# Technical Potential for Local Distributed Photovoltaics in California

## Preliminary Assessment

March, 2012

Energy+Environmental Economics

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PUBLIC UTILITIES COMMISSION

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March 28, 2012

**Release of Consultant Report on Solar PV Market Analysis**

Dear Stakeholders:

We are pleased to announce the release of a Consultant Report on the technical potential, costs, and benefits of local distributed solar photovoltaics (PV) in California. Specifically, CPUC staff requested this consultant report to better understand and to compare the costs and benefits of the various distributed solar PV market segments, including residential rooftop, commercial rooftop, small ground-mount, and larger ground-mount (up to 20 megawatts). The methodology and analysis in this report will be used to inform the broader renewable resource planning and procurement efforts at the CPUC. It is important to note that this report is limited to solar PV and does not include other distributed generation technologies. CPUC staff intends to do similar assessments of other distributed renewable technologies in the future.

While the study methodology builds upon many of the methods used in previous analyses, it takes advantage of better data than was previously available for the evaluation of local distributed PV. The improved data in this study provides more robust estimates of the costs of PV systems, rate of cost reductions, and interconnection costs; data on utility distribution systems; and Geographic Information System (GIS) rooftop and land use information from the U.S. Geological Survey and other sources.

The study also differs from prior studies in its narrow focus. In contrast to previous CPUC analyses, this study focuses narrowly on the development of local distributed PV, which is defined as distributed PV sized so that the power generated is entirely consumed on the distribution system to which it is interconnected. This more narrow definition is in contrast to other more broad definitions of distributed resources, which may simply define distributed resources as generation interconnecting to the distribution system or based on size thresholds such as under 20MW.

In order to limit the scope of the analysis, this report does not:

- Evaluate existing or future CPUC incentive programs or procurement mechanisms for DG.
- Estimate economic potential of local distributed PV.
- Establish solar PV procurement targets. In order to set specific procurement targets, the CPUC would need to do additional analysis regarding the cost and associated viability of the various renewable procurement options, taking into account utility renewable procurement need.
- Evaluate the operational impacts of higher levels of distributed PV on the electrical grid.
- Quantify the impact of high penetrations of solar PV on wholesale power markets (energy and capacity), since large amounts of distributed solar PV could decrease wholesale power prices.

This report is a preliminary assessment of the of local distributed PV potential in California. Once more solar PV projects achieve commercial operation and actual energy and interconnection costs are known, we will have the information to do more refined assessments of DG deployment challenges, better assess the costs and benefits of the different DG market segments, and calculate overall ratepayer impact. In addition, further analysis is needed beyond the technical potential estimated in this study, such as analyses of economic potential or market potential, which will ultimately determine how much local distributed PV can be installed. Actual achievement of this level of PV interconnection at the costs estimated by this study will be dependent on overcoming several potentially significant challenges.

Since this is a preliminary analysis that has not been vetted through a stakeholder process, the CPUC does not adopt the results of this report. It is our hope that this analysis and future analyses will help inform the dialogue surrounding high penetration of distributed generation in California in order to help the state meet its climate change and renewable targets in a cost-effective and efficient manner.

Sincerely,

Paul Douglas, Program and Project Supervisor, Renewable Procurement and Market Development

Melicia Charles, Program and Project Supervisor, Customer Generation

# Table of Contents

# 1 Executive Summary

This study, completed by Energy and Environmental Economics, Inc. (E3) for the California Public Utilities Commission (CPUC), estimates the technical potential for "local" distributed photovoltaics (LDPV or local PV) in California, and assesses the associated costs and benefits. The study relies on the latest available PV cost data and entails a detailed assessment of PV interconnection potential at the distribution substation or feeder level. The information in this report is intended to be used to inform policy-makers in developing or implementing PV procurement policy or incentive programs.

Local distributed PV is defined as PV sized such that its output will be consumed by load on the feeder or substation where it is interconnected. This distinguishes LDPV from other characterizations of "distributed PV," which has typically been defined as 20 MW or less. We focus the study on local distributed PV because compared to distributed PV that is located remotely from load, local PV has the potential for less expensive and faster interconnection. In addition, it may target higher value locations on the grid, and may better achieve other policy goals such as reducing environmental impact, creating local jobs, enhancing energy awareness, and promoting redevelopment. In contrast, some distributed systems of 20 MW or less that are not "local" may export power to serve remote loads without providing these advantages.

In this study, we consider a range of criteria that may act as constraints on potential for local distributed PV. At the most restrictive end of the range we evaluate interconnection potential under the current Rule 21 *15% of peak load* criterion, which limits generators that can bypass an interconnection study to those that are under 15% of the peak load of a circuit or substation. However, the intent of this study is to look beyond current interconnection circumstances and assess the costs and benefits of high penetration PV scenarios, were the potential to be fully developed. For this reason, the central criterion to identify LDPV technical potential is that it be consumed by local load. Specifically, the generation cannot backflow from the distribution system onto the transmission system. We evaluate LDPV installation rates through a review of the rates of installed capacity in Germany and California in order to evaluate the potential and the overall cost of a renewable portfolio dominated by local distributed PV.

We couple the investigation of interconnection potential with an examination of site potential for different PV market segments, which we determine based on a detailed evaluation of residential and commercial rooftops and land available for ground-mounted systems. We use Geographic Information Systems (GIS) data to identify sites surrounding each of the approximately 1,800 substations in California Investor-Owned Utility (IOU) service territories. We compare hourly load at the individual substation level to potential PV generation at the same location. This hour-by-hour calculation of load available for LDPV distinguishes

the present study from others that have preceded it. The study represents the most detailed assessment to date of the LDPV capacity potential.[1]

Finally, we assess the costs and net costs of the LDPV scenarios with a High Cost and a Low Cost case that in our judgment provide bounds on the economics of LDPV. The 'High Cost' case is a conservative view by assuming 2010 PV system costs through 2020. This reflects the most recent pricing of systems that have actually been built. The 'Low Cost' case reflects a continued steep decline in costs observed historically through 2020. The source and means for these cost reductions is unknown. In addition, we assume some integration costs in the High Cost Case ($7.50/MWh) that are not included in the Low Cost Case and we assume that the utilities are able to capture local distribution benefits in the Low Cost case.

## 1.1 Study Approach

The study assesses the technical potential and cost of LDPV by market segment: residential rooftop, commercial rooftop, and ground-mounted PV up to 20 MW. We calculate both the total system cost (including interconnection) and the net cost of LDPV (system cost less avoided cost). The total cost of achieving a given level of LDPV adoption is dependent on the configuration and size of PV systems installed and the procurement approach. We consider three scenarios to guide the selection of PV included in the analysis:

[1] We did not evaluate publicly-owned utilities because they are not within CPUC jurisdiction and data was not available for them. However, we believe the results would be similar for all California utilities.

**Table 1: Three LDPV procurement scenarios**

| Scenario | Description |
|---|---|
| Least Cost Procurement | PV is selected to minimize total system cost (including interconnection). This scenario reflects the status quo procurement approach through the Renewable Auction Mechanism (RAM). |
| Least Net Cost Procurement | PV is selected to minimize net cost (system cost + interconnection - avoided costs). The difference between this scenario and the "least cost" scenario is that systems with benefits that exceed their cost premium are selected first. |
| High Rooftop | Rooftop PV is prioritized over ground systems. Rooftop systems have the lowest environmental impact, and this approach allows significant generation near California load centers where there are few sites available for ground-mounted PV. |

The scenarios guide the *selection* of PV installed (ground-mount vs. rooftop; location). The total quantity installed is guided by an installation rate estimate (see Section 3.2.3) that is the same across all three scenarios.

For each procurement scenario, we develop results under a number of sensitivities:

- **Interconnection Constraint**. The base case allows up to the maximum PV system size given a "no backflow" constraint and no generation curtailment. Sensitivities consider constraints that are more limiting (15% and 30% of maximum load at the point of interconnection) and less limiting (allowing curtailment of 1%, 3%, and 5% of energy generated to meet the "no backflow" constraint).
- **PV Installation Rate**. We develop a base case from an assessment of observed installation rates and create high and low installation rate cases from the base case.
- **Range of Cost Assumptions**. We present a range of costs and benefits reflecting high and low cost drivers including: the rate of PV cost decline

(as defined by a progress ratio – see Section 3.3.1.1); interconnection costs; ancillary services costs; and avoided costs. We believe the range reflects reasonable upper and lower bounds.

- **High Cost.** The upper cost values reflect a conservative scenario that assumes no further decline in PV costs from observed 2010 PV system costs; high estimates for interconnection costs due to higher penetration of PV systems; increased ancillary services cost to accommodate high levels of intermittent distributed PV; and no distribution avoided cost benefits, meaning utilities are unable to achieve distribution savings from local generation sources.
- **Low Cost.** The lower cost values reflect a scenario that assumes continued decline in PV costs at the historically observed rate (80% progress ratio); low interconnection costs based on improvements in interconnection design and increased experience; no increase in ancillary services costs; and inclusion of distribution avoided costs in the net cost calculation.

Table 2 summarizes the assumptions in the high and low cost cases. We do not define a specific base case for costs, but instead present results as a range between the high and low cost cases.

**Table 2: High and Low Cost Case Summary**

| | High Cost Case | Low Cost Case |
|---|---|---|
| Interconnection Cost | High | Low |
| PV Learning Rate | 2010 installed costs | 80% progress ratio |
| Ancillary Services Cost | $7.50/MWh produced | $0/MWh produced |
| Distribution Savings | None | Distribution value by area |

## 1.2 Key Findings

### *THERE IS A LARGE AMOUNT OF TECHNICAL POTENTIAL FOR LDPV, BUT ACHIEVEMENT REQUIRES OVERCOMING SEVERAL CHALLENGES*

Under our base case interconnection constraint (maximum system size with *no backflow*), we estimate LDPV technical potential at more than 15,000 MW between now and 2020. Actual achievement of this level of LDPV interconnection at the costs estimated by this study will be dependent on overcoming several potentially significant challenges, including:

- Potential interconnection issues, such as islanding, voltage regulation, and circuit protection. The potential estimate of more than 15,000 MW assumes that LDPV can be installed up to the point where PV output is equal to local load while mitigating potential interconnection issues. This high level of PV penetration has not yet been the subject of detailed engineering studies, though some are underway. It is possible that achieving this level of interconnection would incur interconnection or ancillary services costs beyond those included in this study.
- Geographic development issues. Because available "local" load is widely distributed throughout the state, the market for LDPV would have to develop in such a way as to widely distribute LDPV development in accordance with available load.
- Industry expansion. To achieve 15,000 MW of installed LDPV by 2020, large scale industry expansion is required, including streamlining of permitting and business and workforce expansion. This is particularly true given that a significant portion of the LDPV technical potential is from rooftop installations.

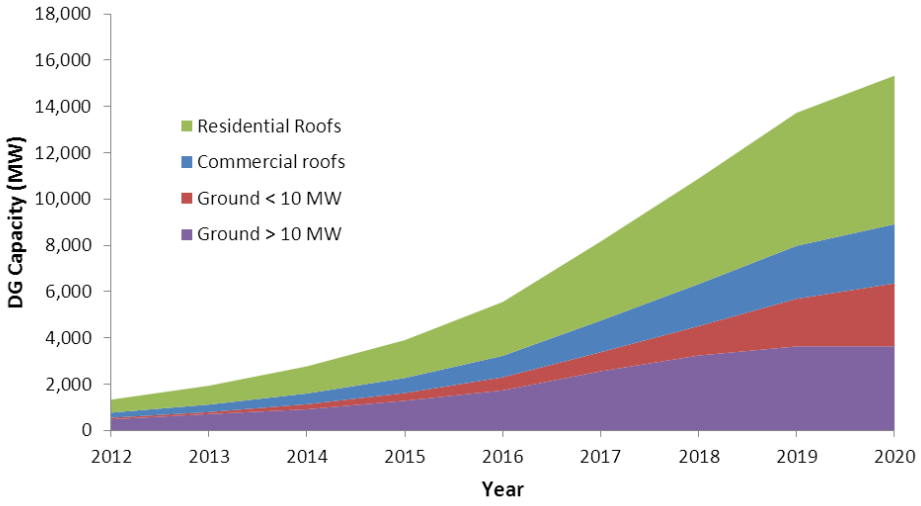
Further, the study does not consider the economic or market potential of LDPV. The public's willingness to pay for LDPV (or lack thereof) and other market factors may constrain the realization of the technical potential identified in this study. Additional study is required to evaluate the economic and market potential of LDPV.

### *"LOCAL" PV MEANS A HIGH RELIANCE ON ROOFTOP SYSTEMS*

The absolute potential of ground-mounted PV systems 20 MW and under in California is enormous when considering available land. However, many of these sites are located remotely from load and would require costly and time-consuming transmission upgrades, distribution upgrades, or both. In this sense, while these generators would often be characterized as "distributed" because of their size and point of interconnection on the distribution system, they are not qualitatively different from larger generators.

This study focuses on "local" PV generation, which requires the energy generated from the PV systems to be consumed locally at the feeder or substation, thus enhancing the prospects for interconnection in a timely manner without lengthy interconnection and deliverability studies and costly upgrades. Because of this constraint, our assessment of PV potential includes a large share of rooftop systems, particularly residential roofs, despite the fact that rooftop systems are more expensive. This is true even under a least cost procurement scenario, as shown in Figure 1.

**Figure 1: Installed PV by Type Under the *Least Cost* Scenario, Maximum Without Curtailment**




## *TO ACHIEVE SIGNIFICANT LOCAL PV, PROJECTS MUST BE EVENLY DISTRIBUTED THROUGHOUT THE STATE IN ROUGH PROPORTION TO LOAD*

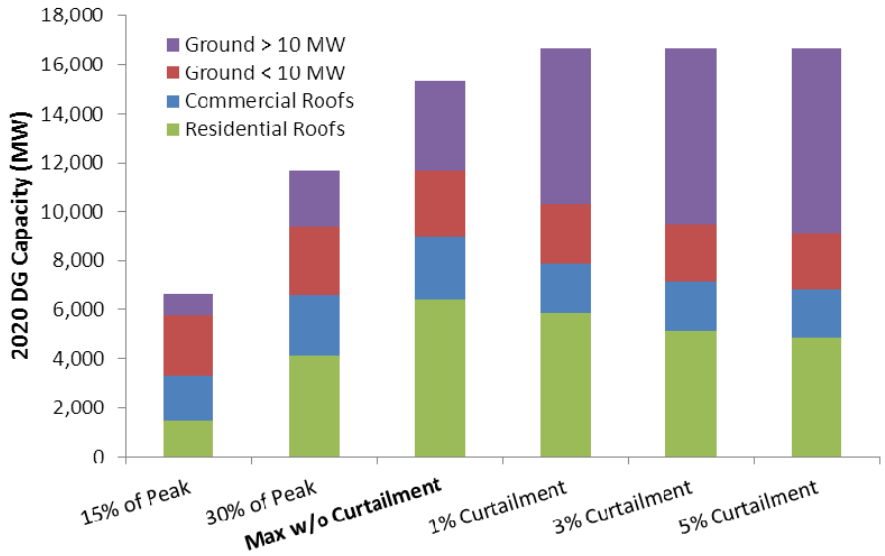
Because our definition of LDPV means generation must be consumed on the feeder or substation at which it is interconnected, PV generation must be distributed throughout the state in rough proportion to load in order to achieve significant penetration. Substations with greater load can accommodate larger levels of PV without "backflow." Areas with a higher concentration of substations and load have more potential than remote areas with fewer substations and less load. However, no single area can accommodate extremely large amounts of PV as the resulting output would need to be fed back onto the transmission system, violating our *no backflow* criterion. Therefore LDPV must be widely distributed to match existing load.

### *THE LDPV TECHNICAL POTENTIAL IDENTIFIED IN THIS STUDY IS SIGNIFICANTLY MORE THAN COULD BE INSTALLED IF POTENTIAL WERE LIMITED BY CURRENT STANDARD INTERCONNECTION TARIFFS*

Rule 21 interconnection tariffs provide several screens for qualifying distributed generation that may be interconnected without extensive study. Among these screens is a criterion limiting cumulative system size to less than 15% of peak load on the line section where it is interconnected. While it is true that the Rule 21 15% criterion does not *prevent* larger PV generators from interconnecting, projects that do not pass the screen are subject to detailed interconnection study and therefore have longer timelines and are riskier projects from a developer perspective.

Application of the Rule 21 15% criterion limits our estimate of 2020 LDPV technical potential to less than 7,000 MW. On the other hand, basing the estimate on PV that could interconnect as long as its generation does not exceed minimum load in any hour more than doubles the technical potential estimate to approximately 15,000 MW (see Figure 2).

**Figure 2: 2020 LDPV Technical Potential Estimate Under Various Interconnection Criteria, *Least Cost* Scenario**




We also considered the effects on LDPV technical potential of a small amount of curtailment if it allows easy interconnection for generators that otherwise would be subject to lengthy interconnection studies and if the resulting projects remain financeable. We recognize that there is currently no mechanism to affect as-needed curtailment of distributed PV on a nearly-instantaneous basis and that such a mechanism would entail additional costs; the purpose of the estimate is simply to show the effect on LDPV technical potential if such a mechanism were to be developed.

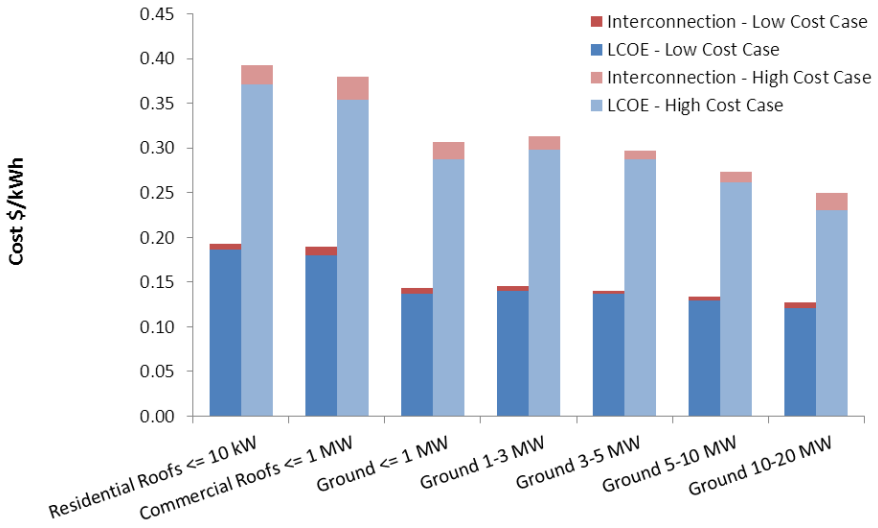
The impact of a small amount of curtailment is significant. Allowing a very small amount of curtailment (no more than 1% of the generated energy associated with any single substation's interconnected PV) further increases the LDPV technical potential by roughly 10%, to more than 16,500 MW. Again, this

estimate does not take into account other economic and market constraints that could dramatically limit the actual installation of LDPV.

### *ROOFTOP PROJECTS ARE SUBSTANTIALLY MORE EXPENSIVE THAN GROUND-MOUNTED SYSTEMS*

Considering both system and interconnection costs, rooftop systems are substantially more expensive than ground-mounted systems on a $/kWh-produced basis, as shown in Figure 3. The figure shows costs as calculated for the high cost case (2010 prices) and the low cost case (historical learning rate/steep price decline) and reveals a clear downward trend in costs as system size is increased.

