CALIFORNIA SOLAR ENERGY INDUSTRIES ASSOCIATION

IMPLEMENTING THE FEED IN TARIFF FOR SMALL-SCALE SOLAR PHOTOVOLTAICS IN CALIFORNIA AS AUTHORIZED BY SB 32 (2009, NEGRETE-MCLEOD, D-CHINO)

The California Solar Energy Industries Association (CalSEIA) commissioned this study to assist the Commission deliberations on the value of renewable generation.

This study shows that the value of electricity from renewable generation is higher than the value of generation from a natural gas power plant. Depending on the location of the renewable generation, the value of electricity is between 5 and 12 cents higher than electricity from natural gas generation. This study shows that the value, per kilowatt-hour (kWh) for renewable generation is between 17 and 24 cents per kWh.

In 2009, Senator Negrete-McLeod's legislation, SB 32, was signed into law by Governor Schwarzenegger. SB 32 received overwhelming support in the Legislature. SB 32 established:

1. Authority for the California Public Utilities Commission (Commission) to establish a price for renewable generation that is based on the attributes of renewable energy generation. Historically, the price for new renewable generation has been based on the price of electricity from natural gas generation. SB 32 provides the authority to the Commission to take into account the value of renewable generation that is over and above the value of electricity from a natural gas power plant.
2. Authority for the Commission to establish standard contracts that renewable energy developers can use to sell electricity to investor owned utilities (Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric).
3. Requires similar programs be implemented by the large publicly owned utilities (Los Angeles Department of Water and Power and the Sacramento Municipal Utilities District)
4. Limits the size of projects eligible for these contracts to no more than 3 Megawatts (MW) to encourage small projects distributed throughout communities in California that can connect to the electricity grid without needing to build new transmission lines.
5. Limits the total MWs eligible to 750 MWs, proportionally among the utilities subject to the requirements of SB 32.

SB 32 also provided that the Commission establish a rate that would provide 'ratepayer indifference.' Ratepayer indifference means recognizing the value of the energy and its attributes on a market value basis. CalSEIA's study demonstrates that the market value for renewable generation is greater than the value of natural gas generation.

SMALL-SCALE SOLAR PHOTOVOLTAICS IN CALIFORNIA: INCREMENTAL VALUE NOT CAPTURED IN THE 2009 MARKET PRICE REFERENT – DESCRIPTION OF METHODOLOGY

23 April 2010

I. INTRODUCTION

The purpose of this analysis is to quantify the incremental value that small-scale solar photovoltaics ("PV") contribute to California *over and above* those values that are already reflected in the 2009 Market Price Referent ("MPR"). The 2009 MPR reflects the levelized long-term cost threshold for baseload electricity generated by a new natural gas combined cycle ("NGCC") proxy plant. The 2009 MPR specifies a levelized 9.674 cents per kilowatt-hour ("kWh") as the "price reasonableness benchmark" for a 20-year contract with a 2010 start date.[1] Utility-specific time-of-delivery factors are applied to the levelized 2009 MPR value to "ensure that the MPR represents 'the value of different products including baseload, peaking, and as-available output.'"[2]

The incremental value of solar PV, or PV Adder, quantified in this analysis reflects value over and above the 2009 MPR cost threshold, as adjusted for utility-specific time-of-delivery ("TOD") factors that reflect the hourly pattern of electricity generated by a representative PV system that is oriented to the south at a 10 degree tilt.[3] The PV Adder is quantified for the service territories of three investor-owned utilities ("IOUs") in California, namely Pacific Gas & Electric Company ("PG&E"), Southern California Edison ("SCE"), and San Diego Gas & Electric Company ("SDG&E"). Because of the large disparity in the cost of emissions allowances and in the avoided cost of distribution capacity between the San Joaquin Valley and the rest of PG&E's service territory, the incremental value of PV for PG&E is calculated separately for the San Joaquin Valley ("SJV") and for the rest of PG&E (excluding the SJV).

The results of the quantification of the incremental value of solar PV over and above the TOD-adjusted 2009 MPR are summarized in Table 1, which shows the range of the regional PV Adder for each of the four regions examined:

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[1] California Public Utilities Commission, December 18, 2009, p. 1. All of the 2009 MPR values referred to in this report are based on applying utility-specific time-of-delivery factors to the levelized 2009 MPR value for a 20-year contract with a 2010 start date. All above-MPR values are stated in the same format as the 2009 MPR values, *i.e.*, with three numbers after the decimal point.

[2] California Public Utilities Commission, December 18, 2009, p. 5.

[3] Time-of-delivery factors and their application are discussed in greater detail in section II.A. of this report.

Table 1. Solar PV Adder: Value Provided Over and Above the 2009 MPR (TOD-Adjusted)

Utility	Minimum PV Adder (cents/kWh)	Maximum PV Adder (cents/kWh)	Total MPR + PV Adder (cents/kWh)
PG&E (Ex. SJV)	4.761	11.738	17.154-24.132
PG&E (SJV)	5.529	11.908	17.619-23.997
SCE	5.279	11.460	17.738-23.919
SDG&E	7.890	12.744	18.608-23.462

The range of values for each regional PV Adder reflects the range of feed-in tariff adders appropriate for a representative PV system under the California's Senate Bill ("SB") 32, which increases the availability of the feed-in tariff for renewable electricity generation to facilities up to 3 Megawatt ("MW"). Figure 1 (below) illustrates the relative magnitude of the individual components that make up each of the Maximum PV Adder values shown in Table 1. The purpose of this report is to discuss the methodology used to quantify each of the components of incremental above-MPR value for solar PV.

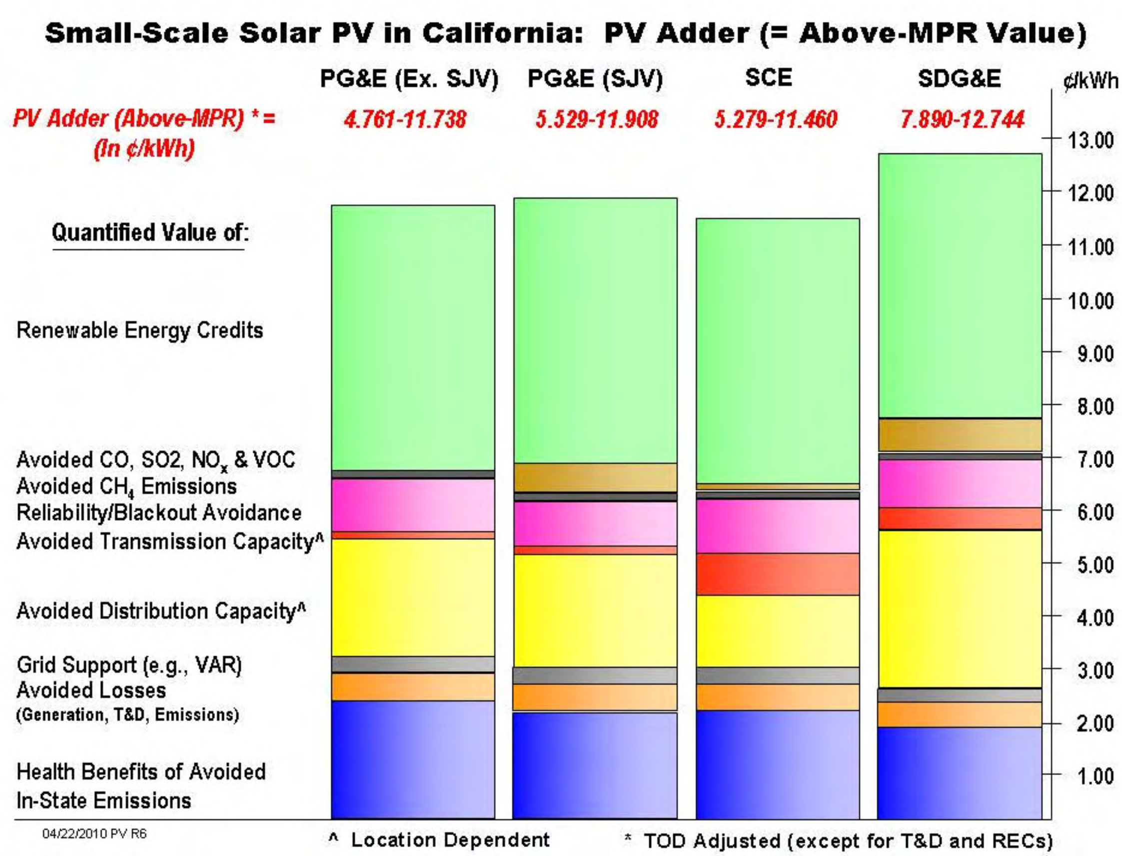

Figure 1. PV Adder: Value Provided in Excess of 2009 MPR, by Component

II. COMPONENTS OF ABOVE-MPR SOLAR PV VALUE

It is important to reiterate that the TOD-adjusted PV Adders graphed in Figure 1 reflect PV value over and above the value that is already captured in the 2009 MPR. This point is emphasized in Figure 2, in which the aggregate value of each PV Adder shown in Figure 1 is added to the TOD-adjusted 2009 MPR to determine the total value of PV. The TOD-adjusted 2009 MPR is calculated by multiplying the weighted average utility-specific TOD factor for each region times the levelized 2009 MPR of 9.674 cents/kWh. Note that the black bars in Figure 2 represent the TOD-adjusted 2009 MPR, the heavy black line represents the levelized 2009 MPR of 9.674 cents/kWh, and the red bars represent the TOD-adjusted, above-MPR PV Adder for each region.

