions a "loading order" of energy resources that will guide decisions made by the agencies jointly and singly. First, the agencies want to optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand. Second, recognizing that new generation is both necessary and desirable, the agencies would like to see these needs met first by renewable energy resources and distributed generation. Third, because the preferred resources require both sufficient investment and adequate time to "get to scale," the agencies also will support additional clean, fossil fuel, central-station generation. Simultaneously, the agencies intend to improve the bulk electricity transmission grid

and distribution facility infrastructure to support growing demand centers and the interconnection of new generation.

In the Governor's endorsement of the IEPR, he highlighted the importance of his *Million Solar Roofs Initiative* and the aggressive pursuit of all cost effective energy efficiency, consistent with the loading order.

Climate Action Initiatives

Since Governor Schwarzenegger took office, climate action has been at the forefront of his Administration's priorities, and these climate actions have been reinforced and expanded by Legislation. In June 2005 the Governor placed California in a global leadership position by issuing Executive Order S-3-05. This Executive Order established aggressive greenhouse gas (GHG) emission reduction targets:

- By 2010, reduce GHG emissions to 2000 levels
- By 2020, reduce GHG emissions to 1990 levels
- By 2050, reduce GHG emissions to 80 percent below 1990 levels

The Governor created the Climate Action Team to plan and take action to achieve the climate change emission reduction targets. The Climate Action Team is a cabinet-level team composed of:

- Chair: Secretary for Environmental Protection
- Members:
    - Secretary of the Business, Transportation and Housing Agency
    - Secretary of the Department of Food and Agriculture
    - Secretary of the Resources Agency
    - Chair of the Air Resources Board
    - Chair of the Energy Commission
    - President of the Public Utilities Commission

The Climate Action Team's 2006 Report to the Legislature highlighted the need for expansion of energy efficiency, coupled with increased penetration of photovoltaic systems. The Report called for all utilities to meet the energy efficiency goals and the Renewable Portfolio Standard required of investor-owned utilities. The Report stated that publicly-owned utilities are essential to the State's overall goal to reduce electricity demand and increase the State's use of renewable resources.

In September, 2006 the Governor signed into law Assembly Bill (AB 32, Nunez), the California Global Warming Solutions Act. The express intent of AB 32 is to achieve the maximum

technologically feasible and cost-effective greenhouse gas emission reductions. The bill places into California law achievement of a statewide greenhouse gas emissions limit in 2020 that is equivalent to the GHG emissions that existed in 1990. The intent of the Legislature is also to continue reductions in emissions of greenhouse gases beyond 2020.

AB 32 included the following Legislative findings:

> California has long been a national and international leader on energy conservation and environmental stewardship efforts, including … energy efficiency requirements, renewable energy standards… [this bill] will continue this tradition of environmental leadership by placing California at the forefront of national and international efforts to reduce greenhouse gases …

By exercising a global leadership role, California will also position its economy, technology centers, financial institutions, and businesses to benefit from national and international efforts to reduce emissions of greenhouse gases.

Energy Efficiency Goals and Resource Procurement

Two key bills have directed how utilities, investor-owned and publicly-owned, should pursue energy efficiency first before other resources and how they should establish and pursue goals for energy efficiency.

In September, 2005 the Governor signed into law Senate Bill 1037 (Kehoe) that directed all electricity corporations subject to the CPUC's authority first meet their unmet resource needs through all available energy efficiency and demand reduction resources that are cost effective, reliable and feasible. It also directed the CPUC in consultation with the Energy Commission to identify all potentially achievable cost-effective electricity efficiency savings and establish efficiency targets for an electrical corporation to achieve. SB 1037 also directed each publicly owned utility, in procuring energy, to first acquire all available energy efficiency and demand reduction resources that are cost effective, reliable and feasible.

In September, 2006 the Governor signed into law Assembly Bill 2021 (Levine), which added that each local publicly owned electric utility shall identify all potentially cost-effective electricity efficiency savings and shall establish annual targets for energy efficiency savings and demand reduction. In enacting AB 2021, the Legislature made the following conclusions:

> To ensure that prudent investments in energy efficiency continue to be made that produce cost-effective energy savings, reduce customer demand, reduce overall system costs, increase reliability, and increase public health and environmental benefits, it is the intent of the Legislature that all load-serving entities procure all cost-effective energy efficiency measures so that the state can meet the goal of reducing total forecasted electrical consumption by 10 percent over the next 10 years … The energy savings achieved through the enactment of this act are an essential component of the state's plan to meet the Governor's greenhouse gas reduction targets established in Executive Order S-3-05.

Green Building Initiative and Action Plan

In December 2004 Governor Schwarzenegger took his first concrete step to pursue the loading order by issuing Executive Order S-20-04, the Green Building Initiative. In so doing the state committed to aggressive action to reduce state building electricity usage by retrofitting, building and operating the most energy and resource efficient buildings by taking all cost-effective measures described in the Green Building Action Plan for facilities owned, funded or leased by the state and to encourage cities, counties and schools to do the same. The Green Building Initiative directed all state agencies under the direct authority of the Governor to take actions to reduce the energy use of state-owned buildings by 20 percent by 2015. The Green Building Initiative also encouraged commercial building owners to take aggressive action to reduce electricity usage in the same manner. The California Public Utilities Commission was urged to apply its energy efficiency authority to improve commercial building energy efficiency by the 20 percent goal.

New Solar Homes Partnership Policies and Approaches

The New Solar Homes Partnership (NSHP), which is aimed at new residential construction, took several steps to implement IEPR policy that address SB 1 directives for the Energy Commission in the establishment of eligibility criteria, conditions for incentives and rating standards. The goal of the NSHP is to create a self-sustaining market for solar homes where builders incorporate high levels of energy efficiency and high performing solar systems. Combining high energy efficiency and high performing solar systems honors the state's loading order and delivers both preferred technologies at once. The accomplishment of this goal will maximize the public's investment by ensuring that each solar home cost-effectively avoids unnecessary, wasteful and uneconomic energy consumption and enjoys a solar system that has been designed and installed for high performance. The homeowner is well served by having low energy bills with a solar system that provides high value with maximum cost effectiveness for the project as a whole.

The Energy Commission concluded that the solar system incentives should be structured to place a premium on performance. The NSHP avoids providing incentives on a capacity-basis that fails to place proper attention on the key factors that impact system performance, including component efficiency, system design and onsite installation and shading. The Energy Commission adopted an expected performance-based incentive (EPBI) structure that focuses on the responsibility of the builder to deliver high performing solar homes and on those key performance factors that are subject to the control of the builder at the time of construction. This type of expected performance-based incentive relies on tools similar to those developed for California's building energy efficiency and appliance energy efficiency standards to encourage high performance systems, including: 1) independent testing and certification of the performance characteristics of key components (in particular modules and inverters); 2) computer analysis of key characteristics of component efficiency, system design and installation to determine expected system performance; and 3) installer and third party field verification protocols to ensure that the system is installed consistent with the performance simulation and

performs as expected. The Energy Commission employed the same time dependent valuation weighting of the time-of-use implications of the utility system that is used for determining compliance with the performance standards for the Title 24 Building Energy Efficiency Standards. The calculations are used to determine the level of incentives earned by the specific solar system, as designed and installed.

The Energy Commission established two levels of energy efficiency targets: Tier I - a minimal level necessary for a builder to qualify for NSHP incentives, and Tier II – a Commission-preferred level that encourages builders to further differentiate their projects with higher energy efficiency. The two levels were chosen to match up with the energy efficiency levels of major energy efficiency programs pursued by California builders. Tier I is consistent with the 15 percent better than Title 24 criteria required to qualify for the current new residential construction programs administered by the California Investor Owned Utilities (IOUs). Tier II was designed to match the energy efficiency levels achieved by California builders who participate in the U.S. Department of Energy's Building America program (35 percent better than Title 24 on a total energy basis and 40 percent better than Title 24 considering cooling energy alone). Both Tiers require appliances installed by builders to meet ENERGY STAR requirements. In setting these energy efficiency targets, the Energy Commission expects California's IOUs to provide appropriate and cost effective public goods charge funded incentives to assist and encourage builders to meet the energy efficiency requirements of each level.

As a long-term goal the Energy Commission supports the achievement of zero energy new homes for mainstream construction. The concept of zero energy new homes is that the energy use of the home is drawn down by high energy efficiency measures to the point where the remainder can be met by the photovoltaic system. The Energy Commission's policy to emphasize the combination of high energy efficiency plus high performing PV systems is intended to facilitate the transition to zero energy new homes. Similar actions would be needed to transition to zero carbon footprint new homes.

CHAPTER 3: Solar Energy System Component Standards

Pertinent Senate Bill 1 Provisions

> PRC 25782(a)(1). Establish … design … and electrical output standards …
>
> PRC 25782(a)(7). The solar energy system has meters or other devices in place to monitor and measure the system's performance and the quantity of electricity generated by the system.
>
> PRC 25782(b)(1). Establish … high quality … solar energy system … guidelines …
>
> PRC 25782(c). Set rating standards for equipment, components, and systems to assure reasonable performance and … develop standards that provide for compliance with the minimum ratings.

Background

Setting rating standards and guidelines to ensure the quality of systems and components is critical to a successful solar incentive program to ensure high performance, quality equipment. The three main components that are subject to standards and ratings specific to PV installations are the modules, inverters and meters.

PV Modules

The nameplate ratings (capacity kW) of PV modules are widely reported under Standard Test Conditions (STC)[3]. Another set of test conditions called the PVUSA Test Conditions (PTC)[4] offer an alternate approach and are considered a more plausible combination of conditions that could indicate the potential power capacity of the module. The Energy Commission under its Emerging Renewables Program (ERP) had used this approach of providing a scaled nameplate rating to list eligible modules (the PTC rating is a calculated modification of the STC nameplate rating). This list of modified nameplate ratings of modules is often referred to as the CEC-PTC rating and has been widely used by other states and solar incentive programs. The PTC rating of modules is typically lower than the STC rating since it is estimated at higher cell

[3] Standard Test Conditions (STC) are 1000W/m2 incident solar radiation and 25° C cell temperature (perceived to occur at 0° C ambient temperature conditions) and 1m/s wind speed.

[4] PV USA Test Conditions (PTC) are 1000W/m2 incident solar radiation and 20° C (equivalent to 68° F) ambient temperature (cell temperatures are normally substantially higher than ambient temperatures) and 1m/s wind speed.

temperatures that are closer to actual installed conditions[5]. The rating values are self-reported by the manufacturers, based on in-house flash testing results, rather than having been determined by an accredited laboratory.

Typically performance reporting has been dependent on the accuracy of the nameplate rating which is not a true indicator of the performance of the module under the range of conditions in effect in an installed system. In moving towards a greater emphasis on system performance, it is important to place emphasis on the detailed performance characteristics of the modules, which impact the production when installed within the system.

The main U.S. standard for PV module performance is the American Society for Testing and Materials, ASTM E1036-02, Standard Test Method for Electrical Performance of Non-Concentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells. This standard is limited to flat-plate terrestrial modules (and arrays), and it covers both crystalline silicon and thin-film modules. The standard describes the essential requirements of the test method used for determining the nameplate power rating of PV modules but lacks specificity concerning the test procedures to be used.

The important international standards for PV modules are:

- IEC[6] 61215, Crystalline Silicon Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval.
- IEC 61646, Thin-Film Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval.

Both IEC 61215 and 61646 describe the requirements for accelerated testing to help ensure module reliability, as well as comprehensive testing of the detailed performance characteristics of the modules at STC and other relevant conditions that the module will operate under. The sub-sections related to the performance testing provide detailed voltage and current (I-V curve) performance, nominal operating cell temperature (NOCT) values as well as temperature coefficients, which are the key characteristics of the module that determine its performance in the field and are needed for hourly expected performance calculations.

The European solar market has demanded more stringency in the testing standards and reporting of PV modules than the United States. The only national standard in the U.S. governing the rated output of PV modules is Underwriters Laboratories, UL-1703, Flat-Plate Photovoltaic Modules and Panels. This standard is primarily for testing product safety, but also covers module reliability to a small extent. UL 1703 requires that the power output of the

---

[5] However, the ambient temperature conditions at PTC (20° C or 68° F) are exceeded in virtually all climate zones in California during the summer. And consequently the PTC ratings do not capture the true performance impact of higher operating temperatures.

[6] International Electrotechnical Commission (IEC)

modules, under STC conditions, be tested on the production line ("flash" testing) to be within 10 percent of their nameplate rating. This UL testing was primarily intended as an operating safety requirement to insure that modules do not produce power significantly in excess of their nameplate rating, rather than being a rigorous rating of performance. UL does not require any third party laboratory testing to ascertain these values, but relies primarily on self reporting

The international standard for module safety, IEC 61730, Photovoltaic Module Safety Qualification, contains two parts: IEC 61730-1, Photovoltaic Module Safety Qualification – Part 1: Requirements for Construction and IEC 61730-2, Photovoltaic Module Safety Qualification – Part 2: Requirements for Testing. The IEC module safety standard is more comprehensive than UL 1703, for both safety and reliability requirements. Current efforts are underway to harmonize the UL and IEC module safety standards and, when completed, it is expected that UL 1703 will be replaced by IEC 61730 Parts 1 and 2.