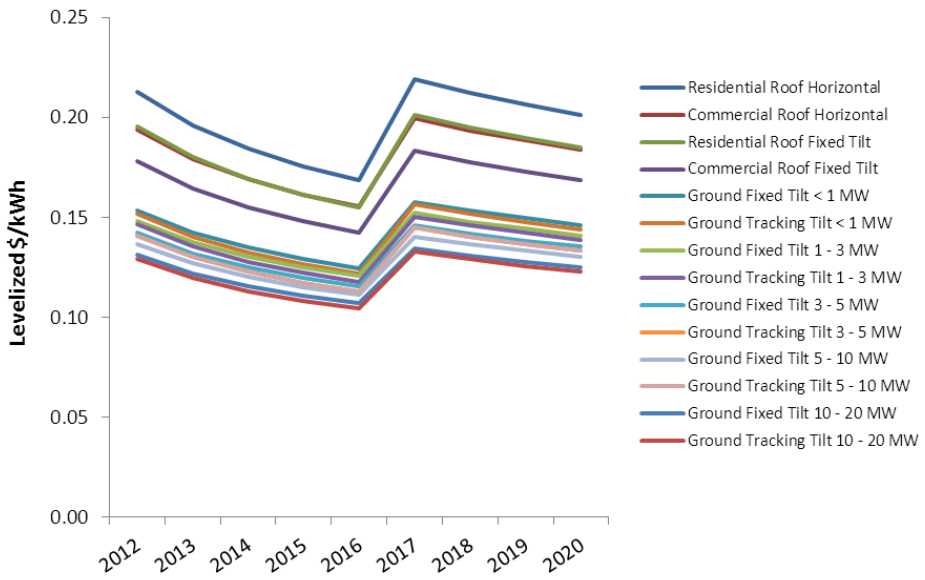
**Figure 3: Average Cost of PV systems Installed by 2020 by type ($2010)**



## *EXPIRATION OF THE 30% FEDERAL INVESTMENT TAX CREDIT IN 2017 SIGNIFICANTLY INCREASES THE EFFECTIVE COST OF LDPV*

Figure 4 shows the projected levelized cost of energy (LCOE) under our low cost case. Costs decline through 2016, rise significantly in 2017 with expiration of the investment tax credit (ITC) – which provides a tax credit for up to 30% of PV systems costs – and do not recover pre-2017 levels within the study period. The effect is even more pronounced under lower learning rates, as in our high cost case. Viewed in this light, California could be considered to be in a "race" against expiration of the ITC to install LDPV in the most cost-effective manner.

**Figure 4: Levelized Cost of PV at a Substation in Fresno (Real $2010) 80% Progress Ratio**

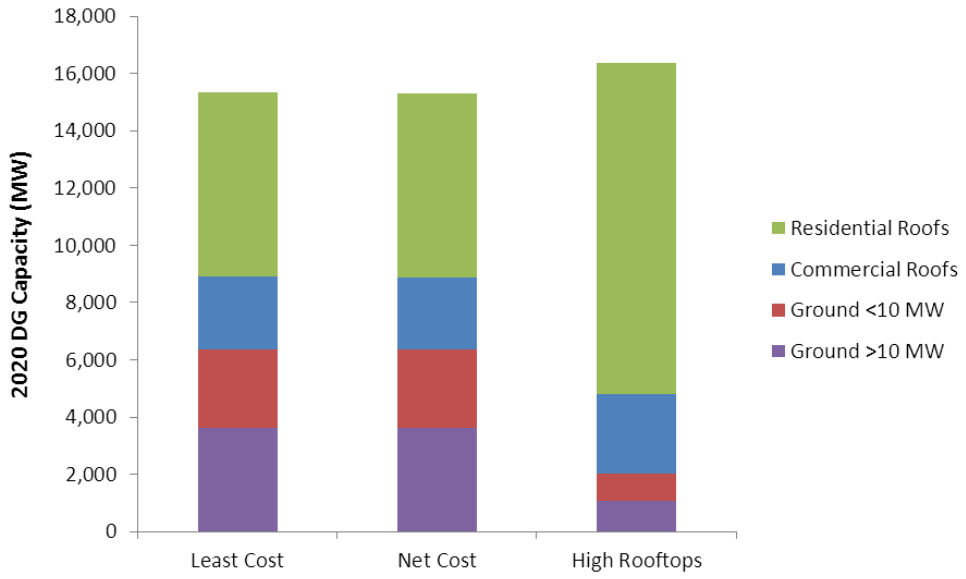


Under our base case installation rate estimate, which reflects a high rate of adoption based on the German experience, roughly 5,500 MW would be installed through 2016 before the ITC expires. This is approximately a third of the identified technical potential, leaving two-thirds to be installed with a lower 10% ITC. Under the high installation rate sensitivity approximately 9,000 MW would be installed; under the low sensitivity roughly 3,300 MW would be installed (see Section 3.2.3).

### *THE PROCUREMENT APPROACH (LEAST COST VS. LEAST NET COST) AFFECTS THE ORDER OF RESOURCE SELECTION AND A LEAST NET COST PROCUREMENT APPROACH CAN PROVIDE RATEPAYER BENEFITS*

Figure 5 shows the mix of resources procured under each of the three procurement scenarios. Total procured resources by 2020 are nearly identical under the *least cost* and *least net cost* procurement scenarios. The interconnected capacity is slightly higher in the high rooftops scenario because the rooftop systems have lower output relative to nameplate capacity and therefore more capacity can be installed without exceeding minimum load in any given hour.

**Figure 5: Portfolio Resource Mix in 2020, by Scenario, Under Maximum PV Without Curtailment, High Cost Case**




Though not visible in Figure 5, there are differences in resource selection between the *least cost* and *least net cost* scenarios, and in particular in the

order and timing upon which resources are selected.[2] Resources located in areas with high avoided costs will be selected earlier in the *least net cost* scenario, since the avoided cost benefits will lower the net costs, potentially offsetting any premium in total installed cost for the system.

Ordering procurement on a *least net cost* basis holds the potential to lower ratepayer costs. This is evident in Table 3, which shows the cumulative net cost of installed systems in 2012, 2016, and 2020 under maximum PV without curtailment and low cost case assumptions. When PV is procured on a *least net cost* basis, opportunities may exist to locate in areas with high avoided costs. In 2012, a *least net cost* procurement approach results in net costs that are approximately $65 million lower assuming avoided transmission and distribution costs can be realized. These benefits carry through to 2016 for the most part, but disappear by 2020, when all potential has been realized regardless of cost. That is to say, simply, that when *all* potential sites are utilized, the procurement approach is not critical.

**Table 3: Cumulative Net Costs Under Maximum PV Without Curtailment, Low Cost Case ($2010 millions)**

| | 2012 | 2016 | 2020 |
|---|---|---|---|
| Least Net Cost Procurement | $ 50 | $ 246 | $ 1,489 |
| Least Cost Procurement | $ 117 | $ 350 | $ 1,489 |

[2] See Appendix A for detailed results by county of resources procured under each scenario.

### *COSTS OF THE LOCAL PV SCENARIOS ARE HIGHER THAN THE RENEWABLE PORTFOLIO IN THE LTPP TRAJECTORY CASE AND THE LTPP ENVIRONMENTALLY CONSTRAINED CASE*

In the Long-term Procurement Planning (LTPP) proceeding (R.10-05-006)[3] procurement costs were estimated under several cases, including, among others, an All Gas Case, a Trajectory Case, and an Environmentally Constrained Case. The All Gas Case is intended for cost comparison purposes only and assumes that renewable generation does not increase beyond the existing levels in 2009. The Trajectory and Environmentally Constrained cases both meet the 33% Renewable Portfolio Standard (RPS) and provide a useful comparison point for the LDPV cost estimates in the current study. The Trajectory Case includes primarily renewable resources that are already under contract or under negotiation with California utilities and includes a mix of large and small renewable generators including wind, solar, geothermal, hydro, and biomass. The Environmentally Constrained casereflects a scenario where siting of large central station renewables and associated transmission is limited due to environmental constraints and is comprised of a higher proportion of distributed PV (roughly 8,800 MW of distributed PV, compared to roughly 2,800 MW in the Trajectory Case)..

The results presented in LTPP proceeding include the projected 2020 Revenue Requirement in each case, reproduced in the first three columns of Table 4. The *least cost* and *high rooftop* scenarios from the present study are shown in Columns (4) and (5) and Columns (6) and (7). (Because the *least net cost* results

[3] For analysis, see https://www.pge.com/regulation/LongTermProcure2010-OIR/Testimony/Joint/2011/LongTermProcure2010-OIR_Test_Joint_20110701_212896.pdf

are nearly identical to the *least cost* results, we omit the *least net cost* scenario from Table 4 for simplicity).

In columns (4) and (5) the comparison assumes that local PV resources displace Trajectory Case resources. In this case, the revenue requirement is higher than the Trajectory Case by $3,113 million (8.4%) and $4,136 million (11.1%) for the *least cost* and *high rooftop* case, respectively.

**Table 4: Comparison of LDPV with LTPP Cases**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | LTPP All Gas | LTPP Trajectory | LTPP Environmentally Constrained | Least Cost with average LTPP Trajectory | High Rooftop with average LTPP Trajectory | Least Cost + LTPP Trajectory | High Rooftop + LTPP Trajectory |
| 2020 Revenue Requirement (Millions $2010) | $34,548 | $37,280 | $37,809 | $40,394 | $41,416 | $43,031 | $44,063 |
| Δ Revenue Requirement from LTPP Trajectory (Millions $2010) | ($2,732) | $0 | $529 | $3,113 | $4,136 | $5,751 | $6,783 |
| %Δ Revenue Requirement from LTPP Trajectory | -7.3% | 0% | 1.4% | 8.4% | 11.1% | 15.4% | 18.2% |
| RPS % Achieved | 12.7% | 33.0% | 33% | 33.0% | 33.0% | 48.0% | 48.0% |

In columns (6) and (7) the comparison assumes that local PV is procured in addition to the LTPP Trajectory Case resources. In this case, 48% of electricity sales would be met with renewable generation. The annual revenue requirement, compared to the Trajectory Case, would be higher by $5,751 million (15.4%) and $6,783 million (18.2%) for the *least cost* and *high rooftop* cases, respectively.

To complete the comparison in Table 4, the *least cost* and *high rooftop* scenarios were calculated on a comparable basis to LTPP. For purposes of using consistent assumptions across analyses, we used the high cost case for the comparison because it makes a "no learning" assumption (no decline in resource costs), which was the same assumption used for all renewable resources in the LTPP analysis. In addition, in order to keep assumptions consistent, we recalculate LDPV costs assuming an extension of the federal investment tax credit through 2020 since this is what the LTPP analysis assumed. To compare the low cost case on the same basis to the LTPP analysis, the LTPP analysis would have to be repeated with assumptions on learning rates across the range of renewable technologies, which is beyond the scope of this study.

# 2 Introduction

There is increasing interest in California in using distributed photovoltaics (PV) to meet California's renewable energy goals. The CPUC included a "High Distributed Generation (DG) Case" in its 2009 *33% RPS Implementation Analysis*[4] report that included approximately 9,000 megawatts (MW) of small-scale PV generation. The Long Term Procurement Plan (LTPP) proceeding (R.10-05-006) contemplated the costs for significant levels of distributed generation (roughly 7,000 MW in IOU territory and 9,000 MW for the state as a whole). Governor Jerry Brown has set a policy goal for 12,000 MW of distributed renewable energy by 2020.[5]

The present study aims to provide a detailed assessment of the technical potential for and costs of distributed PV generation in order to help answer key policy questions:

- How much local distributed PV (LDPV) can be installed without detailed interconnection study under the current interconnection rules? How does this change under more aggressive interconnection criteria? What are the key challenges that will be encountered?

[4] *33% Renewables Portfolio Standard Implementation Analysis Preliminary Results*, June 2009. http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf.
[5] http://gov.ca.gov/docs/Clean_Energy_Plan.pdf

- How much LDPV can be installed before the federal 30% investment tax credit (ITC) expires at the end of 2016? How much LDPV can be installed by 2020?
- How much will high deployment of PV cost? How sensitive is the result to future reductions in the costs of PV?
- How do procurement goals affect the types of solar PV systems installed? What is the mix of rooftop systems (residential and commercial) versus ground-mounted systems under different procurement scenarios?

The answers can help inform ongoing renewable procurement plans and policies at the CPUC and related policy development in California.

While the study methodology builds on many of the methods used in the High DG Case in the 2009 33% RPS Implementation Analysis and the LTPP proceeding, as well as the cost-effectiveness methodology used to evaluate the California Solar Initiative, it takes advantage of better data than has previously been available for the evaluation of local PV generation. The original data from the 33% RPS Implementation Analysis was developed in 2009 and updated in the 2010 LTPP proceeding. The improved data in this study provides more robust estimates of the costs of PV systems, rate of cost reductions, and interconnection costs; data on utility distribution systems; and Geographic Information System (GIS) rooftop and land use information from the U.S. Geological Survey and other sources.

The study also differs from prior studies in its narrow focus. In contrast to the 33% RPS Implementation Analysis, and the LTPP proceeding, which evaluate and compare a number of approaches to meeting the 33% RPS, this study focuses

narrowly on the development of local distributed PV. For the purposes of this study, we define "local" distributed PV as being sized such that the power generated is entirely consumed on the distribution system to which it is interconnected. LDPV has several potential advantages relative to generation located outside of load areas:

- Avoidance of lengthy interconnection study in the California Independent System Operator (California ISO) Generation Interconnection Process (GIP) and potentially slow and expensive transmission upgrades for reliability and deliverability;
- Avoidance of lengthy distribution interconnection studies and potentially slow and expensive upgrades;
- Higher economic benefits in the form of more valuable energy production, reduced line losses, and deferred investments in new distribution and transmission system capacity; and
- Lower environmental impact.

This study estimates the maximum technical potential and costs for LDPV in the service territories of California's three large IOUs[6]. The net cost estimation includes quantifiable benefits of LDPV as captured by utility avoided costs. Other potential benefits associated with LDPV – such as lower environmental impact (particularly for rooftop systems), local jobs installing and maintaining the systems, and greater energy-use awareness at the individual and community level – are not quantified in this study.

[6] California's three large IOUs are Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas and Electric Company (SDG&E).

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# 3 Methodology and Data

This study assesses (1) the technical potential and timeline for local distributed PV in California, and (2) the associated costs and benefits. Our approach for assessing both of these elements is described in this chapter. The elements are not entirely independent; for example, the rate at which PV is installed affects the overall cost, both because PV costs may decline over time and because the federal 30% ITC is currently scheduled to revert to 10% at the end of 2016, effectively increasing the installed cost of PV. We consider these interactions under a number of scenarios, as described in Section 3.1.

The study represents the most detailed assessment to date of LDPV capacity technical potential and costs. It relies on the latest available PV cost data and entails an assessment of PV interconnection potential at the substation or feeder level, using the most granular data available. The study entails:

- An assessment of available hourly substation load data and development of hourly load profiles for every IOU substation in California.
- Development of hourly PV output for each substation through simulation modeling.
- Examination of site potential, including residential and commercial rooftops and land available for ground-mounted systems, using GIS data to identify sites surrounding each substation.

+ Consideration of each IOU's distribution capacity expansion plans at the distribution planning area level, to improve estimates of avoided or deferred distribution capacity costs.

While the overall assessment of costs and technical potential is at the substation level, we aggregate the detailed substation-level results of the study at the state, IOU, county, system size, or climate zone level in order to present the results.

A brief summary of our analysis steps is provided in the tables below. We provide more detailed description of our methodology in the sections that follow these tables, and in Appendices B and C.

**Table 5: Summary of Analysis for Technical Potential and Timeline Assessment**

| # | Step | Description |
|---|---|---|
| 1 | Gather hourly substation load data and remove anomalies | Use 2010 utility SCADA data to develop minimum, maximum, and average load data by hour for each substation (SCE, SDG&E) or feeder (PG&E) |
| 2 | Simulate PV output for each substation | Simulate hourly PV output for each standard configuration (horizontal, fixed tilt, tracking) for each substation based on 2010 weather |
| 3 | Calculate interconnection potential | Use minimum hourly substation or feeder load to calculate hour-by-hour interconnection potential for each substation for each interconnection potential scenario |
| 4 | Identify available PV sites | Use GIS data to identify residential, large roof, and ground sites deemed within reach of each substation (2.5 mile radius urban / suburban, 5 mile rural) |
| 5 | Rank sites according to scenario | Order sites within reach of interconnection to each substation according to scenario (*least cost, least net cost*, and *high rooftop*) |
| 6 | Identify sites based on interconnection potential | Limit sites selected by customer participation assumption and interconnection potential at each substation |

| # | Step | Description |
|---|---|---|
| 7 | Select sites for each year of analysis | For each year (2012 to 2020), select sites in order according to scenario up to the maximum installation capacity by year, as identified by the installation rate forecast |

### Table 6: Summary of analysis for cost and net cost assessment

| # | Step | Description |
|---|---|---|
| 1 | Forecast PV capital costs to 2020 | Forecast PV installed costs for each type of PV by year to 2020 based on California Solar Initiative (CSI) program data, LTPP PV cost data, benchmarking to utility solicitations, and progress ratios ranging from 80% (high learning/price decline) to 100% (no learning/price decline) |
| 2 | Gather interconnection cost data and remove anomalies | Calculate range of interconnection costs based on interconnection cost data from each IOU |
| 3 | Calculate total levelized cost for each site | Calculate levelized total cost for each site at each substation based on installation year using LCOE tool developed for CSI cost-effectiveness analysis[7] |
| 4 | Update avoided costs | Update hourly long-term forecast of energy, generation capacity, transmission capacity, CO2 and loss savings for each utility |
| 5 | Estimate distribution benefits | Calculate area-specific distribution avoided cost by distribution planning area for each IOU |
| 6 | Calculate total levelized benefits for each site | Calculate levelized benefits (avoided costs) for each site at each substation based on installation year |
| 7 | Calculate net levelized costs for each site | Compute net cost of each site at each substation |
| 8 | Tabulate costs and net benefits | Tabulate costs and net costs for each scenario and sensitivity by substation, climate zone, county, utility, as well as state total |

[7] http://www.ethree.com/documents/CSI/CSI%20Individual%20Installation%20Tool%203_11_2011.xls

## 3.1 Scenario Analysis

The total costs associated with our estimate of LDPV technical potential are dependent on the type of PV installed (residential rooftop, commercial rooftop, ground-mounted of various sizes). We select the type of resource based on LDPV supply curves, in order of least cost.

As mentioned earlier, we consider two types of cost in our study: system cost (including interconnection) and net cost (after deducting benefits/avoided costs). The supply curve for LDPV is dependent on the type of cost being considered. Consider two systems: "System A" with levelized system costs of $0.20/kWh, location-specific levelized avoided costs of $0.12/kWh, and hence net cost of $0.08/kWh; and "System B" with system cost of $0.19/kWh, avoided costs of $0.10/kWh, and hence net cost of $0.09/kWh. System B will be selected first based on a "least cost" supply curve, while System A will be selected first based on a "least net cost" supply curve.

Whether LDPV is sourced on a *least cost* or a *least net cost* basis has implications for the order in which resources are selected, and by extension for the total cost estimate of all selected resources. For this reason, we create procurement scenarios that define the order in which resources are selected. In addition to a *least cost* and *least net cost* procurement scenario, we also consider a *high rooftop* scenario in which rooftop PV is preferred over ground-mounted. The scenarios are summarized in Table 7.

**Table 7: Three PV Procurement Scenarios**

| Scenario | Description |
|---|---|
| Least cost procurement | PV is selected to minimize total system cost (including interconnection), for example through a bidding process or reverse auction. This scenario reflects the status quo procurement approach through the upcoming Renewable Auction Mechanism (RAM). |
| Least net cost procurement | PV is selected to minimize net cost (system cost + interconnection - avoided costs). The difference between this scenario and the "least cost" scenario is that systems with benefits that exceed their cost premium are selected first. |
| High rooftop procurement | Rooftop PV is prioritized over ground systems. Rooftop systems have the lowest environmental impact, and this approach allows significant generation near California load centers where there are few available ground sites. |

## 3.2 Estimation of Local PV Technical Potential and Installation Timeline

In order to estimate the technical potential for interconnection of local PV for each substation in the service territories of California's three large IOUs, we evaluate the two major constraints to the system. Interconnection potential is constrained by two factors: first, by the available land and rooftop area where solar PV may be located, and second, by the local consumption criterion. Our method for assessing each constraining factor is described below.

We assess the potential installation timeline using California's and Germany's experience, where favorable policies have facilitated in the widespread adoption of Solar PV.

### 3.2.1 SITE POTENTIAL

We consider three broad categories of PV sites: small roofs (residential), large roofs one acre or more in size (commercial), and land for ground-mounted systems. Using GIS mapping, we identify the available space in each of these categories within reach of each substation. Our sources and assumptions are described in Table 8.

