

# *Crossborder Energy*

---

*Comprehensive Consulting for the North American Energy Industry*

## Re-evaluating the Cost-Effectiveness of Net Energy Metering in California

prepared by:

R. Thomas Beach  
Patrick G. McGuire  
*Crossborder Energy*

January 9, 2012

### **Executive Summary**

California is approaching an inflection point with respect to net energy metering (NEM), a core public policy that has enabled California to become the nation's leading market for the installation of solar photovoltaic (PV) generation. NEM is a simple billing arrangement that has been essential to consumer acceptance of PV and to the success to date of the California Solar Initiative, the state's 10-year, \$3.3 billion dollar rebate program designed to transform the once-fledgling solar market to a self-sustaining industry. NEM and the CSI have reduced the barriers to the adoption of solar and have made the benefits of clean, renewable PV generation accessible to more than 100,000 Californians in more than one gigawatt of PV installations..

Against this backdrop of success, there is a need to re-evaluate the state's net energy metering policy. The end of the CSI rebate program is in sight, several years ahead of schedule, and, under one interpretation of the state's NEM statute, the capacity of NEM systems will soon approach the statutory cap on NEM systems. If policy makers do not act to extend NEM, the growth in the state's solar market could be adversely impacted, as there would be no clear billing arrangement for customers who install PV systems interconnected to the grid. Yet it would be unwise to forge ahead and to raise the statutory NEM cap without re-evaluating the fundamental question: is there a net cost to ratepayers who do not install solar which exceeds the benefits produced by net energy metering? In short, is net metering cost effective?

This report begins to answer the question of whether net metering is cost effective today, by re-evaluating, with more current data inputs, two past studies that have assessed the costs and benefits of NEM. Our work focuses on the Pacific Gas & Electric (PG&E) residential market, because prior studies have calculated that, statewide, two-thirds of the net costs of NEM for non-participating ratepayers are concentrated in the PG&E residential market, and, over all types of customers, 87% of the net costs of NEM are in PG&E's territory. Since those studies were conducted, the California Public Utilities Commission (CPUC) has dramatically re-structured

*Crossborder Energy*

PG&E's residential rates, substantially reducing the rates for high-usage customers than were the most significant contributors to the costs of NEM. In addition, new models of the benefits of the power exported to the grid by NEM customers place greater emphasis on the benefits of NEM as a new source of renewable generation, increasing the benefits of NEM compared to the prior studies. Our re-evaluation of the costs and benefits of NEM in the PG&E residential market concludes that the net cost to other ratepayers (\$0.02 per kWh of NEM exports to the grid) is just one-seventh of the net cost calculated in the CPUC's 2009-2010 NEM cost-effectiveness study (\$0.14 per kWh of NEM exports to the grid). We also take a new look at the cost-effectiveness of NEM for large PG&E commercial customers, and conclude that NEM is cost-effective for such customers. Commercial, governmental, and other non-residential PV installations comprise more than half of the solar PV capacity installed to date.

Although this study did not analyze the solar markets of all of three of the investor-owned utilities, the CPUC's prior NEM cost-effectiveness showed that 87% of the net costs of NEM were in the PG&E market. This justifies the focus of our study on the PG&E market. Our results show that, under today's changed circumstances, the net costs of NEM in the PG&E residential market are now just a small fraction of those calculated in the CPUC's 2009-2010 study, and NEM appears cost-effective for non-residential customers. The new avoided cost model used in this work will also improve the cost-effectiveness of NEM for the other electric utilities, as will the other utilities' continuing efforts to reduce the upper tier rates of their residential customers. These results strongly suggest that the cost-effectiveness of NEM has improved significantly since the prior studies, and that on average over all customer classes NEM may indeed be cost effective throughout the investor-owned utilities' territories.

## **1. Introduction**

Net energy metering (NEM) is a billing arrangement for customers who install clean, on-site distributed generation (DG) that is interconnected to the electric grid, typically solar photovoltaic (PV) systems. At certain times, such as in the middle of the day, such DG systems will produce more energy than the customer uses on its premises, and the excess generation is exported to the grid. NEM provides a way to calculate a bill for the customer which considers that the customer at times imports electricity from the grid and at other times exports power to the grid.

With NEM, the customer's meter runs both forward and backward, and at the end of the billing period the customer simply pays for the net energy used, or receives a credit at the retail rate if more energy is produced than consumed.<sup>1</sup> Consumers understand the idea of running the meter backward, and the simplicity and understandability of NEM are an essential element in marketing DG systems to potential customers. NEM's simplicity ensures that consumers who are considering whether to buy DG systems understand how those systems will impact their energy bills. In contrast, it would be much more confusing if consumers with DG systems received different prices for their energy imports versus exports. The fact that 43 states and the

---

<sup>1</sup> Section 2827 of the California Public Utilities Code provides the statutory basis for net metering in California.

District of Columbia have adopted the use of NEM for DG systems attests to the attractiveness of NEM as a key component in encouraging the use of DG.<sup>2</sup>

For the solar customer, the simplicity of NEM is its chief virtue. In contrast, the economics of NEM for the utility and its other ratepayers are a more complicated question. The economics of NEM are under increasing scrutiny, as the state recently passed the milestone of 1 GW of grid-interconnected DG systems. Given the rapid growth and declining prices for solar DG systems, the California investor-owned utilities (IOUs) seem certain to reach the state's statutory limit for the total capacity of net-metered DG systems: 5% of the aggregate customer peak demand of the utility.<sup>3</sup> The IOUs contend that NEM causes a significant cost shift from customers who install solar to other, "non-participating" ratepayers, and have suggested that NEM should be replaced with a different billing arrangement once this cap is reached. This study presents a new analysis of the economics of net metering, and shows that the utilities' concerns are misplaced. Recent changes in rate design and a new perspective on the utilities' avoided costs suggest that NEM does not produce a significant cost shift to non-participating ratepayers.