Inverters

The U.S. national safety standard for inverters is UL 1741, Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems, which covers both stand-alone and grid-interactive inverters and charge controllers. This UL standard mainly describes tests for inverter and charge controller safety, but also includes some tests for the measurement of performance, including their efficiency.

A more comprehensive testing protocol for the performance measurement of grid-interactive inverters[7] titled "Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems" is used by the Energy Commission to qualify eligible inverters. This protocol expanded on UL 1741 establishing additional tests for the following performance characteristics: Maximum Continuous Output Power, Conversion Efficiency, and Tare Losses. The completion of this protocol results in the establishment of the performance curve for each inverter that reveals the inverter performance over the entire range of operating conditions, enabling determination of the hourly performance of the inverter when combined with specific modules in a system for hourly expected performance calculations.

Meters

Performance meters are an important component for determining the performance of a system, both instantaneous kilowatts (kW) and cumulative kilowatt-hours (kWh). Meters are typically either integrated into the inverters or at times stand alone. There are some specific test standards related to the accuracy of meters that are in use at this time, such as ANSI C12;

---

[7] Performance ratings for each model of inverter are determined according to sections of the test protocol entitled, "Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems", prepared by Sandia National Laboratories, Endecon Engineering, BEW Engineering, and Institute for Sustainable Technology, October 14, 2004 version and the "Guidelines for the Use of the Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems."

performance measurement accuracy is used as the primary program eligibility requirement along with some basic functionality for displaying and storing performance data. The expected tolerance is commonly either ±5 percent or ±2 percent accuracy. There are efforts underway to develop more effective standards for meters.

New Solar Homes Partnership Provisions

The Energy Commission has made some significant advances related to the test standards and performance reporting of PV modules under the New Solar Homes Partnership (NSHP)[8]. As part of its policy to achieve high performance systems, the Energy Commission has moved away from using the capacity-based nameplate rating as the basis for determining incentives. The NSHP relies on the specific performance characteristics that are measured by third party testing laboratories. These performance characteristics include the full I-V curve performance at STC, nominal operating cell temperature (NOCT) and temperature coefficients. The detailed calculation methodology developed under this program (discussed in more detail in later sections), uses the tested characteristics of the specific modules as inputs to produce an accurate estimate of the expected performance of the system. And to ensure the integrity of the data provided, test standards have been referenced and independent testing required when reporting these values.

To ensure basic safety modules are first required to be certified to UL 1703 by a Nationally Recognized Testing Laboratory (NRTL). Detailed performance characteristics tests are required to be performed by a laboratory accredited by the International Laboratory Accreditation Cooperation (ILAC), in accordance with specific portions of either International Electrotechnical Commission Standard (IEC) 61215 (for crystalline modules) or IEC 61646 (for thin film modules), whichever is applicable. For IEC 61215, the required tests are for Maximum Power Determination, Measurement of Temperature Coefficients and Nominal Operating Cell Temperature (NOCT), and Performance at STC and Low Irradiance. For IEC 61646, the additional tests are for Measurement of Temperature Coefficients and NOCT, Performance at STC and Low Irradiance, and for Light-Soaking.

The existing test standards for the measurement of NOCT are more relevant to rack mounted modules and do not address the specific mounting of roof integrated BIPV (building integrated PV) modules. The rack mounted modules tend to operate at much lower temperatures due to the free air flow around them. Therefore the Energy Commission has developed the following

[8] NSHP provides incentives for PV systems based on expected performance determined through detailed hourly calculations accounting for the interaction of components at the range of operating conditions associated with specific installation characteristics, based on the performance characteristics determined by independent testing of the components.

test configuration specifications to determine the NOCT[9] for BIPV modules. In the absence of testing for BIPV modules using this test configuration, the NOCT (in the rack mounted condition) reported by manufacturers is adjusted based on the findings of a Sandia investigation study[10] of the impact of mounting configuration on module operating temperatures. The Energy Commission's approach has been a big step towards estimating the performance of roof integrated BIPV modules through calculations in a more realistic way.

> Mounting Specifications for NOCT testing for Building Integrated Photovoltaic (BIPV) Modules Intended for Roof Integrated Installations:
>
> Tilt angle: the test modules shall be positioned so that they are tilted at 23° ± 5° (5:12 roof pitch) to the horizontal.
>
> Configuration: the test modules shall be located in the middle of an array that is at least four feet high and four feet wide. The array shall be surrounded on all sides with a minimum of three feet of the building system for which the BIPV system is designed to be compatible, and the entire assembly shall be installed and sealed as specified by the manufacturer for a normal installation.
>
> Substrate and Underlayment: the test modules shall be installed on a substrate of oriented strand board with a minimum thickness of 15/32 inch that is covered by #30 roofing felt with a minimum R-10 continuous insulation under and in contact with the oriented strand board and include any other manufacturer-recommended underlayments.

Regarding the nameplate rating that results from UL 1703 testing, the Energy Commission has required the following tighter specification (i.e., no less than 95 percent whereas UL 1703's safety oriented requirement is ±10 percent):

> The factory measured maximum power of each production module, as specified in UL 1703, Section 44.1, and the lower bound of the manufacturer's stated tolerance range, pursuant to UL 1703, Section 48.2, must be no less than 95 percent of the Maximum Power reported to the Energy Commission.

Inverters are required to be certified to UL 1741 standards by a Nationally Recognized Testing Laboratory (NRTL). Additional tests are required to be performed by the NRTL in accordance with the "Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems." This requirement is imposed by the Energy Commission's program for

---

[9] The NOCT tends to be noticeably higher for roof BIPV modules as compared to rack-mounted modules, which are able to cool by air circulation around them. The higher NOCT for roof BIPV modules reduces the module efficiency, which is accounted for in the estimated performance calculations.

[10] Sandia National Laboratories Report, A Simplified Thermal Model for Flat-Plate Photovoltaic Arrays by Martin K. Fuentes, 1987.

listing eligible inverters (in Chapter 4). The PTC rating of modules is adjusted by a single weighted efficiency number derived from the data submitted using this protocol. The NSHP EPBI hourly calculation uses the full detail of the performance curves (power and efficiency over the full range of possible voltages) and the specific night time tare loss that is reported for each inverter, rather than a single weighted efficiency number.

All systems are required to have a performance meter, either built into the inverter or separate. The meter must have a ± 5 percent accuracy, measure total energy produced in kWh (or Wh), and retain production data during power outages. Accuracy of the meter must be either self-certified by the manufacturer or by an independent testing body. The Energy Commission has the authority to define and require additional testing protocols for these meters.

More details about the component testing and certification standards for NSHP can be found in Appendix 3 – Criteria for Testing, Certification and Listing of Eligible Components, of the NSHP Guidebook[11].

California Solar Initiative Provisions

The CSI Handbook requires components to be certified through the procedures that had previously been used by the Energy Commission's Emerging Renewables Program when it offered incentives for solar systems. The CPUC requires PV modules to be certified to the UL 1703 standard (ERP requirements), inverters to be certified to UL 1741 and for the single weighted inverter efficiency to have been determined based on inverter testing using the Energy Commission required protocol. The CPUC's CSI program uses the nameplate capacity rating (PTC and STC) for modules and weighted inverter efficiency rating in their expected performance based buydown (EPBB) calculations.

Performance meters must measure kWh (or Watt hours) with an uncertainty of ±2 or ±5 percent, retain data in the event of a power outage, and be easy to read for the customer's benefit. For systems receiving a Performance Based Incentive (PBI), the required accuracy of the meter is ±2 percent. For recipients of an EPBB incentive, the required accuracy of the meter is ±5 percent. All ±2 percent meters must be tested according to applicable ANSI C-12 testing protocols, while currently ±5 percent must meet the testing guidelines set forth by the California Energy Commission. Also, for ±2 percent meters the accuracy of the meter must be certified by an independent testing body, while ±5 percent can either be certified by an independent testing body, or certified by the manufacturer. Since a performance monitoring and reporting service (PMRS) is required, all meters need to be communication capable to enable such a service. Additionally, the Metering subcommittee set up by CPUC is reviewing the metering requirements and will be recommending changes in the coming months. The specific guidelines and protocols for meters are outlined in the CSI Handbook.

[11] http://www.gosolarcalifornia.ca.gov/documents/index.html

Recommendations for Guidelines

The main purpose for test standards and reporting requirements related to components is to have high confidence in the accuracy of the expected performance calculations and to ensure that expected performance is achieved on actual installations. This protects the interest of the solar customer, as well as promotes a sustainable solar industry. This also puts California on an equal footing with international test standards and certification requirements known to be more rigorous than in the United States.

PV Modules

Staff recommends that strong emphasis be placed on independent laboratory testing of the detailed performance characteristics of PV modules to ensure high quality performance data that determine their performance in the field and are needed for hourly expected performance calculations for estimating production.

Staff recommends the following specific requirements:

- Modules should be certified to UL 1703[12] by a Nationally Recognized Testing Laboratory (NRTL) to ensure safety and reliability.
- Detailed performance data should be reported as certified using the subsections of IEC 61215 or 61646 (as relevant) by an ILAC accredited laboratory.
- The NOCT for roof integrated BIPV products should be determined using the specification as described in the NSHP Guidebook Appendix 3.

The requirements staff recommends are in line with those that have been developed and are in use under the NSHP at the Energy Commission. The CPUC's CSI program basically uses the first of these requirements (UL safety testing) and is proposing to follow the third (NSHP NOCT values for BIPV systems) in the future, but does not require performance testing and certification using the IEC test standards.

Inverters

Energy Commission staff recommend that the eligible inverter UL listing and the inverter test protocol developed and in place at the Energy Commission to produce inverter performance data over the full range of operating conditions be used. The intent is to insure that the reported performance data of efficiency at the full range of operating conditions (power and efficiency at the full range of possible voltages) along with the night time tare loss for each inverter be available for hourly estimating of the overall performance of the system (note that whenever the

[12] Current efforts are underway to harmonize the UL and IEC module safety standards and, when completed, it is expected that UL 1703 will be replaced by IEC 61730 Parts 1 and 2. The Energy Commission proposes to follow this effort and harmonize with it as appropriate.

power that the inverter is capable of producing is less than the power that the modules are capable of producing, the inverter power determines the system output).

Staff recommends the following specific requirements:

- Inverters should be certified to UL 1741 standards by a Nationally Recognized Testing Laboratory (NRTL).
- Reporting of performance data (Maximum Continuous Output Power, Conversion Efficiency, and Tare Losses) tested in accordance with "Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems" by a NRTL.

The requirements staff recommends are in line with those that have been developed by the Energy Commission and are in use under the NSHP. The current CPUC CSI program relies on this Energy Commission required testing, but uses only the weighted efficiency number in the EPBB incentive calculations rather than the full range of inverter performance data.

Meters

Energy Commission staff recommend that performance meters, whether stand alone or integrated with the inverters, be required to meet the following:

- ± 2 percent accuracy for all PBI applicants
- All ± 2 percent accuracy meters be tested according to all applicable ANSI C-12 testing protocols
- ± 5 percent accuracy meters (these are primarily inverter integrated) are allowed for expected performance incentive applicants
- All meters must measure and display, both instantaneous (kW or W) and cumulative energy produced (kWh or Wh)
- All meters must retain production data during power outages
- All meters must be easy to read for the customer's benefit
- All meters must have a communication port capable of enabling connection to remote performance monitoring and reporting service (PMRS).

These requirements are consistent and aligned with those in use by the CPUC's CSI program and under development by the CSI's Metering subcommittee.

Other Issues for Further Consideration

Some reasonable transition time will need to be made for the testing and certification of PV modules.

There are about 900 eligible modules under the ERP list , and about 100 modules have been certified under the NSHP to fulfill the requirements proposed here. So potentially a substantial number of modules will need to get tested and certified to meet the staff's recommended

criteria. There are only a limited number of laboratories in the U.S. that are ILAC accredited to carry out the module testing in accordance with the IEC standards. The effective date for the module testing and certification requirements will need to consider the time needed to accomplish IEC module testing.

While California has long been the leader in setting up test standards and rating requirements for components, there are forums and groups[13], as well as the Department of Energy's Solar America Initiative (SAI)[14], that are trying to address national standards for PV components. Additionally there is the European Union sponsored effort which is looking into the performance test standards for PV modules and systems[15]. All these efforts will be closely watched and followed by the Energy Commission to enable a harmonized set of standards and reporting requirements into the future.