**Table 8: Sources and Assumptions for PV Site Potential**

| Item | Description |
|---|---|
| Residential Roofs | Residential rooftops were mapped from the residential land use layer in the USGS database.[8] We assume that 30% of the residential layer is made up of rooftops and that 10% of this rooftop space is feasible for potential adoption[9] (i.e. 3% of the residential zoning footprint is available for inclusion in our potential estimate). We also assume 5.12 acres of rooftop is required per MW of PV capacity |
| Commercial Roofs | GIS coordinates for all of the large rooftops in California are from the 33% RPS Implementation Analysis.[10] We assume 30% of rooftops are suitable for PV development and will participate.[11] |

[8] USGS DS 240: Enhanced Historical Land-Use and Land-Cover Data Sets of the U.S. Geological Survey. http://water.usgs.gov/GIS/dsdl/ds240/index.html.

[9] Issues that have an impact on the potential for adoption include orientation and shading, structural strength to carry PV, and facility or home owner willingness.

[10] A presentation describing the rooftop analysis is available on the CPUC web site http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/ltpp_history.htm. See B&V and E3 - PV Assessment, June 18, 2010.

[11] We assume a larger share of commercial rooftops participation than residential because these large roofs have significantly fewer orientation and shading problems, and because commercial and industrial customer participation is more likely given an equivalent economic return, due the fact that aesthetic and other barriers are less likely to be a factor. Large roofs, however, do potentially have structural and other constrains such as skylights, and other equipment on the roof that may in some cases make them poor candidates for distributed PV.

| Item | Description |
|---|---|
| Land | GIS coordinates for ground sites able to accommodate up to 20 MW of PV were provided by Black & Veatch from their study of ground-mounted solar potential for the Renewable Energy Transmission Initiative (RETI).[12] Sites identified in the Black & Veatch study have already been screened for participation barriers and are largely located in less densely populated areas. These sites are included in our potential estimate only to the extent they can be used to serve local load. |
| Substations | In response to a CPUC data request, utilities provided GIS coordinates for all substations, which we mapped using open-source GIS mapping software (MapWindow and OpenJump) |

To determine which available land and rooftop area is available to site PV in proximity to each substation, we rely on a proxy defined by a circular area around each substation. We use a circle with a 2.5 mile radius for urban and suburban areas, and a circle with a radius of 5.0 miles for rural areas.[13]

This process is made more complex by the fact that the defined radii of two or more substations may overlap. In such cases, we assign available rooftop and land area to substations in a way that ensures its maximum utilization, as described in Appendix B.

[12] See *Renewable Energy Transmission Initiative Phase 1A Final Report*, Black & Veatch, April 2008. http://www.energy.ca.gov/2008publications/RETI-1000-2008-002/RETI-1000-2008-002-F.PDF.

[13] Use of a radius around a substation to define the area where the majority of load is located is consistent with prior studies by PG&E, including the Tri-Valley Capacity Increase Project: (http://www.cpuc.ca.gov/Environment/info/aspen/tri-valley/2%20-%20Project%20Description.PDF).

### 3.2.2 SUBSTATION INTERCONNECTION CONSTRAINT

Regardless of the amount of site potential surrounding a substation, there are technical concerns or constraints regarding the amount of DG that may be interconnected to the substation. Utility-identified potential challenges include islanding, voltage regulation of circuits with high penetration PV, and fault contribution from voltage source inverters.

When the amount of DG behind the substation is small compared to load, islanding, voltage regulation and fault contribution issues are not a concern. Thus, one of the criteria for expedited interconnection is that the cumulative installed DG capacity does not exceed 15% of peak load at the point of interconnection. For the overwhelming majority of cases, at 15% of peak load there is minimal risk of the generator's output exceeding the local load, and voltage regulation and fault contribution problems are unlikely to arise.

However, if the goal is to maximize the amount of DG that can be interconnected expeditiously, Rule 21's 15% criterion may be too conservative for many circuits. As an alternative for this study, we limit the PV system size so that *no backflow*[14] occurs given hourly energy production and load profiles for each substation.

Inasmuch as it is a reasonable proxy for safe operation of the distribution system, the *no backflow* criterion maximizes distributed PV without incurring lengthy studies or excessive system upgrade expenses. At this level, islanding of

[14] Backflow is defined as flow from the distribution system to the transmission system.

the distribution system is unlikely to occur because the generation is not large enough to sustain grid voltage, causing generator protection equipment to trip DG systems off-line.

Circuit protection problems can occur if not addressed, however. This is accounted for in our study through use of interconnection costs provided by utilities, which include costs of upgrades to limit fault contribution such as direct transfer trip systems.[15]

Finally, at a "steady state," the existing voltage regulation scheme should generally be sufficient to maintain voltage limits. When PV output is zero or very small, loads will be the same or nearly the same as in the absence of PV. When PV output is maximal, loads will be very low but still positive, which the system should also be able to accommodate.

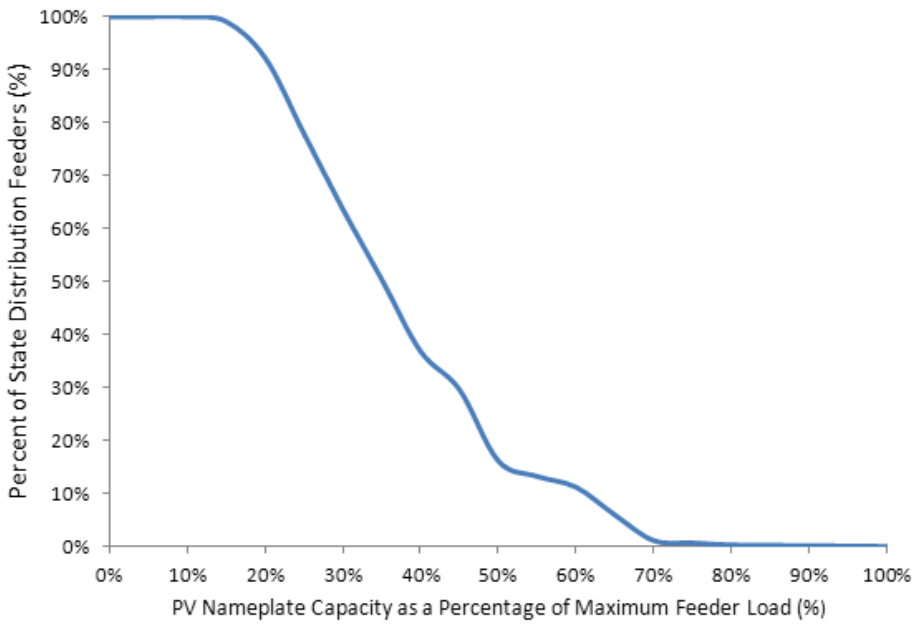
While used for the purposes of this planning level study, the *no backflow* proxy is not perfect. In particular, changes in PV output that are faster than the adjustment time of utility equipment available to control voltage may still cause some voltage problems. Controlling distribution voltage on circuits with a high penetration of PV is an area of significant ongoing research. Moreover, our proxy analysis assumes fixed hourly load and PV production shapes based on 2010 weather. A system designed for no backflow based on 2010 weather, however, might produce backflow during other years.

[15] PG&E and SCE provided interconnection costs in response to a CPUC data request. These costs include projects that are not eligible for expedited interconnection studies and that are therefore likely to include costs associated with accommodating higher levels of DG. Our high cost case includes a high interconnection cost estimate to further account for uncertainty in these costs.

Nevertheless, we believe the *no backflow* criterion is reasonable for the purposes of this study. Depending on the results of on-going engineering assessment, it is possible that new mechanisms would be needed to accommodate such a high level of distributed generation. This study does not assert that the road to the maximum technical potential identified under the *no backflow* criterion is fully paved, nor is it a forecast of LDPV adoption; rather, it is an assessment of technical potential. We provide a range of interconnection and system costs to account for the fact that there is uncertainty regarding the cost of overcoming any hurdles that may exist.

The amount of PV that could be installed based on the *no backflow* criterion far exceeds what would be installed based on a 15% of peak load criterion. Figure 6 shows the share of distribution feeders in California that would backflow at any time as a function PV system size. For over 99% of California IOU feeder lines, PV can exceed 15% of feeder load without causing backflow. The figure shows that more than 60% of the feeders could have PV sized at 30% of peak load without backflow, and approximately 10% could have PV sized at 60% of peak load without causing backflow conditions. The variation is driven by differences between the hourly load profiles in the local areas.

**Figure 6: Maximum PV Penetration without Backflow on California Distribution Feeders**

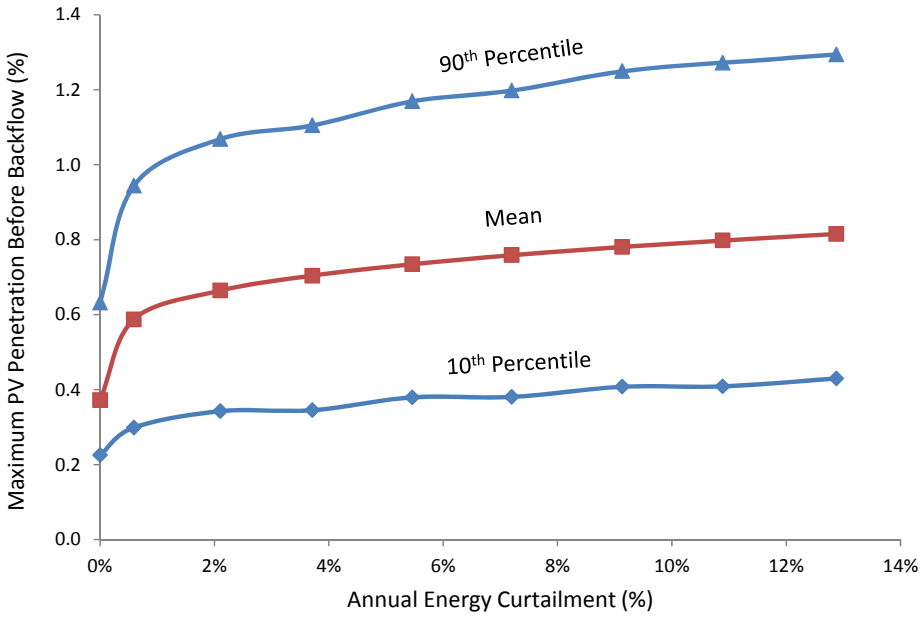



Limited to 15% of peak load, virtually all interconnections do not result in backflow. This may explain the usefulness of a 15% of peak load criterion for Rule 21 tariffs and other interconnection procedures. When the specific feeder line or substation load shapes and the specific DG output shapes are not identified, a 15% of peak load criterion is a good way to guarantee no backflow. In our study, we explicitly identify feeder and substation load shapes compared to LDPV output shapes to ensure the same objective (no backflow) is met while achieving higher levels of penetration.

The size of the PV system that can be interconnected without backflow can be increased significantly if curtailment[16] is allowed in some hours. Figure 7 shows the quantity of PV that can be installed without backflow if some of the energy can be curtailed. We performed this analysis for all substations, but for simplicity and readability we show three representative cases: the 10th and 90th percentile substations in terms of maximum PV penetration before backflow, and the mean of all substations. The mean value of maximum PV penetration before backflow increases from approximately 38% of feeder peak load to almost 60% when less than 1% of annual energy output is curtailed.

[16] Energy curtailment involves removing generation from the system for economic or reliability reasons.

**Figure 7: Maximum PV penetration without backflow allowing for curtailment**

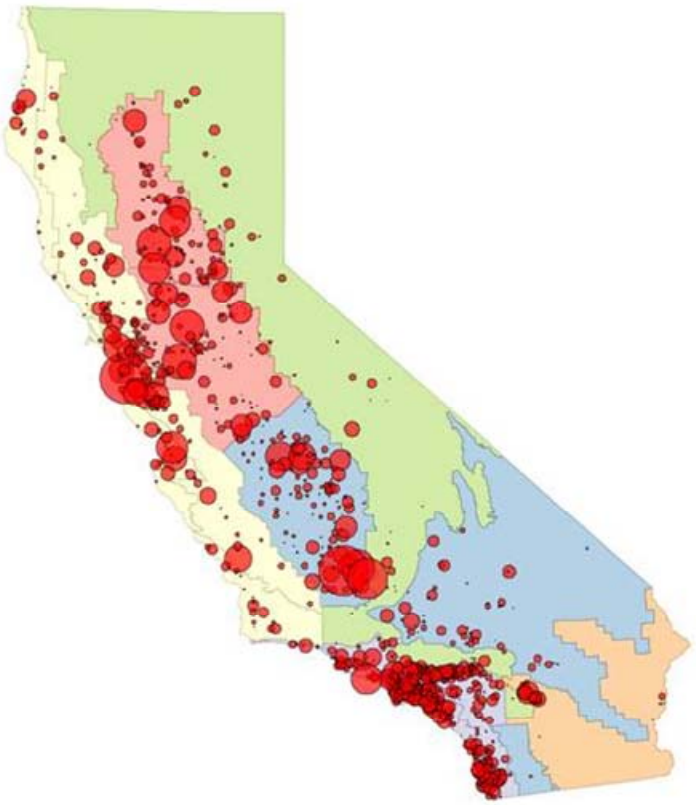



For our base case analysis, we retain the *no backflow* criterion and do not allow for any curtailment. This permits an hour-by-hour comparison of PV output profiles and substation loads. We perform this comparison for each of 1,804 substations in the three IOUs territories. Individual hourly substation load profiles were provided by IOUs for many substations and estimated for the remaining substations. Using simulations, PV output profiles were developed for each substation area and for different types of PV (rooftop and ground-mount).

A substation with high minimum hourly load will have the potential for more local PV than will a substation with low minimum hourly load. This variation is

shown graphically in Figure 8.[17] Local PV interconnection potential is highest in areas where the circles are large or clustered. The calculated LDPV interconnection potential for each substation ranged from a low of 0.0018 MW to a high of more than 65 MW.

**Figure 8: Relative Substation PV Potential**



[17] For PG&E, we perform the analysis at the feeder level and aggregate to the substation level for purposes of this chart.

See Appendix B for a detailed description of our process for developing hourly substation load profiles and PV generation profiles.

In addition to the base case (maximum PV with no backflow and zero curtailment), we consider several sensitivities for estimating substation availability:

- 15% of substation peak load[18] – representing the current Rule 21 guideline and the Fast Track requirement under federal interconnection tariffs
- 30% of substation peak load
- No backflow but occasional curtailment of PV generation allowed, which prevents backflow. We test this at different curtailment levels, with maximum curtailment in each sensitivity equal to 1%, 3%, and 5% of annual PV energy output

The individual segment potential under each assumption is presented in Figure 9. The figure shows the individual potential of residential rooftop, commercial rooftop, and ground-mounted systems, if only that type of system were to be installed. Note that these individual potentials cannot be summed to provide the total potential since installing one type will reduce the amount of load available to absorb other types.

[18] Although the Rule 21 guideline is 15% of load at the point of interconnection, we aggregate to the substation level as a proxy for the purposes of our calculations. This reduces computational complexity and was more workable given available data.

**Figure 9: Individual Segment Statewide Technical Potential for PV under Different Interconnection Rules[19]**

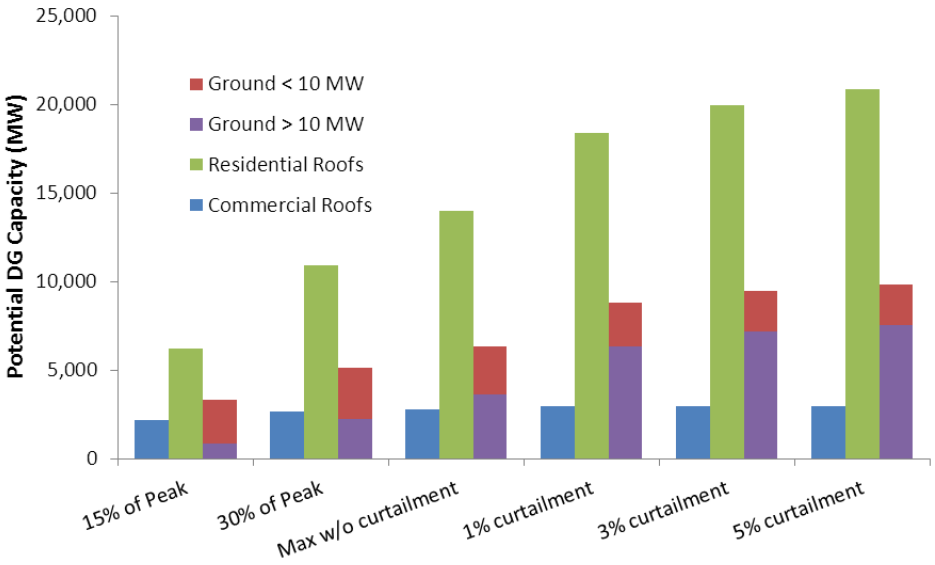



Figure 9 shows that the current 15% of peak rule is the most conservative criterion of those tested for estimating PV interconnection potential. Maximizing PV output while maintaining a no backflow limitation roughly doubles the amount of PV that can be interconnected. Finally, allowing small amounts of curtailment significantly increases this amount.

### 3.2.3 MAXIMUM INSTALLATION RATE FOR LDPV

The previous section described the derivation of technical potential for LDPV. The amount of this PV that can be developed by 2020 is dependent upon PV

[19] The individual segment potential in this figure is calculated assuming only that segment is developed. The values of each segment in this figure cannot be summed to provide total potential, since installing a system from one segment reduces the amount of load available at each substation to absorb the output from other segments.

installation rates. We use a high level "top down" approach to estimate the maximum rate of PV installation in California.[20] We drew on two sources for this assessment: prior experience in California and the solar installation rate in Germany (see Table 9). Germany was chosen as a reference point because Germany's Renewable Energy Act of 2000 established a feed-in-tariff (FiT) for solar PV, which created one of the world's most favorable policies for distributed PV adoption.

**Table 9: Sources for PV Installation Rate**

| Source | Description |
|---|---|
| CSI Installed Capacity | Forecast of CSI installed capacity from E3's CSI cost-effectiveness analysis, as described in the final report, California Solar Initiative Cost-Effectiveness Report, available on the CPUC web site: **http://www.cpuc.ca.gov/PUC/energy/Solar/evaluation.htm** |
| LTPP Forecast of DG | Forecast of distributed solar PV for "Environmentally Constrained" case in LTPP proceeding based on workpapers provided to E3 by Energy Division staff. |
| German Adoption Rate | Rate of installed PV capacity in Germany from Worldwatch Institute (http://vitalsigns.worldwatch.org/vs-trend/another-record-year-solar-power-clouds-horizon) and Wikipedia (http://en.wikipedia.org/wiki/Solar_power_in_Germany) |

Figure 10 presents our estimated installation rate for distributed PV, as well as several reference points on which our estimate is based. This is an estimate of the *maximum* installation rate that could be achieved given favorable LDPV policy, rather than a forecast of LDPV adoption under current conditions. As noted above, the German experience is a key reference point. The solid red line shows the cumulative installed capacity of distributed PV in Germany for the

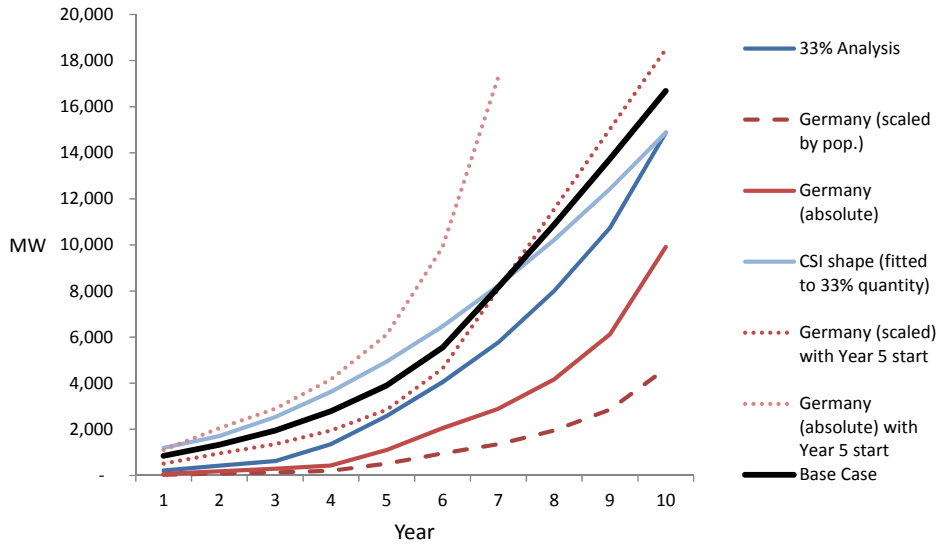
[20] The top down approach estimates the installation rate based on total market size and comparison to other markets. This is in contrast to a "bottom up" approach, which has as its starting point smaller sub-systems, such as residences, businesses, PV installers, etc. and builds a forecast based on the behavior of each of these players.

first 10 years following establishment of the feed-in-tariff. The dashed line below it scales this adoption rate to California based on California's smaller population (scaling on peak demand produces a very similar result).