## 2. The "Three States" of Customer-Owned Solar Generation

To understand the economics of net metering, it is important to appreciate exactly how a DG system located on a customer's premises works. Through the course of the day, a net metered PV system will operate in one of three different "states":

- **The "Retail Customer State."** The sun is down and there is no PV production and all energy flows into the house from the grid. The customer is a regular utility customer.
- **The "Energy Efficiency State."** The sun is up and there is some PV production, but not enough to serve all of the homeowner's instantaneous load. Here the customer is served both with power from the solar system as well as with power flowing in from the grid. In this state, the solar DG serves as a means to reduce the customer's load on the grid, in the same fashion as a more efficient air conditioner or other energy efficiency measure. Typically, 50% to 80% of the output of a solar PV system will be used on-site, without touching the utility's grid.
- **The "Power Export State."** The sun is high overhead and PV production exceeds the customer's instantaneous use. In this state, the solar power flows into the house to serve the entire load, with the excess power flowing back out to the neighborhood grid. As a matter of physics, this power will serve neighboring loads, displacing power that the utility would otherwise generate at a more distant power plant and deliver to that local area over its transmission and distribution (T&D) system. These exports run the meter backward, providing the solar customer with compensation from the utility for these power exports in the form of bill credits that can be netted against the customer's imports.

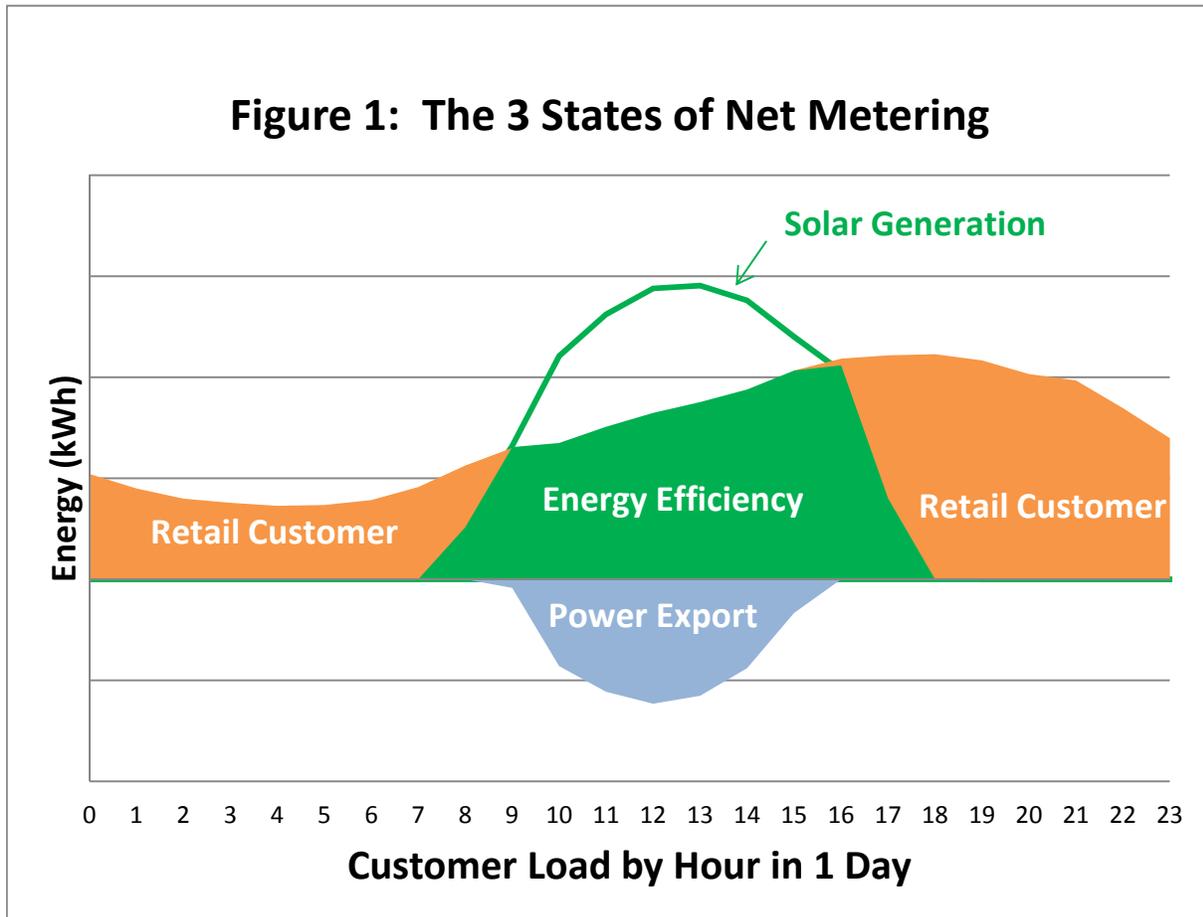
---

<sup>2</sup> See <http://www.dsireusa.org/summarymaps/index.cfm?ee=1&RE=1> . Three other states allow utilities to offer net metering on a voluntary basis.

<sup>3</sup> P.U. Code Section 2827[c][4].

Thus, this compensation is in the form of credits at the full retail rate. The utility re-sells the exported power to neighboring loads.

**Figure 1** shows typical daily profiles of a residential load and of the output of a PV system, and illustrates when each of these three states occurs.



It is critical to recognize that NEM only impacts other utility ratepayers in the third, “power export” state, as this is the only state in which the customer’s generation actually touches the grid. Again, typically just 20% to 50% of the output of a PV system will be exported to the grid, and other utility customers are impacted only by this third state. These facts are important to understanding the economics of NEM from the perspective of the utility and its other customers.

It is in the “power export” state that NEM presents both costs and benefits for the utility’s other ratepayers who do not install solar. The costs for non-participating ratepayers are the bill credits that the utility provides to solar customers as compensation for NEM exports, plus any incremental utility costs to meter and bill NEM customers. The benefits are the costs that the utility avoids by using the NEM exports to serve nearby loads, instead of generating or purchasing a like amount of power and moving that power down to the distribution system. These avoided costs are a benefit for other ratepayers. We next review the existing cost-

effectiveness studies of these costs and benefits of NEM for other, non-participating utility ratepayers in California.