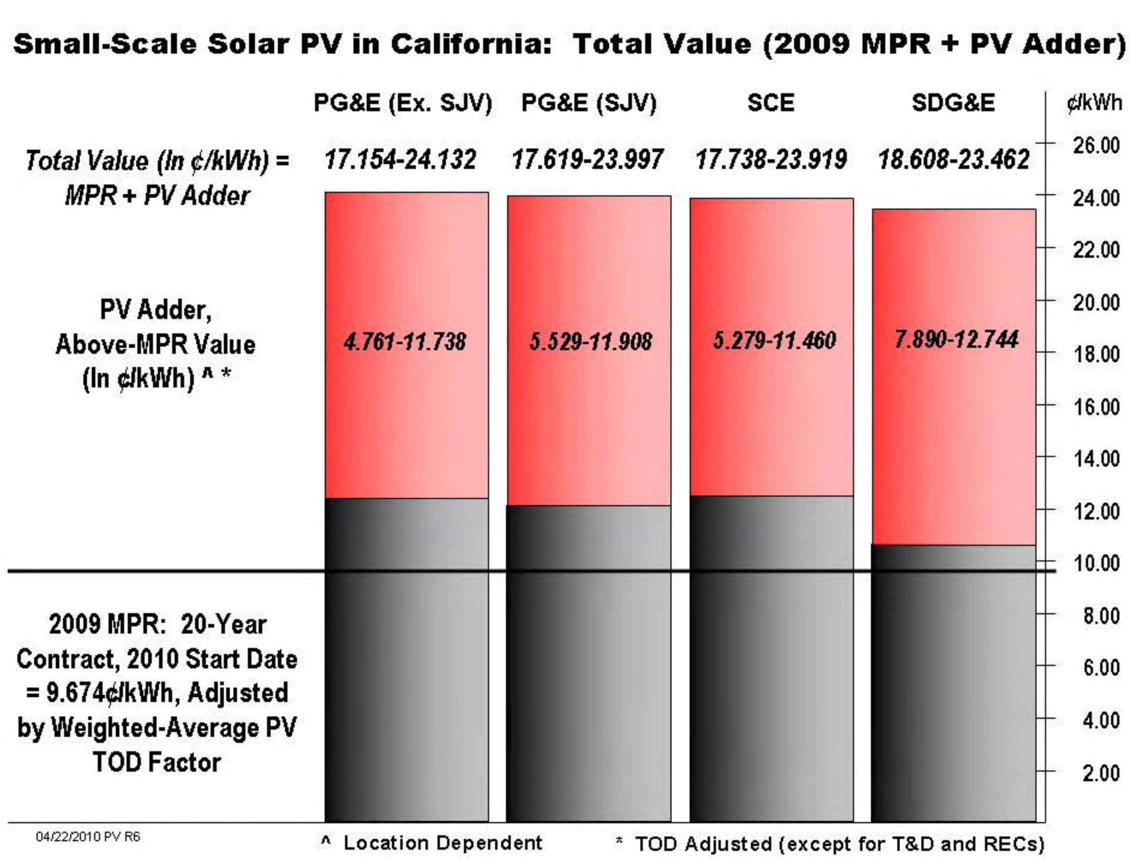

Figure 2. Total PV Value: 2009 MPR Value + Above-MPR PV Adder

To avoid double counting, any PV value component that is already included in the 2009 MPR either is not included among the above-MPR value components illustrated in Figure 1 or, in cases where PV provides above-MPR value, the value already included in the 2009 MPR is subtracted from the PV value components calculated in this analysis. As an example of the first case, there is no incremental value attributed to PV for avoided water use because the proxy plant variable operations and maintenance cost included in the 2009 MPR values already includes the water supply costs associated with the proxy plant's dry cooling system. Examples of the second case (where the 2009 MPR value is subtracted from the above-MPR value attributed to PV) will be explained in greater detail below in the description of the derivation of the individual PV above-MPR value components.

An important attribute of solar PV is that it generates electricity during periods of high demand. The effective load carrying capacity ("ELCC") of any electricity generator is a measure of that generator's capacity to contribute effectively to serving a utility's peak load.[4] The ELCC determines what percentage of a generator's capacity is available to serve a utility's peak demand. The electricity generated by solar PV peaks when the sun is at its zenith, whereas California's peak electricity demand usually occurs later in the afternoon, sometime between 2:00-4:00 p.m. Figure 3 shows the peak capacity contribution of various distributed generation technologies, including PV, during the 2008 peak hour for the California Independent System Operator ("CAISO"), which occurred between 3:00-4:00 p.m. on June 20, 2008.[5]

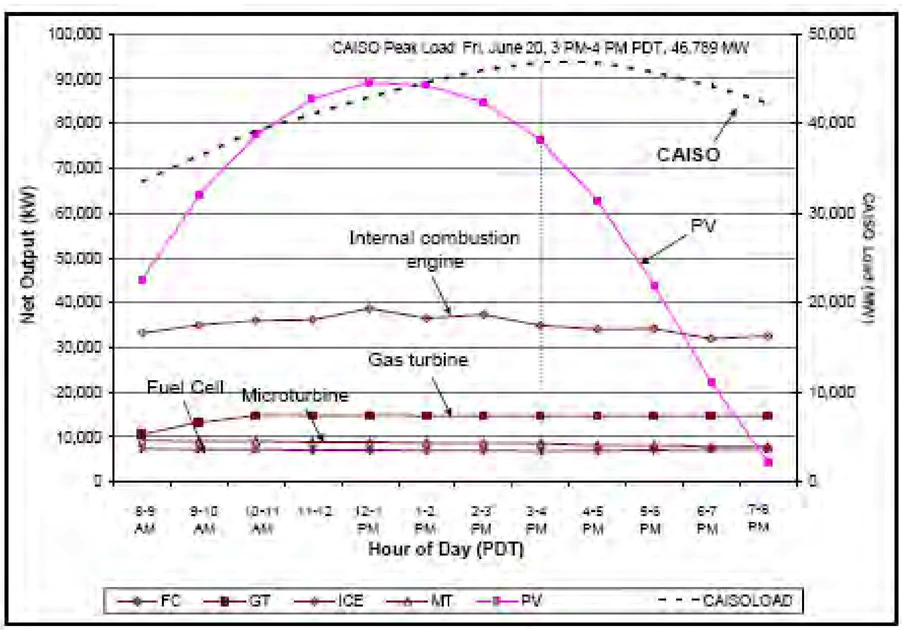

Figure 3. Self-Generation Incentive Program, Technology-Specific Capacity Contribution to California Independent System Operator Peak, 2008

Based on the data from which the generation profiles in Figure 3 are derived, the ELCC of the representative PV system assumed in this analysis (oriented to the south at a

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4 Herig, September 2001, p. 2,

5 Itron, Inc., July 2009, p. 1-6, Figure 1-4.

10 degree tilt) is estimated to be approximately 60 percent.[6] This is consistent with an independent estimate of the ELCC for PV in California of 59 percent for a horizontal PV system, 61 percent for a PV system directed to the south at a 30 degree tilt, and 69 percent for a PV system directed to the southwest at a 30 degree tilt.[7] The ELCC plays an important role in converting avoided costs that are expressed in $/kW-year into cents/kWh, the latter of which is the metric used in this analysis.

A. APPLICATION OF TIME-OF-DELIVERY FACTORS

As seen in Figure 3, electricity demand varies over the course of the day; peak demand is usually met by natural gas peaking units that have significantly higher heat rates than the 2009 MPR proxy plant.[8] The higher heat rate of peaking units means that the electricity generated during peak demand periods is more costly than electricity generated during off-peak demand periods. To reflect the difference in the value of electricity delivered during different time periods, each IOU has utility-specific TOD factors. Attachment A defines the time periods and the TOD factors that apply during each time period for the three IOUs included in this analysis.