For roughly the first four years, there is relatively little addition of PV capacity in Germany. However, there are significant differences between Germany in 2000 and California in 2011. Most importantly, the global market for PV technologies has undergone tremendous evolution since 2000, with module prices declining significantly and overall demand rising. Additionally, California is past the first stages of stimulating local PV installation with several programs driving forward the local market for PV, most notably the CSI.

For these reasons, we also show the rate of solar PV installation in Germany beginning in 2004, the fifth year into the new policy regime following passage of the Energy Act and establishment of the feed-in-tariff (shown in the dotted lines).

**Figure 10: Installed Capacity Forecast for Distributed PV**




The dark blue line in Figure 10 shows the underlying PV installation rate assumed the "Environmentally Constrained" case created for the 2010 LTPP proceeding. The light blue line takes this same Year 10 installed capacity, but shapes the installation curve according to our forecast of CSI program participation, which was based on observed installations for the first three years of the CSI. This adjusted CSI installation rate starts faster, with more capacity installed in the earlier years, but increases at a more gradual rate.

These historical installation rates are only reference points. There is no precise way to estimate the maximum PV installation rate in California, which is subject to policy conditions and other factors that are not known in advance. To form our installation rate used in the analysis, we select an average of the adjusted CSI installation rate and the German installation rate scaled to California with a

Year 5 starting point. We use Germany's scaled Year 5 since California already has significant experience deploying solar PV.

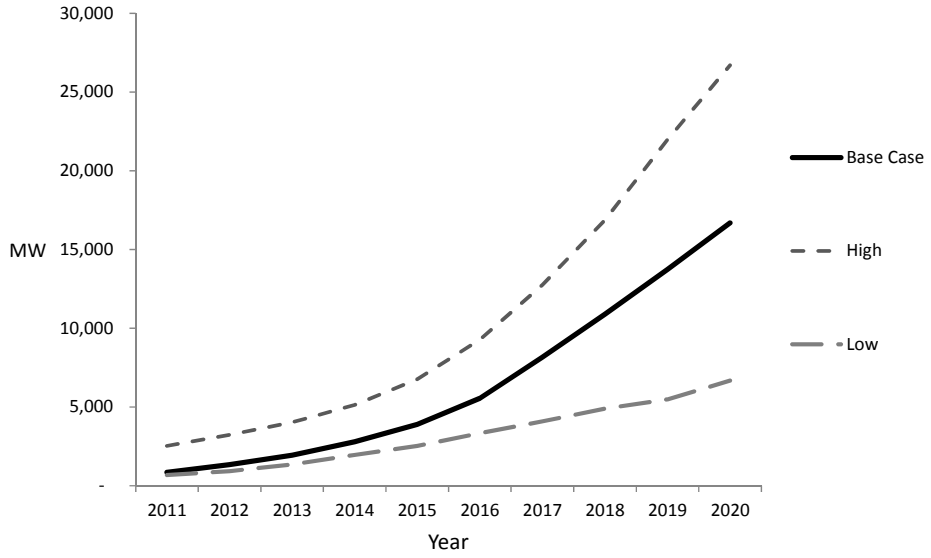
Under this assumed maximum installation rate, in Year 1 (2011), a little over 850 MW of distributed PV is projected to be installed in California, which is roughly equivalent to the amount installed to-date through the CSI program. By Year 3 (2013), this amount rises to approximately 2,000 MW; by Year 6 (2016), the year the 30% ITC expires, the amount rises to more than 5,500 MW.

### 3.2.4 PV INSTALLATION RATE SENSITIVITIES

We develop "high" and "low" installation rate sensitivities to test the effects of different installation rates. Our high installation rate posits a rate of acceleration in the installation trend that is roughly a midpoint between the highest reference from the German experience and our base case forecast. However, to this curve, we add a "fast start boost" of 1,500 MW in years 1-6. The intention is to test the effect on total costs of rapid installation in the early years, since a greater number of systems will receive the cost reduction from the federal ITC if installations can be completed before the ITC expires at the end of 2016.

For the low installation sensitivity, we decrease the installation rate by the same amount as the high sensitivity was increased, ignoring the fast start boost. The results are shown in Figure 11.

**Figure 11: Installation Rate Sensitivities**




Under the high installation sensitivity, over 9,000 MW of PV are installed by 2016, and more than 26,000 MW by 2020. Under the low sensitivity, under 4,000 MW are installed by 2016 and under 7,000 MW are installed by 2020.

## 3.3 PV Costs and Net Costs

Our assessment of the costs of distributed PV considers both the installed system costs of different types of PV over time and the net costs of specific installations of this PV. We apply the avoided cost methodology for distributed resources adopted in Decision (D.) 09-08-026 to estimate avoided cost

benefits.[21] The net cost is calculated as the difference between the lifecycle cost of distributed PV and the avoided costs that result from the PV generation.

We use the Total Resource Cost (TRC)[22] test approach throughout the study for both grid-interconnected (wholesale or system-side DG) and behind-the-meter (customer-installed or retail) PV systems. This approach is useful for three reasons:

- TRC test provides comparable treatment to all types of PV projects, whether grid-connected or behind the customer meter.
- TRC test provides an assessment independent of the mechanism used to procure PV, such as incentives, feed-in tariffs, or net-energy metering (NEM) subsidies. This study is intended to inform policy and not design the procurement approach.
- The other economic distributional tests defined in CPUC Decision 09-08-026 such as the Ratepayer Impact Measure (RIM), Program Administrator Cost test (PAC) and Participant Cost Tests (PCT) should be used to define specific rate treatment, incentives or subsidies if high LDPV is pursued.

[21] See Appendix C for a complete description of the avoided cost methodology.
[22] The total resource cost test is a test in the CPUC-adopted Standard Practices Manuel and is used to evaluate the cost-effectiveness of demand-side programs. The Standard Practices Manual is available here: ftp://ftp.cpuc.ca.gov/puc/energy/electric/energy+efficiency/em+and+v/Std+Practice+Manual.doc

For an extensive evaluation of the cost-effectiveness of the existing policy structure for behind-the-meter PV generation, including net-energy metering, see the prior two California Solar Initiative studies.[23]

In addition, we present a range of costs and benefits reflecting high and low cost drivers titled the High Cost Case and Low Cost Case respectively. The cost drivers that differ between the cases are the rate of PV cost decline, interconnection costs, ancillary services costs, and avoided costs. We believe the range reflects reasonable upper and lower bounds.

- **High Cost Case.** The upper cost values reflect a conservative scenario that assumes no further decline in PV costs from observed 2010 PV system costs; high estimates for interconnection costs due to higher penetration of PV systems; increased ancillary services cost to accommodate high levels of intermittent distributed PV; and no distribution avoided cost benefits, meaning utilities are unable to achieve distribution savings from local generation sources.
- **Low Cost Case.** The lower cost values reflect a scenario that assumes continued decline in PV costs at the historically observed rate (80% progress ratio); low interconnection costs based on improvements in interconnection design and increased experience; no increase in ancillary services costs; and inclusion of distribution avoided costs in the net cost calculation.

[23] Energy and Environmental Economics, *Net Energy Metering (NEM) Cost-Effectiveness Evaluation*, January, 2010 (http://www.cpuc.ca.gov/PUC/energy/DistGen/nem_eval.htm) and Energy and Environmental Economics, *California Solar Initiative Cost-Effectiveness Evaluation*, April, 2011 (http://www.cpuc.ca.gov/PUC/energy/Solar/evaluation.htm).

**Table 10: High and Low Cost Case Summary**

| | High Cost Case | Low Cost Case |
|---|---|---|
| Interconnection Cost | High | Low |
| PV Learning | 2010 installed costs | 80% progress ratio |
| Ancillary Services Cost | $7.50/MWh produced | $0/MWh produced |
| Distribution Savings | None | Distribution value by area |

### 3.3.1 COST OF DISTRIBUTED PHOTOVOLTAIC SYSTEMS

The delivered cost of distributed PV is calculated in three components: the levelized cost of energy from the system (which is dependent on installed system cost); the interconnection costs; and ancillary services (AS) costs. Each is described in the sections that follow.

#### *3.3.1.1 Installed System Cost*

Installed costs by system type reflect the latest available cost data for PV systems in California. We use system costs for PV already in service, and the Black and Veatch solar PV cost estimates developed for the 2010 LTPP Environmentally Constrained Cost. We benchmarked these estimates against market data for future projects and adjusted for learning derived from historical rates of cost reduction to establish current costs and a forecast through 2020.[24]

[24] For a complete discussion of our assumptions on price declines due to learning over time, see the CSI cost-effectiveness evaluation, ibid

For the Low Cost Case estimate, we consider an 80% progress ratio (20% reduction in costs for every doubling in installed capacity), which is consistent with historically observed learning rates.[25] For the High Cost Case estimate, we consider a 100% progress ratio (no decline in costs over time as installed capacity increases). While historical rates of PV module price decline have been shown to follow an 80% progress ratio, there may be a floor on cost reductions in balance-of-system costs that would prevent total installed costs from continuing to decline at this rate indefinitely. This is particularly important for rooftop PV where a larger portion of installed cost is related to labor.

**Table 11: Data Sources and Installed System Cost**

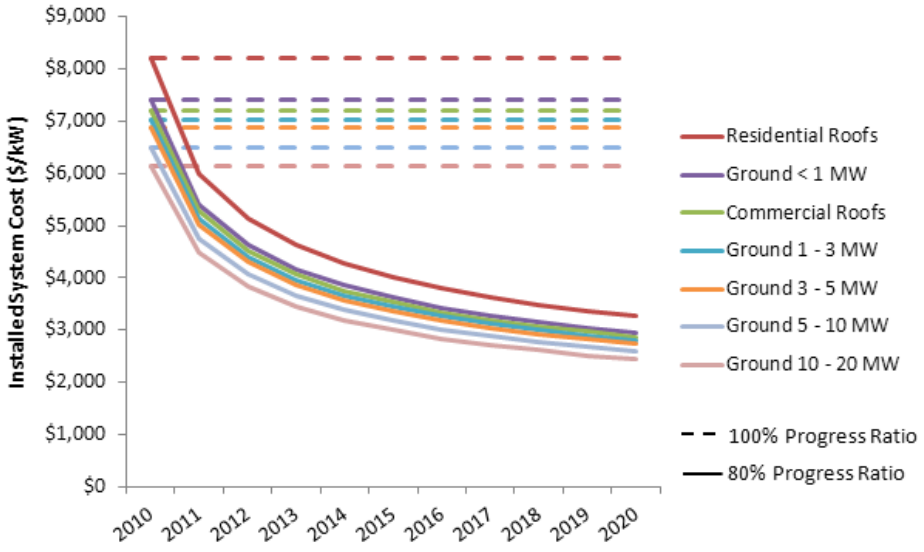
| | Data Source | 2009 Median Installed Cost ($2010 $/kW) |
|---|---|---|
| Residential Roof | Installed PV system costs for systems less than 1 MW in size are based on publicly reported costs in the CSI program database through 2009: http://www.californiasolarstatistics.org/current_data_files/. | $8,325 |
| Commercial Roof | | $7,317 |
| Ground-mount, <1 MW | Derived from Black and Veatch (B&V) cost estimates produced for the 2010 LTPP 33% RPS Environmentally Constrained Case. We benchmarked the Black and Veatch estimates against market data that was obtained through a confidentiality agreement. In the benchmarking process we adjusted the B&V estimates of 2009 system costs accounting for the progress ratio assumptions and the median value of market data. | $7,502 |
| Ground-mount, 1-3 MW | | $7,138 |
| Ground-mount, 3-5 MW | | $6,963 |
| Ground-mount, 5-10 MW | | $6,599 |
| Ground-mount, 10-20 MW | | $6,219 |

note 23.

[25] See, for example, Thomas Surek, National Renewable Energy Laboratory, Progress in U.S. Photovoltaics: Looking Back 30 Years and Looking Ahead 20.

Figure 12 extends the installed costs detailed in Table 11 from 2009 to 2020 based on application of the 80% progress ratio and 100% progress ratio (no learning).

**Figure 12: Installed System Cost of Distributed PV under 80% and 100% Progress Ratios**




### *3.3.1.2 Levelized Cost of Energy*

We calculate LCOE for systems throughout California using the installed system cost, financing assumptions, simulated PV performance by substation location, and 1% annual system degradation. These costs include permitting and land costs as captured in CSI program data for small rooftop systems and benchmarking of market data for larger, ground-mounted systems. The levelized cost of energy is expressed on a real levelized $/kWh basis and

includes all financing costs and other charges, which are levelized over the lifetime generation of the PV system. Key assumptions underlying our LCOE calculation are shown in Table 12 and Table 13.

### Table 12: Key System Cost and Performance Assumptions

| Description | Value |
|---|---|
| System Lifetime (Years) | 25 |
| Degradation Factor (%/yr) | 1.00% |
| Operation and Maintenance (O&M) Costs ($/kW) | $20.0 |
| O&M Cost Escalator (%/yr) | 2.0% |
| Inverter replacement cost ($/W) | $0.250 |
| Inverter replacement time (Years) | 10 |
| Insurance Expense ($/kW) | $20.0 |
| Insurance Escalator (%/yr) | 2.0% |
| DC:AC derate factor - Horizontal PV | 84.6% |
| DC:AC derate factor - Fixed Tilt | 90.3% |
| DC:AC derate factor - Tracking | 84.6% |

### Table 13: Key Financing Assumptions

| Description | Value |
|---|---|
| After-Tax Weighted Average Cost of Capital (WACC) | 8.25% |
| Debt Interest Rate | 7.50% |
| Target minimum DSCR | 1.40 |
| Debt Period in Years | 20 |
| Federal Tax Rate | 35% |
| State Tax Rate | 9% |
| Tax Credit Rate before 2017 | 30% |

| | |
|---|---|
| Tax Credit Rate after 2017 | 10% |
| MACRS Term (years)[26] | 5 |
| Escalator (%/yr) | 2% |

For the LCOE calculation, we use the pro forma model developed for use in the CSI program cost-effectiveness evaluation.[27] Figure 13 and Figure 14 show the resulting real levelized cost of energy by year for each system type under an 80% and 100% progress ratio, respectively. For illustrative purposes, we chose a substation in Fresno, California. The LCOE shown in the figures is busbar cost[28] and does not include interconnection. Note that these are *real* levelized costs, and therefore would need to include the 2% escalation to be shown in nominal dollars.[29]

[26] Modified Accelerated Cost Recovery System
[27] http://www.ethree.com/documents/CSI/CSI%20Individual%20Installation%20Tool%203_11_2011.xls
[28] Busbar costs are the generation costs up to the point of interconnection and do not transmission and distribution costs.
[29] Often, solar PV power purchase agreements (PPAs) are quoted in prices that stay fixed over time (nominal levelized). We use real costs since our study aggregates purchase costs of systems with different vintages.

**Figure 13: Levelized Cost of PV Generation at a Substation in Fresno (Real $2010) with an 80% Progress Ratio**

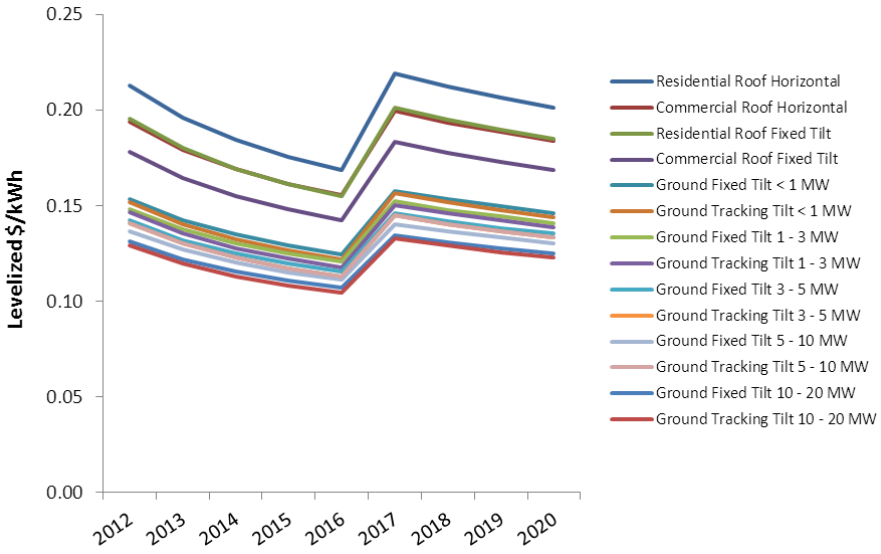
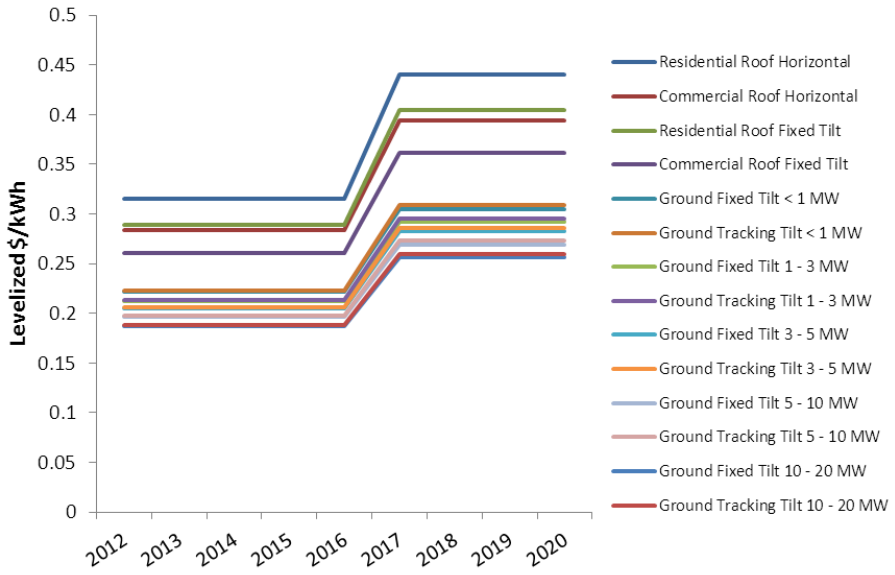


**Figure 14: Levelized Cost of PV Generation at a Substation in Fresno (Real $2010) with a 100% Progress Ratio**

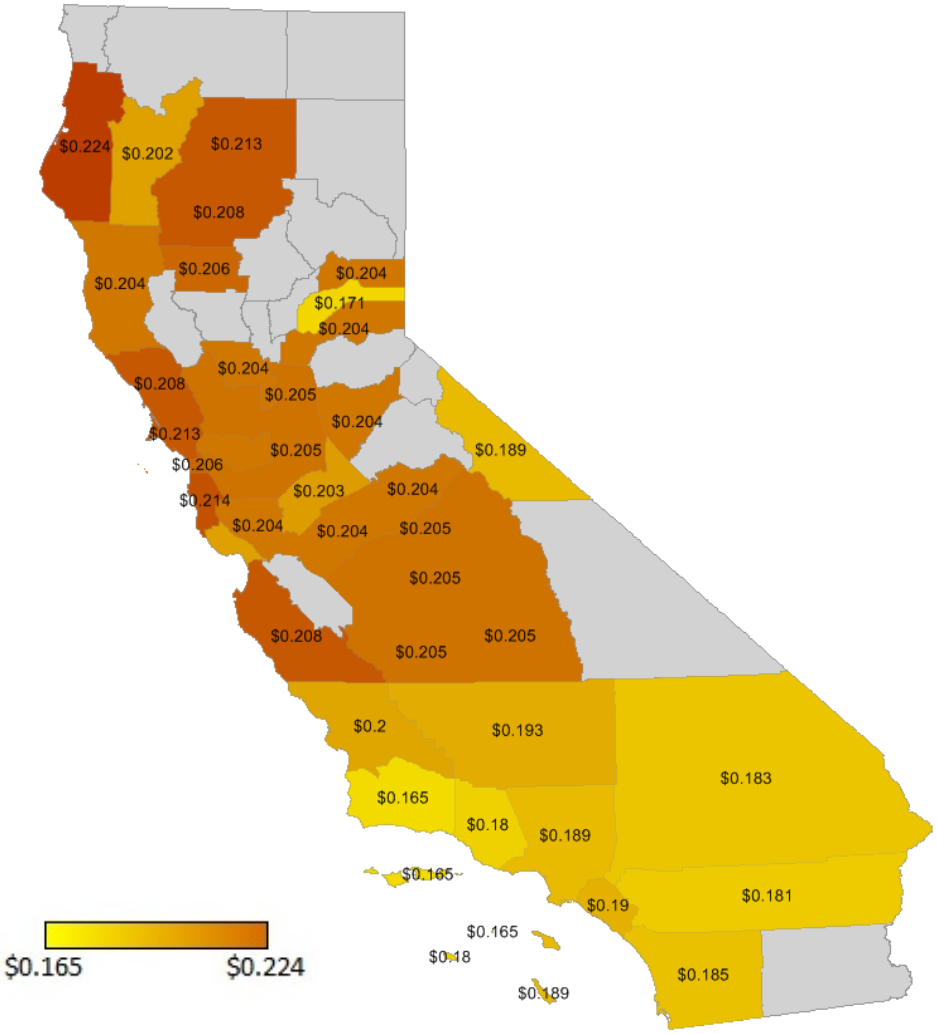



A significant cost increase can be seen in Figure 13 and Figure 14 in 2017, when the federal ITC is scheduled to revert from the current temporary level of 30% of qualifying investment costs to the permanent level of 10%.