### 3. Cost-effectiveness Studies of NEM in California

**The CPUC NEM Cost-effectiveness Study.** There have been two significant studies of the cost-effectiveness of NEM in California. The first is the 2009 study conducted by the consulting firm Energy and Environmental Economics (E3) for the CPUC, with the final version published in March 2010.<sup>4</sup> This study was mandated by P.U. Code Section 2827[c][5]. The E3 analysis essentially computes the “cost” of NEM as the bill credits provided for the customer’s hourly NEM exports, plus the utilities’ incremental billing costs, and compares these to the “benefits” of the costs which the utilities avoid from NEM exports. To calculate these avoided cost benefits, E3 used the avoided cost model which it developed under contract to the CPUC for use in evaluating the benefits of energy efficiency programs, and which the Commission has reviewed and approved for that purpose. It is important to recognize that the E3 study focused only on the ratepayer impacts of NEM in its third “state,” when power is exported to the grid.

The following are key findings of the E3 NEM Study:

- “If the total installed capacity of NEM solar generation reached 2,550 MW of solar capacity by 2017 to reach the [California Solar Initiative] CSI related goals within the areas of the investor-owned utilities, the total cost of the program would be approximately \$137 million per year (in 2008 dollars)... This total cost would be approximately 0.38 percent of projected IOU revenues in 2020, which would imply an average rate impact of \$0.00395 per kWh in 2020.” (page 5)
- “The report estimates that the average net cost of NEM is \$0.12 per kilowatt-hour (kWh) exported.” (Table 3, pages 6-7) This includes both residential and non-residential systems. The calculated cost shift is much higher for the residential market (\$0.19 per kWh exported) than for the non-residential market (\$0.03 per kWh exported). It is important to emphasize that the amount of power exported is just a fraction of the total power produced by on-site DG. To express these numbers in terms of dollars per kWh of power produced by solar DG, these numbers should be divided roughly by a factor of 2 to 5, because only 20% to 50% of the generation is exported.
- “The volume of (NEM) energy exported to the utilities is small compared to the total solar generation and it is *de minimus* (sic) compared to the total energy procured by utilities.” (page 7)
- 87% of the cost shifts resulting from NEM calculated in the E3 Study are in the residential market, with fully two-thirds (67%) of the calculated NEM cost shift tied to PG&E’s residential customers. (see Table 3, page 7)

---

<sup>4</sup> *Net Energy Metering Cost Effectiveness Evaluation*, (E3, March 2010), the “E3 NEM Study,” as well as the CPUC Energy Division’s introduction to this study, available at [http://www.cpuc.ca.gov/NR/rdonlyres/0F42385A-FDBE-4B76-9AB3-E6AD522DB862/0/nem\\_combined.pdf](http://www.cpuc.ca.gov/NR/rdonlyres/0F42385A-FDBE-4B76-9AB3-E6AD522DB862/0/nem_combined.pdf)

- 14% of the NEM cost shift is due to incremental billing costs (Table 6, page 8), with most of this impact from PG&E's stated billing costs. PG&E provided E3 with billing costs that assume manual billing of 20% of NEM customers. E3 did not review the reasonableness of these costs. PG&E's manual billing costs per NEM customer (\$29.34) are almost ten times larger than SCE's reported costs (\$2.34 to \$3.03); even PG&E's "automatic" billing costs (\$15.55) are five times higher than SCE's costs. (see Tables 23-24, pages 39-40) Almost one-third (32%) of the costs of NEM for PG&E are incremental billing costs. (see Table 44)
- "NEM . . . provides a **small fraction** of the total costs of the demand side programs. Overall, the demand side programs provide a net benefit to ratepayers." (page 5)

**The LBNL Study on Residential NEM.** In April 2010, the Lawrence Berkeley National Lab (LBNL) completed a study on the economics of net metering in California for residential solar customers.<sup>5</sup> The LBNL NEM Study is an extensive investigation of the economic value that NEM provides to residential customers with PV in California. The LBNL study emphasizes that the value of NEM to the solar customer depends heavily on the structure of the underlying retail electricity rate that the customer pays, as well as on the characteristics of the customer and the PV system. LBNL's analysis is based on a sample of 215 residential customers of Pacific Gas and Electric (PG&E) and Southern California Edison (SCE) for whom LBNL obtained hourly usage data and then simulated the addition of a solar PV system. Importantly, the LBNL study compares the value of the bill savings under NEM to three potential alternative compensation mechanisms, each of which provides bill credits for some or all PV production at prices based on the state's Market Price Referent (MPR).<sup>6</sup> These three alternatives are:

- (1) ***A Full MPR-based feed-in tariff***, with all of the customer's PV generation credited at the time-of-use-adjusted (TOU) MPR rate, with the customer paying the standard rate for all of its usage;
- (2) ***Hourly netting***, whereby PV production offsets up to 100% of customer usage within each hour, with any excess hourly production that is exported in that hour credited at the TOU MPR rate for that hour; and
- (3) ***Monthly netting***, whereby PV production can offset up to 100% of customer usage within each TOU period of each month, but any excess monthly production is credited at an MPR-based rate.

The LBNL study concludes that NEM provides substantial value to solar customers relative to the first option of a full MPR-based feed-in tariff, and that the third option – monthly netting of PV imports and exports – is almost the same as the current NEM program where netting happens on an annual basis.

---

<sup>5</sup> Dargouth, N; Barbose, G; and Wiser, R., "The Impact of Rate Design and Net Metering on the Bill Savings from Distributed PV for Residential Customers in California" (April 2010, LBNL), the "LBNL NEM Study," available at <http://eetd.lbl.gov/ea/emp/reports/lbnl-3276e.pdf>.

<sup>6</sup> The MPR is the price used to evaluate wholesale contracts with renewable generators and is intended to represent long-run avoided generation supply costs, based on the cost of a combined-cycle natural gas-fired generator.