Since the CSI's Metering subcommittee is looking into various aspects of meter and metering requirements over the coming months, these efforts will be followed to align the requirements accordingly.

Questions for Further Consideration

- How long will it take to test modules to the performance subsections of IEC 61215 and IEC 61646 by an ILAC accredited laboratory? Are there other issues raised by the proposed requirements for module testing and certification?
- What meter testing requirements and eligibility criteria need to be considered, that are not in use by the CSI or NSHP or under review by the metering subcommittee at CSI?

---

[13] Interstate Renewable Energy Council (IREC) has started this discussion at a national level through PV Product Certification Meetings held in conjunction with various solar conferences and meetings.

[14] To fulfill solar energy's promise, the President's Advanced Energy Initiative proposed a new $148 million Solar America Initiative to accelerate the development of advanced solar electric technologies, including photovoltaics (PV) and concentrating solar power (CSP) systems, with the goal of making them cost-competitive with other forms of electricity by 2015.

[15] The general idea behind the PERFORMANCE project is to provide the PV community with tools to measure the quality of products – devices, systems and services – to ensure their usefulness and reliability, and to deliver data to predict the useful lifetime of the products. The project will develop reliable test and calibration procedures for standard and for innovative types of PV modules; it will harmonize measurement and evaluation techniques for PV systems. PERFORMANCE will cover all relevant aspects from cell to system level and from instantaneous device characterization and system measurements to life-time performance prediction and assessment. http://www.pv-performance.org/

CHAPTER 4: Solar Energy System Installation Standards

Pertinent Senate Bill 1 Provisions:

> PRC 25782(a)(1). Establish … design, installation and electrical output standards.
>
> PRC 25782(b)(1). Establish … appropriate siting and high quality installation of the solar energy system by developing installation guidelines that maximize the performance of the system and prevent qualified systems from being inefficiently or inappropriately installed. … The goal … is to achieve efficient installation of solar energy systems to promote the greatest energy production per ratepayer dollar.
>
> PRC 25782(b)(2). Establish … optimal solar energy system performance during periods of peak electricity demand.

Background

High performance solar electric generation is accomplished through optimal operation of system components working effectively together in the installed system. System performance is assured not only by the performance efficiencies of the individual components over the range of operating conditions that they are subjected to, but also by the quality of the installation practices that impact the production from the system as a whole.

The key factors that affect the production of a system in addition to the component efficiencies are the actual location (latitude, longitude, solar resources and weather conditions), the orientation of the modules with respect to the path of the sun (tilt, azimuth, fixed position or tracking systems), the interconnection of modules in the electrical circuit (modules in series and strings in parallel), the match of the inverter size to the expected output capacity and voltage, and the wiring runs and type and environmental and physical factors that degrade the performance, such as dirt, dust, and shading.

To address the PRC 25782(a)(1) and 25782(b)(1) mandates, it is important that eligible systems are carefully installed using installation and field verification protocols that effectively account for all of these key factors. This is important for systems that will be paid incentives based on their ongoing performance over time (PBI), and is doubly important for systems that will receive an expected performance incentive at the completion of installation/construction to insure control of the quality of the installation. Quality installation of systems needs to address the following considerations: system design using expected performance calculation approach, shading, installer training, and third party field verification.

Expected Performance Calculations

To qualify systems that are paid incentives at the time of completion of installation based on expected performance, it is important for the calculation methodology to as fully as possible capture the interaction of the detailed performance characteristics of the components with the

installation characteristics of the system. The expected performance calculations should, as much as possible with currently-available computer models and technological information, capture the interactive impact of the performance characteristics of the specific component (e.g., unique inverter and module performance characteristics that depend on ambient temperature, wind and solar insolation at the site) combined with the specific module/inverter matching implications, and the specific installation details. The calculation methodology should address and account for these factors in a rigorous manner so as to accurately incentivize systems under the expected performance based incentives approach.

Shading

Shading is a very important determinant of the performance of PV systems. Even a small amount of shading has the potential of negating the production from a string of modules or entire array depending on the circuit wiring design and bypass diode placement. Crystalline silicon cell technologies are more susceptible to this disproportionate impact as compared to thin film technologies. Therefore it is important to emphasize the avoidance of shading to ensure high performing systems. Shading can occur from a number of obstructions that commonly exist in the vicinity of an array, such as trees, vent pipes, chimneys, utility poles, other neighboring structures and building components.

Measuring and quantifying the extent and impact of shading depends on whether the PV system is installed on new buildings being constructed on bare ground or on existing buildings that are in an existing, mature environment. When estimating the performance for PV systems on newly constructed buildings, one needs to rely on a calculation method to capture the potential impact of existing obstructions as well as obstructions that will cause shading in the future. Measuring and quantifying shading for PV installations on existing structures can be a simpler matter, as trees are more likely to be at their mature heights and other shading obstructions are more likely to exist as one would expect them to remain in the future. Physical site analysis regarding shading relies on estimation of the impact of existing obstructions and assessment of the expected future shading of expected obstructions.

Trees are one of the bigger concerns in the estimate of shading impact since their height and growth rate over time, dependent on species. For expected performance calculations, in particular, it becomes important to either avoid or estimate the impact of expected future shading that can not be avoided. To ensure high performance systems, installations must be mindful of these shading issues.

Tree planting and maintenance guidelines for builders and owners (or commercial property managers) are important to ensure the continued high performance from systems over time by avoiding shade.

Addressing Peak Load

Production from PV systems varies by time of day throughout the year and is highly dependent on the orientation of the modules. It is important to encourage systems that can generate electricity at a time when it has the greatest benefit to the state grid in reducing the peak demand pursuant to the PRC 25782(b)(c) directive of the bill. This can be achieved through

valuing the electricity production at peak higher than at other times consistent with the cost avoided by that peak reduction to the utility system.

Installer Training

Installation of solar systems is very specialized and requires expertise not only in solar science but also electrical principles and particularly in the case of building integrated products, the building trades as well. The success of a system is largely in the hands of a qualified and experienced installer. Proper training is critical. Installers can be rewarded by enhancing their professional credentials through participation in training programs, such as those sponsored by the North American Board of Certified Energy Practitioners (NABCEP).

Third Party Field Verification

Although installer training is critical, it is not sufficient to achieve high performance systems. A third party field verification process is necessary to ensure high performance systems. Third party verification provides a quality control check before the system is in full use to address key problems and make corrections to ensure system performance.

New Solar Homes Partnership Provisions

High Quality Performance and Design

The New Solar Homes Partnership (NSHP) exclusively serves the residential new construction market and is aimed primarily towards production home builders. The Energy Commission adopted expected performance based incentives for this program. The NSHP promotes high quality design and installation of systems by tying incentive payments to accurately estimated performance, capturing all known factors that impact performance in a calculation methodology. The Expected Performance Based Incentive (EPBI) approach and the calculation methodology accounts for the following:

Location (latitude and longitude)

Hourly Weather data

- Solar radiation (solar resource available)
- Ambient temperature
- Wind speed

Installation characteristics

- Azimuth
- Tilt
- Mounting type and offset (rack mounted vs. BIPV)
- Height above ground (for scaling wind impact)
- Number of modules per string and number of strings in parallel)

- Shading impact

Detailed Tested and Certified Equipment Performance Characteristics

PV Modules

- Full Current-Voltage (I-V)[16] curve at STC (the Energy Commission staff intends to add the full I-V curve at low irradiation in the future)
- Normal Operating Cell Temperature (NOCT)[17]
- Temperature coefficients[18]

Inverter

- Full Performance efficiency curves for the range of voltage and power conditions applicable
- Night time tare loss
- Maximum Power Point Tracking (MPPT) (the Commission staff intends to add in the future)

System degradation/derating

- Dirt and dust build up
- Wiring mismatch

The Energy Commission's PV calculator (CECPV) is based on the Five-parameter model[19] developed at the University of Wisconsin Solar Energy Laboratory by Dr. William Beckman and his group. The implementation of this model was customized for California to include the inverter performance model and California specific climate data (using the 16 climate zones similar to the Title 24 energy efficiency calculations).

---

[16] The typical I-V curve values include short-circuit current (I_{sc}), maximum power current (I_{mp}), open-circuit voltage (V_{oc}) and maximum power voltage (V_{mp}) measured at STC.

[17] Under most climatic conditions, PV cells in a module operate substantially hotter than the ambient air temperature. The NOCT is an indicator of the temperature differential between PV cells and air temperature.

[18] Temperature coefficients provide the rate of change of different photovoltaic performance parameters with respect to temperature. They are determined for the following parameters: short-circuit current (I_{sc}), maximum power current (I_{mp}), open-circuit voltage (V_{oc}), maximum power voltage (V_{mp}), and maximum power (P_{mp}) and symbolized by α,β and γ.

[19] W. De Soto, S.A. Klein and W.A. Beckman, Improvement and validation of a model for photovoltaic array performance, Solar Energy, Volume 80, Issue 1, January 2006, Pages 78-88.

The analysis accounts for the tested and certified performance characteristics of the specific module and inverter under the full range of conditions these components would encounter during operation, the mounting type and cell temperature, the azimuth and tilt of the modules, and the extent to which the system is shaded. The production of the system is limited by the maximum power rating of the inverter or the maximum production capabilities of the array, to prevent over incentivizing systems with mismatched sizes of components. An overall degradation factor (0.88) is applied to the hourly production to account for losses associated with dirt and dust and mismatched wiring. The PV Calculator (CECPV) accounts for all parameters that are under the control of the builder, as well as the solar and climatic conditions for the locale of the building, to determine the hourly estimated performance over a year. The hourly performance is weighted to account for the time-of-use value of the system generation to the utility system (referred to as time dependent valuation – TDV).

The weighted TDV, annual kilowatt-hour (kWh) production of an applicant system is compared to the weighted TDV, annual kWh production of a reference system. The PV Calculator converts the available $/watt (expressed in PTC) incentive level into the equivalent incentive amount for the TDV-weighted kWh of annual production for the reference system. This equivalent incentive per TDV-weighted kWh rate is applied to the expected annual TDV performance determined by the PV Calculator for the applicant system to determine the incentive for the specific equipment and installation characteristics of that system.

The reference system is fixed and always remains static to establish a single point of comparison against the full range of configurations of the applicant's proposed system. The reference system is assumed to be located in San Jose, California with system components and installation characteristics the same as those used in the solar systems installed at the Premier Gardens sub-division in Sacramento, facing south on a 5:12 roof pitch. The annual TDV production of the proposed system is always compared to the production of the reference system to which the capacity incentive has been applied to determine the total incentive payment[20]. This approach enables the incentive amount to recognize and go up to reward improvements in system performance compared to the reference system and penalize reductions in system performance relative to the reference system. The performance comparison between the proposed and reference systems is sensitive to the actual location, specific performance characteristics of the components and the installation characteristics of the proposed system.

California Flexible Installation

In lieu of site-specific installation characteristics that likely are not known at the time of program reservation applications, the NSHP permits applicants to use the California Flexible Installation criteria as an alternative approach to estimate the EPBI. The California Flexible

[20] The production of the reference system is determined one time and the primary purpose is to convert the capacity based description of the incentive ($/W) to the equivalent EPBI in terms of TDV weighted $/kwh.

Installation criterion offers a simplified approach to estimating the incentives for those solar systems in a new residential development that are designed and installed to meet the criteria. One EPBI calculation can be made for all solar systems in a subdivision that meet all of the following criteria: 1) have an azimuth ranging from 150° to 270°; 2) have a tilt corresponding to a roof pitch between 1:12 and 7:12; 3) meet the "minimal shading criteria" and 4) use the same module models, number of modules, and inverter. The specification was based on analysis that included varying azimuth and tilts of a system, and showed that the production was less sensitive to tilts in the low slope ranges from 1:12 (4.8°) through 7:12 (30.3°) while varying azimuth ranges between 150° and 270°[21].

Shading

The primary policy goal of the Energy Commission related to shading is to establish a simple method to address shading that encourages builders to make efforts to avoid all but minimal shading. The Energy Commission established a "minimal shading criteria" that requires that no existing, planned or potential shading obstructions are closer than a distance of twice the height that the obstruction extends above any point on the modules (obstructions that are north of the modules and cause virtually no shading are exempted). If the minimal shading criterion is met, the precise shading impact of possible obstructions do not have to be considered in the expected performance calculations.

If the minimal shading criteria is not met (i.e., there is at least one obstruction that fails the criterion), the performance impact of all existing, planned or potential shading obstructions needs to be determined. The calculation approach employs a methodology that assumes zero production in those hours where these obstructions shade the system, based on the comparison of the location of the obstruction to the solar position (altitude and azimuth combination). These protocols serve to encourage the avoidance of shading wherever possible and use simple estimation techniques where shading is not avoided. To simplify the installer's and field verifier's task of determining the degree of shading, the basic field protocol purposefully avoids the necessity to use complicated shading analysis tools and instrumentation, as only simple distance measurements and defaulted height values (for mature trees) are needed as inputs into the PV Calculator to determine the calculated impact of shading. Shading analysis tools and instrumentation are allowed as an alternative for those installers who are able to use them and are motivated to do so.