We calculate levelized cost by substation, taking into consideration the particular capacity factors that can be expected of local generation in each area. In addition to temporal variation from cost reductions and ITC, there is also geographic variation in LCOE, as PV in sunnier locations will produce more energy and thus be cheaper on an energy basis even when the installed capacity costs are the same. Figure 15 aggregates substation-level cost data at the county level for the cost of residential rooftops installed up to 2020 in the least-cost procurement scenario, based on the 80% progress ratio. Average county-level residential rooftop LCOE for systems installed from 2012-2020 ranges from

as low as $0.17/kWh in the best Southern California locations to as high as $0.22/kWh in the most expensive Northern California locations.

**Figure 15: Map of Average LCOE for systems installed from 2012-2020 by County for Residential Rooftops Installed in the Least Cost Scenario (2010 $), 80% Progress Ratio**



Though LCOE values differ by PV segment (small rooftops, large rooftops, ground-mounted of various sizes) the geographic pattern of LCOE is similar across segments, with lower LCOEs in sunny southern counties.

#### *3.3.1.3 Interconnection Cost*

The second component of the cost of distributed PV is interconnection cost. We use data from completed interconnection studies for interconnection cost estimates. The estimated interconnection costs for installed and in-progress distributed PV projects were provided by PG&E and SCE for systems of different types based on their interconnection studies.[30] Since there are some very high outliers, we use the median of these costs for each of the respective size categories.

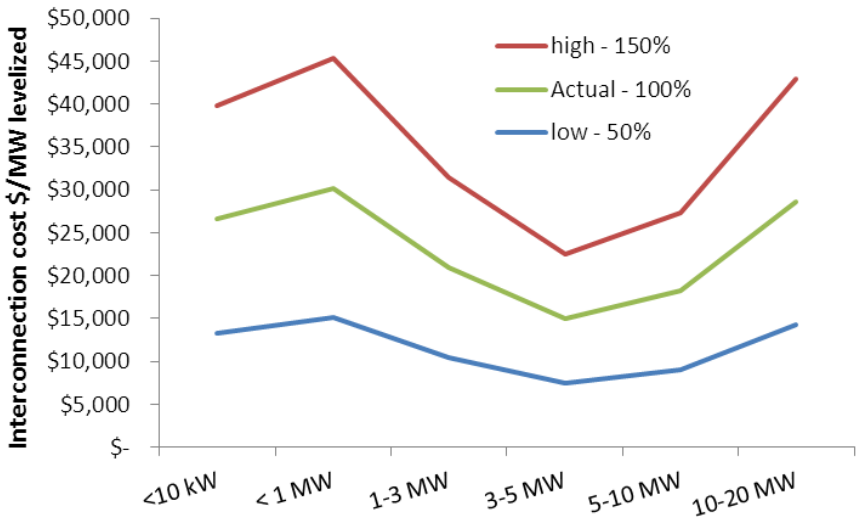
Table 14 provides median interconnection costs across the state in dollars per MW, as well as the median cost by utility. There is significant uncertainty regarding interconnection cost data. For the most part, PG&E's costs (which were based on far fewer data points) are much higher than SCE's, though it is not clear why this should be the case. In addition, there is uncertainty as to how well these historical values represent future interconnection costs under a high DG penetration scenario. Therefore, we calculate high and low interconnection cost ranges based on plus or minus 50% of the observed overall median (see Figure 16).

[30] Interconnection costs are derived from confidential utility data provided in response to the CPUC's data request on Distributed Solar PV Cost-Benefit Analysis and Interconnection Information, initiated April 22, 2011.

**Table 14: Median Interconnection costs (levelized $/MW) by Project Size Category**

| | <10 kW | < 1 MW | 1-3 MW | 3-5 MW | 5-10 MW | 10-20 MW |
|---|---|---|---|---|---|---|
| SCE | $26,576 | $30,225 | $20,974 | $10,487 | $9,580 | $54,106 |
| PGE | $26,576 | $159,630 | $110,772 | $80,909 | $43,151 | $21,576 |
| Overall | $26,576 | $30,225 | $20,988 | $14,966 | $18,187 | $28,613 |
| Low Estimate | $13,288 | $15,112 | $10,494 | $7,483 | $9,093 | $14,307 |
| High Estimate | $39,864 | $45,337 | $31,482 | $22,449 | $27,280 | $42,920 |

**Figure 16: High and Low Interconnection Cost Estimates**




The overall median interconnection costs follow an "S" shaped curve. Per megawatt interconnection costs generally decline with size as the total costs are spread over larger systems. At the larger sizes, however, per megawatt costs begin to climb again. This may be an indication that significantly more

investment is being made to accommodate interconnection of larger DG systems, including upgrades to the transmission system.

#### *3.3.1.4 Ancillary Services Cost*

The ancillary services costs necessary to integrate high penetration of local PV are uncertain. At a high level, there is evidence that intermittent generation requires some level of additional operating reserves, but the exact level and cost remains a subject of ongoing study. Additionally, to the extent LDPV replaces other intermittent resources including central station solar or wind, the need for operating reserves or other ancillary services may increase or decrease.

We account for uncertainty in ancillary services costs by evaluating two cases. In the first, we apply a $7.50/MWh additional ancillary services cost to our high cost estimate. This cost is applied to increase the costs of local PV relative to natural gas procurement. For the low estimate, we assume no increase in ancillary services cost. This is consistent with a view that geographic diversity of small PV generators spread throughout the state will provide an extremely predictable output profile and therefore not increase reserve or other ancillary services requirements.

### 3.3.2 AVOIDED COST

To calculate the net system cost, we compare the LCOE discussed in the previous section to the expected lifecycle benefits (avoided costs) for each hour and IOU substation using hourly forecasts of avoided costs over the life of the PV systems. The analysis framework employs the methods adopted in CPUC

Decision 09-08-026, *Decision Adopting Cost-Benefit Methodology for Distributed Generation*.[31] Components of avoided cost are shown in Table 15.

**Table 15: Components of Avoided Cost**

| Component | Description |
|---|---|
| Generation Energy | Estimate of hourly wholesale value of energy adjusted for losses between the point of the wholesale transaction and the point of delivery |
| System Capacity | The costs of building new generation capacity to meet system peak loads |
| Ancillary Services | The marginal costs of providing system operations and reserves for electricity grid reliability |
| Transmission and Distribution (T&D) Capacity | The costs of expanding transmission and distribution capacity to meet peak loads |
| Environment | The cost of carbon dioxide emissions associated with the marginal generating resource |
| Line Losses | The loss in energy from transmission and distribution across distance |

Our avoided cost methodology has been described in detail in previous CSI evaluation reports,[32] and Appendix C to this report describes the method and data sources for calculating each of the avoided cost components. For this report only the methodology for assessing the distribution avoided costs were modified. Those methods are explained in detail below.

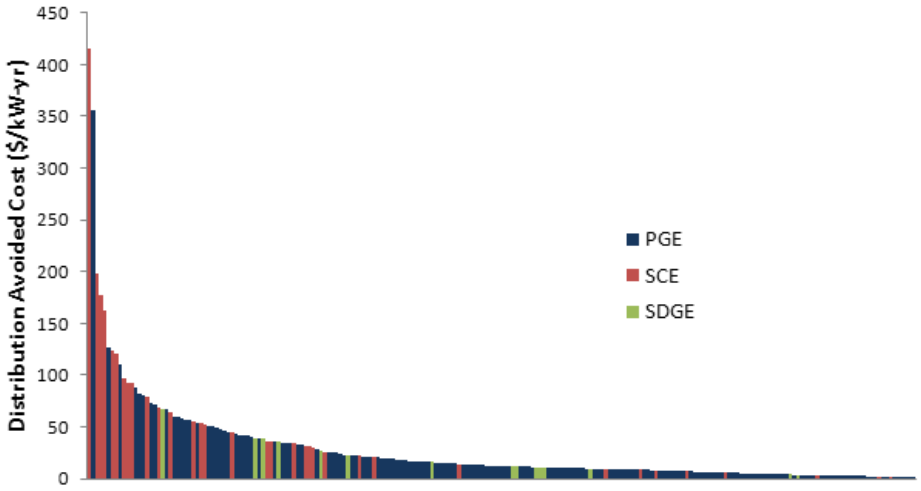
[31] http://docs.cpuc.ca.gov/published/FINAL_DECISION/105926.htm
[32] Previous CSI evaluation reports are available on the CPUC website: http://www.cpuc.ca.gov/PUC/energy/Solar/evaluation.htm.

#### *3.3.2.1 Distribution Avoided Costs*

In our high cost case, we assume no distribution investment deferral is realized from LDPV. For the low cost range calculation, we assume distribution avoided cost benefits do apply to LDPV.

Where prior avoided cost calculations completed for previous CPUC analyses have estimated distribution avoided costs aggregated to the climate zone level, the present evaluation develops distribution avoided costs at a more granular level to better estimate the specific local value of distributed PV. We base our specific distribution avoided costs on utility investment plans at the planning area level, which we collected from each IOU. Additionally, we consider the hourly load profile for each substation and base the avoided cost value on the correlation between LDPV output and substation peak load. Figure 17 displays the calculated distribution avoided costs by IOU planning area, sorted from highest to lowest.

**Figure 17: Distribution Avoided Costs by IOU Planning Area**




In most cases, distribution avoided costs are less than $50/kW-year. In a few areas, distribution avoided costs are significantly higher, indicating high levels of planned investment that could be avoided with relatively low reduction in peak load, and thus the potential to save significant costs by meeting demand with local generation.

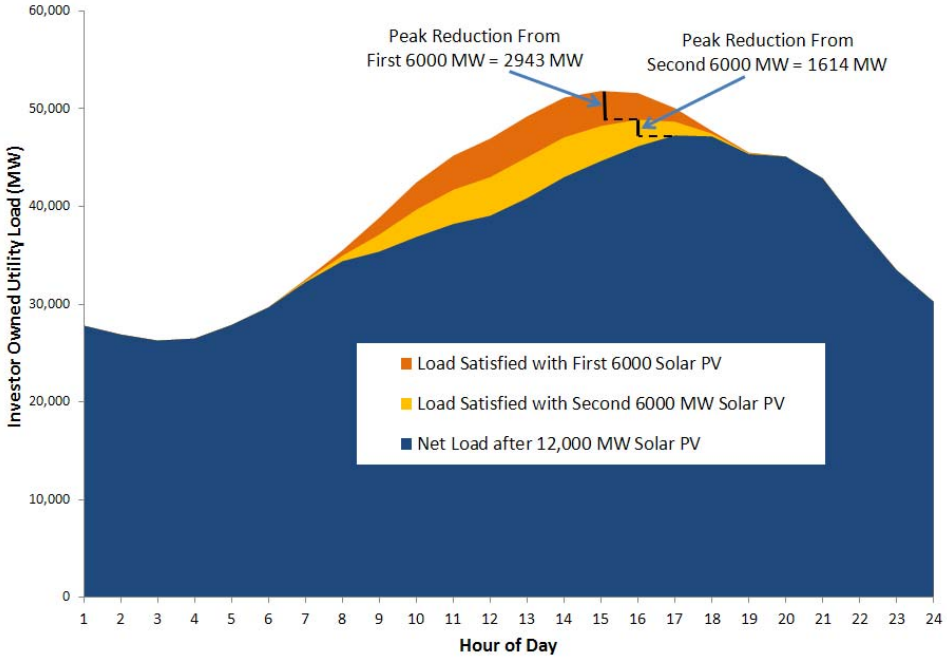
#### *3.3.2.2 Adjustment for High Penetration*

Estimates of distribution avoided cost are multiplied by PV output profiles for each substation and system type to estimate total lifecycle avoided costs. Given the high penetration of solar contemplated in this study, these "marginal" values are adjusted to reflect larger increments of distributed generation. We do this by decreasing capacity and energy value as high penetration of distributed PV is achieved.

To make the adjustment for capacity value we de-rate the capacity value by calculating the Effective Load Carrying Capability (ELCC) at different penetrations of PV, which results in a reduction as installed capacity is increased. Based on this analysis, the first megawatt of installed PV has an ELCC of 63% and the 15,000$^{th}$ megawatt has an ELCC of 26%.

Conceptually, Figure 18 can be used to understand the capacity value reduction. The chart shows the expected system profile in 2020 for a summer day with the addition of two 6,000 MW blocks of solar PV. Adding the first block decreases the peak load by 2,943 MW, and adding the second block decreases the peak by 1,614 MW. Incremental PV will reduce the peak load less and less, thereby decreasing the capacity value of PV.

**Figure 18: IOU load shape for a summer day before and after the addition of solar PV**




The second adjustment made is that as more and more solar is added onto the system, the market price of electricity decreases because a less pronounced peak means that the marginal generator that sets the market price is likely to be more efficient. With the depression of market prices, additional solar PV on the system has a lower energy value than early installations. In practice, this manifests as a reduction in energy value for all generators during high solar hours.[33] We evaluate the reduction in market value of PV by comparing the

[33] Some may note that a reduction in market price is also a benefit since consumers will be purchasing electricity at lower costs during these hours. For the purposes of this analysis, we assume the market price effect would also occur with alternative approaches to meeting the RPS and do not add that benefit to the avoided cost. However,

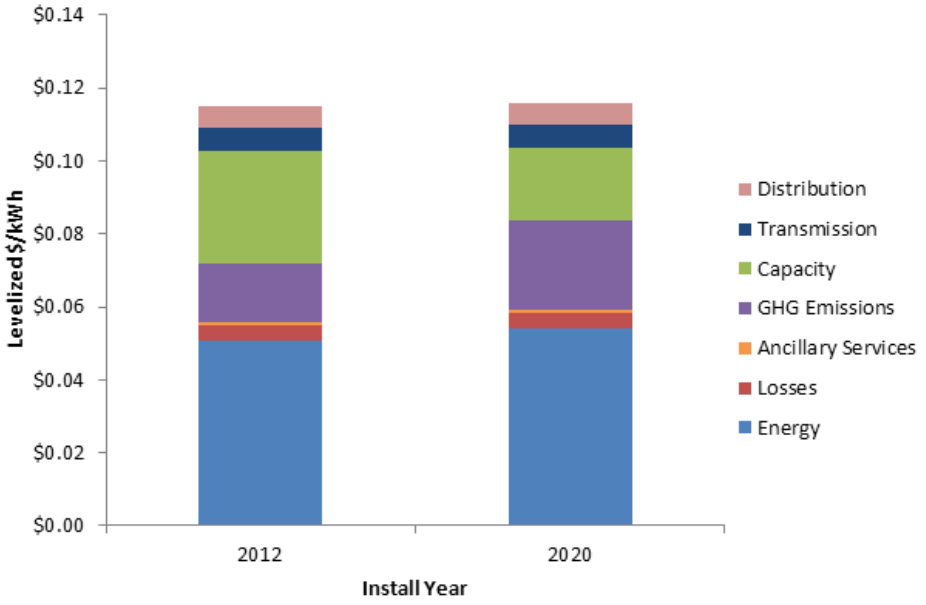
marginal energy value of a PV output load shape in the LTPP production simulation runs developed for the All Gas and Environmentally Constrained cases in the LTPP proceeding. Over the decade, this results in a 15% reduction in energy value.

#### *3.3.2.3 Resulting Avoided Costs*

The total avoided costs are calculated as the sum of avoided cost components. Figure 19 shows the lifecycle value of the avoided cost components for the first incremental megawatt installed in 2012 and the last megawatt installed in 2020 for a substation in Fresno.

this effect is incorporated into the benchmarking exercise to compare to the Trajectory Case discussed in Section 4.3.

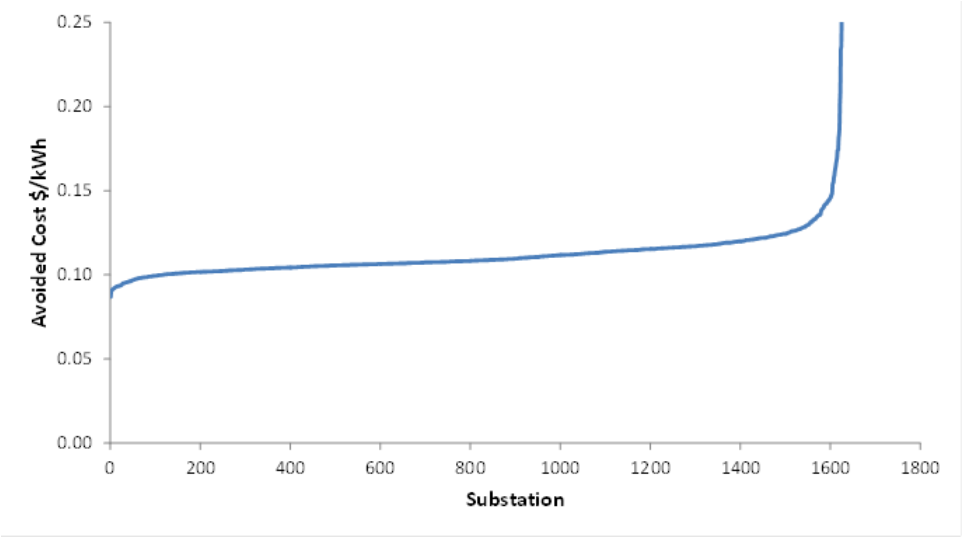
**Figure 19: Lifecycle avoided cost in 2012 and 2020 for a PG&E substation in Fresno**




Because of the "high penetration adjustment" discussed above, the capacity value of a system installed in 2020 is lower than that of one installed in 2012 and the energy value is lower than it otherwise would be without the significant penetration of PV.

The range of avoided costs across all substations is shown in Figure 20. For most substations, avoided costs are similar – roughly $0.10 - $0.11/kWh. For a small number of substations in areas with large planned capacity investments, avoided costs are much higher, up to $0.25/kWh.