The LBNL study's most important analysis is the second option, where LBNL netted imports and exports on an hourly basis. This is the same approach taken in the E3 NEM cost-effectiveness study, which also analyzed NEM customers' net import and export of electricity on an hourly basis, and valued the net exports at avoided cost. The LBNL researchers determined the difference between the value of its hourly netting option and the value of full net metering; this difference is essentially the same metric as the net cost of NEM that E3 calculated in its study. The only significant difference appears to be that, instead of E3's avoided cost model, LBNL used the 2009 MPR as the measure of the avoided cost benefits of exported generation. Significantly, LBNL's analysis found that standard net metering was only slightly more beneficial for solar customers (and thus only slightly more costly for other ratepayers), compared to the hourly netting option. For both PG&E and SCE residential customers, the difference was about \$0.02 per kWh of total PV production. (Figure ES-3) LBNL also observed that consideration of avoided transmission and distribution costs and avoided line losses would bring the hourly netting analysis even closer to standard net metering. For example, LBNL estimated that avoided T&D costs of \$0.01 per kWh and avoided line losses of 10% would eliminate over half of the remaining difference for a customer whose solar system meets 75% of his load. (Table 5) This would bring the net cost of residential NEM to under \$0.01 per kWh of solar production, or less than about \$0.02 to \$0.05 per kWh of power exported.

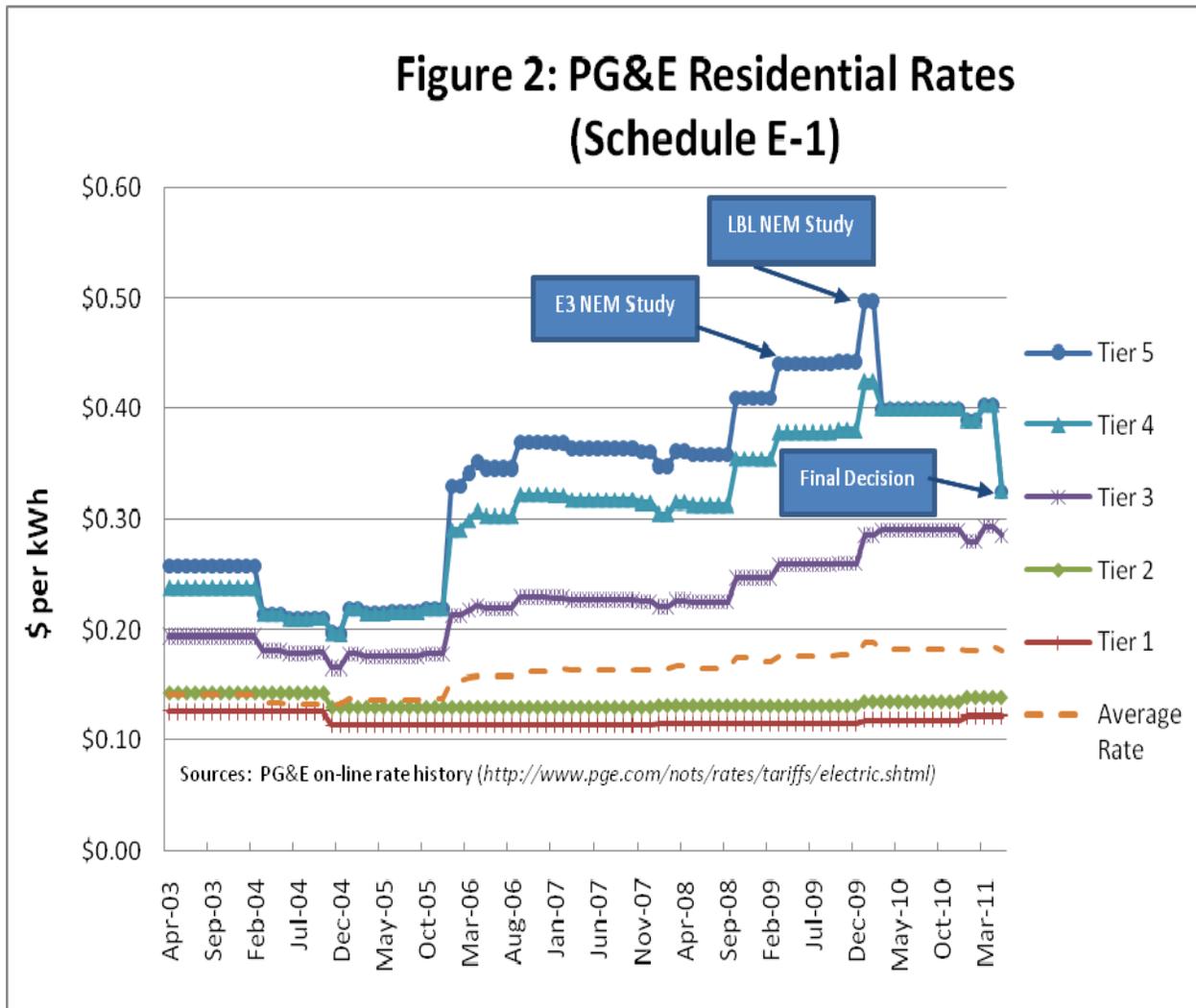
**A Tale of Two Studies.** Although the E3 and LBNL studies used similar approaches to evaluating the economics of NEM, their conclusions present different perspectives. The E3 NEM Study cites a cost of NEM of \$137 million per year once the CSI is fully built-out, in 2017. This is not an insignificant amount of money, even if it is small in the context of the IOUs' entire revenue requirement. Similarly, E3 calculates that residential NEM customers impose a net cost of \$0.19 per kWh of power exported to the grid, which appears to be significant given that the average IOU residential rate is in the range of \$0.17 to \$0.19 per kWh, even though only a fraction of PV output is exported. On the other hand, the LBNL study suggests that NEM is only slightly more expensive than if the power exported to the grid were priced at an avoided cost rate (the MPR) plus avoided line losses and T&D costs – as noted above, less than \$0.02 to \$0.05 per kWh of power exported. The LBNL work thus can be read as suggesting that there is not a significant problem with NEM for residential customers.

Which perspective is correct? One key point on which both studies agree is that, in the final analysis, any "cost shift" resulting from NEM is function of rate design. The largest contributors to the NEM "cost shift" are large residential customers who install smaller systems that move them out of the expensive upper rate tiers, but which preserve their benefits from the low Tier 1 and 2 rates for their remaining usage. This is an artifact of the design of California's residential rates, not of NEM. Thus, as California's rate structures change over time, so will the economics of NEM.