The 2:1 ratio corresponds to a solar altitude equivalent to 26.5° above the horizon. The loss in production due to obstructing the sun below this altitude has been determined to be about 15 percent at the most. This is a simplification that rewards installations that make a substantial effort to avoid shading. For species of trees that are not yet mature, the mature height is used for determining the performance impact of shading and is based on the categorization of species

[21] Note that of all the variables that affect system performance, the tilt of the modules over the normal range of roof pitches is one of the least significant determinants of performance.

as small, medium and large using the tree guides, published by the Center for Urban Forestry Research at the U.S. Department of Agriculture, for tree zones that are applicable for California.

Peak Load

The hourly electrical production of the system is weighted according to hourly TDV factors, which are specific for each California climate zone. The TDV factors account for the hourly variation in value of electricity due to statewide demand as adjusted for local distribution system factors. The annual performance is the sum of the hourly TDV weighted electricity production. This hourly weighting of production is intended to provide an incentive for systems with installations that are optimized to address peak demand.

Third Party Field Verification

Home Energy Rating System (HERS) raters act as the third party for field verification of a sample of installed systems consistent with the approach used for the Building Energy Efficiency Standards (Title 24) and PGC funded residential new construction energy efficiency programs. The Energy Commission developed a detailed verification protocol that combines the visual inspection of components, installation characteristics, and shading and the verification of system performance. The protocol is directly linked to the key performance factors and the estimated system output that is reported by the CEC PV Calculator. The system performance verification checks that the expected production shown in the expected output table generated by the CEC PV calculator is actually achieved. The expected output look up table from the CECPV shows the expected performance in watts of the specific proposed system, at combinations of solar irradiation on the plane of the array and ambient temperature measurements. The HERS rater determines the actual solar irradiation and ambient temperature at the time of the field verification, looks up on the expected output table the expected performance of the specified system at those conditions, and checks the output displayed on the inverter or performance meter to verify the performance of the system. There are tolerance values specified for all of these measurements that allow for any reasonable inconsistencies in measurement between instruments and means used by the installer and field verifiers, to avoid inappropriate questioning of installations by the HERS rater. The third party field verification may be done on the same 1-in-7 sampling approach that is used for Title 24 and residential new construction energy efficiency programs.

Installer

The Energy Commission requires all contracted installations to be done by entities with a valid A, B, C-10 or C-46 contractor license. When systems are installed by the builder's employees, those employees are not required to be licensed. However, the Energy Commission strongly encourages installation by qualified installers since the expected performance and incentive amount depend in part on the quality of system installation. NABCEP certification of installers is encouraged though not required.

Installer self-inspection is expected on 100 percent of the systems installed and is reported on a Certificate, the CF-6R-PV, which is cross verified by the third party field verification. The protocol to field verify the system components, installation characteristics, shading, and

performance, is detailed in the NSHP Guidebook, Appendix 4. The only difference in circumstances expected between the installer self-inspections and the third party field verifications is the expectation that the installer can get on the roof to make observations and measurements and the field verifier can not. It is the responsibility of the installer to document all proof for items that may be more easily observed and measured by the installer than by the rater.

California Solar Initiative Provisions

High Quality Performance and Design

The CSI administers two different incentive mechanisms: 1) a Performance-Based Incentive (PBI) that makes payments based on the first five years of actual production of the system; and 2) an Expected Performance-Based "Buydown" (EPBB). The EPBB intent has been to raise the performance of systems and more appropriately spend rate payer money compared to the previous capacity only rebates, by addressing geographical and installation characteristics.

A PBI is required for systems that are larger than 100 kW (Alternating Current - AC), which is proposed to be changed to 50 kW (AC) by 2008 and 30kW (AC) by 2010, in conformity with SB 1. The payments are made over 5 years on a monthly basis in terms of $/kWh. All other systems can use the EPBB approach; however, they are encouraged to opt for the PBI approach as well. Up until recently, BIPV products were required to use the PBI mechanism, irrespective of size, due to the limitation of the EPBB calculation methodology to predict the performance of BIPV products. A recent decision allows BIPV modules to use NOCT values certified to the Energy Commission under the NSHP approach to address this aspect of the expected performance incentive calculation.

Expected Performance Calculation

The EPBB calculations are based on a capacity incentive ($/W), which is adjusted by a "design factor" that takes into account aspects of the variation in performance of specific systems. The capacity is calculated using the PTC nameplate rating of the modules and the weighted efficiency of the inverter. The design factor calculations account for the impact of geographic and design related differences between the proposed and reference locations and installation characteristics (such as tilt, azimuth and shading).

EPBB Incentive = Incentive Rate x System Capacity Rating x Design Factor

The CSI calculator for EPBB is a web-based application and uses the National Renewable Energy Laboratory (NREL) developed PV Watts v2 engine as a basis for calculating the design factor. The PV Watts engine evaluates the expected energy output of a default crystalline silicon module in the climate and location conditions of a particular installation to establish weighting factors that are used to adjust the system capacity rating (PTC) of the installed modules to

calculate the EPBB incentive[22]. The performance characteristics assumed for the default module include the temperature coefficients and NOCT for typical crystalline silicon cells, assuming an open-rack mounting configuration (regardless of whether the proposed modules are open rack mounted or BIPV). The PTC capacity rating includes inverter efficiency by using a single weighted efficiency number. This is an approximation to actual inverter performance using a default flat performance curve as opposed to the full performance efficiency curves of actual inverters over the specific range of operating conditions at each site. This reduction of inverter efficiency to a single number limits the capability of accounting for mismatch of inverter capacity (both power and voltage) with the array size and stringing configuration (note that the calculation does not handle multiple parallel strings in an array). As a result only the potential production capacity of the array can be checked against the maximum capacity of the inverter[23]. When the array capacity is between 100 and 125 percent of the inverter capacity a note is made that the inverter capacity is exceeded by the estimated system production, but the system output is not reduced to match the inverter capacity. Array capacities greater than 125 percent of the inverter capacity are not allowed by the model.

The design factor calculation assesses energy production in summer months and near-summer months by determining the impact of location, orientation, and shading on the default module and inverter based on the accumulated hourly production that is expected during the summer and near-summer months (May through October). The following calculation methodology is used to determine the design factor:

Design Factor: This is the product of the Design Correction and Geographic Correction[24].

Design Correction: This is the ratio of the 6-month summer and near-summer output of the default system installed as proposed divided by the summer output of the same system assuming reference assumptions. This comparison is made assuming the proposed geographic location. This calculation isolates the comparison of the default system in the proposed azimuth and tilt to the reference assumptions for azimuth and tilt. For systems that are at an azimuth between south and west, the reference assumption for azimuth[25] is the same as the proposed

---

[22] The weighting factors are determined by comparing the azimuth and tilt of the proposed system to the azimuth and tilt of a reference system; the azimuth and tilt of the reference system vary depending on the location and installation of the proposed system.

[23] This is a capacity check of the PTC rating of the array modules against the rated capacity of the inverter. This prevents the under sizing of the inverter beyond 1.25 times the rated capacity.

[24] CSI EPBB Design Factor Calculator User Guide

[25] All proposed installations with azimuth between 180 and 270 degrees result in being compared with the exact same azimuth in the design correction calculations. Proposed installations with azimuths between 270 and 45 degrees are compared with 270 degree azimuth and those between 45 and 180 degrees are compared with 180 degree azimuth in the calculation of the design correction. Note that this approach sets up comparisons with different levels of performance. North facing systems, which will

system, which takes the impact of the azimuth out of the comparison. The design correction compares the proposed tilt to a tilt that results in highest production[26].

Geographic Correction: This is the ratio of the annual output of a south facing system (with an optimal tilt for that location) at the proposed location divided by the annual output of the same south facing system at the reference location (with optimal tilt for that location). For all practical purposes this isolates a comparison of the default system in the proposed geographic location to the same system in the reference location.

The reference location is Orange, California, chosen by the CPUC to reflect approximately median production in populated areas (based on being 44 percent below the high end in the range of annual production with 39 percent of the population living in communities that have an annual production that is equal to or better than the City of Orange).

The design factor is capped at 1.0 to preserve program budget. That is, if the design factor calculation results in a value greater than one, it is set to be one. This practice preserves budget by capping incentives for higher-performing systems. A capped design factor does not reward a system with better proposed tilt and location than the optimal tilt at the reference location. If the system is at an azimuth between south and west, the applicant can not achieve a higher incentive reward for improved azimuth.

While the EPBB incentive calculation considers performance effects of location, azimuth and tilt for lower-performing systems (subject to the 1.0 cap), it does not account for the actual, detailed hour by hour performance characteristics of the proposed module and inverter interaction. At this point in time the CPUC is considering updating the PV Watts engine used by the calculator to address at least some of the actual component performance characteristics in more detail, as well as make some accommodation for a more accurate assumption regarding the mounting configuration of BIPV products. However, additional rigor in the engine to capture the performance characteristics of the components will not significantly impact the overall incentive calculation without fully defining the performance characteristics of the reference system. If the same performance characteristics are modeled in both the numerator and denominator of the design factor calculation and then applied as a multiplier to the nameplate rated capacity of the system, factors important to the design of modules and their interaction with the inverters and

---

tend to be the worst performing are compare to west facing systems, which tend to be low-performing due to low sun angles late in the day. East and south east facing systems, which will tend to perform significantly better than north-facing systems, are compared to the high performing south facing systems.

[26] The EPBB calculator has an internal routine that calculates the tilt that produces the highest summer production at the proposed location to arrive at the optimal tilt that the proposed tilt is compared to. Note that the impact on performance of the PV system is relatively insensitive to tilt (especially in the range 1:12 through 7:12).

the climate will not be captured by the calculation, and therefore improvements in performance due to these factors will not be effectively incentivized.

Shading

The EPBB calculation also allows for a similar to NSHP "Minimal Shading Criteria" for obstructions that minimally impact the production based on the 2:1 ratio of the obstruction location with respect to the array. All shading obstructions which are at a distance twice the height they project above the array are considered as minimal shading and do not need to be accounted for in the shading derate factor.

For all other shading obstructions not meeting this criterion, input is required on monthly non-shaded results from a shading study conducted at the proposed system site. The study must use a shade analysis tool[27] (and accompanying software). The inputs are monthly derate factors (100 percent = no shading, 0 percent = total shading) to adjust the monthly PV Watts output for shading in summer months and near-summer months only. The shade analysis tool must be specific to the location, azimuth and tilt of the system being measured and must correct for magnetic declination. The shading study is verified by the field inspector during spot checks and the documentation is the responsibility of the applicant. However, the methodology does not specifically address shading from trees that are not yet mature or potential shading from future (known) structures not present at the time of the system installation.

Peak Load

The EPBB calculations use the summer and surrounding months as a means to place emphasis on the half of the year that utility peak load conditions occur. This method does not account for the estimated hourly production during the peak afternoon hours of the day of a proposed system, but rather sums up the un-weighted kWh production that occurs over the six month period for the dawn to dusk hours of the day. The calculation provides little incentive for higher system performance at peak periods of the day that commonly occur late in the afternoon, as opposed to late morning or early afternoon production. In addition, because the EPBB calculation do not model detailed module characteristics and their hourly interaction with inverter performance, it does not capture or incentivize increased system performance at peak load conditions. The important design properties to improve the performance at peak conditions include the temperature coefficients [reference footnote 18] of the cell material and the NOCT [reference footnote 15] of the modules. These impact the production during late afternoon periods when the solar radiation and the ambient temperature are both high and the degradation due to high operating cell temperatures are most significant.

---

[27] Shading Analysis tools such as the Solar Pathfinder, the Solmetric SunEye™, the Wylie Electronics ASSET or similar instrument.

Field Inspection

Field inspection is carried out through random samples by CSI trained and certified inspectors for projects under 30kW. Projects between 30 and 100kW are required to have a field inspection, and systems higher than 100 kW, which must use a 5-year PBI incentive mechanism, may also be subject to inspections. At this time CSI guidelines are unclear as to what is the sampling rate under both the EPBB and PBI approaches. The CSI administrators inspected a 100 percent of the EPBB systems in the early months of the program and are currently using a 1 in 7 sampling approach to inspect EPBB systems. As a result of these inspections, CSI administrators discovered a number of problems with system installations. Most notably, these problems were inadequate identification of shading obstructions rooted in a lack of installer ability to use shading analysis tools and instrumentation, and errors installing inverters. The early experience in conducting these inspections and points of failure, are being used to consider improved inspection procedures that will be used by all the CSI inspectors.