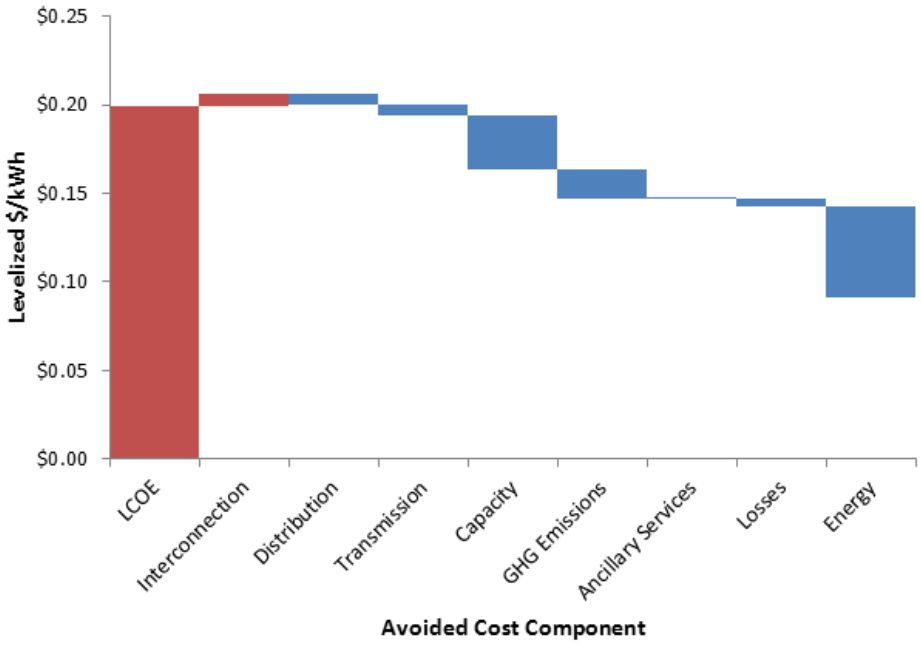
**Figure 20: Avoided Costs by Substation (2010 $)**




### 3.3.3 NET COST OF DISTRIBUTED PV

The net cost is calculated as the difference between the lifecycle system costs and the lifecycle avoided cost benefits. For example, Figure 21 shows the costs and avoided costs for a single system in the same location as in prior examples, under an 80% progress ratio. The example shows a distribution avoided cost value, but as noted earlier, we include distribution avoided costs only in calculating the low end of our cost range; the high end of the cost range does not include distribution avoided costs.

**Figure 21: Costs and Benefits for Residential PV Installed on a PG&E Substation in Fresno in 2012, 80% Progress Ratio**




In the example in Figure 21, total PV cost is 20.6 cents/kWh, 0.7 cents/kWh of which is interconnection. Avoided cost benefits total 11.5 cents/kWh, bringing the net cost of PV in this location to roughly 9 cents/kWh.

Figure 22 and Figure 23 summarize the relationship between costs and net costs across different system types under an 80% and 100% progress ratio, respectively.

**Figure 22: Average Cost of PV systems Installed by 2020 by type ($2010), 80% Progress Ratio**

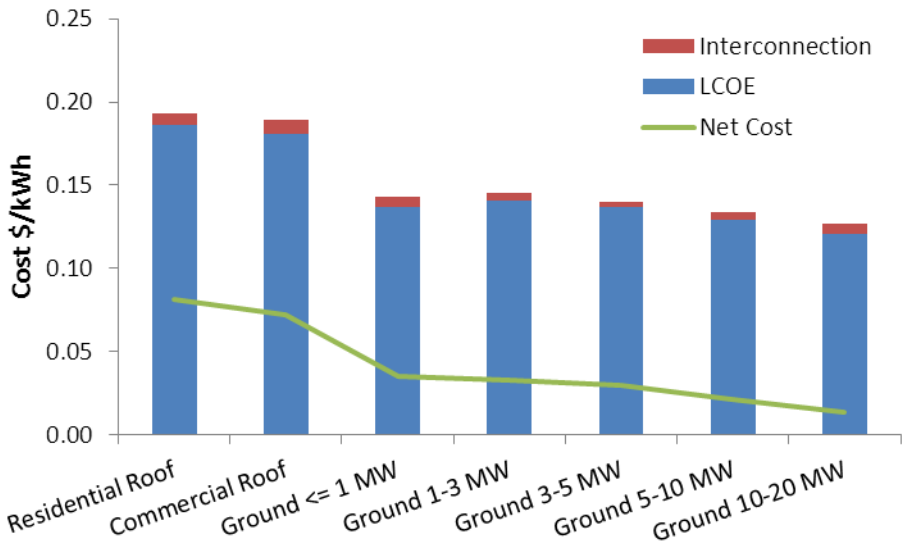
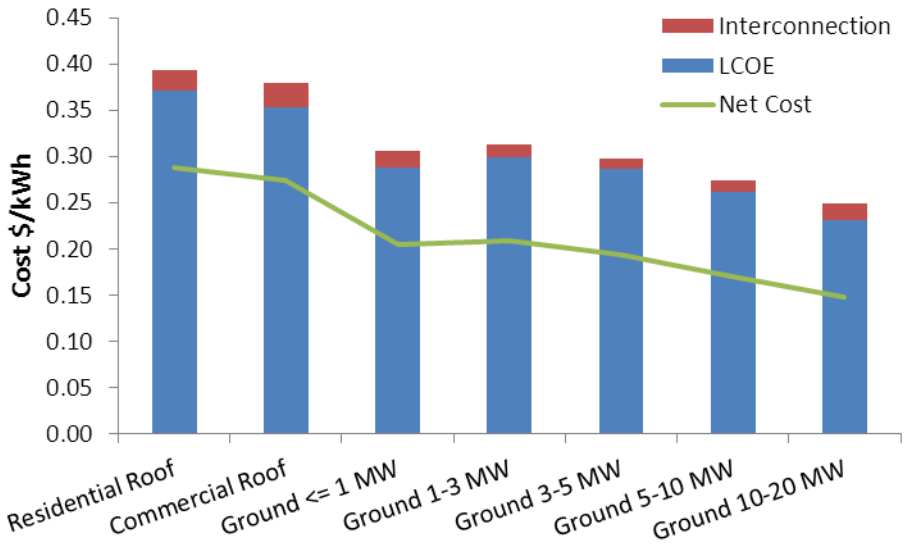



**Figure 23: Average Cost of PV Systems Installed by 2020 by type ($2010), 100% Progress Ratio**

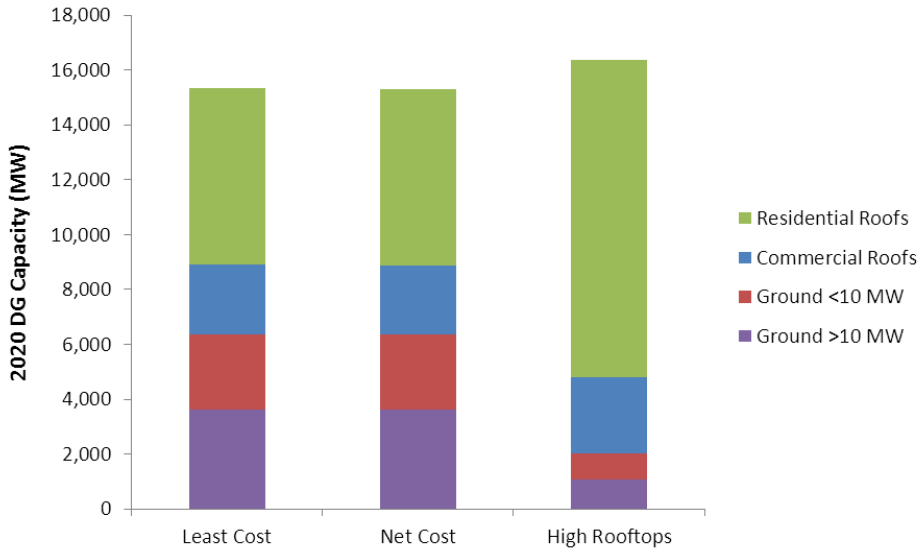


# 4 Results

This section presents the results of our analysis. Below we present our estimate of LDPV technical potential under each scenario and supply curves for the *least cost* and *least net cost* scenarios. In the sections that follow, we present detailed cost and technical potential results for each of the three scenarios described in Section 3.1 and discuss the results of our sensitivity analyses.

The total LDPV capacity in 2020 under each of the three scenarios is shown in Figure 24 and assumes an 80% progress ratio in the low cost case.

**Figure 24: Portfolio Resource Mix in 2020, by Scenario, Under a "Maximum PV Without Curtailment" Interconnection Policy; Low Cost Case**




The *least cost* and *least net cost* scenarios produce nearly identical resource mixes; there are slight differences that are not visible in this figure regarding resource selection and in particular the order and timing upon which resources are selected.

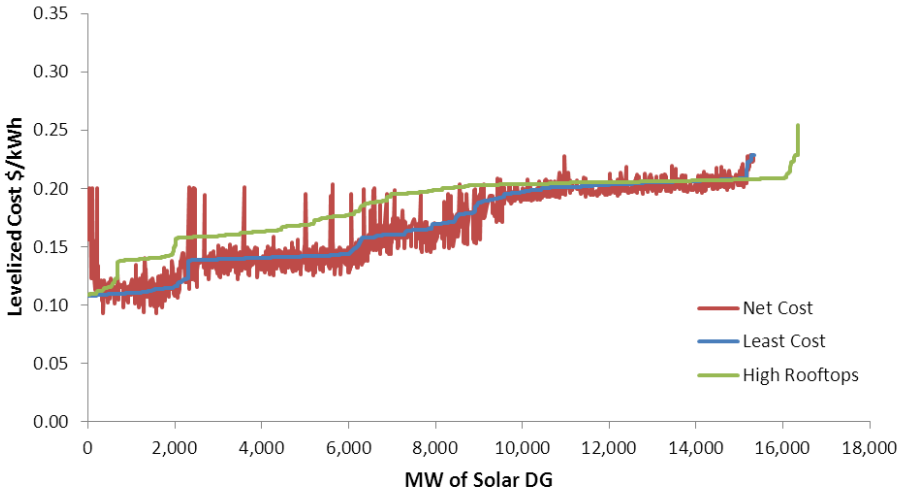
The *high rooftop* scenario installs PV on a much larger proportion of roofs. The total estimated technical potential in this scenario is slightly higher as a result of our method for assigning capacity to substations. As discussed in Section 3.2, we perform an hour-by-hour comparison of available substation load to PV output. Because the roof-mounted PV systems have lower capacity factors than the ground-mounted systems, an equivalent amount of hourly output from a rooftop system will come from a system with greater nameplate capacity than that of a ground-mounted system. The potential results are very similar in the

high cost case since the relative costs between market segments of PV are not significantly different.

We developed supply curves of local distributed PV by assigning different types of PV (residential rooftop, commercial rooftop, and ground-mounted systems) to potential sites by substation. The order in which types of PV were assigned depended on the scenario: *least cost*, *least net cost*, and *high rooftop*.

First, in Figure 25, we show the PV supply curve as measured on a cost basis (as opposed to a net cost basis) under the low cost case. A comparison of the blue and red lines shows that, while on the whole costs are similar between the *least cost* and *least net cost* scenario, there are significant differences along the way. The sharp upward spikes on the least net cost supply curve indicate cases where a PV system has significant avoided costs and would thus be installed early on a *least net cost* basis, but in fact is costly on an absolute cost basis. These differences have implications for procurement policy. If these avoided costs can in fact be realized, installing these systems first results in lower net costs to society.

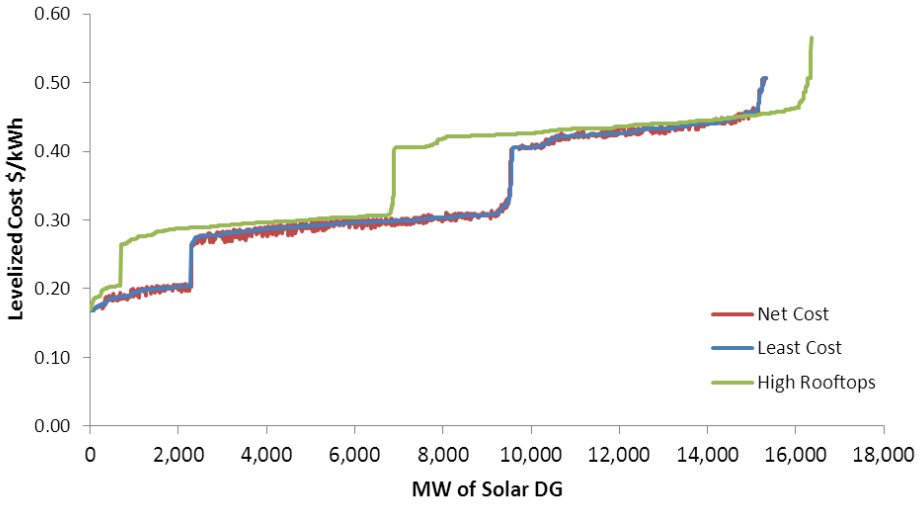
**Figure 25: Levelized Cost PV Supply Curves for Three Scenarios Under a "Max Without Curtailment" Interconnection Policy; Low Cost Case**




The supply curve for the *high rooftop* scenario in Figure 25 shows that roughly the first 10,000 MW of installed PV would be more expensive than under a *least cost* scenario.

Figure 26 shows the supply curve under the high cost case. The net cost line has much less variation in Figure 26 than in Figure 25 because distribution avoided costs, which can make up a significant portion of avoided costs in capacity-constrained areas, are not included in the high cost case. When distribution avoided costs are not included, the difference between a *least cost* and *least net cost* procurement approach is minimal.

**Figure 26: Levelized Cost PV Supply Curves for Three Scenarios Under a "Max Without Curtailment" Interconnection Policy; High Cost Case**




Next, in Figure 27 and Figure 28, we show the PV supply curves selected on a net cost basis. In this case, the *least net cost* scenario produces a smooth supply curve since this is the basis on which PV is being selected. For the low cost case (Figure 27), the *least cost* scenario is slightly more expensive in most cases on a net cost basis since the lower cost installations do not always have significant avoided cost benefits; occasional sharp downward spikes represent cases where avoided cost benefits are significant. The *high rooftop* scenario remains generally more expensive, also with downward spikes representing cases with significant avoided costs. For the high cost case (Figure 28), the least cost and net cost cases are closely aligned since distribution avoided costs are not included and the wide variation in distribution avoided cost is not a factor.

**Figure 27: Levelized Net Cost PV Supply Curves for Three Scenarios Under a "Max Without Curtailment" Interconnection Policy; Low Cost Case**

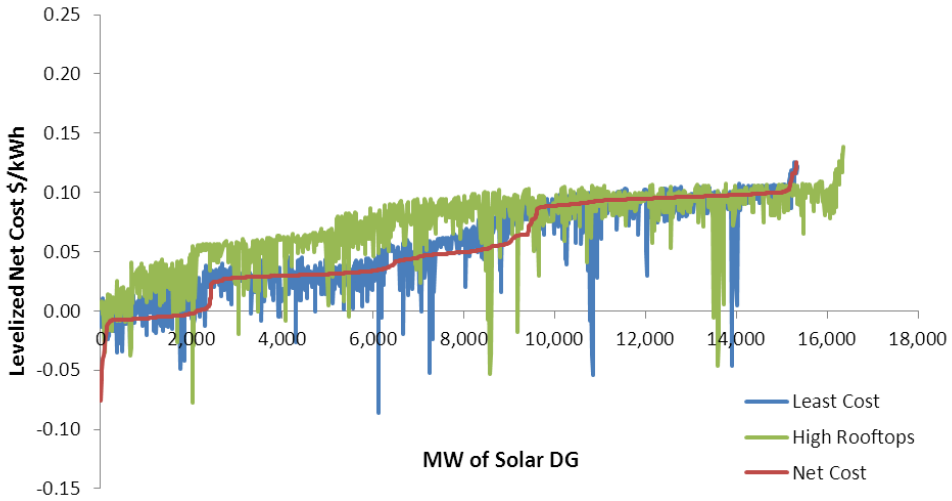
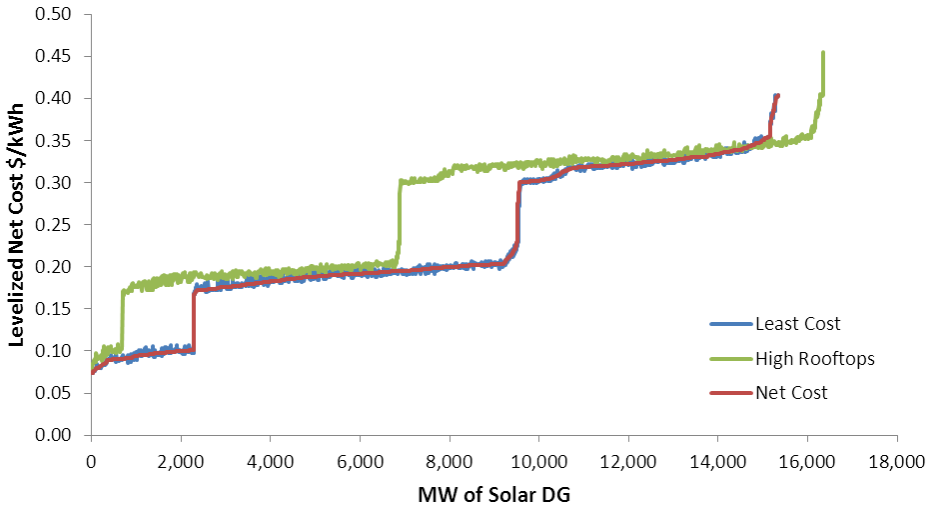



**Figure 28: Levelized Net Cost PV Supply Curves for Three Scenarios Under a "Max Without Curtailment" Interconnection Rule; High Cost Case**



More detailed results are presented for each scenario in Section 4.1, below. Section 4.2 summarizes the results of sensitivity analyses on key drivers.

## 4.1 Base Case Scenario Results

The following sections present results for each scenario under base case assumptions. The base case is based on maximum interconnection potential without backflow and the base case installation rate estimate. We present all results showing a range of cost estimates (Low Cost Case and High Cost Case).

### 4.1.1 LEAST COST SCENARIO

The allocation of capacity, the anticipated cost, and the anticipated net cost to ratepayers in 2020 by IOU and climate zone are presented in Table 16 for the low cost case and in Table 17 for the high cost case.

By 2020, 15 GW of potential is identified across the three IOUs. The primary limiting factor in the estimated technical potential is the available capacity of loads on substations to absorb the PV generation. In a smaller number of cases, excess load was available on substations, but not enough available sites were situated within reach of the substation. Approximately 1,240 MW of additional PV could be accommodated by loads on substations if additional sites were located within the substation radii assumed in our analysis (2.5 miles urban and suburban, 5 miles rural).