#### 4. Re-Evaluating NEM in California

Our review of the E3 and LBNL NEM studies underscores the need for a re-evaluation of the economics of net metering in California. These studies used rates from 2008 or early 2010 and were conducted in 2009 and early 2010. Since then, several of the critical drivers of these results have changed significantly, as follows:

- Two-thirds of the NEM cost shift calculated in the E3 NEM Study was tied to PG&E residential customers, who paid steeply tiered rates in 2008, as shown in **Figure 2**. The LBNL study used early 2010 rates, when PG&E's Tier 5 rate reached its peak of \$0.50 per kWh. Since these analyses were performed, the CPUC has ordered PG&E to eliminate its highest rate tier (Tier 5) and has lowered PG&E's Tier 4 rate substantially (e.g., the top tier has been lowered from \$0.50 per kWh to \$0.33 per kWh). As shown in Figure 2, the result is a dramatic reshaping of the E-1 rate compared to the rates in effect when the E3 and LBNL NEM studies were performed.



- E3 calculated the 20-year levelized cost shift from NEM assuming that retail rates would escalate at 4.5% per year. (Table 20, p. 37) This sharp escalation is well above the historical trends in IOU rates (which have increased by 1.4% to 1.8% over last decade and by 2% over the last two decades).<sup>7</sup> Moreover, in the recent LTPP case, the IOUs projected rate increases of about 2.7% per year (nominal) over the 2011-2030 period.<sup>8</sup>
- E3 used an avoided cost model based on short-term market prices until 2015, and new fossil resources thereafter. (see Appendix A, Figure 9, p. 13) LBNL used the MPR, which is a benchmark for RPS costs but which is based on fossil resources. The recent 33% RPS legislation directed the CPUC to replace the MPR with a benchmark for the RPS program based on the costs of renewables.<sup>9</sup> Projections of the costs of RPS power are generally above the MPR.<sup>10</sup> In the light of SB 2, CSI generation avoids central station RPS renewables at a higher cost than either E3's mix of market and fossil resources or LBNL's MPR.
- It is frequently asked whether NEM exports avoid the costs of other renewable generation, given that CPUC policy allows the solar customer to retain ownership of the renewable attributes (RECs) associated with his or her output. To answer this question, one must focus on the impact of NEM generation on the utility's costs. The customer's solar output reduces the IOU's retail sales, because the solar customer serves its own load. This drop in the IOU's retail sales reduces the utility's own RPS obligations and the amount of renewable power that the IOU must buy to meet that obligation. It is these avoided RPS costs for the utility that we have included in the avoided cost calculations, because these are a benefit for the utility's other ratepayers. Thus, CSI generation avoids above-market RPS costs even though the IOUs do not receive direct RPS credit for behind-the-meter solar and the solar customer retains ownership of the RECs associated with his or her output. The E3 and LBNL NEM studies provide some value for avoided RPS costs associated with NEM export volumes, but do not account for the fact that the IOU's sales (and its RPS obligations and associated costs) are reduced not just by NEM export volumes but by total production from the NEM generator.

These changed circumstances warrant a re-evaluation of the cost-effectiveness of net energy metering in California.

---

<sup>7</sup> Based on statewide EIA data and CEC IOU-specific data from 1990 – 2010. See <http://www.eia.gov/electricity/data.cfm#sales> or [http://energyalmanac.ca.gov/electricity/Utility-Wide\\_Average.xls](http://energyalmanac.ca.gov/electricity/Utility-Wide_Average.xls).

<sup>8</sup> “Joint IOU Supporting Testimony at Appendix A: Performance Evaluation Metrics – Testimony of E3, Inc.,” (IOU LTPP Testimony) served July 1, 2011 in R. 10-05-006, at page A-72, Figure 4 and associated workpapers (*LTPP\_EM\_C\_07-01-2011.xlsm*) for the CPUC Trajectory case.

<sup>9</sup> See P.U. Code Section 399.15[c][2].

<sup>10</sup> See workpapers for the IOU LTPP Testimony (*LTPP\_EM\_C\_07-01-2011.xlsm*), comparing system average electric rates for 2011-2030 between the CPUC Trajectory and All-Gas cases.

## 5. A New Analysis of the Economics of NEM in PG&E's Residential Market

We have undertaken a new analysis of the economics of NEM in PG&E's residential market. We focus on this segment because fully two-thirds of the NEM cost shift that the E3 NEM Study identified came from this market.

We employ the same hourly approach used in the E3 and LBNL studies. Although we do not have access to the billing records of individual NEM customers that E3 used, we have modeled the economics of net metering on an hourly basis for a wide range of customer and PV system sizes in four representative PG&E climate zones (T, X, S, and W). The customers' hourly load profiles are simulated using PG&E's dynamic load profiles for its residential class. We analyze annual customer loads ranging from 100% of the baseline amount (about one-half of average residential usage) up to 350% of baseline (i.e. double average usage and well into Tier 4 of PG&E's E-1 rate) and PV system sizes that produce from 30% to 100% of the customer's annual kWh usage.

We first compute the customer's net savings under standard NEM, with all exports credited to the customer at the full retail rate. Then we re-compute the savings assuming that, in any hour in which the customer's generation exceeds its load, the exported power is priced at avoided costs, such that other ratepayers are indifferent to the export. If the savings in the second case are equal to or greater than those under standard NEM, then NEM will not harm non-participating ratepayers and is cost-effective. If the savings are less than under standard NEM, there is a cost to NEM for non-participating ratepayers. We calculate these savings as 20-year levelized values, assuming rates increase by 2.7% per year with a discount rate of 7.62%.

