Expected Performance Based Buydown (EPBB) Incentive Structure: Rationale and Implications

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Introduction

On March 16, 2006, the California Public Utilities Commission (CPUC) held the first workshop in establishing the CSI program. On April 24, 2006, CPUC staff (Staff) issued its proposal for the Design and Administration of the California Solar Initiative.[1] Staff had a large number of topics to address during those five weeks.

Incentive structure is one issue that was addressed by Staff. Staff recommended two incentive structures: one for systems under 100 kW and one for systems greater than 100 kW. The recommended structure for the smaller systems is the Expected Performance Based Buydown (EPBB). The EPBB is an up-front incentive payment where the incentive amount is adjusted to reflect verifiable system capacity as well as the effect of system orientation and shading on energy production. The recommended structure for the larger systems was a fixed rate 5-year performance based incentive (PBI).

Staff recommended that the EPBB be calculated according to the following formula:[2]

$$Incentive(\$) = Incentive\ Rate(\$/kW_{AC})\ x\ System\ Rating(kW_{AC})xDesign\ Factor$$

System Rating is the AC rating of the entire installed system as defined under PVUSA Test Conditions (PTC). Design Factor, which is calculated at the time of the application submission, equals the ratio of simulated output for the designed system divided by the simulated output for a system with an identical rating that is oriented south and tilted 30º with no shading over a given period of time.

The proposal also recommended that the EPBB Incentive Rate be set at \$2.25/$Watt_{AC}$ for residential customers and non-profits and at \$1.50/$Watt_{AC}$ for commercial entities.

When one accounts for the adjustment in rating methodologies, these EPBB Incentive Rates represent a large decline compared to the incentives that are currently available under the Self-Generation Incentive Program (SGIP) and the California Energy Commission's Emerging Renewables Program (ERP). To put the magnitude of the proposed decline into perspective, consider the EPBB incentive that would be paid for a horizontal system. The EPBB residential incentive would drop at least 35 percent (compared to the current

[1] CPUC Energy Division Staff Proposal for California Solar Initiative Design and Administration 2007-2016, Rulemaking 06-03-004 (Filed March 2, 2006), April 24, 2006, http://www.cpuc.ca.gov/PUBLISHED/RULINGS/55786.htm.
[2] Pages 21-22 of Reference 1.

\$2.80/Watt$_{AC\text{-}CEC}$ ERP incentive) and the commercial incentive would drop at least 50 percent (compared to the current \$2.50/Watt$_{AC\text{-}CEC}$ SGIP incentive).

The effect of issuing a proposal with such large incentive declines can have negative effects. When a drastic cut in incentives is presented as part of the proposal, the tendency of parties with a financial interest in the success or failure of a market is to focus on the negative aspects of the proposal and to miss the good elements of the proposal.

The proposal, however, is just what the word implies: a proposal. The proposal is not set in stone. Staff has publicly stated that every aspect of the proposal can and should be commented on. In fact, at the May 4, 2006 workshop, Staff reiterated the desire to receive comments throughout the workshop.

Objective

While there are a number of positive aspects to the proposal, there is one aspect of the proposal in particular that constitutes an important move forward for the PV industry: the EPBB incentive structure. The EPBB incentive structure would be very beneficial to the CSI program. The proposed EPBB Incentive Rates, however, are unrealistically low and if accepted would significantly damage the PV market in California.

The objective of this paper is to explain why the EPBB incentive structure is so beneficial. The paper also discusses the fact that transitioning to the EPBB structure may require higher incentive rates (rather than lower incentive rates) because the incentive rates under the current SGIP program versus the EPBB system are not directly comparable.

Analysis

Direct EPBB Calculation

The most straightforward way to calculate an EPBB incentive is to define a baseline energy production incentive rate (\$ per kWh) and multiply it by the simulated output of the designed system over some period of time. That is,

$$Incentive\,(\$) = Energy\ Rate(\$/kWh)\ x\ Simulated\ Ouptut\ \ for\ Designed\ System\,(kWh) \qquad (1)$$

While this equation has intuitive appeal because of its simplicity, it has a critical limitation. Performance simulations are inherently subject to error, thus making it difficult to validate results without requiring extended duration tests. As a result, it is desirable to derive a form of the above equation that minimizes simulation error and provides for direct field verification over a short period of time.

First, consider how one would establish the Energy Rate (\$ per kWh) presented in (1). One needs to set an Incentive Rate (\$ per kW$_{AC}$), multiply it by the System Rating (kW$_{AC}$), and divide the result by the simulated output (kWh) for some Reference System over a given time period (typically a year should be sufficient).