Installer

Installers must have a valid license A, B, C-10 or C-46 license. NABCEP certification is encouraged though not required. The CSI application contract requires the installer to certify the details of the installation, but unlike NSHP, there are no additional responsibilities of the installer to certify the installation as meeting all the specifications of the initial application including performance, based on using an inspection protocol.

Recommendations for Guidelines

Energy Commission staff recommends that similar to the provisions under CSI, the Performance Based incentive approach should be required for systems that are larger than 100 kW (AC), which is proposed to be changed to 50 kW (AC) by 2008 and 30 kW (AC) by 2010. The payments are made over 5 years on a monthly basis and the incentive is paid on a $/kWh basis. All systems which are smaller than 100 kW can be either under PBI or opt to use an expected performance based – incentive calculation approach.

In summary there are currently two expected performance calculation approaches:

- The CPUC's EPPB is a capacity-based estimated performance incentive approach with an adjustment, called the "design factor," that considers variables such as geographic location, azimuth and tilt of the system, shading, and aggregated equipment characteristics to provide an estimate of system performance. The result, when considering the capped design factor calculation, is to incent installations to have summer performance as good as a reference system in a mid-range climate. The incentive relies on the self-reported estimates of the nameplate rating for modules (the production line testing of actual modules are allowed to be within 10 percent of the manufacturer reported nameplate rating for UL listing purposes) and an average efficiency of the inverter over the range of conditions that the inverter may be subject to, and allows the production of the system to be the maximum output that the modules are capable of even when the size of the inverter does not allow that much output (note the

system provides a check when the inverter is sized more than 25 percent smaller than the overall PTC rating of the modules). The incentives are based on an adjusted watts rating for the system.

- The EPBI used for the NSHP is an expected performance based incentive approach based on thorough hourly modeling of the interactive performance results of the combination of detailed tested and third-party performance characteristics of the specific modules and the inverter over the range of conditions that impact component performance, addressing all installation characteristics that are expected to have significant impacts on the performance of the components. The interactive performance of the components is determined in each hour using the performance characteristics, based on the independently certified test results of each component, that would occur due to the conditions that exist in that hour. The hourly production is weighted by TDV to account for the time-of-use value to the utility system of that hour's production, and those results are then summed to obtain the annual TDV energy results for the system. The calculation is not based on self-reported nameplate ratings (usually with the 10 percent tolerance levels allowed by UL which are more geared towards addressing safety rather than performance), and the performance of the system in each hour is based on the maximum capability of the inverter in that hour. The incentives are based on the system's TDV-weighted kWh output.

Both of these systems were developed through significant effort, expense, and stakeholder input as the CEC developed the NSHP and the CPUC developed the CSI. The CEC and CPUC have both recognized the benefit of a uniform, statewide approach, and expressed the intent of achieving that if possible.

Expected Performance Calculation Methodology

Energy Commission staff recommend that the EPBI approach be used for SB 1 programs to ensure all interactive component performance characteristics, determined by independent testing, are used for establishing time-of-use (TDV) weighted kWh performance based incentives that affect the performance of an installation.

Shading

Staff recommends that the shading methodology developed and used by the NSHP (NSHP Guidebook, Appendix 4) be used as the basis for addressing shading systems installed on newly constructed buildings (residential and non residential) and on systems installed on existing buildings. This recommendation is particularly appropriate for expected performance based incentives applicants but benefits the PBI applicants[28] equally in preserving the long term

[28] There is the provision in the California Civil Code (Public Resources Code Section 25982) to preserve solar access on upto 90 percent of the area of the installation between 10 am and 2 pm. However, the performance degradation associated with even a small amount of shade can be potentially disproportionately large and needs to be addressed through avoidance of all potential shade.

(beyond the 5 year payment time frame) high performance from systems. The solar contractor or builder should be required to provide the actual owner/facility operator with a guide on their solar electric system with detailed information about future shading avoidance to ensure long term performance.

Peak load

Energy Commission staff recommends that the TDV multiplier weighted production be used to incent systems to address time-of-use peak performance.

Field Verification

Energy Commission staff recommends that systems be required to have third party field verification on a sampling basis for visually checking components, installation characteristics, shading, and verifying performance. The protocol developed for field verification under NSHP (NSHP Guidebook, Appendix 4) is appropriate for most residential installations on both new and existing construction. The protocol can be modified to address the nonresidential scale of systems, which include for example, tracking (1 and 2 axis) and concentrating type installations.

Installer

The Energy Commission Staff recommends that installers be required to have a valid license A, B, C-10 or C-46 license, and that NABCEP certification be encouraged, though not required.

Additionally, staff recommends that the installer self-certify all the aspects of the installation that are being verified during field verification. This would include the actual components used, the installation characteristics, shading and performance. The only difference in circumstances expected between the installer self-inspections and the third party field verifications is the expectation that the installer can have better access to the installation to make observations and measurements and the field verifier can not. It is the responsibility of the installer to document all proof for items that may be more easily observed and measured by the installer than by the inspector.

Other Issues for Further Consideration

Expected Performance Calculation Methodology

Both the CPUC's CSI and the Energy Commission's NSHP have independent calculators and approaches for incentive calculations. It is recognized that there has been considerable time and effort invested in the development of these approaches. SB 1, however points to a unified calculation approach for statewide use to avoid confusion in the marketplace. This staff report recommends a calculation method, but further discussions are necessary to compare both methodologies and narrow and reconcile the points of differences. In particular there are differences about the approach used for handling performance characteristics of components and installations at an hourly level, shade estimation and incentive calculations that adequately address expected performance.

Shading

Both the NSHP and CSI use a similar "minimal shading criteria" at this time, which is consistent with the recommendations. However, the CSI Shading subcommittee is considering ways to improve the effectiveness of how the CSI handles shading. Conclusions of this group should be reviewed for merit relative to the NSHP shading approaches with consideration for how the proposed NSHP guidelines can be improved further.

Peak Load

While the NSHP approach has been to recognize the peak load at the hour it occurs, the CSI approach uses just the six summer and near-summer months without recognition of time of day. It is important to consider in the calculation of the expected performance the weighting of production based on time of day and year. This is enabled by the detailed hourly calculation approach that has been suggested.

Questions for Further Consideration

- Does the proposed detailed performance calculation approach address the SB 1 intent of incentivizing high quality and high performance particularly during peak load hours?
- Is there merit to using a unified approach statewide rather than different approaches in different jurisdictions and sectors?
- Are there any market barriers to adopting the proposed approach? Could they be addressed through phased transitioning with the ultimate goal of providing incentives to high performance systems?
- What changes to the proposed calculation approach could be useful to address all solar markets and technologies statewide?
- Are there any barriers and issues related to adopting the NSHP protocol based approach for shading estimation and verification?
- Is TDV (or other TOU weighting) a good approach to incentivize systems that optimize installations to address peak load?
- Does the proposed field verification protocol have any limitations to address all the various installations and technologies of equipment? If so, can they be addressed through extending the protocol to cover outlying cases? What lessons could be learned and applied from the current CSI inspections?

CHAPTER 5: Energy Efficiency

Pertinent Senate Bill 1 Provisions:

> PRC 25782(b)(3). Establish … appropriate energy efficiency improvements in the new or existing home or commercial structure where the solar energy system is installed.

Background

Section PRC 25782(b) (3) will require applicants for a rebate for PV systems to meet established energy efficiency requirements. There are many recognized energy efficiency programs that support both new building construction and existing building efficiency improvements. These programs are operated through PGC-funded programs administered by the CPUC and POUs or are supported through federal, state and locally administered programs.

Newly Constructed Buildings

Commercial

In December of 2004, Governor Schwarzenegger signed Executive Order S-20-04 and the supporting Green Building Action Plan, together known as the Green Building Initiative (GBI). The order directs all state buildings in California to reduce energy purchased from the grid by 20 percent by the year 2015. The Order encourages private sector buildings to reduce energy use also.

This comprehensive initiative addresses how buildings are designed, constructed and operated. Section 1.1 of the Green Building Action Plan requires all new state building construction and major renovations to be constructed according to the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) standards. LEED is a nationally known program that promotes integrated design and uses a whole building approach to address sustainability. One of the five key areas this design process addresses is Energy and Atmosphere. In June of 2007, the members of the USGBC approved a requirement for all new construction projects seeking LEED certification to earn two points in the "Energy and Atmosphere" section. This equates to requiring state new construction projects to exceed the California Building Energy Efficiency Standards by at least 15 percent.

One of the most well known and widely supported Investor Owned Utility (IOU) programs for commercial new construction is "Savings By Design[29]." This is a statewide PGC funded program administered by Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison Company. Savings By Design provides technical assistance and incentives to design and construct energy efficient buildings. Incentives are available for both the owner and the design team for exceeding the California Building Energy Efficiency

[29] http://www.savingsbydesign.com/overview.htm

Standards. A design team must demonstrate that the project exceeds the Standards by a minimum of 15 percent. The Owner is also eligible for an additional incentive if the project exceeds the Standards by a minimum of 10 percent. Together, the utility and the design team present a list of efficiency options that can be incorporated into the design. It is up to the owner to accept the options presented by the utility and design team. The higher requirement for the design team encourages the team to bring as much energy efficiency input to the table for the owner to consider. The program supports the new construction project by reviewing design plans for the proposed building and provides recommendations to improve the overall efficiency of the project, taking an integrated whole building approach and modeling the building with various options that would reduce energy use. The incentive is based on the actual amount of energy that is estimated to be reduced below the T-24 compliant baseline building model.

The Energy Policy Act of 2005 provides federal tax incentives for buildings that are designed to use 50 percent less energy than a building would use if it was designed according to the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 90.1 - 2001[30]. This requirement is comparable to exceeding the 2005 California Building Energy Efficiency Standards by about 30 percent[31]. The federal tax deduction equals the cost of the energy efficiency measures installed up to a maximum tax deduction of $1.80 per square foot of the building.

Assembly Bill 32 (Nunez) is a comprehensive bill that requires California to reduce greenhouse gas (GHG) emissions to the 1990 level by the year 2020. The USGBC states if half of new commercial buildings were built to use 50 percent less energy, they would save over 6 million metric tons of CO2 for the life of the building. In May, 2007, ASHRAE, the Illuminating Engineering Society of North America (IESNA), Architecture 2030 and the USGBC entered into a memorandum of understanding (MOU) that agreed that buildings are responsible for almost half of all GHG emissions annually. Through the MOU, the consortium adopted "The 2030 Challenge." The 2030 Challenge long term goal is to design net zero energy use and carbon-neutral buildings by 2030. This is a global initiative that calls for all new buildings and major renovations to immediately reduce their greenhouse gas emitting energy consumption by 50 percent (using a combination of high energy efficiency and PVs is the most viable strategy to do so). This goal gradually increases to 60 percent in 2010, 70 percent in 2015, 80 percent in 2020, and 90 percent in 2025. ASHRAE is working closely with the IESNA and USGBC to develop a green building standard, ASHRAE Standard 189, to meet these aggressive goals. This green building standard is targeted to result in a building being 30 percent more energy efficient than

---

[30] http://www.gettingtofifty.org/

[31] Eley Associates; California 2001 vs. ASHRAE 1999; August 2001and Eley Associates, et al; Impact Analysis 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings.

if it were designed to meet the current ASHRAE Standard 90.1-2004. If compared to the 2005 California Building Energy Efficiency Standards, this would equate to about 30 percent better than those requirements also.

Residential

The Investor Owned Utilities and publicly owned utilities provide programs to support inclusion of energy efficiency measures in new home construction. The investor owned utilities for the past several years have offered incentives for exceeding Title 24 Standards by 15 percent. The IOUs also offer rebates for high efficiency HVAC systems, lighting and other measures, such as duct sealing. The Sacramento Municipal Utility District (SMUD) has the SolarSmart program for new homes. A photovoltaic system and energy efficiency measures, such as attic radiant barrier, 90 percent efficient furnace, 14 SEER/ 12 EER air conditioning and ENERGY STAR windows are achieved.

Newly constructed residential buildings applying for PV incentives through the NSHP are expected to achieve high levels of energy efficiency. NSHP uses a two Tier system. Tier I is the minimum level necessary for an applicant to qualify for PV incentives. Tier II, the Energy Commission's preferred level, encourages applicants to differentiate their projects with higher energy efficiency. The two levels are designed to match the energy efficiency requirements of major energy efficiency programs in which California builders participate. Tier I is consistent with the 15 percent better than Title 24 criteria required to qualify for the current new residential construction programs administered by the California Investor Owned Utilities (IOUs). Tier II equals the energy efficiency levels achieved by California builders who participate in the U.S. Department of Energy's Building America program (35 percent better than Title 24 on a total energy basis and 40 percent better than Title 24 considering cooling energy alone). Both Tiers require appliances installed by builders to meet ENERGY STAR requirements.