## Table 16: 2020 Technical Potential , Cost, and Net Cost of LDPV Under a *Least Cost* Scenario, by IOU, System Type, and Climate Zone; Low Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,478 | $303.1 | $0.205 | $141.9 | $0.096 |
| | | Commercial Roof | 257 | 425 | $84.8 | $0.200 | $37.5 | $0.088 |
| | | Ground < 10 MW | 851 | 1,841 | $257.7 | $0.140 | $58.1 | $0.032 |
| | | Ground 10-20 MW | 469 | 995 | $137.8 | $0.138 | $31.7 | $0.032 |
| | North Central Valley | Residential Roof | 1,026 | 1,793 | $368.8 | $0.206 | $156.8 | $0.087 |
| | | Commercial Roof | 310 | 507 | $102.6 | $0.202 | $45.0 | $0.089 |
| | | Ground < 10 MW | 848 | 1,825 | $252.4 | $0.138 | $42.7 | $0.023 |
| | | Ground 10-20 MW | 1,278 | 2,740 | $366.0 | $0.134 | $40.2 | $0.015 |
| | South Central Valley | Residential Roof | 404 | 713 | $145.5 | $0.204 | $64.5 | $0.090 |
| | | Commercial Roof | 154 | 256 | $50.9 | $0.199 | $21.8 | $0.085 |
| | | Ground < 10 MW | 415 | 898 | $124.8 | $0.139 | $22.7 | $0.025 |
| | | Ground 10-20 MW | 273 | 585 | $77.2 | $0.132 | $12.3 | $0.021 |
| | Mountain | Residential Roof | 64 | 112 | $23.0 | $0.205 | $10.2 | $0.091 |
| | | Commercial Roof | 21 | 36 | $7.1 | $0.198 | $3.1 | $0.087 |
| | | Ground < 10 MW | 101 | 216 | $30.8 | $0.142 | $6.6 | $0.031 |
| | | Ground 10-20 MW | 35 | 76 | $10.5 | $0.139 | $2.1 | $0.027 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.9 | $0.140 | $0.3 | $0.042 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,418 | $822.6 | $0.186 | $318.0 | $0.072 |
| | | Commercial Roof | 1,358 | 2,301 | $421.6 | $0.183 | $151.7 | $0.066 |
| | | Ground < 10 MW | 273 | 633 | $77.6 | $0.123 | $6.3 | $0.010 |
| | | Ground 10-20 MW | 1,074 | 2,451 | $285.3 | $0.116 | $3.8 | $0.002 |
| | South Central Valley | Residential Roof | 417 | 756 | $140.7 | $0.186 | $55.4 | $0.073 |
| | | Commercial Roof | 200 | 340 | $64.7 | $0.190 | $15.7 | $0.046 |
| | | Ground < 10 MW | 74 | 174 | $22.1 | $0.127 | $3.0 | $0.017 |
| | | Ground 10-20 MW | 173 | 403 | $47.5 | $0.118 | $2.5 | $0.006 |
| | Desert | Residential Roof | 177 | 318 | $63.9 | $0.201 | $29.2 | $0.092 |
| | | Commercial Roof | 37 | 62 | $11.9 | $0.192 | $5.0 | $0.081 |
| | | Ground < 10 MW | 41 | 98 | $11.8 | $0.119 | $0.4 | $0.004 |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.3) | ($0.004) |
| | Mountain | Residential Roof | 128 | 237 | $42.9 | $0.181 | $18.1 | $0.077 |
| | | Commercial Roof | 67 | 113 | $19.8 | $0.175 | $7.4 | $0.065 |
| | | Ground < 10 MW | 29 | 68 | $7.7 | $0.112 | $0.3 | $0.004 |
| | | Ground 10-20 MW | 50 | 110 | $13.9 | $0.126 | $2.7 | $0.024 |
| SDGE | South Coast | Residential Roof | 909 | 1,627 | $300.6 | $0.185 | $135.4 | $0.083 |
| | | Commercial Roof | 154 | 259 | $49.1 | $0.190 | $22.5 | $0.087 |
| | | Ground < 10 MW | 85 | 190 | $24.1 | $0.127 | $4.5 | $0.024 |
| | | Ground 10-20 MW | 252 | 549 | $64.4 | $0.117 | $9.2 | $0.017 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.182 | $0.6 | $0.089 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.120 | $0.1 | $0.026 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.5 | $0.109 | $0.1 | $0.014 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 15,336 | 29,695 | 4847 | 0.16 | 1489 | 0.05 |

## Table 17: 2020 Technical Potential , Cost, and Net Cost of LDPV Under a *Least Cost* Scenario, by IOU, System Type, and Climate Zone; High Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,476 | $663.5 | $0.449 | $506.4 | $0.343 |
| | | Commercial Roof | 257 | 425 | $185.6 | $0.437 | $139.9 | $0.329 |
| | | Ground < 10 MW | 851 | 1,841 | $547.0 | $0.297 | $355.5 | $0.193 |
| | | Ground 10-20 MW | 469 | 996 | $288.1 | $0.289 | $184.7 | $0.185 |
| | North Central Valley | Residential Roof | 1,026 | 1,793 | $807.9 | $0.451 | $613.1 | $0.342 |
| | | Commercial Roof | 310 | 507 | $223.5 | $0.441 | $168.6 | $0.333 |
| | | Ground < 10 MW | 848 | 1,824 | $531.9 | $0.292 | $339.5 | $0.186 |
| | | Ground 10-20 MW | 1,278 | 2,741 | $750.4 | $0.274 | $459.6 | $0.168 |
| | South Central Valley | Residential Roof | 404 | 713 | $319.4 | $0.448 | $242.7 | $0.341 |
| | | Commercial Roof | 154 | 256 | $111.1 | $0.434 | $83.3 | $0.325 |
| | | Ground < 10 MW | 415 | 898 | $264.3 | $0.294 | $169.7 | $0.189 |
| | | Ground 10-20 MW | 273 | 585 | $158.4 | $0.271 | $97.2 | $0.166 |
| | Mountain | Residential Roof | 64 | 112 | $50.4 | $0.451 | $38.4 | $0.343 |
| | | Commercial Roof | 21 | 36 | $15.4 | $0.430 | $11.5 | $0.323 |
| | | Ground < 10 MW | 101 | 216 | $66.3 | $0.307 | $43.6 | $0.202 |
| | | Ground 10-20 MW | 35 | 76 | $21.6 | $0.285 | $13.6 | $0.180 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.8 | $0.286 | $1.2 | $0.190 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,420 | $1,599.9 | $0.362 | $1,144.1 | $0.259 |
| | | Commercial Roof | 1,358 | 2,301 | $818.6 | $0.356 | $578.4 | $0.251 |
| | | Ground < 10 MW | 273 | 632 | $146.7 | $0.232 | $84.4 | $0.134 |
| | | Ground 10-20 MW | 1,074 | 2,451 | $502.0 | $0.205 | $262.9 | $0.107 |
| | South Central Valley | Residential Roof | 417 | 756 | $269.7 | $0.357 | $192.5 | $0.255 |
| | | Commercial Roof | 200 | 340 | $130.3 | $0.383 | $94.7 | $0.279 |
| | | Ground < 10 MW | 74 | 174 | $42.7 | $0.246 | $25.8 | $0.149 |
| | | Ground 10-20 MW | 173 | 404 | $86.1 | $0.213 | $46.9 | $0.116 |
| | Desert | Residential Roof | 177 | 318 | $124.1 | $0.390 | $91.2 | $0.287 |
| | | Commercial Roof | 37 | 62 | $22.0 | $0.356 | $15.6 | $0.252 |
| | | Ground < 10 MW | 41 | 98 | $21.2 | $0.216 | $11.8 | $0.119 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.6 | $0.095 |
| | Mountain | Residential Roof | 128 | 237 | $77.6 | $0.328 | $53.9 | $0.228 |
| | | Commercial Roof | 67 | 113 | $36.3 | $0.322 | $24.6 | $0.218 |
| | | Ground < 10 MW | 29 | 68 | $14.0 | $0.205 | $7.3 | $0.107 |
| | | Ground 10-20 MW | 50 | 110 | $26.9 | $0.244 | $15.8 | $0.143 |
| SDGE | South Coast | Residential Roof | 909 | 1,627 | $601.4 | $0.370 | $436.9 | $0.269 |
| | | Commercial Roof | 154 | 259 | $97.5 | $0.377 | $71.0 | $0.274 |
| | | Ground < 10 MW | 85 | 190 | $48.9 | $0.257 | $29.8 | $0.157 |
| | | Ground 10-20 MW | 252 | 551 | $130.5 | $0.237 | $75.4 | $0.137 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.194 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.9 | $0.234 | $0.6 | $0.139 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.108 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 15,336 | 29,695 | 9820 | 0.33 | 6741 | 0.23 |

Table 16 shows that our projection of costs in 2020 under the low cost case (expressed in 2010 $) range from a low of $0.109/kWh (SDG&E Desert, <10 MW ground-mounted) to a high of $0.206/kWh (PG&E North Central Valley, Residential Roof).

Under the high cost case (Table 17), costs range from $0.188/kWh (SCE Desert, 10-20 MW ground-mounted) to $0.451/kWh (PG&E North Central Valley and Mountain, Residential Roof).

For the most part the results in Table 16 and Table 17 show a clear upward progression in costs from larger ground-mounted (10-20 MW) systems, to smaller ground-mounted, to large rooftop, to small rooftop. The exceptions, such as where large ground-mount is more expensive than small ground, result from higher interconnection costs. On average over all three utilities, rooftop systems are $0.061/kWh more expensive than ground-mounted under the low cost case, and $0.126/kWh more expensive under the high cost case.

Figure 29 and Figure 30 show the amount of PV installed by type by year under the least cost scenario. The low cost and high cost cases are nearly identical in terms of the type and amount of LDPV installed.

**Figure 29: Installed PV by Type Under The *Least Cost* Scenario, "Maximum Without Curtailment" Interconnection Policy; Low Cost Case**

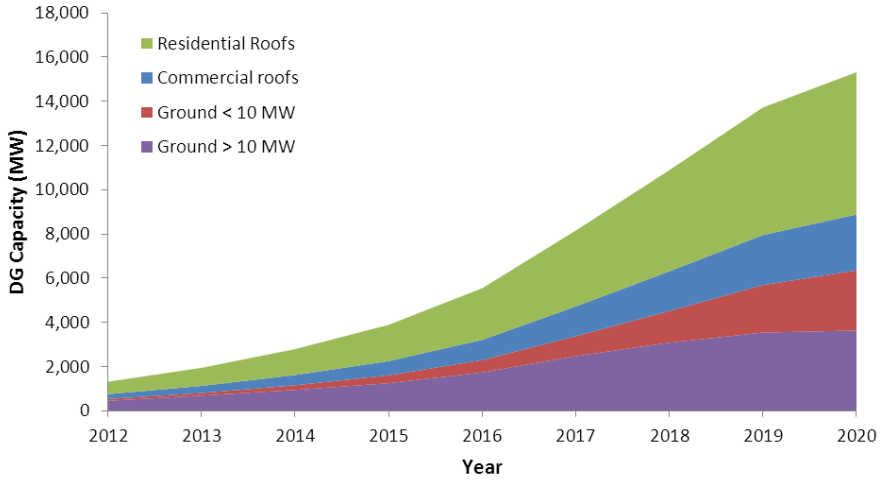
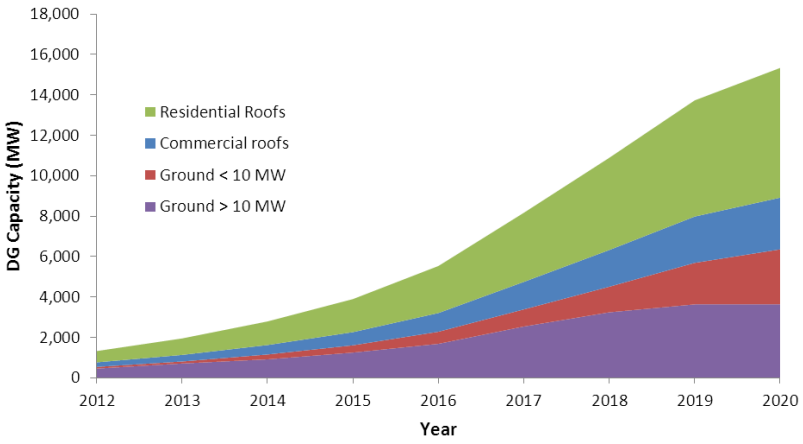



**Figure 30: Installed PV by Type Under The *Least Cost* Scenario, "Maximum Without Curtailment" Interconnection Policy; High Cost Case**




Based on the technical potential assessment, a total of 15 GW of local PV can be installed. However, several potentially significant barriers would need to be overcome to install this level of capacity, including:

- **Potential interconnection issues, such as islanding, voltage regulation, and circuit protection.** The base case potential estimate of more than 15,000 MW assumes that LDPV can be installed up to the point where PV output is equal to local load while mitigating potential interconnection issues at reasonable cost. This high level of PV penetration has not been the subject of detailed engineering studies. It is possible that achieving this level of interconnection would incur interconnection costs beyond those included in this study.
- **Geographic development issues.** Because available "local" load is widely distributed throughout the state, the market for LDPV would have to develop in such a way as to widely distribute LDPV development in accordance with available load.
- **Industry expansion.** To achieve 15,000 MW of installed LDPV by 2020, large scale industry expansion is required, including streamlining of permitting and business and workforce expansion. This is particularly true given that a significant portion of the LDPV technical potential is from rooftop installations.

This 15,300 MW installed in our modeling over the course of the study period follows the assumed PV installation curve (see Section 3.2.3). PV from the different market segments (residential roof, commercial roof, and ground-mounted) is assigned to "fill" the 15,300 MW based on its priority in the supply curve. The final 2020 proportional allocation of these three market segments is applied to each year, representing the likely reality that different segments would develop in parallel. Allocation within the ground-mounted segment between large and small ground-mounted systems is on a least cost basis. Specifically, we select larger, cheaper systems to be installed first, but if not enough load is available for the larger system, we move up the cost curve to smaller systems.

Residential roofs, though expensive compared to ground-mount, are nevertheless the largest segment in terms of megawatts because for many substations there are not enough ground-mount sites to meet the substation's available capacity to absorb solar DG.

Figure 31 and Figure 32 show supply curves by segment under the least cost scenario for the low and high cost cases, respectively.

**Figure 31: Supply Curves by PV Type Under the *Least Cost* Scenario; Low Cost Case**

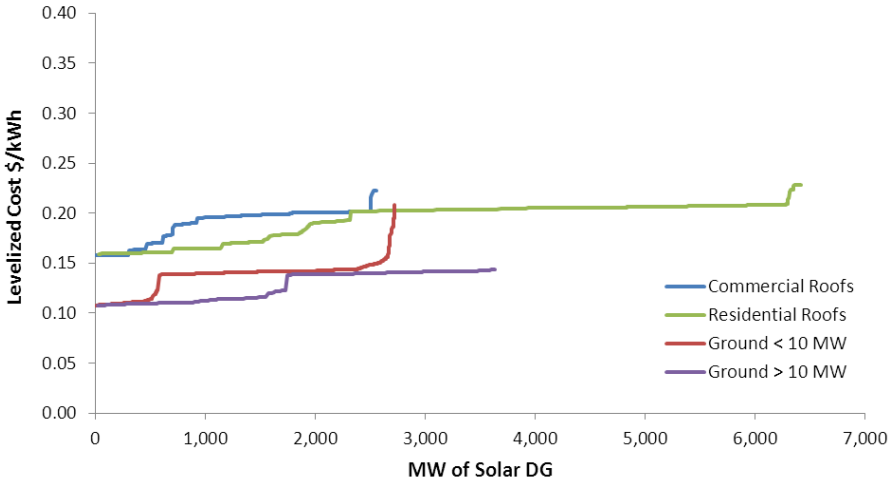
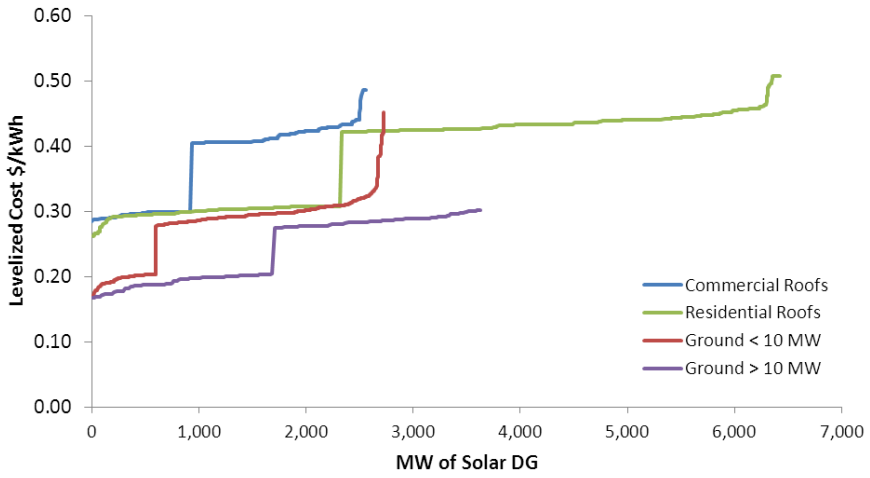


**Figure 32: Supply Curves by PV Type Under the *Least Cost* Scenario; High Cost Case**




The supply curve for residential roofs appears below the supply curve for commercial roofs because there are many more megawatts of residential roof available in the highest insolation areas. However, residential rooftop systems actually have slightly higher average costs (see Figure 22 on page 66 and Figure 23 on page 66).

### 4.1.2 LEAST NET COST SCENARIO

Table 18 and Table 19 present the estimated technical potential, anticipated cost, and anticipated net cost to ratepayers in 2020 under the *least net cost* scenario. Total cost under this scenario is very similar to that under the *least cost* scenario, ranging from $4.8- to $9.8-billion. Net cost is also very similar – $1.5- to $6.7-billion. A comparison of estimated technical potential by utility and climate zone under the *least cost* and *least net cost* scenarios indicates that for the most part, the same generation is installed by 2020 in the same locations

under either scenario, *when the full technical potential is realized*. As discussed in Section 1.2, procurement on a *least net cost* basis can result in lower net costs *if less than the full technical potential is realized*. This is because procuring on a *least net cost* basis locates LDPV in areas with high transmission and distribution avoided cost benefits first. In contrast, when the full technical potential is realized, all sites are eventually utilized (those with and those without high transmission and distribution avoided costs) and the net cost advantage disappears.

## Table 18: 2020 Technical Potential, Cost, and Net Cost of LDPV Under a *Least Net Cost* Scenario; Low Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,468 | $296.2 | $0.202 | $135.9 | $0.093 |
| | | Commercial Roof | 257 | 423 | $83.6 | $0.198 | $36.5 | $0.086 |
| | | Ground < 10 MW | 851 | 1,847 | $259.0 | $0.140 | $58.9 | $0.032 |
| | | Ground 10-20 MW | 469 | 1,006 | $138.1 | $0.137 | $31.2 | $0.031 |
| | North Central Valley | Residential Roof | 1,026 | 1,746 | $335.4 | $0.192 | $128.0 | $0.073 |
| | | Commercial Roof | 297 | 482 | $95.6 | $0.198 | $40.4 | $0.084 |
| | | Ground < 10 MW | 848 | 1,810 | $247.3 | $0.137 | $39.2 | $0.022 |
| | | Ground 10-20 MW | 1,278 | 2,702 | $342.5 | $0.127 | $20.8 | $0.008 |
| | South Central Valley | Residential Roof | 404 | 701 | $135.5 | $0.193 | $55.3 | $0.079 |
| | | Commercial Roof | 154 | 253 | $48.5 | $0.192 | $19.6 | $0.077 |
| | | Ground < 10 MW | 415 | 894 | $125.8 | $0.141 | $24.1 | $0.027 |
| | | Ground 10-20 MW | 273 | 586 | $77.6 | $0.133 | $12.6 | $0.022 |
| | Mountain | Residential Roof | 64 | 111 | $21.7 | $0.196 | $9.0 | $0.082 |
| | | Commercial Roof | 21 | 35 | $7.2 | $0.203 | $3.2 | $0.091 |
| | | Ground < 10 MW | 101 | 215 | $31.0 | $0.144 | $7.0 | $0.032 |
| | | Ground 10-20 MW | 35 | 76 | $10.5 | $0.139 | $2.1 | $0.027 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.8 | $0.132 | $0.2 | $0.035 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,483 | 4,491 | $856.7 | $0.191 | $342.8 | $0.076 |
| | | Commercial Roof | 1,328 | 2,260 | $418.6 | $0.185 | $158.1 | $0.070 |
| | | Ground < 10 MW | 273 | 637 | $80.2 | $0.126 | $8.7 | $0.014 |
| | | Ground 10-20 MW | 1,074 | 2,472 | $295.8 | $0.120 | $12.1 | $0.005 |
| | South Central Valley | Residential Roof | 414 | 757 | $141.5 | $0.187 | $56.6 | $0.075 |
| | | Commercial Roof | 202 | 336 | $63.9 | $0.190 | $16.3 | $0.049 |
| | | Ground < 10 MW | 74 | 175 | $21.6 | $0.124 | $2.3 | $0.013 |
| | | Ground 10-20 MW | 173 | 406 | $46.6 | $0.115 | $1.1 | $0.003 |
| | Desert | Residential Roof | 168 | 304 | $55.4 | $0.182 | $22.1 | $0.073 |
| | | Commercial Roof | 46 | 79 | $12.8 | $0.163 | $3.9 | $0.050 |
| | | Ground < 10 MW | 41 | 98 | $12.3 | $0.126 | $1.1 | $0.011 |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.3) | ($0.004) |
| | Mountain | Residential Roof | 128 | 240 | $43.9 | $0.183 | $18.7 | $0.078 |
| | | Commercial Roof | 67 | 115 | $20.6 | $0.179 | $7.9 | $0.068 |
| | | Ground < 10 MW | 29 | 70 | $8.8 | $0.127 | $1.3 | $0.019 |
| | | Ground 10-20 MW | 50 | 113 | $14.9 | $0.132 | $3.4 | $0.030 |
| SDGE | South Coast | Residential Roof | 909 | 1,663 | $329.2 | $0.198 | $160.3 | $0.096 |
| | | Commercial Roof | 154 | 265 | $51.3 | $0.194 | $24.1 | $0.091 |
| | | Ground < 10 MW | 85 | 193 | $25.7 | $0.133 | $5.8 | $0.030 |
| | | Ground 10-20 MW | 252 | 564 | $74.2 | $0.132 | $17.6 | $0.031 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.1 | $0.145 | $0.4 | $0.049 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.129 | $0.1 | $0.034 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.127 | $0.2 | $0.031 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 15,322 | 29,683 | 4841 | 0.16 | 1489 | 0.05 |