That is,

$$Energy\ Rate(\$/kWh) = \frac{Incentive\ Rate(\$/kW_{AC})\ x\ System\ Rating(kW_{AC})}{Simulated\ Ouptut\ \ for\ Reference\ System\ (kWh)}$$

Substituting this back in to Equation (1), the Incentive equals the Energy Rate times the Simulated Output for Designed System (kWh).

$$Incentive\ (\$) = \frac{Incentive\ Rate(\$/kW_{AC})\ x\ System\ Rating(kW_{AC})}{Simulated\ Ouptut\ \ for\ Reference\ System\ (kWh)}\ xSimulated\ Ouptut\ \ for\ Designed\ System\ (kWh)$$

The terms in this equation, however, can be rearranged to result in

$$Incentive\ (\$) = Incentive\ Rate(\$/kW_{AC})\ x\ System\ Rating(kW_{AC})x\frac{Simulated\ Ouptut\ \ for\ Designed\ System\ (kWh)}{Simulated\ Ouptut\ \ for\ Reference\ System\ (kWh)}$$

which can be written as

$$Incentive\ (\$) = Incentive\ Rate(\$/kW_{AC})\ x\ System\ Rating(kW_{AC})xDesign\ Factor$$

where (2)

$$Design\ Factor = \frac{Simulated\ Ouptut\ \ for\ Actual\ System\ (kWh)}{Simulated\ Ouptut\ \ for\ Reference\ System\ (kWh)}$$

Equation (2) is identical to the Staff's proposed EPBB calculation when the Reference System is Fixed 30º South-Facing with no Shading.

Discussion

Equation (2) is more complex than Equation (1). It does not, however, have the limitations associated with Equation (1). In addition, as listed below, it also offers a number of advantages.

Potential Performance Issues Are Disaggregated

All of the performance factors and sources of error are lumped into a single term (the Simulated Output for Designed System) in Equation (1). Equation (2), on the other hand, disaggregates the performance factors into two terms: performance due to system rating issues are captured by the System Rating term; performance due to system orientation and shading issues are captured by the Design Factor term.

System Rating Has Potential to Be Directly Measurable and Thus Verifiable

With Equation (2), the System Rating has the potential to be directly verifiable through field measurements. This is a fundamental feature that has been lacking throughout most capacity based incentive structures: most are operated using rating conventions that rely on calculated values but cannot be directly verified using field measurements.

The System Rating in Equation (2) captures all of the losses and inefficiencies that make up the verifiable AC rating of the system. Inaccuracies in PV module and inverter equipment rating methodologies as well as internal wiring and other losses are captured by the System Rating. The potential exists to specify test procedures that, when implemented, can verify the System Rating.

In the extreme case, when one relies on anything but a verifiable system rating (and a system AC rating is the only verifiable rating), if even one of the system's components is not included in the rating calculation and that component fails to work as specified, it is possible that the system might not produce any power at all. A verifiable system rating prevents this possibility.

Verification Can Be Performed

Verification can be performed since the System Rating is directly verifiable. The only part of the verification that requires testing of any sort is the System Rating. The only verification that is required for the Design Factor is a visual inspection of the system to confirm that it is installed in the orientation and with the shading factors as specified by the applicant.

The Calculation Rewards Good Installations and Penalizes Poor Installations

Since the System Rating can be directly verified once the system is installed, the System Rating will be higher for effective installations, rewarding manufacturers of efficient components and designers who perform high quality installations. Poor quality equipment as well as poor quality installations will be penalized, protecting the market from disreputable companies.

The Calculation Tolerates Model and Data Inaccuracies

In Equation (1), it is critical that both the model and data used in the incentive calculation be highly accurate. Paying an incentive that is highly dependent on model accuracy results in a situation of uncertainty among installers and others as to how the system performance is verified. This could result in the situation where participating parties protest and challenge model and data accuracy. For example, the debates could begin about whether or not the model is an accurate predictor of how much energy the system will produce (i.e., what is the correct capacity factor).

This situation is much less likely to occur with Equation (2). The simulated kWh production of the system is only factored into the Design Factor. Since the Design Factor is the ratio of two simulated quantities, relative model and data accuracy is of importance, not absolute accuracy. The Design Factor determines what percent of annual energy production the actual design should have relative to the Reference System. As long as the Design Factor uses the same model and same weather data for both the numerator and the denominator, the relative accuracy of the results will be preserved, even if the model is only pretty good. This will help to avoid the model accuracy and data assumption debates.

The form of the Design Factor in Equation (2) normalizes the results relative to the Reference System. Bias in any element of the modeling would be present in both the numerator and the denominator, tending to cancel out in the ratio. For example, if the simulation were based on an optimistic weather data set, the error would tend to cancel when the same data set were used for both the actual System and the Reference System.

Implications

The previous section presented the benefits of the EPBB incentive structure. There are two major factors, however, that need to be accounted for when transitioning from the SGIP and ERP capacity based buydowns to the EPBB incentive structure. First, the system rating used in the EPBB calculation is a system AC rating while the SGIP and ERP are based on a component AC rating. A system AC rating will reduce the total incentive to the customer by 10 percent when the Staff's Estimated Rating calculation is used.