Existing Buildings

Determining appropriate levels of energy efficiency in existing buildings is a substantially different matter than for newly constructed buildings. Existing buildings vary in age and the level of energy efficiency features that have already been installed. The California Building Energy Efficiency Standards first went into effect in 1978 with regular updates approximately every three years. This progression results in different levels of energy efficiency measures typically installed to meet the Standards depending on what Standards were in place at the time of construction. Also, buildings have been retrofitted with energy efficiency measures over time, sometimes coinciding with renovations or tenant improvements. In addition, the energy use of the buildings can often be reduced substantially by improved maintenance and improved operational practices. Also, efficiency of a building often decreases over time due to system decay, effective useful life and replacement of equipment with the least cost option. As a result, efficiency opportunities in existing buildings will vary depending on the circumstances of the individual building

For existing buildings it is important to make an assessment of the current energy use and the existing condition of the building to identify energy efficiency improvement opportunities. Approaches to accomplish that include benchmarking, energy audits, home energy ratings (HERS ratings), building performance contractor assessments, and building commissioning.

Commercial

Commonly used tools to identify and assess energy efficiency opportunities in existing commercial buildings, listed in order from least to most comprehensive, are benchmarking, an energy audit, and building retro-commissioning. All of these tools are supported by PGC funded energy efficiency programs, and enable the evaluation of the existing condition of the building and determination of cost effective operational and energy efficiency improvements.

Benchmarking is the process in which building owners can assess their building's energy use and compare it to other similar buildings. The energy use per square foot of building space, is compared with (benchmarked to) the energy use of other buildings of the same type and location. Benchmarking is also useful to track a specific building's performance over time. Benchmarking is a requirement of the Green Building Initiative (GBI) for state buildings and recommended for all commercial buildings (note that the CPUC is directed by the GBI to facilitate benchmarking for all commercial buildings). Section 1.1.2.3 of the Green Building Action Plan directs all state owned buildings to be benchmarked[32].

The USGBC's LEED for Existing Buildings (LEED-EB) rating system requires the use of an online energy benchmarking program called Portfolio Manager, developed and maintained by the US EPA (www.energystar.gov). LEED EB is a comprehensive rating system that measures and tracks building systems operation and maintenance and other strategies for reducing a building's environmental impacts. The system has five topic areas of sustainability that help to identify needed improvements to building systems in those five key areas and tracks improvements completed. In order to receive a LEED EB certification, the building must have an ENERGY STAR rating of 75 or better from Portfolio Manager. A building also receives an award and plaque from ENERGY STAR for achieving a rating of 75 or greater. This rating is based on the Commercial Building Energy Consumption Survey (CBECS) database. This is a representative sample survey that collects data based on building characteristics, energy consumption, and energy cost for commercial buildings in the United States. Achieving a rating of 75 means that the candidate building is at the 75th percentile based on the range of buildings included in the survey. This tool lets the user know how the building compares with the energy used by other similar buildings nationally. The Green Building Initiative requires all state buildings and recommends that all commercial buildings in the state larger than 50,000 square

[32] The GBI also requires all state buildings and recommends that all commercial buildings that are larger than 50,000 square feet have a building commissioning assessment, and make all repairs, operational changes and energy efficiency improvements found to be cost effective by the building commissioning process.

feet meet at least LEED for Existing Building standards including an ENERGY STAR rating of 75 or better to the maximum extent cost effective[33]. However, it is important to note that the Portfolio Manager tool does not cover all of the building types found in California's commercial sector so an ENERGY STAR rating is not universally achievable.

In the Energy Commission Report, Benchmarking System for California Commercial Buildings[34], the Energy Commission recommended the use of the U.S. EPA's Energy Star Portfolio Manager (PM) as a starting point to benchmark the energy performance of commercial buildings in California. The Commission also committed Public Interest Energy Research (PIER) funds towards two projects to specifically address limitations in current commercial building energy benchmarking tools. The first project is comparing energy use in California commercial buildings to national data, to determine the appropriateness of using the national PM tool to benchmark California buildings. The interim project results indicate that there are some building types where the PM tool adequately represents California buildings, but other building types where it may be best to develop a benchmarking approach that is specific to California. The second PIER project is developing a prototype for a new type of energy benchmarking tool. The intent of this project is to use the detailed information on energy characteristics available from the California Commercial End Use Survey to provide a tool that offers comparative information about heating, cooling, ventilation and lighting energy use, so that CA building decision-makers can identify areas within their building where energy saving opportunities exist. Use of this new type of benchmarking tool may fill the gap between the whole building benchmarking tools such as PM and the onsite energy audit.

The energy audit has long been used in commercial applications. An energy audit evaluates the existing conditions of a building's energy using systems (typically lighting and HVAC systems) and building features, and prioritizes the energy saving improvements according to the greatest to least cost effective. Energy audits can be done at varying levels of intensity ranging from "walk through" audits to "engineering" audits. To achieve a systematic level of consistency of audits over a range of buildings, a protocol is necessary to identify what will be addressed by the audit and what audit tools will be used.

Existing building commissioning, also known as retro-commissioning, is a process to identify how major energy using equipment are being operated and maintained and to identify specific improvements to the performance of those energy using systems.

---

[33] The Energy Commission's Public Interest Energy Program is developing Cal-Arch, which is another online benchmarking tool that provides a comparison of energy use per square foot with other buildings that are in California in similar climate zones and are in the same square footage range and same building type.

[34] Benchmarking System for California Commercial Buildings, California Energy Commission, CEC-400-2005-051CMF, September 2005.

The process uses a whole building systems approach to identify problems and needed repairs or adjustments to achieve energy savings, occupant comfort and improved systems performance as a result. A commissioning agent identifies and makes the necessary equipment adjustments and identifies energy efficiency projects that will improve overall building performance. Retro-commissioning projects can produce energy savings of 5-20 percent of total building energy costs, with a simple payback averaging less than 2 years[35].

The investor owned utilities provide PGC funding to support commissioning. The Green Building Action Plan requires that state buildings and recommends that all commercial buildings over 50,000 square feet be retro-commissioned and then re-commissioned every five years after that. Whenever any major energy using equipment is replaced it is also required to be commissioned.

The energy efficiency improvements identified in building commissioning and energy audits may qualify for federal tax incentives and utility rebates. Federal tax Incentives are provided for lighting, HVAC and building envelope improvements. The investor owned utilities are currently providing rebates for lighting, central air conditioning duct sealing, boilers and water heating, food service equipment, HVAC, refrigeration and some appliances.

Residential

One way to begin to determine energy efficiency improvements is to identify the home's energy use per square foot and compare that to the energy use per square foot of similar homes in similar climates. This process is called "targeting" from an energy efficiency program planner's point of view. It can provide direction on the likelihood that cost effective energy efficiency improvements can be achieved. There are several options available to assess a home's energy performance. Listed in order from least to most extensive and sophisticated, these include: 1) online audit or phone audit, 2) onsite energy audit, 3) Home Energy Rating System (HERS) rating, and 4) Whole House or Building Performance Contractor assessment. An online energy audit is a self-completed audit where the homeowner answers a series of questions online and receives suggestions for how to reduce energy use based on that cursory information. A variant of the online energy audit is the "phone-in" audit which is a similar quick survey administered by a person over the phone. California utilities often offer online and sometimes phone-in audits. They commonly recommend behavioral changes as well as measures for which the utility offers incentives.

An onsite energy audit is a more thorough investigation by a trained person who makes a visual inspection of a home, including the amount of insulation in the ceiling, age and condition of the water heater, Heating, Ventilation and Air Conditioning (HVAC) equipment, refrigerator, cooking stove, lighting, controls, pool and spa, and other equipment and features of the home that may affect energy use. The auditor makes a utility bill analysis and identifies energy

[35] www.sce-rcx/learn_about.html

efficiency improvements that could be made. No actual diagnostic testing is performed nor are repairs made or efficiency improvements installed. A report is provided that summarizes the condition of the areas inspected, identifies installed efficiency technologies, and prioritizes recommended cost effective energy efficiency projects that can be implemented.

A HERS rating also provides an investigation of the energy efficiency improvement opportunities in the home. This service is provided by a certified professional, and includes a detailed onsite energy audit, identifies the energy efficiency opportunities and evaluates their cost effectiveness. The HERS rater inspects insulation and window performance, heating and cooling system rated efficiency, and building envelope and duct air leakage. HERS raters commonly use diagnostic equipment in the evaluation to assess HVAC and duct performance. After the inspection, the rater will provide a report that includes an estimation of annual energy use and costs. The report also includes recommended energy improvements ranked in order of cost effectiveness, the cost of the improvements and the annual energy cost savings if the improvements are made. The rater may produce a rating of the house on a comparative scale before and after the improvements are made. A HERS rating is different from an energy audit primarily in terms of the use of the diagnostic testing, which is not commonly done by an energy auditor. HERS raters do not perform the work to make the improvements.

Whole House or Building Performance Contractors assess the energy performance of the "house as a system," focusing on extensive diagnostic evaluation. Licensed contractors who have in depth training on performing whole house diagnostic testing evaluate heating and cooling equipment, insulation performance, and air infiltration. They perform in-depth analysis of the HVAC system (including refrigerant charge and airflow), duct work and building envelope. They commonly perform more comprehensive diagnostic testing than HERS raters and make the needed adjustments, repairs or improvements. The whole house building performance contractor process is endorsed by the United States Environmental Protection Agency (USEPA) ENERGY STAR[36], who together with the Department of Energy (DOE) sponsor a program called "Home Performance with ENERGY STAR[37]."

The investor owned and a majority of the publicly owned utilities also have public goods charge funded programs that provide incentives for energy efficiency measures. These rebate or financing programs commonly provide incentives for clothes washers, dishwashers, water heaters, wall and attic insulation, air conditioners, gas furnaces, duct sealing, heat pumps and pool/spa pumps.

[36] http://www.sustainablespaces.com/services.html

[37] http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_hpwes

New Solar Homes Partnership Provisions

The NSHP administered by the Energy Commission, has established a two tier energy efficiency criteria expressed in terms of a percentage beyond the California Building Energy Efficiency Standards requirements. Tier I is the minimum level of energy efficiency necessary for a builder to qualify for NSHP PV incentives. Tier I requires a 15 percent reduction in the residential building's combined space heating, cooling and water heating energy compared to the current California Building Energy Efficiency Standards.

Tier II is the Energy Commission's preferred efficiency level that encourages buildings to further differentiate their projects. The Tier II level requires a 35 percent reduction in the residential building's combined space heating, cooling and water heating energy and 40 percent in the residential building's cooling energy compared to the current California Building Energy Efficiency Standards. Additionally, for either Tier I or Tier II, appliances provided by the builder for the new home must be ENERGY STAR appliances if an ENERGY STAR designation is applicable for that appliance.

The NSHP Tiers are based on levels of energy efficiency called for by other prominent California residential new construction programs. The Tier I level was based on the efficiency requirement of the California investor owned utility new construction programs. Since January of 2006, this program requires new homes to be 15 percent more efficient than the 2005 California Building Energy Efficiency Standards. The Tier II level matches the energy efficiency improvements needed for California new homes to participate in the US Department of Energy's Building America Program. The Energy Commission supports the Building America goal to move new homes towards achievement of zero net energy homes.

The NSHP also requires installer and third-party, HERS rater, field verification of compliance with the energy efficiency requirements, consistent with the protocols and procedures used by the Building Energy Efficiency Standards and IOU residential new construction programs.

California Solar Initiative Provisions

The current CSI administered by the CPUC, provides incentives for solar systems installed in existing residential buildings and new and existing commercial buildings. The CSI program requires existing home or building applicants to:

- Complete an energy audit through the applicant's utility provider; at a minimum an online or phone-in energy audit must be completed
- In lieu of an energy audit, applicants can instead provide:
    - proof of Title 24 energy compliance within the last three years
    - an energy audit report summary that has been completed within the last three years through the customer's local utility company
    - a Home Energy Inspection Report

- a Home Energy Rating from a certified Home Energy Rating System (HERS) rater
- a valid certification through the United States Green Building Council's LEED (requires an ENERGY STAR rating of at least 75)
- a valid certification through the United States Environmental Protection Agency's ENERGY STAR program (requires an ENERGY STAR rating of at least 75)

- Currently, there is no CPUC requirement to implement cost effective efficiency measures identified in the energy audit. However, the CPUC plans to review the policy for energy efficiency requirements for the CSI program.

Recommendations for Guidelines

Newly Constructed Buildings

Residential

The Energy Commission staff recommends that the NSHP Tier I and Tier II criteria be incorporated into the solar incentive programs operated by utilities for all residential newly constructed buildings statewide. The Tier II level is consistent with the CPUC proposed Big/Bold Energy Efficiency Strategies.