The weighted average TOD factor for each region reflects the approximate hourly generation profile of a representative PV system located in the city noted and oriented to the south with a 10 degree tilt. The weighted average TOD factor for each region is calculated by allocating the kWh generated by the representative PV system into each of the applicable TOD time periods for the IOU serving that region. The weighted average TOD factors used in this analysis are as follows:

Region	Location	Weighted Average TOD Factor
• PG&E (Ex. SJV)	Oakland	1.281
• PG&E (SJV)	Fresno	1.250
• SCE	Rosemead	1.288
• SDG&E	San Diego	1.108

Except for Renewable Energy Credits ("RECs") and the Value of Avoided Transmission & Distribution ("T&D"), each of the value components shown in Figure 1 has been TOD-adjusted by multiplying the raw component value times the Weighted Average TOD Factor for each region shown above. The purpose of the TOD adjustment is to reflect the higher value of electricity generated and delivered by PV systems during

6 Itron, Inc., September 2008, p. 1-6, Table 1-7, indicates a 60.1% coincident-peak capacity factor in 2007 for PV systems receiving incentives under the Self-Generation Incentive Program ("SGIP"); Itron, Inc., July 2009, p. 1-6, Table 1-7, indicates a 58.5% peak capacity factor in 2008 for PV systems receiving SGIP incentives.

7 Perez, *et al.*, July 2006, p. 5, for up to a 2 percent statewide PV penetration.

8 The 2009 MPR proxy plant has a new-and-clean heat rate of 6,879 British thermal units ("Btu") per kWh and a maximum heat rate of 6,932 Btu/kWh. This 2009 MPR proxy plant heat rate range of 6,879-6,932 Btu/kWh is used throughout this analysis.

higher demand periods when, for instance, the level of avoided emissions increases because higher heat rate generators are required to meet the increased load. To simplify the discussion that follows, however, only the raw component values (prior to the TOD adjustment) will be presented in the discussion of each component's derivation. For comparison, Table 2 presents the range of the regional PV Adder for each of the four regions examined before and after application of the utility-specific TOD factors:

Table 2. Regional Above-MPR PV Adder for Representative PV System, With and Without TOD Factor Adjustment

Above-MPR PV Adder (¢/kWh)	Without TOD Factor Adjustment		Wt. Avg. TOD Factor	With TOD Factor Adjustment *	
	Minimum	Maximum		Minimum	Maximum
PG&E – Ex. SJV	4.233	10.801	1.281	4.761	11.738
PG&E – SJV	5.013	10.957	1.250	5.529	11.908
SCE	4.758	10.494	1.288	5.279	11.460
SDG&E	7.650	12.324	1.108	7.890	12.744

* Not applied to Avoided T&D or Value of RECs

It is important to note that the hourly generation profile of a PV system will differ significantly based on both the geographic location and the orientation of the system. The fact that each utility has different TOD factors means that the optimal orientation for a PV system may vary by region, depending on whether the goal is to maximize (i) the total amount of kWh produced or (ii) the weighted average TOD factor. The tables below demonstrate the magnitude of this impact for each of the four regions included in this analysis, for each of four different PV system orientations.[9] As a reference point, the values for the representative PV system underlying the results presented in this report are indicated in bold italic print.

[9] The PV generation profile for each PV system orientation and region was calculated by members of the California Solar Energy Industries Association using PVSYST software and TMY3 weather data.

Table 3. PG&E (Ex. SJV), Solar PV Adder, by PV Orientation

PV Orientation, 100 kW_{ac} System	Total kWh Per Year	Wt. Average TOD Factor *	Above-MPR PV Adder (¢/kWh)	
			Minimum	Maximum
Flat	157,847	1.294	4.786	11.782
South, 10º Tilt	***168,600***	***1.281***	***4.761***	***11.738***
Southwest, 20º Tilt	170,552	1.307	4.809	11.824
West, 30º Tilt	149,442	1.355	4.899	11.984

* Not applied to Avoided T&D or Value of RECs

Table 4. PG&E (SJV), Solar PV Adder, by PV Orientation

PV Orientation, 100 kW_{ac} System	Total kWh Per Year	Wt. Average TOD Factor *	Above-MPR PV Adder (¢/kWh)	
			Minimum	Maximum
Flat	168,676	1.260	5.550	11.947
South, 10º Tilt	***179,416***	***1.250***	***5.529***	***11.908***
Southwest, 20º Tilt	178,410	1.281	5.595	12.028
West, 30º Tilt	154,392	1.337	5.711	12.242

* Not applied to Avoided T&D or Value of RECs

Table 5. SCE, Solar PV Adder, by PV Orientation

PV Orientation, 100 kW_{ac} System	Total kWh Per Year	Wt. Average TOD Factor *	Above-MPR PV Adder (¢/kWh)	
			Minimum	Maximum
Flat	172,536	1.370	5.429	11.738
South, 10º Tilt	***184,563***	***1.288***	***5.279***	***11.460***
Southwest, 20º Tilt	184,610	1.331	5.358	11.607
West, 30º Tilt	159,494	1.411	5.503	11.875

* Not applied to Avoided T&D or Value of RECs

Table 6. SDG&E, Solar PV Adder, by PV Orientation

PV Orientation, 100 kW_{ac} System	Total kWh Per Year	Wt. Average TOD Factor *	Above-MPR PV Adder (¢/kWh)	
			Minimum	Maximum
Flat	176,143	1.112	7.899	12.761
South, 10º Tilt	***188,496***	***1.108***	***7.890***	***12.744***
Southwest, 20º Tilt	191,772	1.122	7.920	12.798
West, 30º Tilt	168,481	1.143	7.967	12.880

* Not applied to Avoided T&D or Value of RECs

Because the weighted average TOD factor differs for each region even for the representative PV system, the above-MPR value components presented in the body of this report reflect the raw values for each above-MPR value component, prior to application of the weighted average TOD factor for each region applicable to a PV system directed south at a 10 degree tilt.

B. RENEWABLE ENERGY CREDITS

Electricity generated by solar PV is 100% renewable and will therefore have incremental, above-MPR value in the form of RECs. There is no explicit value for RECs included in the 2009 MPR since the proxy plant for which MPR costs are calculated is a natural gas-fired combined cycle generator that relies on fossil fuel rather than on a renewable source of energy.

The range of values for RECs is based on both regulatory and market input. The California Public Utilities Commission ("CPUC") issued Decision 10-03-021 on March 16, 2010, in Docket No. 06-02-012 under its Order Instituting Rulemaking to Develop Additional Methods to Implement the California Renewables Portfolio Standard. In the Decision (p. 59), the CPUC adopted a temporary price cap of $50/MWh for RECs, which is the penalty amount for noncompliance with the California Renewables Portfolio Standard ("RPS"). This $50/MWh temporary price cap for RECs is used as the upper end of the range of above-MPR value for the RECs associated with PV electricity generation. The lower end of the range of value for RECs is based on the $20/MWh market price index for RECs for the Western Electricity Coordinating Council (of which the California Independent System Operator is a member), as quoted by the CantorCO2 Environmental Brokerage.

Converting the $/MWh price range for RECs to the cents/kWh metric used in this analysis results in a range of incremental, above-MPR value for RECs associated with PV-generated electricity of 2-5 cents/kWh. Because RECs are priced on a per unit basis that is not adjusted for the time of delivery, the range of value for RECs is not adjusted by the utility-specific weighted average TOD factors in this analysis.

Although RECs are defined by the CPUC as including “all renewable and environmental attributes associated with the production of electricity from the renewable energy resource,” there is also an explicit recognition that “although avoided emissions are included in the definition of the REC, this definition does not create any right to use those avoided emissions to comply with any [greenhouse gas] regulatory program.” [10] Whereas a REC can be used for compliance with California’s RPS program, separate emissions reduction credits must be purchased for compliance with individual air quality district regulations and separate greenhouse gas allowances will have to be purchased to comply with the mandates of California’s Global Warming Solutions Act of 2006 (“AB 32”). Consequently, separate above-MPR value components have been included in this analysis for both the value of RECs and the value of avoided proxy plant emissions of criteria pollutants and greenhouse gases.

C. AVOIDED FUEL USE AS A NATURAL GAS PRICE HEDGE

The 2009 MPR includes a 10-year levelized forecast of delivered natural gas prices equal to $7.39 per million British thermal units (“MMBtu”). This is the natural gas price assumed for natural gas use by the 2009 MPR proxy plant. Since this fuel cost is already included in the 2009 MPR value, there is no above-MPR value attributed to solar PV for any avoided natural gas costs.