For avoided costs, we have used E3's latest avoided cost model for DG resources, dated January 2011. We have updated this model to use the input assumptions adopted by the CPUC in Resolution E-4442 on December 1, 2011 for use with the 2011 MPR. In the E3 model, we do not use the "resource balance year" concept in which short-run avoided costs are used until some chosen "resource balance year" after which long-term resources are assumed to be avoided. E3's determination of a resource balance year that is 5-7 years in the future assumes the addition of large amounts of preferred renewable resources (from both the RPS and the CSI) between today and 2015-2017. However, these include the resources we are trying to value. When these resources are removed from the resource plan, the resource balance year is much closer to the present. In addition, the use of lower short-run marginal costs in the years leading to the resource balance year results in a cost-effectiveness benchmark for the generation costs of renewable DG that is always below the full costs of a long-term resource, such as the combined-cycle gas turbine (CCGT) that is the basis for the MPR. This treats renewable DG in a manner that is inconsistent with, and much more conservative than, the treatment of large-scale RPS resources, which the IOUs have had to purchase if their costs were less than the MPR.<sup>11</sup> In short,

---

<sup>11</sup> Fundamentally, the fact that resources are not in balance with demand until some year in the future results from the "lumpy" nature of large electric resource additions and the long lead times needed to develop, permit, and build major new power plants. New resource additions "overshoot" the amount of needed capacity, pushing out the resource balance year until demand growth catches up. In contrast, DG resources typically have much shorter lead times and can be installed in a less lumpy, more continuous fashion than large plants, and thus should not bear the

the resource balance year concept ignores the facts that there is an ongoing need today for new RPS resources, that RPS resources are being added today, and that renewable DG avoids RPS costs. Finally, we note that E3's latest avoided cost model, unlike its 2008 model, recognizes that behind-the-meter DG reduces the IOUs' sales, and thus allows them to avoid the above-market costs of RPS central-station generation in years before 2020.

The results of our analysis for PG&E's E-1 rate are shown in **Table 1**. The table shows the net costs or benefits of net metering for PG&E E-1 residential customers over a range of both customer usage and PV system sizes. As in the E3 NEM Study, the costs and benefits are expressed in \$ per kWh of exported power, with costs as positive (red) values and benefits as negative (green). The table shows that net metering is cost-effective for PG&E residential customers with usage through Tier 3 (200% of baseline). NEM is most costly for larger customers with significant usage in Tier 4 (over 300% of baseline) who install smaller systems, such that the PV system only offsets higher-tier usage. These results are driven not by net metering itself, but by PG&E's existing residential rate design, with statutory limits under AB 1x on the rates in Tiers 1 and 2. For the four climate zones and the range of customer/PV sizes analyzed, the average cost of NEM for PG&E residential customers is \$0.02 per kWh exported.

The results shown in Table 1 are substantially different than those that E3 obtained in 2009; E3's study showed net costs from NEM for all PG&E residential customers regardless of customer size. (Tables 33 and 34) We have used E3's avoided cost model from 2008, plus the PG&E E-1 rates in effect in 2008, to run our model under the assumptions used in the E3 NEM Study. These assumptions also include the 4.5% annual growth in rates that E3 used. These results are shown in **Table 2**. This table, like the E3 NEM Study, shows net costs of NEM for all PG&E residential customers. The average cost of NEM for PG&E's residential customers from our model is \$0.12 per kWh exported, close to \$0.14 per kWh exported reported in the E3 NEM Study. (Table 6, Bill Impacts less Avoided Costs, omitting the impacts of Incremental Billing Costs) This comparison verifies the accuracy of our model of the costs and benefits of NEM even though we do not have access to the detailed set of NEM billing data that E3 used.

Comparing Tables 1 and 2 shows that circumstances have changed substantially since the 2009 E3 NEM Study. Using 2011 rates and avoided costs, the net cost of NEM for PG&E residential customers (\$0.02 per kWh) is only one-seventh as large as reported by E3 in its NEM Study (\$0.14 per kWh). This comparison is shown in **Figure 3**. Particularly important to these results are the major reforms in PG&E's residential rates that the CPUC has adopted since 2008, as well as a new avoided cost model that more fully values the RPS costs that DG power displaces.

---

avoided cost penalty imposed by a resource balance year that is far in the future. It is quite ironic that E3 calculated the avoided costs for "unlumpy," short-lead-time DG resources using a resource balance year approach, whereas the cost-effectiveness of large-scale renewables has been evaluated against a measure (the MPR) that does not consider the lumpiness of those large additions.

**Table 1:**

*PG&E Residential (E-1) -- NEM Costs / (Savings) per kWh Exported, at 2011 Rates and Avoided Costs*

<b>Annual</b>	<b>350%</b>	\$ 0.174	\$ 0.177	\$ 0.145	\$ 0.105	\$ 0.075	\$ 0.058	\$ 0.047	\$ 0.033
<b>Customer</b>	<b>300%</b>	\$ 0.156	\$ 0.146	\$ 0.109	\$ 0.067	\$ 0.046	\$ 0.035	\$ 0.026	\$ 0.017
<b>Usage</b>	<b>250%</b>	\$ 0.106	\$ 0.085	\$ 0.041	\$ 0.022	\$ 0.014	\$ 0.006	\$ 0.001	\$(0.003)
<b>As a</b>	<b>200%</b>	\$ 0.008	\$(0.001)	\$(0.004)	\$(0.008)	\$(0.012)	\$(0.014)	\$(0.015)	\$(0.015)
<b>Percent</b>	<b>150%</b>	\$(0.053)	\$(0.034)	\$(0.029)	\$(0.027)	\$(0.026)	\$(0.027)	\$(0.028)	\$(0.028)
<b>of Baseline</b>	<b>100%</b>	\$(0.064)	\$(0.041)	\$(0.039)	\$(0.038)	\$(0.037)	\$(0.036)	\$(0.035)	\$(0.034)
<b>Quantity</b>		<b>30%</b>	<b>40%</b>	<b>50%</b>	<b>60%</b>	<b>70%</b>	<b>80%</b>	<b>90%</b>	<b>100%</b>
<b>PV System Size (as a percent of usage)</b>									