Staff recommends that investor owned and publicly owned utilities be strongly encouraged to provide PGC funded energy efficiency incentives for each tier.

Commercial

The Energy Commission staff recommends a Tier structure for newly constructed commercial buildings similar to the NSHP. Staff recommends that Tier I be the minimum requirement for qualifying for solar incentives and set to be 15 percent beyond the California Building Energy Efficiency Standards. This requirement is in line with the goals of Executive Order S-20-04 and the energy efficiency requirements of Savings by Design and LEED New Construction.

To contribute to the Administration's Climate Action Initiative and the Assembly Bill 32 greenhouse gas emissions limit, the staff recommends a preferred Tier II requirement that is 30 percent beyond the California Building Energy Efficiency Standards. This Tier II level is in line with the immediate goal of the 2030 Challenge, the new ASHRAE Standard 189, the Federal tax credit, and is consistent with the CPUC proposed Big/Bold energy efficiency programs strategies.

Staff recommends that investor owned and publicly owned utilities provide PGC funded energy efficiency incentives for each Tier.

Existing Buildings

Commercial

Energy Commission staff recommend that existing commercial buildings seeking ratepayer funded incentives for PV systems should at a minimum meet the Green Building Initiative, as delineated in section 1.1.2 of the Green Building Action Plan. All commercial buildings seeking solar energy system incentives should benchmark their energy use intensity (EUI) using Portfolio Manager or an equivalent system for building types that cannot receive an ENERGY STAR rating. If the rating is at 75 or above, and the building is equal to or smaller than 50,000 square feet, then no further action should be required for the owner to receive the incentive for the PV system. If the score is below 75 and for all buildings greater than 50,000 square feet, retro-commissioning should be completed. Equipment repairs and adjustments identified in the building commissioning assessment and cost effective energy efficiency measures should be implemented up to those measures required to move the building's benchmarking rating up to ENERGY STAR rating of 75. If equipment/appliance replacement is recommended during the retro-commissioning process, it should be replaced with ENERGY STAR equipment or equipment that qualifies for utility measure-specific incentives, whichever is more efficient. Utilities should provide PGC funds for the retro-commissioning and for the installation of cost effective efficiency measures.

Residential

Energy Commission staff recommend that the CPUC's current requirement for an online audit be continued at this point in time. Staff recommends that the CPUC sponsor an investigation to determine the results of the CSI required audit and determine what measures have been installed by the applicants. This investigation could provide information useful for the development of future program requirements.

Energy Commission staff proposes the following concepts for achieving cost effective energy efficiency improvements for existing residential buildings. Staff recommends first that California utilities develop a targeting system that would enable comparison (benchmarking) of an individual home's energy use per square foot to the range of energy use of the utility's residential customers for the purpose of identifying what quartile of energy use per square foot the home falls into. Based on this information the home can be targeted to identify what level of investigation or assessment would be appropriate to determine cost effective energy efficiency improvements specifically for that home.

This conceptual idea would establish a system for existing homes conceptually similar to the benchmarking process for existing commercial buildings. Homes that fall into the best quartile of energy use per square foot, 75 percent to 100 percent (termed the "75 percent quartile") would continue to follow the CSI program requirements and use the online (or phone-in)

energy auditing tool provided by the utility[38]. The homeowner should implement those cost effective energy efficiency measures that are identified in the audit for which the utility provides measure-specific incentives.

Homes in the lower quartiles are prime candidates for further onsite investigation or assessment. Options to complete that assessment or investigation include an onsite energy audit, HERS rating or building performance contractor assessment. The homeowner should install cost effective measures identified in the assessment up to the level needed to move the home's energy use per square foot to the 75 percent quartile.

This concept needs to be further developed and would require the utilities to identify the range of home energy use among their customers, and then make that information available to the homeowner. The details for procedures to determine how cost effectiveness would be assessed also would need to be developed. Also, there may be an increase in demand for the services of energy auditors, HERS raters and whole building performance contractors and plans for how those services would be adequately provided need to be developed.

Other Issues for Further Consideration

Coordination and development of utility programs to support the energy efficiency requirements that will meet the requirements of SB 1 need to be addressed. The utilities will need to develop programs and provide incentives that meet cost effectiveness test requirements of the CPUC and POU administrators.

Consideration may also need to be given to limit the cost of required energy efficiency measures for existing buildings in comparison to the total cost of the PV system. Currently, cities such as the City of San Francisco and the City of Berkeley have requirements for property owners to make energy efficiency improvements before the transfer of ownership of the property and there is a maximum limit on the funding required to be spent on these measures as a percentage of the value of the building.

Commercial

To support the recommendation of using a commissioning agent to assess energy using systems and specific equipment and identify efficiency improvements will require a continued growth in the number of engineering and/or commissioning firms that offer these services. Commissioning is no longer a new concept and it is expected that as the demand for this service grows, the engineering industry will respond and will continue to expand their services to include the commissioning task. The California Commissioning Collaborative (http://www.cacx.org/) can assist the building owner or operator in identifying a commissioning

[38] The current CPUC exception that waives the audit for homes built within the past three years should be continued.

agent. Utilities will want to consider programs that support retrocommissioning for those projects seeking PV incentives.

Residential

Once a home has been assessed, recommendations have been made, and efficiency measures installed, verification should be made on a sampling basis to insure that these efficiency measures were in fact installed and installed properly. A HERS rater could be used to accomplish this verification. The NSHP requires a HERS rater to verify that the energy efficiency measures are properly installed to assure they will perform as expected. This same process could be used for existing residential homes.

Questions for Further Consideration

The Energy Commission staff seeks stakeholder input on the recommendations contained in this report, recommendations to meet the directives of Senate Bill 1, California Solar Initiative goals, and which also support statewide energy efficiency policies.

- Are these proposals the best way to achieve the energy efficiency goals of SB 1, and the state's loading order? What other approaches should be considered? If a prescriptive approach is proposed, how would these measures be identified and applied?
- What will the effect of these or similar energy efficiency eligibility requirements be on solar demand and deployment? How can we most effectively move to approaches that will accomplish both solar and energy efficiency?
- How should the cost-effectiveness of energy efficiency requirements in SB 1 guidelines be calculated and incorporated in program protocols?

CHAPTER 6: Other Eligibility Criteria Established in Statute

Pertinent SB 1 provisions:

There are a number of eligibility criteria that are established in the statute (Senate Bill 1) itself. These eligibility criteria include the following:

> PRC 25782(a)(2). The solar energy system is intended primarily to offset part or all of the consumer's own electricity demand.
>
> PRC 25782(a)(3). All components in the solar energy system are new and unused, and have not previously been placed in service in any other location or for any other application.
>
> PRC 25782(a)(4). The solar energy system has a warranty of not less than 10 years to protect against defects and undue degradation of electrical generation output.
>
> PRC 25782(a)(5). The solar energy system is located on the same premises of the end-use consumer where the consumer's own electricity demand is located.
>
> PRC 25782(a)(6). The solar energy system is connected to the electrical corporation's electrical distribution system within the state.
>
> PRC 25782(a)(7). The solar energy system has meters or other devices in place to monitor and measure the system's performance and the quantity of electricity generated by the system.
>
> PRC 25782(a)(8). The solar energy system is installed in conformance with the manufacturer's specifications and in compliance with all applicable electrical and building code standards.

Background

System Sizing

Consistent with section PRC 25782(a)(2), the solar system should be appropriately sized to produce only as much energy as is consumed on site.

System Warranty

The SB 1 warranty requirement on the whole system will serve to ensure production throughout the life of the warranty and protect against faulty components with short lifetimes.

New and Unused Equipment

The requirement for new and unused equipment is vital to ensure only certified and quality components are installed, maximizing the effectiveness and life of the system. Requiring that the components have not previously been placed in service in any other location or for any

other application guarantees that existing solar systems are not un-installed then re-installed elsewhere in order to take double advantage of rebate funds.

Grid Connected

Eligible systems must be permanently interconnected to the electrical distribution grid of the utility serving the customer's electrical load. This utility must also be one of the in-state electrical corporations which collect funds to support the program.

Performance Monitoring and Maintenance

The use of Performance Monitoring and Reporting Services (PMRS) is critical to the PBI incentives approach and desirable for all systems to enable alerts on low performing systems to allow for timely maintenance and repair and correction of shading problems that may occur over the lifetime of the system. Detecting unexpected outputs or changes in the normal output of the system will allow the customer to be aware and take appropriate action should their system become damaged, faulty or shaded. The service providers typically remotely monitor the system over broadband or other communications medium. The inverter or performance meters in these cases need to be able to interface with the communication protocols. The cost of the service is the only barrier to PMRS services for a system owner.

To ensure that the system produces maximum output over the system's expected life, ongoing maintenance is important. System performance can be compromised by several factors including dirt building up on the panels, loose or faulty electrical connections, failed components and shading. Developing a maintenance plan that limits these problems is important to a functional PV system. PMRS when coupled with maintenance service can be very beneficial to ensure the output of a system over long term, as long as the PMRS is cost viable.

New Solar Homes Partnership Provisions

Sizing

A 5 kW system size threshold was set as the maximum size allowed before the applicant is required to prove that the installed system will not produce more electricity than the estimated annual onsite electricity consumption. This threshold assumes that the systems sized 5 kW or lower are already in compliance with the requirement based on the average annual residential electricity consumption in California, which is 7000 kwh/year. The system can be sized larger if a qualified professional demonstrates that the load that the solar system will serve is larger than 5 kW. For systems that are proposed that exceed the expected load, the incentive amount is limited by the estimated annual electricity consumption by the new home.

Warranty

A warranty of the installed system must cover at least the first 10 years of operation and include the PV modules (panels), inverters, and meters. This warranty must include protection against defective workmanship, system or component breakdown or degradation in electrical output of more than 15 percent from the originally rated electrical output during the first ten-years.

Moreover the minimum ten-year warranty must provide for no-cost repair or replacement of the system or system components, including any associated labor during the warranty period.

New and Used Components

All components in the solar energy system should be new and unused, and should not have previously been placed in service in any other location or for any other application. Also, all equipment must be listed on the Energy Commission's eligible equipment list at the time of approval. Equipment purchased or installed more than 24 months before applying for a reservation is not eligible.

Grid Connected

Eligible PV systems must be permanently interconnected, and installed in accordance to applicable electrical and building codes as well as manufacturer's specifications, to the electrical distribution grid of the utility serving the customer's electrical load. This utility must also be one of the in-state electrical corporations which collect funds to support the program.

Performance Monitoring and Maintenance

NSHP currently only requires affordable housing applicants to provide a maintenance and monitoring plan. The plan is to be provided to the building or property manager and should outline specific maintenance, monitoring, and inspections that need to take place to ensure that the system produces maximum output over the system's expected life. Following are some items that must be addressed by the maintenance and monitoring plan:

- Cleaning schedule for the module array of dirt and dust build up.
- Periodic checking of electrical connections for corrosion and erosion.
- Checking the inverter for instantaneous power and long term energy output and diagnosing and taking corrective action if production is significantly lower than expected.
- Checking for tree/plant growth or other obstructions that are causing shading on the array and taking action to eliminate that shading.

California Solar Initiative Provisions

Sizing

CSI administrators proposed to use a 5 kW threshold to begin requiring sizing justification in order to ease the administrative burden on installers serving small systems, which will go into effect if approved by the CPUC. All sized systems may not exceed the actual energy consumed during the previous 12 months at the site as calculated by the following equation:

$$\text{Maximum System Capacity (kW)} = \text{12-months previous energy usage (kWh)} / (0.18 \times 8760 \text{ hours/year})$$

Justification for the sizing of the system must be provided by the applicant at the time of the initial application.

Warranty

A warranty of the installed system must cover at least the first 10 years of the system and cover the solar generating system (including the PV modules [panels], inverters, and meters). This warranty must include protection against defective workmanship, system or component breakdown or degradation in electrical output of more than 15 percent from the originally rated electrical output during the first ten-years.

Except for systems that are self-installed, the minimum ten-year warranty must provide for no-cost repair or replacement of the system or system components, including any associated labor during the warranty period. In the case of systems that are self-installed, the warranty need not cover the labor costs associated with removing or replacing major components because any repairs would be done by the self-installer or at the self-installer's expense.

New and Unused Equipment

All equipment eligible for CSI incentive needs to be new and unused.

Grid Connected

Eligible PV systems must be permanently interconnected, installed in accordance with applicable electrical and building codes as well as manufacturer's specifications, to the electrical distribution grid of the utility serving the customer's electrical load. This utility must also be one of the in-state electrical corporations which collect funds to support the program.