Natural gas futures prices are notoriously volatile, as illustrated in Figure 4, which compares the monthly rolling average of daily settlement prices for prompt-month natural gas futures contracts on the New York Mercantile Exchange (“NYMEX”) with the same trading day’s prompt-month settle price.[11] As can be seen in Figure 4, the daily NYMEX prompt-month price range since January 2006 has been $2.51-$13.58/MMBtu and the monthly rolling average range has been $2.96-12.97/MMBtu, for natural gas located at the Henry Hub, onshore Louisiana. Natural gas prices delivered to the California border have been lower than Henry Hub prices over the past few years, and the 2009 MPR reflects this difference in its forecast of delivered natural gas prices.[12]

[10] California Public Utilities Commission, August 22, 2008, p. 45. Note that there is some debate about how much of the value of the “environmental attributes associated with the production of electricity from the renewable energy resource” is captured in the price of RECs. This analysis has added the above-MPR Value of Avoided Emissions to the price of RECs based on the fact that a utility must procure both RECs and emissions reduction allowances for separate compliance purposes. To the extent that it could be demonstrated otherwise, it may be appropriate to reduce the value of RECs included in the PV Adder.

[11] The term “prompt month” refers to the earliest month for which futures contracts are trading. Trading of futures contracts for any given delivery month ends prior to the end of immediately previous month. Therefore, “the prompt month” in mid-April would be May, but by the end of April, after trading for the May futures contract closes, the prompt month becomes June. The monthly rolling average of daily settlement prices is based on a 22-day trading month and is appropriate for those generators buying natural gas on a monthly basis; the daily settlement prices are appropriate for natural gas purchases made on an as-needed basis.

[12] A negative cost adjustment of $0.21/MMBtu is made to the 10-year average projected value of transportation from the Henry Hub to California for the 2009 MPR proxy plant. (*See* California Public

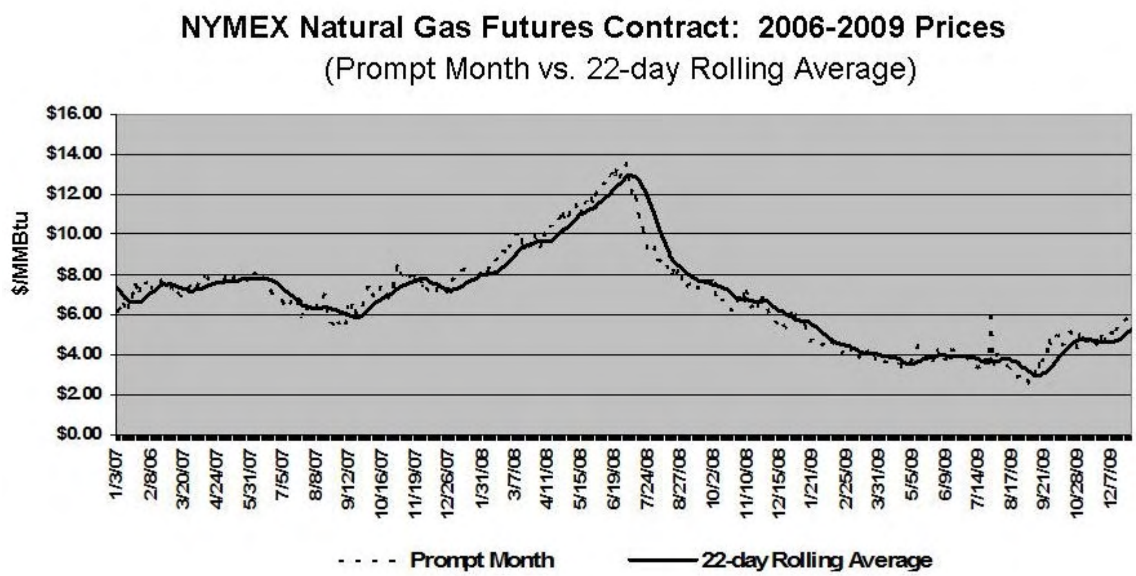

Figure 4. NYMEX Natural Gas Futures Contract, Daily Settlement Prices and 22-Day Rolling Average, 2006-2009

The 2009 MPR levelized forecast of delivered natural gas prices includes a Hedging Transaction Cost of $0.082/MMBtu of natural gas. The Hedging Transaction Cost reflects the cost of entering into a long-term natural gas supply contract for the purpose of fixing (hedging) the natural gas price. Hedging removes the buyer's exposure to natural gas price volatility (up or down), but it comes at a cost. The fact that the 2009 MPR incorporates hedged natural gas prices based on a forward market price curve removes the volatility in natural gas prices faced by the proxy plant. There is therefore no above-MPR value attributable to PV systems for the ability of these systems to act as a natural hedge against natural gas price volatility.

D. VALUE OF GRID SUPPORT

The estimated incremental, above-MPR Value of Grid Support reflects the avoided ancillary services costs associated with the electricity load displaced by solar PV generation. This value, which is not captured in the 2009 MPR, is based on 2.84% of the range of natural gas costs discussed above, since fuel cost is assumed to be a major driver of wholesale electricity prices in California. Note that 2.84% is the same value used in several significant cost studies in California, including the 2004 avoided cost analysis

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Utilities Commission, December 18, 2009, p. 19 and Energy and Environmental Economics, Inc., 2009, "CA_Gas_Forecast" tab.) This transportation value (known as the "basis") is highly volatile, varies seasonally, and has historically had both positive and negative values from the Henry Hub to California.

developed by Energy and Environmental Economics, Inc. ("E3 Avoided Cost Study")[13] and E3's more recent Net Energy Metering Cost-Effectiveness Evaluation.[14] Both studies apply the 2.84% value of ancillary services to the avoided market price of electricity to estimate the value of avoided ancillary services. In this analysis, the 2.84% value is applied to the range of natural gas prices as a surrogate for the avoided market price of electricity. The result is converted to cents/kWh by multiplying by the heat rate range of 6,879-6,932 Btu/kWh of the 2009 MPR proxy plant.[15] The resultant above-MPR Value of Grid Support for PV ranges from 0.051-0.249 cents/kWh, prior to application of the utility-specific TOD adjustment.

E. AVOIDED TRANSMISSION & DISTRIBUTION COSTS

Because the 2009 MPR calculates the threshold costs for a proxy plant that is represented by a central station natural gas combined cycle generator, it does not include any value related to potential avoided T&D costs. For purposes of quantifying the above-MPR value of solar PV, this means that there is no value included in the 2009 MPR to reflect the fact that PV systems located at specific points within the electric grid may avoid the need for T&D investments by reducing peak load.

The potential value of avoided T&D costs depends on the specific location of the PV system on the electric grid, as noted in the graph in Figure 1. Small-scale PV systems typically interconnect to the electric grid at distribution-level voltages, and therefore have a Value of Avoided Transmission Capacity component, as well as an upstream Value of Avoided Distribution Capacity component related to the fact that PV-generated electricity displaces the T&D use associated with delivering electricity from remote central station electricity generators.

To adequately capture the potential value of avoided T&D costs attributable to PV systems placed at various locations on the electric grid, the upper end of the range of avoided transmission costs is calculated separate and distinct from the upper end of the range of avoided distribution costs; both are taken from the E3 Avoided Cost Study, and have been adjusted to reflect (i) the assumed California average ELCC of 60% for small-scale PV and (ii) the average availability of 99% for small-scale PV systems. Because the E3 Avoided Cost Study adjusts the avoided T&D costs by attributing all costs to the peak demand hours for each utility and climate zone, the avoided T&D costs in the E3

13 Energy and Environmental Economics, October 25, 2004, pp. 146-147.

14 Energy and Environmental Economics, January, 2010, Appendix A, p. 14.

15 The average California avoided natural gas-fired plant had a five-year weighted-average heat rate for 2003-2007 that was approximately 10.6% less efficient than that of the 2009 MPR proxy plant, based on state-specific electricity generation and fuel consumption values as reported by the U.S. Department of Energy at http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html for electricity generation and at http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm for natural gas consumption.

Avoided Cost Study already capture the higher value of avoiding T&D utilization during the peak periods. Therefore, to avoid double counting, the avoided T&D costs from the E3 Avoided Cost Study are not TOD-adjusted.