**Table 2:**

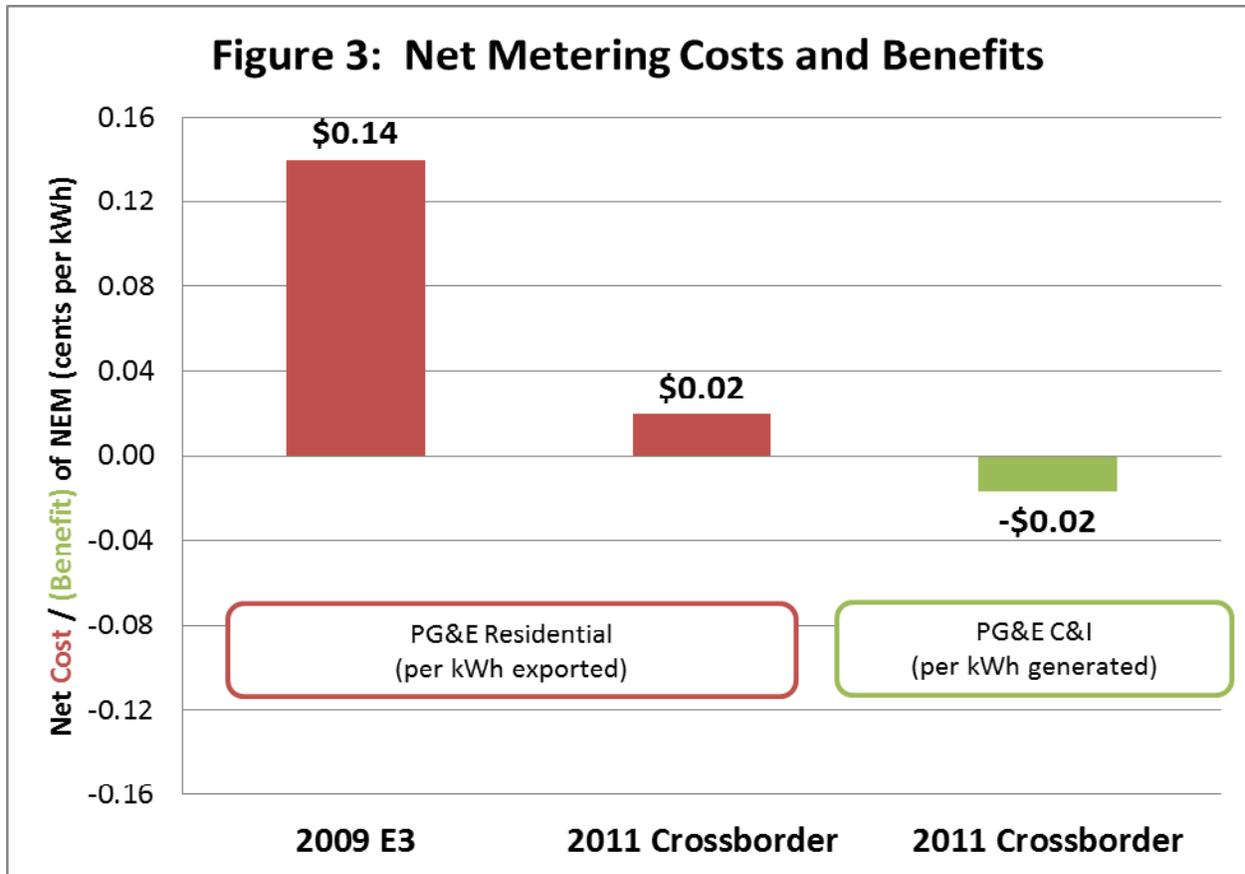
*PG&E Residential (E-1) -- NEM Costs / (Savings) per kWh Exported, at 2008 Rates and Avoided Costs*

<b>Annual</b>	<b>350%</b>	\$ 0.388	\$ 0.319	\$ 0.257	\$ 0.208	\$ 0.170	\$ 0.145	\$ 0.129	\$ 0.111
<b>Customer</b>	<b>300%</b>	\$ 0.322	\$ 0.260	\$ 0.213	\$ 0.161	\$ 0.132	\$ 0.115	\$ 0.102	\$ 0.091
<b>Usage</b>	<b>250%</b>	\$ 0.253	\$ 0.193	\$ 0.135	\$ 0.107	\$ 0.094	\$ 0.083	\$ 0.074	\$ 0.067
<b>As a</b>	<b>200%</b>	\$ 0.151	\$ 0.104	\$ 0.087	\$ 0.074	\$ 0.064	\$ 0.057	\$ 0.053	\$ 0.050
<b>Percent</b>	<b>150%</b>	\$ 0.089	\$ 0.068	\$ 0.060	\$ 0.054	\$ 0.048	\$ 0.044	\$ 0.040	\$ 0.037
<b>of Baseline</b>	<b>100%</b>	\$ 0.078	\$ 0.060	\$ 0.049	\$ 0.043	\$ 0.038	\$ 0.035	\$ 0.033	\$ 0.032
<b>Quantity</b>		<b>30%</b>	<b>40%</b>	<b>50%</b>	<b>60%</b>	<b>70%</b>	<b>80%</b>	<b>90%</b>	<b>100%</b>
<b>PV System Size (as a percent of usage)</b>									

**Table 3:**

*PG&E Commercial & Industrial (E-19) -- NEM Costs / (Savings) per kWh of PV Output, at 2011 Rates and Avoided Costs*

<b>Peak</b>	<b>1,000 kW</b>	\$(0.017)	\$(0.014)	\$(0.013)	\$(0.012)	\$(0.011)	\$(0.011)	\$(0.011)	\$(0.013)	\$(0.015)
<b>Customer</b>	<b>900 kW</b>	\$(0.016)	\$(0.013)	\$(0.012)	\$(0.012)	\$(0.011)	\$(0.011)	\$(0.013)	\$(0.015)	\$(0.017)
<b>Usage</b>	<b>800 kW</b>	\$(0.015)	\$(0.013)	\$(0.012)	\$(0.011)	\$(0.011)	\$(0.013)	\$(0.015)	\$(0.018)	\$(0.022)
<b>(kW)</b>	<b>700 kW</b>	\$(0.014)	\$(0.012)	\$(0.012)	\$(0.011)	\$(0.012)	\$(0.015)	\$(0.018)	\$(0.023)	\$(0.028)
	<b>600 kW</b>	\$(0.013)	\$(0.012)	\$(0.011)	\$(0.012)	\$(0.015)	\$(0.019)	\$(0.025)	\$(0.030)	\$(0.035)
	<b>500 kW</b>	\$(0.013)	\$(0.011)	\$(0.011)	\$(0.015)	\$(0.020)	\$(0.027)	\$(0.033)	\$(0.038)	\$(0.042)
		<b>200 kW</b>	<b>300 kW</b>	<b>400 kW</b>	<b>500 kW</b>	<b>600 kW</b>	<b>700 kW</b>	<b>800 kW</b>	<b>900 kW</b>	<b>1,000 kW</b>
<b>PV System Size</b>										