Performance Monitoring and Maintenance

All systems taking the EPBB incentives approach are required to have a Performance Monitoring and Reporting Service (PMRS), just as systems over 20 kW, unless the cost of the PMRS is above a specified cost cap (the cost of the minimum metering, communication, and reporting system over the first five years shall be less than 1 percent of total installed cost for systems up to 30 kW and 0.5 percent for larger systems). The customer seeking exemption must demonstrate to the Program Administrator that they were not able to satisfy the metering requirements within the applicable cost cap. All PBI customers are required to show a contract with a PMRS for five years.

The CSI handbook does not require any maintenance service or plan for any system.

Recommendations for Guidelines

System Sizing

CSI and NSHP currently address SB 1 requirements for system sizing. Systems receiving incentives must be appropriately sized to offset no more than the actual or expected electricity use of the building they serve.

Warranty

CSI and NSHP currently address the SB 1 requirement for a system warranty. All systems must have a 10 year warranty to protect against faulty equipment, workmanship and undue loss in production.

New and Unused Equipment

As in the existing CPUC and CEC programs, all equipment must be new and unused, and not be relocated from a previous installation except where it remains on the same site and within a prescribed period for relocation.

Performance Monitoring and Maintenance

Energy Commission staff recommend that a third party monitoring of system performance be required as long it is economically reasonable, by setting a cost cap on systems under an expected performance based incentive mechanism, using the approach taken by CSI. All systems under PBI need to show a five year service contract with a PMRS. The approval of a PMRS should be based on the communication protocol being developed by the metering subcommittee for CSI.

Energy Commission staff recommend that a maintenance plan be required for all systems installed on newly constructed affordable housing and for all other systems that are over 10 kW. The maintenance plan should address at a minimum the following considerations:

- Cleaning schedule for the module array of dirt and dust build up.
- Periodic checking of electrical connections for corrosion and erosion.
- Checking the inverter for instantaneous power and long term energy output and diagnosing and taking corrective action if production is significantly lower than expected.
- Checking for tree/plant growth or other obstructions that are causing shading on the array and taking action to eliminate that shading.

CHAPTER 7: Guideline Development and Implementation Schedule

Guideline Schedule

Pertinent Senate Bill 1 provisions:

> PRC 25784. The [Energy] commission shall adopt guidelines for solar energy systems receiving ratepayer funded incentives at a publicly noticed meeting offering all interested parties an opportunity to comment. Not less than 30 days' public notice shall be given of the meeting required by this section, before the commission initially adopts guidelines. Substantive changes to the guidelines shall not be adopted without at least 10 days' written notice to the public

Senate Bill 1 requires the Energy Commission to "… adopt a set of guidelines for solar energy systems at a publicly noticed meeting…" This staff report is a basis for discussion on implementing Senate Bill 1 requirements not already addressed by CSI and NSHP. Information contained in this report, input from the interested public, IOUs, municipal utilities and other interested parties will be used to develop the guidelines. The Energy Commission's time schedule for developing and adopting the guidelines is as follows:

- 8/22/07 – Committee Workshop on Staff Report, Eligibility Criteria and Conditions for Incentives
- 9/20/07 – Staff Draft Guidebook posted for public comments
- 10/4/07 – Committee Workshop for public input on Staff Draft Guidebook
- 12/19/07 – Commission Adoption of Guidebook

Transition

Pertinent Senate Bill 1 provisions:

> PRC 25782(a). The [Energy] commission shall, by January 1, 2008, in consultation with the Public Utilities Commission, local publicly owned electric utilities, and interested members of the public, establish eligibility criteria for solar energy systems receiving ratepayer funded incentives …
>
> PUC 387.5(c). A local publicly owned electric utility shall initiate a public proceeding to fund a solar energy program … The public proceeding shall be completed and the comprehensive solar energy program established by January 1, 2008.
>
> PUC 2851(a)(2). The commission [PUC] shall adopt a performance-based incentive program … by January 1, 2008 …

> PUC 2851(a)(1). … The commission [PUC] shall determine the eligibility of a solar energy system … until the time the State Energy Resources Conservation and Development Commission establishes eligibility criteria

In order for publicly owned utilities and the CPUC to have solar energy programs that meet the deadlines established by SB 1, they need to develop, publicly review and adopt those programs prior to the deadline imposed by SB 1 for the Energy Commission to adopt the eligibility criteria (and conditions for incentives and component rating standards) that the publicly owned utilities and the CPUC programs are required to be consistent with.

The CPUC launched the California Solar Initiative on January 1, 2007. That program is in effect and operating. SB 1 would explicitly allow the CPUC to continue operating under those guidelines until the Energy Commission's guidelines are adopted.

Publicly owned utilities either already have solar energy programs in place (e.g., SMUD, City of Roseville) or are in the process of adopting such programs (e.g., LADWP). Publicly-owned utilities often operate their programs on a fiscal year (July 1 to June 30) basis rather than a calendar year (January 1 to December 31) basis. Thus, to meet the SB 1 January 1, 2008 program start deadline, they may need to complete their program design work in time for budget planning or maybe even program rollout on July 1, 2007.

The CPUC and the publicly owned utilities would reasonably want to have the Energy Commission's guidelines for eligibility criteria (and conditions for incentives and component rating standards) in place long before the SB 1 deadlines for their programs to be rolled out. Ideally, the Energy Commission's guidelines would be in place long in advance of the major program planning that is needed to revise existing programs or initiate new ones and would allow for public review of the resultant proposed CPUC and publicly owned utility programs. That would allow for a reasonable transition period between guideline approval and program start.

Program participants have frequently pointed out to program administrators that abrupt changes in program requirements are disruptive and discourage participation. It is logical for the CPUC's program or the existing or soon to be established publicly owned utilities' programs to be allowed a substantial transition period before the Energy Commission's guidelines take effect to reduce this type of disruption.

In addition, stakeholders will need time to transition to the eligibility requirements and conditions for incentives. Not only will the requirements affect the PV industry, but it will also affect the providers of energy efficiency services.

The PV system component industry will need time to get their products tested to meet the eligibility criteria.

Time will also be needed to insure that there are an adequate number of trained energy efficiency service providers, including energy auditors, HERS raters, building performance contractors and building commissioning agents.

Utilities and program administrators will need to plan for expanded solar and residential and commercial energy efficiency programs. The California Public Utilities Commission will need to approve utility solar and energy efficiency programs that will support the Guidelines adopted by the Energy Commission.

Recommendations for implementation of Guidelines

Energy Commission staff recommends that the required effective date for conformance with the guidelines for eligibility criteria and conditions established by the Energy Commission be January 1, 2009.

This transitional period will allow for utilities to develop and implement programs that support the energy efficiency requirements and that meet the CPUC and POU test requirements for cost effectiveness.

During this transitional period staff recommends formation of a working group to further develop the concepts discussed in this report for existing residential energy efficiency requirements. Staff also recommends a review of the results of the online and phone in energy audit now required by the CSI program. A review of the results of these audits will provide information on how that requirement is raising public awareness of installing cost effective energy efficiency improvements. That information can be used in the development of energy efficiency requirements for existing residential buildings for a future SB 1 guideline update.

Appendix 1

Senate Bill 1 (Murray, Statutes of 2006)

SB 1 (2006) directed the California Energy Commission to adopt eligibility criteria and conditions for ratepayer incentives for solar energy systems administered by the Energy Commission, the California Public Utilities Commission and local publicly owned electric utilities. The following language from SB 1 applies to this directive.

Legislative Counsel's Digest

… This bill would require the Energy Commission, by January 1, 2008, and in consultation with the PUC, local publicly owned electric utilities, and interested members of the public, to establish and thereafter revise eligibility criteria for solar energy systems and to establish conditions for ratepayer funded incentives that are applicable to the California Solar Initiative. The bill would require the Energy Commission to adopt guidelines for solar energy systems receiving ratepayer funded incentives at a publicly noticed meeting. The bill would, upon establishment of eligibility criteria by the Energy Commission, prohibit ratepayer funded incentives from being made for a solar energy system that does not meet the eligibility criteria. …

This bill would require the PUC, in implementing the California Solar Initiative, to authorize the award of monetary incentives for up to the first megawatt of alternating current generated by an eligible solar energy system, that meets the eligibility criteria established by the Energy Commission. The bill would authorize the PUC, prior to the establishment of eligibility criteria by the Energy Commission, to determine the eligibility of a solar energy system, as defined, to receive monetary incentives. … The bill would require the PUC, by January 1, 2008, to adopt a performance-based incentive program, as specified. The bill would require that the PUC, by January 1, 2008, and in consultation with the Energy Commission, require reasonable and cost-effective energy efficiency improvements in existing buildings as a condition of providing incentives for eligible solar energy systems.

This bill would require all local publicly owned electric utilities, as defined, that sell electricity at retail, on or before January 1, 2008, to adopt, implement, and finance a solar initiative program, as prescribed …

The people of the State of California do enact as follows:

SECTION 1. (a) The Legislature finds and declares that the Public Utilities Commission (PUC) adopted the California Solar Initiative in Decision 06-01-024.

(b) Nothing in this act shall be construed to codify PUC Decision 06-01-024.

SECTION 2. Section 25405.5 is added to the Public Resources Code

25405.5. (a) As used in this section …

(3) "Solar energy system" means a solar energy device that has the primary purpose of providing for the collection and distribution of solar energy for the generation of electricity, that produces at least one kW, and not more than five megawatts, alternating current rated peak electricity, and that meets or exceeds the eligibility criteria established pursuant to Section 25782.

SECTION 4. Chapter 8.8 (commencing with Section 25780) is added to Division 15 of the Public Resources Code …

25782. (a) The [Energy] commission shall, by January 1, 2008, in consultation with the Public Utilities Commission, local publicly owned electric utilities, and interested members of the public, establish eligibility criteria for solar energy systems receiving ratepayer funded incentives that include all of the following:

(1) Design, installation, and electrical output standards or incentives.

(2) The solar energy system is intended primarily to offset part or all of the consumer's own electricity demand.

(3) All components in the solar energy system are new and unused, and have not previously been placed in service in any other location or for any other application.

(4) The solar energy system has a warranty of not less than 10 years to protect against defects and undue degradation of electrical generation output.

(5) The solar energy system is located on the same premises of the end-use consumer where the consumer's own electricity demand is located.

(6) The solar energy system is connected to the electrical corporation's electrical distribution system within the state.

(7) The solar energy system has meters or other devices in place to monitor and measure the system's performance and the quantity of electricity generated by the system.

(8) The solar energy system is installed in conformance with the manufacturer's specifications and in compliance with all applicable electrical and building code standards.

(b) The [Energy] commission shall establish conditions on ratepayer funded incentives that require all of the following:

(1) Appropriate siting and high quality installation of the solar energy system by developing installation guidelines that maximize the performance of the system and prevent qualified systems from being inefficiently or inappropriately installed. The conditions established by the commission shall not impact housing designs or densities presently authorized by a city, county, or city and county. The goal of this paragraph is to achieve efficient installation of solar energy systems to promote the greatest energy production per ratepayer dollar.

(2) Optimal solar energy system performance during periods of peak electricity demand.

(3) Appropriate energy efficiency improvements in the new or existing home or commercial structure where the solar energy system is installed.

(c) The [Energy] commission shall set rating standards for equipment, components, and systems to assure reasonable performance and shall develop standards that provide for compliance with the minimum ratings.

(d) Upon establishment of eligibility criteria pursuant to subdivision (a), no ratepayer funded incentives shall be made for a solar energy system that does not meet the eligibility criteria.

25784. The [Energy] commission shall adopt guidelines for solar energy systems receiving ratepayer funded incentives at a publicly noticed meeting offering all interested parties an opportunity to comment. Not less than 30 days' public notice shall be given of the meeting required by this section, before the commission initially adopts guidelines. Substantive changes to the guidelines shall not be adopted without at least 10 days' written notice to the public.

SECTION 5. Section 387.5 is added to the Public Utilities Code …

(d) The solar energy program of a local publicly owned electric utility shall be consistent with … :

(1) That a solar energy system receiving monetary incentives comply with the eligibility criteria, design, installation, and electrical output standards or

incentives established by the State Energy Resources Conservation and Development Commission pursuant to Section 25782 of the Public Resources Code.

SECTION 7. Section 2851 is added to Chapter 9 of Part 2 of Division 1 of the Public Utilities Code …

The commission [PUC] shall authorize the award of monetary incentives for up to the first megawatt of alternating current generated by solar energy systems that meet the eligibility criteria established by the State Energy Resources Conservation and Development Commission pursuant to Chapter 8.8 (commencing with Section 25780) of Division 15 of the Public Resources Code. The commission [PUC] shall determine the eligibility of a solar energy system, as defined in Section 25781 of the Public Resources Code, to receive monetary incentives until the time the State Energy Resources Conservation and Development Commission establishes eligibility criteria pursuant to Section 25782. Monetary incentives shall not be awarded for solar energy systems that do not meet the eligibility criteria.