1. Value of Avoided Transmission Cost

Depending on utility service territory, the Value of Avoided Transmission Cost for a PV system ranges from a low of 0.045 cents/kWh for transmission into PG&E's service territory to a high of 0.746 cents/kWh for transmission capacity into SCE's service territory; the Value of Avoided Transmission Cost for a PV system in SDG&E's service territory is 0.407 cents/kWh. SCE's Value of Avoided Transmission Cost of 0.746 cents/kWh is calculated by multiplying its 2010 E3 avoided transmission cost of $22.01/kW-yr[16] times the 60% ELCC and 99% availability and dividing it by 1,752 hours per year (= 8,760 hours/year x the 20% average annual PV capacity factor). SDG&E's 2010 E3 avoided transmission cost is $12.01/kW-yr and PG&E's E3 2010 avoided transmission cost is $1.33/kW-yr.

It should be noted that even SCE's 2010 E3 avoided transmission cost of $22.01/kW-yr is relatively low, based on a recent survey of analyses of the cost of new transmission required to bring renewable energy supplies to market.[17] For California-specific analyses, the estimated cost of new transmission ranged from $90-$1230/kW of incremental generation capacity. Applying a 15% annual capacity charge to these estimates, the annualized cost of new transmission capacity would be $13.50-$184.50/kW-yr, or $13.50-$81.00/kW-yr if the high-end cost-outlier of $1230/kW is replaced by the second-highest estimate of $540/kW. Thus, the Value of Avoided Transmission Capacity could be nearly four times greater than even SCE's avoided transmission cost, which is based on the E3 Avoided Cost Study and included as an above-MPR PV value component in Figure 1.

2. Value of Avoided Distribution Cost

Similar to the Value of Avoided Transmission Cost, the Value of Avoided Distribution Cost also depends on the utility service territory, but the Value of Avoided Distribution Cost also depends on the climate zone in which the PV system is located within any given utility service territory. Thus, the Value of Avoided Distribution Cost for a PV system ranges from 0.200-1.389 cents/kWh within SCE's service territory, 0.308-2.421 cents/kWh for PG&E's service territory outside of the San Joaquin Valley, 0.902-2.102 cents/kWh for PG&E's service territory in the San Joaquin Valley, and is 3.025 cents/kWh within SDG&E's service territory. Using SDG&E as an example, the Value of Avoided Distribution Cost is calculated by multiplying SDG&E's 2010 E3 avoided distribution cost of $89.23/kW-yr[18] times the 60% ELCC and 99% availability

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16 Energy and Environmental Economics, Inc., October 25, 2004, p. 136.

17 *See* Mills, *et al.*, February 2009, p. 23.

18 Energy and Environmental Economics, Inc., October 25, 2004, p. 136.

and dividing it by 1,752 hours per year (= 8,760 hours/year x the 20% average annual PV capacity factor).

F. AVOIDED EMISSIONS AND RELATED HEALTH BENEFITS

Solar PV does not have any generation-related emissions. Therefore, the emissions-related incremental, above-MPR value of small-scale PV depends on how the region-specific value of avoided emissions attributed to PV compares to the cost of emissions allowances that is included in the 2009 MPR.

To calculate the region-specific value of avoided emissions related to PV installations, it is first necessary to identify *for each pollutant* (i) the emissions rate in pounds per MMBtu ("lb/MMBtu") of natural gas applicable to the avoided generating technology and (ii) the resultant emissions rate in pounds per MWh ("lb/MWh") over an assumed range of heat rates. Natural gas is typically the marginal fuel source that sets the market price of electricity in California and the 2009 MPR calculates statewide average costs associated with electricity generated by a new natural gas combined cycle proxy plant. Because SB32 specifies that the tariff "shall include all current and anticipated environmental compliance costs…associated with the operation of new generation facilities in the local air pollution control or air quality management district," the emissions avoided by electricity generated by a PV installation are based on (i) the emissions rates for the 2009 MPR proxy plant and (ii) the regional market value of those avoided emissions compared to the statewide average value that is included in the 2009 MPR. Therefore, the above-MPR value of avoided emissions is calculated through the following three-step process:

- The emissions rate range for each pollutant in pounds per MWh ("lb/MWh") is determined by multiplying the 2009 MPR proxy plant emissions rate in lb/MMBtu by the 2009 MPR proxy plant heat rate range.

- The minimum and maximum amounts of physically-avoided emissions in lb/MWh are then valued at the end points of a range of regional emissions allowance prices to determine the range of total value for each type of avoided emissions in cents/kWh of PV electricity generated.

- The average cost of emissions allowances included in the 2009 MPR (where applicable) is then subtracted from the regional range of total value for each type of avoided emissions to ensure that only the above-MPR value is attributed to the small-scale PV installations.

The underlying assumptions and results for the avoided emissions and related health benefits calculations are summarized in Attachment B. Because there are not yet any market prices for CO_2 emissions allowances in California, there is no incremental value attributed to PV beyond what is already included in the 2009 MPR. There is, however, an incremental statewide Value of Avoided CH_4 Emissions attributed to PV systems in California that is calculated to be 0.005-0.043 cents/kWh (prior to TOD factor adjustment) compared to the 2009 MPR proxy plant. The combined incremental, above-MPR value of all other avoided emissions (prior to TOD factor adjustment) for PV compared to the 2009 MPR proxy plant varies by region and by utility, as follows:

- PG&E, Non-SJV: (0.004) - (0.077) cents/kWh
- PG&E, SJV: 0.111 - 0.472 cents/kWh
- SCE: (0.144) - 0.021 cents/kWh
- SDG&E: 0.262 - 0.554 cents/kWh

The specific derivation of these aggregate values will be discussed on an emissions-by-emissions basis below, with all values presented being prior to TOD factor adjustment.

In addition, assuming that the Value of Health Benefits associated with avoided emissions is not reflected in emissions allowance prices,[19] the statewide incremental Value of Health Benefits for PV is calculated to be 1.743-1.757 cents/kWh based on the avoided emissions of the 2009 MPR proxy plant. Specific details for each avoided pollutant and related health benefits are discussed below.

1. Value of Avoided CO_2 Emissions

Although CO_2 and other GHG emissions are not yet subject to mandatory regulation in the United States, there is increasing pressure for the implementation of some type of carbon regulation, particularly on the transportation and electric utility sectors of the economy. The CPUC in 2005 began requiring the investor-owned utilities that it regulates to "penalize" potential new generation resources with an \$8/ton CO_2 cost (escalating at 5% per year) for resource planning and bid evaluation,[20] and CO_2 markets in Europe have traded anywhere from €2-€35/metric tonne since October 2005.[21]

The 2009 MPR includes a CO_2 adder that reflects a CO_2 compliance cost of \$10.44/ton starting in 2012, escalating to \$90.17/ton over the 20-year period to 2029. The 2012 CO_2 compliance cost of \$10.44/ton of CO_2 in the 2009 MPR approximates the CPUC's \$8.00/ton CO_2 price escalated at 5 percent for 5-6 years. The fact that the 2029 CO_2 compliance cost of \$90.17/ton of CO_2 is higher than CO_2 compliance costs seen in

[19] Inclusion of this value component in the analysis is subject to debate. In an efficiently operating market for emissions allowances, the Value of Health Benefits would be included in the price of the emissions allowances. However, current markets for emissions allowances in California are relatively thinly traded and likely do not (fully) reflect the Value of Health Benefits associated with the avoided emissions attributed to PV plants.

[20] Energy and Environmental Economics, Inc., October 25, 2004, the supporting documentation for the Updated E3 Electric Avoided Costs Workbook of March 20, 2006, uses a cost estimate of \$0.004/lb of CO_2 in its avoided cost calculations, equivalent to the \$8/ton of CO_2 penalty applied in the CPUC's Integrated Resource Planning process.

[21] Chicago Climate Exchange, various dates.

CO_2 markets in Europe is indicative of the uncertainty surrounding the magnitude of future CO_2 compliance costs.

Annual proxy plant CO_2 emissions in the 2009 MPR are calculated based on a CO_2 emissions rate of 0.0585 tons/MMBtu of natural gas burned.[22] Because the 2009 MPR includes future CO_2 compliance costs associated with the proxy plant CO_2 emissions avoided by PV-generated electricity, there is no CO_2-related incremental value attributable to PV included in this analysis.

2. Value of Avoided Methane (CH_4) Emissions

The 2009 MPR does not include any consideration of the estimated 1.4% of gross natural gas production is lost to the atmosphere as fugitive emissions during natural gas "extracting, processing, transmitting, storing, and distributing."[23] Avoiding proxy plant natural gas use through the increased use of PV technologies therefore avoids this amount of fugitive natural gas emissions. Natural gas is 75-95% methane[24] and methane "is 21 times as potent as CO_2 as a global warming pollutant."[25] These factors are applied to the physical natural gas savings from the avoided proxy plant generator attributable to PV technologies at the 2009 MPR CO_2 compliance cost range of $10.44-$90.17/ton CO_2-equivalent emissions. The result is an additional Value of Avoided Methane (CH_4) Emissions attributable to PV of approximately 0.043 cents/kWh.