## 6. The Economics of NEM for the Non-Residential Market

The E3 NEM Study showed that the NEM cost shift is much smaller for non-residential customers, and close to zero for large commercial customers, particularly for SCE and SDG&E. (see Tables 3 and 34) With an avoided cost model that more fully values the RPS costs that DG avoids, it is also important to re-evaluate the cost-effectiveness of NEM for commercial and industrial (C&I) customers. Non-residential PV systems account for more than half (57%) of the capacity installed under the California's solar programs.<sup>12</sup>

We have applied our NEM model to PG&E's E-19S customer class of large C&I customers with peak loads between 500 kW and 1 MW. This class has been the focus of debate in the PG&E general rate case (A. 10-03-014), where PG&E and other parties are opposing rate options with reduced demand charges for such customers. PG&E argues that NEM already subsidizes such customers, and thus that rate options which increase these customers' bill savings would represent an added subsidy. **Table 3 and Figure 3** show the results of our model for essentially all likely combinations of customer and PV system sizes in the E-19 class. Note that we express these results in terms of costs or (savings) per kWh generated by the PV system,

<sup>12</sup> See *CSI 2010 Impact Evaluation: Results* (Itron webinar, August 3, 2011), Slide 12, available at <http://www.cpuc.ca.gov/NR/rdonlyres/6C1CF950-93C7-485C-8CC6-2633CB49218D/0/CompleteCSIwebinarpresentations.pdf>.

instead of per kWh exported. We do so because C&I customers' loads typically peak in the afternoon, and thus when such customers install solar there are zero or very low exports if the size of the PV system is small in comparison to the customer's peak demand. The analysis shows that NEM is cost-effective for typical E-19S customers across the full range of customer and PV system sizes.

## **7. The NEM Analysis as a Cost-Effectiveness Test of Solar DG**

It is important to appreciate the relationship between these evaluations of the cost-effectiveness of NEM and broader evaluations of the state's demand-side programs and DG resources. The NEM analyses discussed in this study are, in the lexicon of the cost-effectiveness tests used in California, ratepayer impact measure (RIM) tests.<sup>13</sup> The CPUC routinely adopts energy efficiency and demand response programs that do not pass the RIM test (i.e. these programs result in higher rates for non-participants), if those programs score well on broader, societal cost-benefit tests such as the total resource cost test. For example, the 2010 CSI cost-effectiveness study, conducted by E3, used such broader tests to confirm that the CSI is on course to achieve its goal of a cost-effective solar industry by 2017.<sup>14</sup> The CPUC's 2009 decision on the cost-effectiveness evaluation of DG programs rejected use of RIM tests except for very limited purposes.<sup>15</sup> The CPUC also does not rely on ratepayer impact tests in assessing energy efficiency programs. Thus, any conclusions drawn from the rate impacts of NEM should be viewed from a broader perspective of the societal costs and benefits of renewable DG.

## **8. Conclusion**

NEM is a crucial component of California's efforts to encourage electric ratepayers to install clean, renewable DG. NEM is a simple and understandable way to bill customers who install DG, and removes what might otherwise be a substantial barrier to customer acceptance of DG systems as integral features of their homes and businesses. NEM does impact other, non-participating utility ratepayers, because a minority of the power produced is exported to the grid and is credited to the customer-generator at the full retail rate. Whether the impact of these exports is a net cost or benefit for other ratepayers depends on the design of the NEM customer's rate and on the avoided cost benefits to the utility of this source of renewable generation located on the distribution grid. This study shows that the recent significant changes that the CPUC has adopted in PG&E's residential rate design, plus the recognition that exports of solar DG avoid other purchases of renewable power (and not fossil resources), result in a significant improvement in the economics of residential NEM compared to the CPUC's 2009 E3 NEM Study. Further, NEM appears to be cost-effective for the large PG&E C&I customers; such non-residential customers account for a significant share of the installed solar DG capacity in California.

---

<sup>13</sup> See the *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects* (October 2001), available at [http://www.energy.ca.gov/greenbuilding/documents/background/07-J\\_CPUC\\_STANDARD\\_PRACTICE\\_MANUAL.PDF](http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF).

<sup>14</sup> *CSI Cost-Effectiveness Evaluation* (E3, April 2011), available at [ftp://ftp.cpuc.ca.gov/gopher-data/energy\\_division/csi/CSI%20Report\\_Complete\\_E3\\_Final.pdf](ftp://ftp.cpuc.ca.gov/gopher-data/energy_division/csi/CSI%20Report_Complete_E3_Final.pdf).

<sup>15</sup> D. 09-08-026, at 24-26.

The E3 NEM Study found that 87% of the net costs of NEM were focused in the PG&E market overall, with 67% of the net costs in the residential market alone. The results of our new analysis of PG&E's residential market show that the net costs of NEM in the PG&E residential market have been reduced to one-seventh of the level calculated in the E3 NEM Study. Our analysis of the PG&E E-19 market shows that NEM is now cost-effective for these large non-residential customers. These improvements in the cost-effectiveness of NEM also will apply to the other electric utilities in the state, through the use of the new avoided cost model that emphasizes the ability of NEM exports to displace other sources of renewable generation. In addition, like PG&E, the other investor-owned electric utilities also are making efforts to reduce the upper tier rates of their residential customers. These results strongly suggest that the cost-effectiveness of NEM has improved significantly since the prior E3 and LBNL NEM studies, to the point that on average over all customer classes, NEM may now be cost effective throughout the investor-owned utilities' territories.