Second, the Design Factor as defined by Staff reduces the incentive to the customer[3] because the Reference System is a fixed-30º south-facing system with no shading. Most fixed systems will have a Design Factor that is less than 1 because of suboptimal orientation and shading issues.

As a result, the transition from the SGIP and ERP programs to an EPBB incentive structure will reduce the total incentive to the customer unless an adjustment is made. Stated in another way, if one does not want the incentive to decline, an adjustment needs to be made to the EPBB incentive calculation to account for the incentive structure change.

One option to offset the reduction is to increase the Incentive Rate. Another option is to define a different Reference System in the Design Factor calculation.

Increase Incentive

One option to offset the reduction is to increase the Incentive Rate.

There are two factors that the EPBB calculation accounts for that the SGIP incentive does not: (1) the AC system rating represents a 10 percent reduction compared to the rating under the SGIP; (2) he Design Factor represents a loss in energy production due to suboptimal orientation and shading.[3]

Suppose that the typical system installed in the program produces 94 percent as much energy as the Reference System. Suppose that a customer installs a 100 $kW_{AC\text{-}CEC}$ and the program wants to maintain economic parity with the existing SGIP incentive of \$2.50/$Watt_{AC\text{-}CEC}$.

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[3] The one exception to this is tracking systems. The Design Factor will probably increase the incentive to the customer.

As presented in Table 1, the customer would receive $250,000 under the current SGIP program. What would it require for a customer to be equally well off under the EPBB structure? A 100 kW_{AC-CEC} is equivalent to 90 kW_{AC} and the Design Factor is 94 percent. As a result, the EPBB Incentive Rate needs to increase by 18 percent to $2.96/$Watt_{AC}$ to provide the customer with the same economic benefit as the SGIP incentive.

Table 1. Incentive comparisons (higher Incentive Rate).

	SGIP Program	EPBB Staff Proposal w/ Higher Incentive Rate
Intentive Rate ($/Watt)	$2.50	$2.96
Rating Calculation		
Number of Modules	1,000	1,000
PV PTC Module Rating (W)	105.2	105.2
Inverter Efficiency	95%	95%
Other Losses	-	90%
Estimated Rating (kW)	99.9	89.9
Design Factor	-	94%
Incentive Amount ($K)	**$250**	**$250**

Use Different Reference System

The previous subsection described how to adjust for the transition to the EPBB incentive structure by increasing the Incentive Rate. This subsection describes how to leave the Incentive Rate unchanged and to make the adjustment by using a different Reference System in the Design Factor calculation.

An analysis was performed using the Clean Power Estimator for a system in San Jose, CA.[4] A fixed 30º south-facing system with no shading is estimated to have a DC-based capacity factor of 16 percent. A recent report by the California Energy Commission, however, found that the average DC-based capacity factor for systems including the effect of orientation and shading was 15 percent.[5] Thus, based on the CEC report, it appears that systems have an average of 6 percent design losses. When the 6 percent design losses are combined with the 10 percent rating losses, the result is a combined loss of 15 percent.

In order to compensate for this loss through the Design Factor, the Reference System needs to be chosen to have an expected output that is 85 percent of a fixed 30º south-facing

[4] PV Watts is another on-line simulation tool. It does not, however, have the capability of performing a shading analysis as is incorporated into the Clean Power Estimator (http://www.njcep.com/html/estimator_f.html). The Clean Power Estimator was run with 10 percent PV Output Adjustment to be consistent with PV Watts 0.77 derating factor.

[5] Nellie Tong (Kema Inc.). Emerging Renewables Program Systems Verification Report 2004-2005, December 2005.

system with no shading.[6] Analysis using the Clean Power Estimator suggests that one system that fits this description is a horizontal system with 5 percent shading losses.

The capacity factors for various system configurations are presented in the top part of Table 2. The Design Factors using a horizontal system with 5 percent shading losses as the Reference System are presented in the bottom part of Table 2.

Table 2. Capacity Factor and Design Factor (San Jose, CA using Clean Power Estimator).