3. Value of Avoided NO_x Emissions

For purposes of calculating the above-MPR Value of Avoided NO_x Emissions, the proxy plant NO_x emissions rate calculation starts with the 0.0105 lb/MMBtu emissions rate used in the 2009 MPR Model.[26] Using the proxy plant's assumed heat rate range of 6,879-6,932 Btu/kWh, the resultant NO_x emissions rate is approximately 0.075-0.076 lb/MWh, including incremental losses. The full Value of Avoided NOx Emissions is determined based on observed prices for Emissions Reduction Credits ("ERCs") bought and sold in California over the past two years. The range of prices used is this analysis varies by region, as shown in greater detail in Attachment B.[27]

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22 *See* California Public Utilities Commission, December 18, 2009, p. 9; line 9 of the "CF_Data_Set" tab in the 2009 MPR model 2009_MPR_Model_Final.xls.

23 Spath and Mann, February 2001, pp. 8-9.

24 Spath and Mann, February 2001, p. 8. The Value of Avoided Methane (CH_4) Emissions is calculated based on methane having a density of 0.717 kg/m^3 (Wikipedia) and making up 75% of total the energy content of natural gas.

25 California Air Resources Board, October 2008, p. 194.

26 Derived using proxy plant average annual emissions generation from the "Install_Cap" and "Var_Comp" tabs. Respectively, as found in the 2009 MPR model 2009_MPR_Model_Final.xls.

27 All emissions prices used in this analysis are based on Market Price Index ranges reported online by CantorCO2e Environmental Brokerage for the period from mid-September 2007 to mid-September 2009.

Since PV technologies have no generation-related emissions, all of the NO_x emissions from the avoided generating units are avoided. However, the 2009 MPR already includes NOx emissions costs of $20,000/tpy, which must be deducted from the full Value of Avoided NOx Emissions calculated above to avoid double counting.

The net incremental, above-MPR Value of Avoided NO_x Emissions attributable to PV for each region is determined through the three-step process described in the introduction to this section of the report. That is, the calculated range of avoided NO_x emissions is valued at the applicable range of NO_x emissions allowance prices for each region considered in this analysis, with the resultant range of value subsequently reduced by the proxy plant NO_x emissions allowance costs already included in the 2009 MPR.

4. Value of Avoided SO_2 Emissions

For the 2009 MPR proxy plant, the SO_2 emissions rate is calculated using the 0.0014 lb/MMBtu emissions rate in the 2009 MPR Model. This new-and-clean emissions rate is slightly over half of that estimated by the Societal Benefits Topic Team of the California Hydrogen Highway Network, which estimates SO_2 emissions from a natural gas combined cycle plant at 0.0026 lb/MMBtu of natural gas.[28] For the assumed heat rate range of 6,879-6,932 Btu/kWh for the 2009 MPR proxy plant, the resultant SO_2 emissions rate using the 2009 MPR Model is approximately 0.010 lb/MWh, grossed up for incremental losses; all of these SO_2 emissions are avoided by the electricity generated by solar PV.

As was the case for NO_x emissions, the region-specific value of the avoided SO_2 emissions is based on observed prices for ERCs bought and sold in California, as shown in Attachment B. Combining the calculated range of avoided SO_2 emissions and the applicable range of prices for each region yields a region-specific range of total Value of Avoided SO_2 Emissions attributable to PV. The 2009 MPR value of SO_2 emissions allowances of 0.011 cents/kWh is subtracted from the region-specific range of values to avoid double counting. The 2009 MPR value of SO_2 emissions allowances is based on an SO_2 emissions allowance price of $21,500/tpy and a proxy plant SO_2 emissions rate of 0.009 lb/MWh.

5. Value of Avoided VOC Emissions

The VOC emissions rate for the proxy plant is estimated to be 0.003 lb/MMBtu in the 2009 MPR Model.[29] Applying the applicable heat rate range of 6,879-6,932 Btu/kWh

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[28] California Hydrogen Highway Network, May 2005, p. 1-60, Table 1-27.

[29] Abt Associates, October 2000, Exhibit C-2, p. C-5, estimated a 0.012 lb/MMBtu VOC emissions rate for a natural gas combined cycle plant at that time.

yields a range of VOC emissions of 0.021-0.022 lb/MWh for the 2009 MPR proxy plant, grossed up for incremental losses.

The Value of Avoided VOC Emissions attributable to PV relies on region-specific observed California VOC ERC prices, which are presented in detail in Attachment B. Combining the calculated range of avoided VOC emissions and the applicable range of prices for each region yields a region-specific range of Value of Avoided VOC Emissions attributable to PV. The 2009 MPR value of VOC emissions allowances of 0.027 cents/kWh is subtracted from the region-specific range of values to avoid double counting. The 2009 MPR value of VOC emissions allowances is based on a VOC emissions allowance price of $24,829/tpy and a proxy plant VOC emissions rate of 0.018 lb/MWh.

6. Value of Avoided PM10 Emissions

The methodology for calculating avoided emissions of particulate matter less than 10 microns in diameter ("PM10") is the same as that used for valuing avoided NO_x, SO_2 and VOC emissions. For ease of analysis, only direct PM10 emissions are included in the analysis, likely resulting in an underestimated Value of PM10 Emissions due to lack of consideration of secondarily-formed PM10 emissions. The PM10 emissions rate for the proxy plant of approximately 0.018 lb/MWh is calculated using the 0.003 lb/MMBtu emissions rate from the 2009 MPR Model and the proxy plant heat rate range of 6,879-6,932 Btu/kWh.

The Value of Avoided PM10 Emissions attributable to PV uses region-specific observed California PM10 ERC prices, as shown in Attachment B. The same three-step process used in the previous calculations of the value of avoided emissions is used for PM10 emissions. That is, the 2009 MPR value of PM10 emissions allowances of 0.122 cents/kWh is subtracted from the region-specific range of calculated values to avoid double counting. The 2009 MPR value of PM10 emissions allowances is based on a PM10 emissions allowance price of $43,000/tpy and a proxy plant PM10 emissions rate of 0.003 lb/MWh, as shown in Attachment B.

7. Value of Avoided CO Emissions

The CO emissions rate is estimated to be 0.0213 lb/MMBtu for the 2009 MPR proxy plant.[30] Applying the applicable heat rate range results in a proxy plant range of CO emissions of 0.152-0.154 lb/MWh, including incremental losses.

The Value of Avoided CO Emissions is based on the region-specific observed California CO ERC prices shown in Attachment B. Multiplying the endpoints of these prices times the end-points of the avoided CO emissions results in a Value of Avoided CO Emissions attributable to PV that varies by region. The 2009 MPR does not include

[30] *Ibid.* Abt Associates estimated a 0.1095 lb/MMBtu CO emissions rate for a natural gas combined cycle plant.

any cost for CO emissions allowances for the proxy plant, so there is no need to subtract anything from the region-specific calculated values. The 2009 MPR Model shows a $500/tpy cost of CO emissions allowances and a proxy plant CO emissions rate of 0.131 lb/MWh, but these values are not included in the 2009 MPR value. These placeholder values from the 2009 MPR Model are shown alongside the region-specific CO emissions allowance prices and average proxy plant emissions rates in Attachment B.

8. Value of Health Benefits

By far the largest contributor to the Value of Health Benefits associated with avoided emissions is any reduction in particulate matter, particularly any reduction in particulate matter less than 2.5 microns in diameter ("PM2.5"). PM2.5 emissions are a subset of PM10 emissions, but PM2.5 emissions are more damaging to health because they lodge deeper in the lungs, and cannot readily be coughed out.

PM2.5 emissions are estimated to comprise 98% of total PM10 emissions in California's electricity generation sector, based on the statewide estimated annual average emissions published by the California Air Resources Board for calendar year 2000 for electric generation and cogeneration.[31] Calendar year 2000 emissions of direct PM2.5 and PM10 provided the basis upon which to calculate the tons per day of each that would be required to achieve the 33% reduction underlying California-specific calculations of the health-related economic value of reducing PM2.5 and PM10 emissions.[32] [33] Combining results from these sources, the health-related economic value of the 33% reduction in PM2.5 and PM10 emissions was divided by the corresponding physical tons to calculate the Value of Health Benefits for PM2.5, which ranges from 1.724-1.738 cents/kWh for the 2009 MPR proxy plant; the additional value for avoided >PM2.5-PM10 emissions is approximately 0.008 cents/kWh.

The health benefits of reduced NO_x and SO_2 power plant emissions on a cents/kWh basis are derived using the results of an extensive October 2000 study by Abt Associates. The Abt Associates study provides both nationwide and state-specific estimates of health benefits in terms of avoided incidences of mortality, hospitalizations,

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[31] California Air Resources Board, 2001, online Almanac Emission Projection Data.

[32] *See* Hall, *et al.*, 2006; California Environmental Protection Agency and California Air Resources Board, May 3, 2002, May 31, 2003, and March 21, 2006. (Note that Appendix A to the March 21, 2006 report was included in the September 2008 Public Health Analysis Supplement of the California Air Resources Board Climate Change Draft Scoping Plan.)

[33] *See* Hall, *et al.*, 2008, for a more-recent analysis of the benefits of ozone and PM2.5 reductions in California's South Coast Air Basin and San Joaquin Valley. Derived benefits per avoided incident are similar to those in the Abt Associates study except in the instance of avoided Mortality, where the derived value of avoided Mortality is $6.6 million per incident in Hall, *et al.*, (pp. 78-83) compared to the Abt Associates derived value of $7.3 million (in 2008$). The Abt Associates derived value used in this study is approximately mid-way between the recent Hall, *et al.*, analysis and the $8.7 million (in 2008$) value of avoided Mortality in the California Environmental Protection Agency and California Air Resources Board March 21, 2006 report (p. A-67).

and various categories of illness. These estimates were used to calculate the value of California-specific benefits based on the proportion of California-specific avoided health-related incidences to nationwide totals.[34]

Total California health benefits as derived from the Abt Associates study were divided by 75% of California's total 1997 NO_x and SO_2 power plant reductions to arrive at a value of $1.02/lb (1999$) of reduced emissions.[35] The $1.02/lb (1999$) of reduced emissions was inflated to 2009$ and then converted to cents/kWh using the estimated NO_x and SO_2 emissions rates for the 2009 MPR proxy plant heat rate range of 6,879-6,932 Btu/kWh. The Value of Health Benefits for avoided NO_x and SO_2 emissions is approximately 0.011 cents/kWh for the avoided 2009 MPR proxy plant.

The total Value of Health Benefits, calculated by combining the values for avoided PM2.5, PM10, NO_x and SO_2, is 1.743-1.757 cents/kWh for the 2009 MPR proxy plant. The specific components of the Value of Health Benefits are summarized in Attachment B. Since the 2009 MPR does not include any health-related costs associated with avoided emissions of any type from the proxy plant, no deductions were made from the calculated total Value of Health Benefits of 1.743-1.757 cents/kWh attributable to PV-generated electricity.

G. VALUE OF AVOIDED LOSSES (NOT ALREADY IN 2009 MPR)

This category of incremental PV value accounts for the fact that distributed generation from small-scale PV does not have to pass through the electrical grid and thus does not incur the associated T&D line losses. This means that 6% less electricity has to be generated by central generating stations, with an equivalent percentage reduction in generation-related capacity requirements, O&M costs, fuel input, and emissions output.[36]

The 2009 MPR includes 0.50% transformer losses and 1.49% generation-related losses. This nearly 2% in losses has been subtracted from the avoided losses attributable to PV to avoid double counting. The above-MPR, incremental Value of Avoided Losses value for PV ranges from 0.145-0.436 cents/kWh, prior to application of the TOD factor. Application of the utility-specific weighted average TOD factor is intended to replicate the fact that grid losses are highest during the highest load hours.[37]

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[34] Abt and Associates, October 2000, Exhibits 6-2 and 6-7.

[35] A 75% reduction in NO_x and SO_2 was the underlying assumption in the health benefits calculated in the Abt Associates study. A 75% reduction in total 1997 California electricity utility emissions as reported by the U.S. Department of Energy was used to calculate the $/lb value, based on the total California-specific health benefits derived from the Abt Associates study. (*See* U.S. Department of Energy, Electric Power Annual, Table 5.1.)

[36] This value approximates the 5.52% volume-weighted average for California's three investor-owned utilities as agreed to by Working Group for use in 2007 market price benchmark calculation (CPUC, January 25, 2007, p.7).

[37] Energy and Environmental Economics, Inc., January, 2010, Appendix A, p. 13.

H. VALUE OF IMPROVED RELIABILITY AND BLACKOUT AVOIDANCE

1. Value of Improved Reliability/Blackout Avoidance/Power Quality

Electricity generated by small-scale PV reduces the amount of electricity generated at central stations that must pass through the electric grid, thereby relieving potential overloading of many grid components (*e.g.*, transformers). To the extent that reduced overloading reduces the likelihood of load loss, PV provides additional above-MPR value in improved grid reliability and blackout avoidance.

The calculated Value of Improved Reliability and Blackout Avoidance for small-scale PV in California is based on the following six factors:

- The percentage of the state's population affected by a blackout.
- The duration of a blackout.
- The penetration of small-scale PV.[38]
- The 60% ELCC of small-scale PV.
- California's daily per capita Gross State Product ("GSP"), as a surrogate measure of the direct costs of a blackout.[39]
- An assumption that indirect costs related to a blackout are 60% as large as the direct costs.[40]

The current calculated range of the Value of Improved Reliability and Blackout Avoidance is 0.009-0.742 cents/kWh, using 2007 values for GSP and PV penetration.[41] The lower end of the range is based on a 1-hour blackout that affects 10% of the state's population; the upper end is based on a 24-hour blackout affecting 33% of the state's population.

Results calculated using the methodology described above were compared to estimated losses derived by others for both California (in whole or in part) and for the Northeastern U.S. August 2003 blackout (as it affected New York City).[42] Although not

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[38] The penetration of small-scale PV is calculated as the ratio of (ELCC-adjusted) PV-generated MWh to total California retail electricity sales in MWh. For 2007, this ratio was estimated to be 0.34%.

[39] Population and state GSP data as reported by the California Department of Finance, 2009.

[40] ICF Consulting, Summer 2003, estimates "Aggregate Indirect Costs" as 63% of "Aggregate Direct Costs" in its modeling of "Economic Costs of a Simulated Attack on the California Electric Grid."

[41] The Value of Increased Reliability/Blackout Avoidance/Power Quality of 0.010-0.853 cents/kWh shown in Figure 1 combines the Value of Increased Reliability and Blackout Avoidance with the Value of Increased Power Quality (discussed below).

[42] *See*, for instance, Anderson Economic Group, August 19, 2003; Consortium for Electric Infrastructure to Support a Digital Society ("CEIDS"), June 2001; Clean Power Research, LLC, March 17, 2006; Center for Risk and Economic Analysis of Terrorism Events ("CREATE"), May 31, 2005; Electricity Consumers

identical, the results were such that the methodology used here was deemed to be a reasonable means of valuing the improved reliability and blackout avoidance attributable to distributed small-scale PV in California.

The calculated range of the Value of Improved Reliability and Blackout Avoidance is anticipated to increase significantly as the penetration of PV throughout the state increases. Assuming the California Solar Initiative goal of 3,000 MW of installed small-scale PV capacity is achieved by 2020,[43] PV penetration would increase nearly six-fold from today's level, potentially generating nearly 2% of the total MWh consumed in California, providing up to 4 cents/kWh (in 2007$) in Value of Improved Reliability and Blackout Avoidance.

2. Value of Improved Power Quality

The Value of Improved Power Quality is calculated as being 15% of the Value of Reliability and Blackout Avoidance.[44] This percentage is based on an analysis done for the New York State Energy Research and Development Authority ("NYSERDA") that provided separate estimates of the total U.S. cost of outages and of power quality problems. As defined in the NYSERDA report:

- "The ability of the electric system to deliver electric power without interruption is termed 100% *reliability*.
- The ability to deliver a clean signal without variations in the nominal voltage or current characteristics is termed high *power quality*." (Emphasis in original.)[45]

The calculated range for the current Value of Improved Power Quality for the representative small-scale PV system is 0.001-0.111 cents/kWh. This is value provided by small-scale PV over and above the 2009 MPR values. As was the case for the Value of Increased Reliability and Blackout Avoidance, this value is expected to increase significantly as the penetration of small-scale PV increases in California.

I. OTHER VALUES NOT YET QUANTIFIED

In addition to the components of above-MPR value attributed to PV that have been quantified above, there are other benefits of PV that are not reflected in the 2009

Resource Council ("ELCON"), February 9, 2004; ICF Consulting, August 21, 2003; ICF Consulting, Summer 2003.

43 California Public Utilities Commission, December 15, 2005, p. 5.

44 Because of its relationship with the Value of Increased Reliability and Blackout Avoidance, the Value of Improved Power Quality is added to the Value of Increased Reliability and Blackout Avoidance under the category of Increased Reliability/Power Quality/Blackout Avoidance in Figure 1.