Capacity Factor (Based on DC Rating)

	Degrees of Shading				
Tilt	***0***	***5***	***10***	***15***	***20***
Horizontal	14.2%	14.2%	14.1%	14.0%	13.5%
10	15.2%	15.2%	15.0%	14.8%	14.3%
20	15.8%	15.8%	15.6%	15.3%	14.7%
30	16.0%	15.9%	15.7%	15.4%	14.8%

Design Factor (Reference: Horizontal System, 5% or 20º Shading)

	Degrees of Shading				
Tilt	***0***	***5***	***10***	***15***	***20***
Horizontal	105%	105%	104%	103%	100%
10	112%	112%	111%	109%	106%
20	117%	116%	115%	113%	109%
30	118%	118%	116%	114%	109%

To illustrate how the calculations work, assume that a customer installs a fixed 10º south-facing system with minor shading (i.e., a system with a 15 percent DC capacity factor). As presented in Table 2, the Design Factor for this system is 111 percent. Assume that the Incentive Rate is $2.50 per $\text{Watt}_{\text{AC-CEC}}$ under the SGIP and remains at $2.50 per Watt_{AC} under the EPBB incentive program. Table 3 demonstrates that the total incentive is $250K for both structures.

[6] 1/0.85 = 1.18.

Table 3. Incentive comparisons (Reference System is horizontal w/ shading).

	SGIP Program	EPBB Staff Proposal w/ Modified Design Factor
Intentive Rate ($/Watt)	$2.50	$2.50
Rating Calculation		
Number of Modules	1,000	1,000
PV PTC Module Rating (W)	105.2	105.2
Inverter Efficiency	95%	95%
Other Losses	-	90%
Estimated Rating (kW)	99.9	89.9
Design Factor	-	111%
Incentive Amount ($K)	**$250**	**$250**

Conclusions

The EPBB incentive calculation proposed by Staff allows the industry to transition to a performance based incentive structure. The EPBB structure creates an incentive calculation that has the potential to provide a number of the benefits of a PBI structure without the full PBI implementation. In particular,

1. Short duration field testing (as yet to be fully specified) and visual inspection can verify the accuracy of critical factors that affect energy production
2. The incentive can be adjusted for the expected energy production of the system by using a verified system rating (thus promoting efficient components and good installations)
3. The incentive is adjusted for expected energy production of the system due to orientation and shading (thus promoting effective system design)
4. The incentive calculation procedure is not highly sensitive to modeling and data accuracy (thus resulting in greater program objectivity)

Transitioning to the EPBB incentive structure, however, will result in a reduction in the incentive for fixed PV systems when compared to the SGIP program.[3] If the goal is to retain a total incentive amount that is unchanged compared to existing SGIP incentive levels, an adjustment needs to be made to the EPBB incentive calculation. Either the Incentive Rate or the Reference System needs to be changed. It is estimated that the Incentive Rate increase needs to be increased by about 18 percent. An Incentive Rate of \$2.96 per Watt_{AC} will result in a total incentive that is comparable to the SGIP \$2.50 per $\text{Watt}_{AC\text{-}CEC}$. Alternatively, leaving the EPBB Incentive Rate at \$2.50 per Watt_{AC} but defining the Reference System to be a horizontal system with 5 percent shading losses (i.e., a system that has 85 percent of the energy production of a fixed-30º south-facing system) is also comparable to the SGIP \$2.50 per $\text{Watt}_{AC\text{-}CEC}$ rate.[7]

[7] A horizontal system with 5 percent shading losses produces 85 percent as much power as a 30º south-facing system with no shading. Since the Reference System is in the denominator of the Design Factor calculation, this translates to an increase of 18 percent (i.e., 1/0.85 - 1 = 18%).

Appendix: Consistency in Ratings, Prices, and Capacity Factors

An issue that should be addressed by Staff is the need to maintain consistency once a rating system is selected. In particular, there must be consistency in the rating, price, and capacity factor (or energy production).

Assume that the price of 1 $kW_{AC\text{-}CEC}$ of PV under the current SGIP is $8,000 and the system has an 18 percent capacity factor. As shown in Table 1, in order to obtain 1 kW_{AC} worth of PV on an AC system rating basis, the cost would cost $8,900 and the system would have a 20 percent capacity factor.

Table 4. Comparison of ratings, prices, and capacity factor.

Rating Method	Rating	Price	Capacity Factor
Component AC (ERP & SGIP)	1.00 $kW_{AC\text{-}CEC}$	$8,000 per $kW_{AC\text{-}CEC}$	18%
System AC (CSI EPBB)	0.90 kW_{AC}	$8,900 per kW_{AC}	20%
DC or Nameplate	1.17 kWDC	$6,840 per kWDC	15%

As a result, there are several areas where there is a need for consistency between prices, incentives, and output. If the energy production is stated in units of kWh per kW_{AC} (i.e., a 20 percent capacity factor), then the prices must also be stated in $ per kW_{AC}. For example, page 17 of the proposal has the price in units of component AC but the incentive and the energy production are listed in units of system AC. The proposal needs to be consistent in how the units are presented.

Another implication of this is that program goals should be adjusted. The current goals for the program have been stated as 2.6 GW at a cost of $2.4 Billion. The program goals were stated in component AC terms and should be restated in system AC terms. As a result, the goal of the program should be about 2.3 GW_{AC} at a cost of $2.4 Billion.