45 Energy and Environmental Analysis, Inc., and Pace Energy Project, December 2005, pp. ES1 and ES3.

MPR and that have not yet been quantified. Two examples of such PV benefits not included in this analysis are discussed briefly below.

1. Value of Reduced Reliance on Natural Gas Imports

Although the market value of natural gas use by the 2009 MPR proxy plant is included in the 2009 MPR, the intrinsic value to Californians of reduced natural gas import reliance due to reduced natural gas use as the penetration of solar PV systems increases has not been quantified in this analysis.

2. Value of Reduced Natural Gas Prices

The greater the number of PV systems that are installed in California, the greater will be the resultant natural gas savings. As natural gas consumption for central station electricity production (as represented by the 2009 MPR proxy plant) declines, a threshold of natural gas savings may occur such that natural gas prices in California begin to soften.[46] Because the benefits of this price impact would predominantly occur in future years, the value of this price impact has not been included in this analysis.

3. Value of Increased National Energy Security

The national energy security benefits of using California's indigenous and bountiful solar resource are intuitive, but difficult to quantify. Any national energy security benefits attributed to increased use of California's indigenous solar resources must be net of any identifiable security risks related to increased solar-generated electricity. The (net) national energy security benefits of renewable energy resources are not included in the 2009 MPR and have not been quantified in this analysis.

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[46] *See*, for instance, Wiser, *et al*., January 2005.

J. CONCLUSIONS

Solar PV systems in California provide significant value to Californians *above and beyond* the threshold costs of the natural gas-fired proxy plant that are quantified in the 2009 MPR. This analysis has identified and quantified as a PV Adder those components of above-MPR value attributable to electricity generated by a representative PV system using California's bountiful and indigenous solar resource. These components of the PV Adder include the value of avoided T&D, the value of increased reliability, blackout avoidance and power quality, as well as the above-MPR value of incremental avoided air emissions associated with natural gas combustion and the associated health benefits. Depending on the specific region and utility service territory, solar PV generation provides a combined above-MPR PV Adder value ranging from 4.761-12.744 cents/kWh after the application of utility-specific weighted average TOD factors. When combined with the TOD-adjusted 2009 MPR value for a 20-year contract with a 2010 start date, the representative solar PV system directed south at a 10-degree tilt provides a total TOD-adjusted value ranging from 17.154-24.132 cents/kWh.

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ATTACHMENT A

UTILITY-SPECIFIC TIME-OF-DELIVERY PERIODS AND FACTORS[47]

Pacific Gas and Electric[48]

Month	Period	Definition	Factor
June - September	Super-Peak	Hours Ending (HE) 13-20 Monday-Friday (except NERC holidays)	**2.20490**
	Shoulder	HE 7-12, 21 and 22 Monday-Friday (except NERC holidays); HE 7-22 Saturday, Sunday and all NERC holidays	**1.12237**
	Night	HE 1-6, 23 and 24 all days (including NERC holidays)	**0.68988**
October - February	Super-Peak	Defined above	**1.05783**
	Shoulder	Defined above	**0.93477**
	Night	Defined above	**0.76384**
March - May	Super-Peak	Defined above	**1.14588**
	Shoulder	Defined above	**0.84634**
	Night	Defined above	**0.64235**

47 2009 MPR Resolution, Appendix B.

48 PG&E 2009 RPS Solicitation, pro forma contract, pp. 45-46. http://www.pge.com/includes/docs/word_xls/b2b/wholesaleelectricsuppliersolicitation/FinalAttH2009RPSPPA(amendedforSTOffers)(00084346).DOC

Southern California Edison Company[49]

Season	Period	Definition	Factor
Summer June 1 - September 30	On-Peak	WDxH[1], noon-6 pm	**3.13**
	Mid-Peak	WDxH, 8-noon, 6-11 pm	**1.35**
	Off-Peak	All other times	**0.75**
Winter October 1 - May 31	Mid-Peak	WDxH, 8 am-9 pm	**1.00**
	Off-Peak	WDxH, 6-8 am, 9 pm-midnight; WE/H[2] 6 am-midnight	**0.83**
	Super-Off-Peak	Midnight-6 am	**0.61**

1/ WDxH is defined as weekdays except holidays
2/ WE/H is defined as weekends and holidays

San Diego Gas &Electric[50]

Season	Period	Definition[1]	Factor
Summer July 1- October 31	On-Peak	Weekdays 11am-7pm	**1.6411**
	Semi-Peak	Weekdays 6am-11am; Weekdays 7pm-10pm	**1.0400**
	Off-Peak	All other hours	**0.8833**
Winter November 1 - June 30	On -Peak	Weekdays 1pm-9pm	**1.1916**
	Semi -Peak	Weekdays 6am-1pm; Weekdays 9pm-10pm	**1.0790**
	Off-Peak	All other hours	**0.7928**

1/ All hours during National Electric Reliability Council (NERC) holidays are Off-Peak.

[49] SCE 2009 RPS Solicitation, pro forma contract, Exhibit K, p. 2. http://www.sce.com/NR/rdonlyres/4F174486-40D2-470B-AB23-96A3A583C2E5/0/20090629_RFP_Appendix_B1_ProForma_Agreement.doc

[50] SDG&E 2009 RPS Solicitation, pro forma contract, pp. 39-40. http://www.sdge.com/documents/rfo/renewable2009/ModelPPA.doc

ATTACHMENT B

ASSUMPTIONS AND RESULTS FOR AVOIDED EMISSIONS AND RELATED VALUE OF HEALTH BENEFITS (Prior to Time-of-Delivery Adjustment)

	Heat Rate Range (Btu/kWh)	Emissions Rate (CO_2 in tons/MWh; all others in lb/MWh)					
		NO_x	SO_2	PM10	CO	VOC	CH_4
2009 MPR Proxy Plant	6,932 6,879	0.063	0.009	0.047	0.131	0.018	n/a
		NO_x	SO_2	PM10	CO	VOC	CO_2
Emissions Prices	In-State:	($/ton/year)	($/ton/year)	($/ton/year)	($/ton/year)	($/ton/year)	($/ton)
2009 MPR	Average	$20,000	$21,500	$43,000	$ 500	$24,829	$10.44 (2012) $90.17 (2029)
PG&E – Ex. San Joaquin Valley (Bay Area ERCs)	Maximum	$ 11,750	$14,000	$ 42,500	$ 796	$13,250	$90.17
	Minimum	$ 9,500	$ 7,500	$ 27,500	$ 769	$ 8,450	$10.44
PG&E – San Joaquin Valley (SJV ERCs)	Maximum	$ 68,325	$44,667	$ 87,500	$ 769	$48,705	$90.17
	Minimum	$ 22,450	$22,250	$ 57,500	$ 769	$22,667	$10.44
SCE (South Coast ERCs)	Maximum	$ 55,450	$40,275	$300,000	$8,337	$18,667	$90.17
	Minimum	$ 47,000	$40,275	$ 53,000	$8,337	$ 6,633	$10.44
SDG&E (San Diego or South Coast ERCs)	Maximum	$132,500	$40,275	$136,668	$8,337	$63,750	$90.17
	Minimum	$ 87,500	$40,275	$ 53,000	$8,337	$40,000	$10.44
PV: Value of Avoided Emissions, Net of 2009 MPR Cost of Emissions Reduction Credits (cents/kWh)							
		NO_x	SO_2	PM10	CO	VOC	Total (All)
PG&E – Ex. San Joaquin Valley	Maximum	(0.022)	(0.003)	0.024	0.007	(0.010)	(0.004)
	Minimum	(0.032)	(0.007)	(0.028)	0.007	(0.016)	(0.077)
PG&E – San Joaquin Valley	Maximum	0.235	0.016	0.177	0.007	0.036	0.472
	Minimum	0.026	0.002	0.073	0.007	0.002	0.111

SCE	Maximum	(0.029)	(0.007)	0.065	0.014	(0.023)	0.021
	Minimum	(0.037)	(0.007)	(0.089)	0.014	(0.025)	(0.144)
SDG&E	Maximum	0.527	(0.007)	(0.037)	0.014	0.056	0.554
	Minimum	0.319	(0.007)	(0.089)	0.014	0.025	0.262

PV: Value of Health Benefits Associated with Total Avoided Emissions (cents/kWh)					
Statewide (Not Utility-Specific)		NO_x & SO_2	PM10	PM2.5*	. Total (All Emissions)
vs. 2009 MPR Proxy Plant	Maximum	0.011	0.008	1.738	1.757
	Minimum	0.011	0.008	1.724	1.743

** PM2.5 = 98% of PM10 emissions by weight, per California Air Resources Board 2000 Emissions Inventor*