## Table 19: 2020 Technical Potential, Cost, and Net Cost of LDPV Under a *Least Net Cost* Scenario; High Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,478 | $664.4 | $0.449 | $507.1 | $0.343 |
| | | Commercial Roof | 257 | 425 | $185.7 | $0.437 | $139.9 | $0.329 |
| | | Ground < 10 MW | 851 | 1,842 | $550.9 | $0.299 | $359.3 | $0.195 |
| | | Ground 10-20 MW | 469 | 997 | $292.4 | $0.293 | $188.9 | $0.189 |
| | North Central Valley | Residential Roof | 1,026 | 1,790 | $804.5 | $0.449 | $609.9 | $0.341 |
| | | Commercial Roof | 312 | 509 | $224.6 | $0.441 | $169.5 | $0.333 |
| | | Ground < 10 MW | 848 | 1,822 | $532.8 | $0.293 | $340.9 | $0.187 |
| | | Ground 10-20 MW | 1,278 | 2,731 | $725.2 | $0.266 | $435.2 | $0.159 |
| | South Central Valley | Residential Roof | 404 | 712 | $319.0 | $0.448 | $242.4 | $0.341 |
| | | Commercial Roof | 154 | 256 | $110.8 | $0.434 | $83.2 | $0.325 |
| | | Ground < 10 MW | 415 | 897 | $264.1 | $0.294 | $169.6 | $0.189 |
| | | Ground 10-20 MW | 273 | 583 | $153.0 | $0.262 | $91.9 | $0.158 |
| | Mountain | Residential Roof | 64 | 111 | $50.2 | $0.451 | $38.3 | $0.343 |
| | | Commercial Roof | 21 | 36 | $15.4 | $0.430 | $11.5 | $0.323 |
| | | Ground < 10 MW | 101 | 216 | $66.3 | $0.307 | $43.6 | $0.202 |
| | | Ground 10-20 MW | 35 | 76 | $21.6 | $0.285 | $13.6 | $0.180 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.8 | $0.286 | $1.2 | $0.190 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,374 | $1,567.8 | $0.358 | $1,116.7 | $0.255 |
| | | Commercial Roof | 1,358 | 2,299 | $822.9 | $0.358 | $583.0 | $0.254 |
| | | Ground < 10 MW | 273 | 635 | $150.0 | $0.236 | $87.4 | $0.138 |
| | | Ground 10-20 MW | 1,074 | 2,455 | $502.8 | $0.205 | $263.2 | $0.107 |
| | South Central Valley | Residential Roof | 417 | 755 | $264.3 | $0.350 | $187.3 | $0.248 |
| | | Commercial Roof | 200 | 339 | $122.1 | $0.360 | $86.5 | $0.255 |
| | | Ground < 10 MW | 74 | 174 | $42.9 | $0.246 | $25.9 | $0.148 |
| | | Ground 10-20 MW | 173 | 404 | $86.1 | $0.213 | $46.9 | $0.116 |
| | Desert | Residential Roof | 177 | 317 | $109.4 | $0.345 | $76.5 | $0.241 |
| | | Commercial Roof | 37 | 62 | $19.6 | $0.317 | $13.2 | $0.213 |
| | | Ground < 10 MW | 41 | 99 | $22.1 | $0.224 | $12.6 | $0.128 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.6 | $0.095 |
| | Mountain | Residential Roof | 128 | 236 | $77.6 | $0.328 | $53.9 | $0.228 |
| | | Commercial Roof | 67 | 114 | $40.9 | $0.360 | $29.1 | $0.256 |
| | | Ground < 10 MW | 29 | 69 | $14.9 | $0.218 | $8.2 | $0.119 |
| | | Ground 10-20 MW | 50 | 110 | $26.9 | $0.244 | $15.8 | $0.143 |
| SDGE | South Coast | Residential Roof | 909 | 1,637 | $639.9 | $0.391 | $474.2 | $0.290 |
| | | Commercial Roof | 154 | 261 | $101.5 | $0.389 | $74.7 | $0.287 |
| | | Ground < 10 MW | 85 | 191 | $50.5 | $0.264 | $31.4 | $0.164 |
| | | Ground 10-20 MW | 252 | 554 | $142.3 | $0.257 | $87.0 | $0.157 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.194 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $1.1 | $0.283 | $0.8 | $0.189 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.108 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 15,338 | 29,657 | 9804 | 0.33 | 6729 | 0.23 |

Figure 33 shows the amount of PV installed by type by year under the *least net cost* scenario, low cost case. The results are similar to the *least cost* scenario in Figure 29, with the main difference being that the ground-mounted PV greater than 10 MW takes slightly longer to reach its final 2020 value. This is a result of smaller ground-mounted systems having better avoided cost benefits due to increased likelihood of proximity to load in high value areas, thus pushing larger systems further down the supply curve.

**Figure 33: Installed PV by Type under the *Least Net Cost* Scenario, "Maximum Without Curtailment" Interconnection Policy; Low Cost Case**

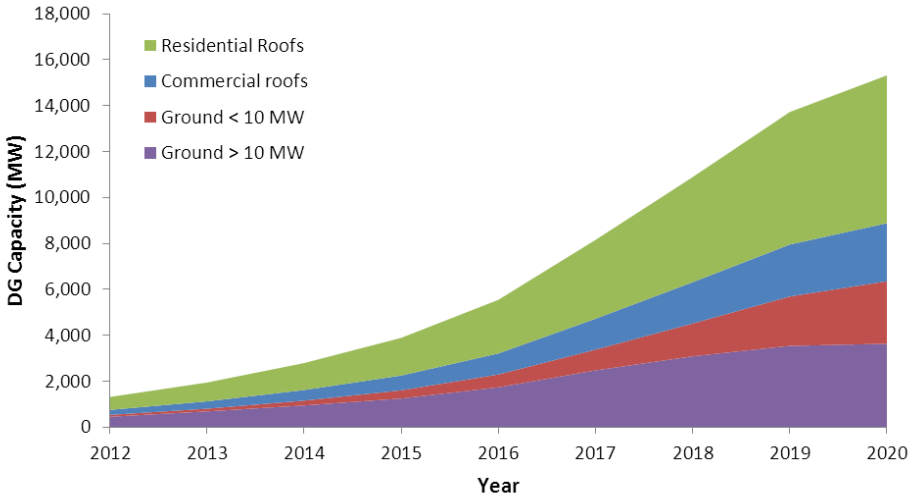



Figure 34 and Figure 35 show supply curves under the *least net cost* scenario in the low and high cost cases respectively. These figures differ from Figure 31 in that the vertical axis is net cost rather than cost. The curves are similar, however, with ground-mounted systems less expensive than rooftop.

**Figure 34: Supply Curves by PV Type under the *Least Net Cost* Scenario; Low Cost Case**

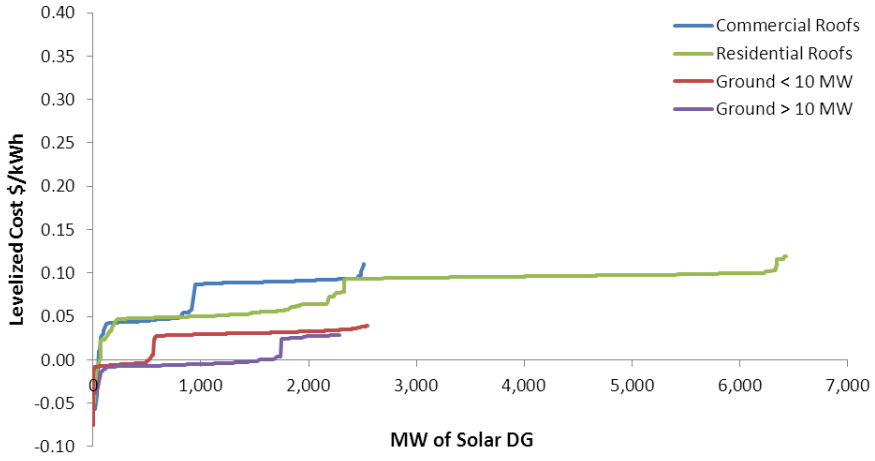
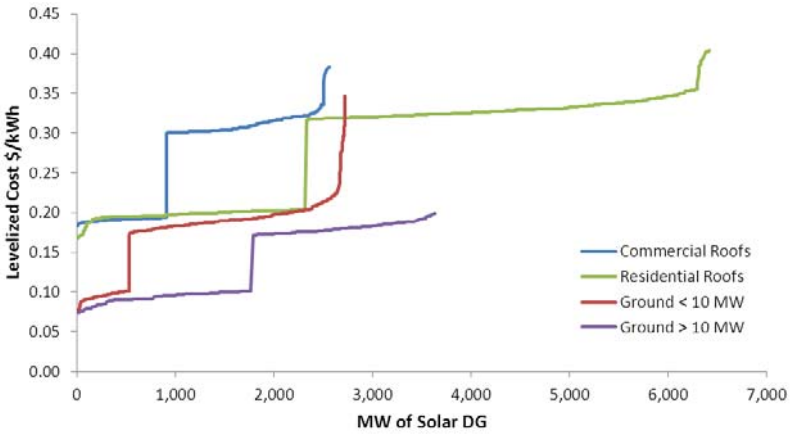



**Figure 35: Supply Curves by PV Type under the *Least Net Cost* Scenario; High Cost Case**



### 4.1.3 HIGH ROOFTOP SCENARIO

Table 20 shows results under the *high rooftop* scenario, low cost case. Costs are significantly higher under this scenario – $5.5 billion compared to $4.8 billion in the *least cost* and *least net cost* scenarios. For the high cost case (Table 21) the total cost is $11.2 billion compared to $9.8 billion in the *least cost* and *least net cost* scenarios. The technical potential increases somewhat compared to the other two scenarios and the total energy generation declines. This is due to the fact that the rooftop PV has lower capacity factors than ground-mounted, so more nameplate capacity can be installed without exceeding hourly minimum loads even while less energy is generated over the course of the year.

## Table 20: 2020 Technical Potential, Cost, and Net Cost of Technical Potential Under a *High Rooftop* Scenario, by IOU, System Type, and Climate Zone; Low Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,780 | 3,122 | $639.4 | $0.205 | $298.4 | $0.096 |
| | | Commercial Roof | 278 | 461 | $91.3 | $0.198 | $40.3 | $0.087 |
| | | Ground < 10 MW | 315 | 694 | $94.3 | $0.136 | $21.5 | $0.031 |
| | | Ground 10-20 MW | 210 | 449 | $59.7 | $0.133 | $12.0 | $0.027 |
| | North Central Valley | Residential Roof | 2,450 | 4,296 | $868.0 | $0.202 | $362.4 | $0.084 |
| | | Commercial Roof | 359 | 590 | $118.1 | $0.200 | $51.2 | $0.087 |
| | | Ground < 10 MW | 373 | 811 | $110.1 | $0.136 | $15.5 | $0.019 |
| | | Ground 10-20 MW | 599 | 1,288 | $170.1 | $0.132 | $16.3 | $0.013 |
| | South Central Valley | Residential Roof | 1,097 | 1,931 | $389.7 | $0.202 | $168.6 | $0.087 |
| | | Commercial Roof | 122 | 203 | $40.1 | $0.198 | $16.7 | $0.082 |
| | | Ground < 10 MW | 110 | 243 | $32.4 | $0.133 | $5.9 | $0.024 |
| | | Ground 10-20 MW | 41 | 89 | $10.9 | $0.122 | $1.3 | $0.014 |
| | Mountain | Residential Roof | 214 | 375 | $77.1 | $0.206 | $34.6 | $0.092 |
| | | Commercial Roof | 21 | 36 | $7.1 | $0.198 | $3.1 | $0.087 |
| | | Ground < 10 MW | 13 | 28 | $4.0 | $0.142 | $0.8 | $0.029 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 3 | 6 | $1.1 | $0.188 | $0.5 | $0.092 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,644 | 6,637 | $1,219.9 | $0.184 | $462.6 | $0.070 |
| | | Commercial Roof | 1,499 | 2,549 | $470.8 | $0.185 | $175.8 | $0.069 |
| | | Ground < 10 MW | 96 | 221 | $28.3 | $0.128 | $2.2 | $0.010 |
| | | Ground 10-20 MW | 193 | 441 | $52.7 | $0.120 | ($2.0) | ($0.004) |
| | South Central Valley | Residential Roof | 708 | 1,302 | $243.3 | $0.187 | $95.5 | $0.073 |
| | | Commercial Roof | 184 | 314 | $59.6 | $0.190 | $13.9 | $0.044 |
| | | Ground < 10 MW | 9 | 22 | $2.9 | $0.134 | $0.3 | $0.013 |
| | | Ground 10-20 MW | 12 | 30 | $3.4 | $0.113 | $0.8 | $0.026 |
| | Desert | Residential Roof | 261 | 477 | $90.9 | $0.190 | $37.4 | $0.078 |
| | | Commercial Roof | 32 | 54 | $10.3 | $0.189 | $4.2 | $0.078 |
| | | Ground < 10 MW | 6 | 16 | $1.8 | $0.115 | $0.1 | $0.005 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 167 | 307 | $56.3 | $0.183 | $24.4 | $0.079 |
| | | Commercial Roof | 107 | 180 | $32.0 | $0.178 | $12.5 | $0.069 |
| | | Ground < 10 MW | 16 | 39 | $4.5 | $0.116 | $0.1 | $0.003 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,221 | 2,193 | $399.2 | $0.182 | $176.2 | $0.080 |
| | | Commercial Roof | 183 | 309 | $56.8 | $0.184 | $25.0 | $0.081 |
| | | Ground < 10 MW | 18 | 40 | $5.8 | $0.144 | $1.7 | $0.042 |
| | | Ground 10-20 MW | 16 | 34 | $3.8 | $0.110 | $0.3 | $0.009 |
| | South Central Valley | Residential Roof | 6 | 11 | $2.0 | $0.180 | $1.0 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $0.9 | $0.181 | $0.4 | $0.087 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,366 | 29,804 | 5458 | 0.18 | 2081 | 0.07 |

## Table 21: 2020 Technical Potential, Cost, and Net Cost of Technical Potential Under a *High Rooftop* Scenario, by IOU, System Type, and Climate Zone; High Cost Case

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,780 | 3,122 | $1,400.4 | $0.449 | $1,069.6 | $0.343 |
| | | Commercial Roof | 278 | 461 | $201.3 | $0.436 | $151.9 | $0.329 |
| | | Ground < 10 MW | 315 | 693 | $198.2 | $0.286 | $127.4 | $0.184 |
| | | Ground 10-20 MW | 210 | 450 | $123.2 | $0.274 | $76.9 | $0.171 |
| | North Central Valley | Residential Roof | 2,450 | 4,290 | $1,886.0 | $0.440 | $1,424.0 | $0.332 |
| | | Commercial Roof | 359 | 590 | $259.2 | $0.439 | $195.7 | $0.332 |
| | | Ground < 10 MW | 373 | 810 | $233.1 | $0.288 | $148.0 | $0.183 |
| | | Ground 10-20 MW | 599 | 1,290 | $345.8 | $0.268 | $209.7 | $0.163 |
| | South Central Valley | Residential Roof | 1,097 | 1,931 | $846.2 | $0.438 | $639.2 | $0.331 |
| | | Commercial Roof | 122 | 203 | $88.0 | $0.434 | $66.1 | $0.326 |
| | | Ground < 10 MW | 110 | 243 | $67.8 | $0.280 | $42.8 | $0.177 |
| | | Ground 10-20 MW | 41 | 89 | $21.3 | $0.238 | $12.1 | $0.136 |
| | Mountain | Residential Roof | 214 | 375 | $168.5 | $0.449 | $128.4 | $0.342 |
| | | Commercial Roof | 21 | 36 | $15.4 | $0.430 | $11.6 | $0.323 |
| | | Ground < 10 MW | 13 | 28 | $8.5 | $0.303 | $5.6 | $0.199 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 3 | 6 | $1.7 | $0.296 | $1.2 | $0.201 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,644 | 6,637 | $2,340.7 | $0.353 | $1,665.0 | $0.251 |
| | | Commercial Roof | 1,499 | 2,549 | $924.0 | $0.363 | $659.3 | $0.259 |
| | | Ground < 10 MW | 96 | 220 | $55.0 | $0.250 | $33.2 | $0.151 |
| | | Ground 10-20 MW | 193 | 441 | $88.2 | $0.200 | $46.0 | $0.104 |
| | South Central Valley | Residential Roof | 708 | 1,302 | $465.2 | $0.357 | $333.6 | $0.256 |
| | | Commercial Roof | 184 | 314 | $120.8 | $0.385 | $88.0 | $0.280 |
| | | Ground < 10 MW | 9 | 22 | $6.0 | $0.278 | $3.9 | $0.179 |
| | | Ground 10-20 MW | 12 | 30 | $5.4 | $0.179 | $2.8 | $0.092 |
| | Desert | Residential Roof | 261 | 477 | $172.3 | $0.361 | $123.9 | $0.260 |
| | | Commercial Roof | 32 | 54 | $19.8 | $0.365 | $14.2 | $0.261 |
| | | Ground < 10 MW | 6 | 16 | $2.9 | $0.184 | $1.4 | $0.090 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 167 | 307 | $106.4 | $0.346 | $75.5 | $0.246 |
| | | Commercial Roof | 107 | 180 | $57.0 | $0.317 | $38.4 | $0.213 |
| | | Ground < 10 MW | 16 | 39 | $7.6 | $0.195 | $3.9 | $0.100 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,221 | 2,193 | $801.0 | $0.365 | $579.3 | $0.264 |
| | | Commercial Roof | 183 | 309 | $113.9 | $0.369 | $82.2 | $0.266 |
| | | Ground < 10 MW | 18 | 40 | $12.1 | $0.300 | $8.1 | $0.200 |
| | | Ground 10-20 MW | 16 | 34 | $7.3 | $0.212 | $3.8 | $0.111 |
| | South Central Valley | Residential Roof | 6 | 11 | $3.1 | $0.284 | $2.1 | $0.191 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $1.3 | $0.285 | $0.9 | $0.191 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,366 | 29,798 | 11175 | 0.38 | 8076 | 0.27 |

Figure 36 shows the amount of PV installed by type by year under the *high rooftop* scenario. The additional rooftop capacity in the *high rooftop* scenario comes mainly from residential roofs, as these are more plentiful than large commercial roofs.

**Figure 36: Installed PV by Type Under the *High Rooftop* Scenario, Maximum Without Curtailment; Low Cost Case**

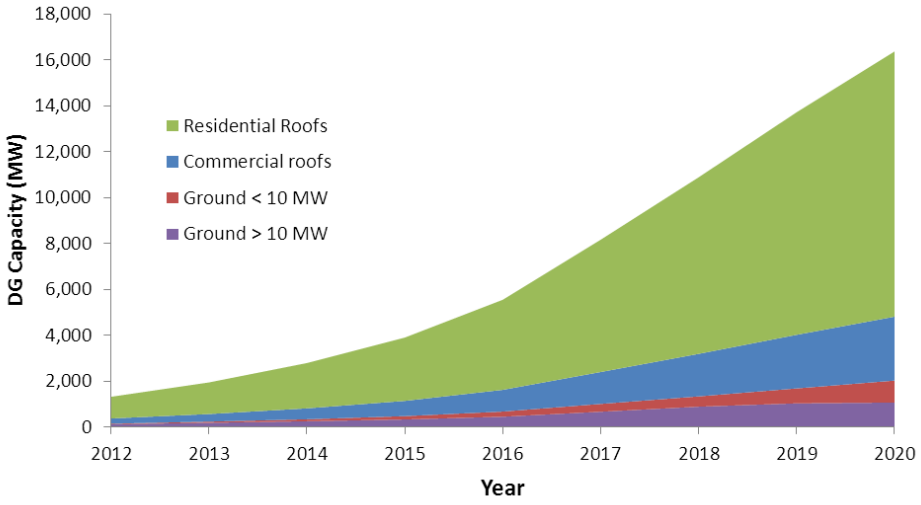



Figure 37 and Figure 38 show the supply curves for resources selected under the *high rooftop* scenario. Because rooftop PV is selected first under this scenario, many of the ground-mounted sites can no longer be interconnected under the interconnection limit as the capacity for DG at a particular substation may have been largely or completely filled by the rooftop PV and are no longer available. The remaining ground-mount sites are both fewer and in many cases among the more expensive ground-mount sites, hence the steep supply curve.

**Figure 37: Supply curves by PV type under the *high rooftop* scenario; Low Cost Case**

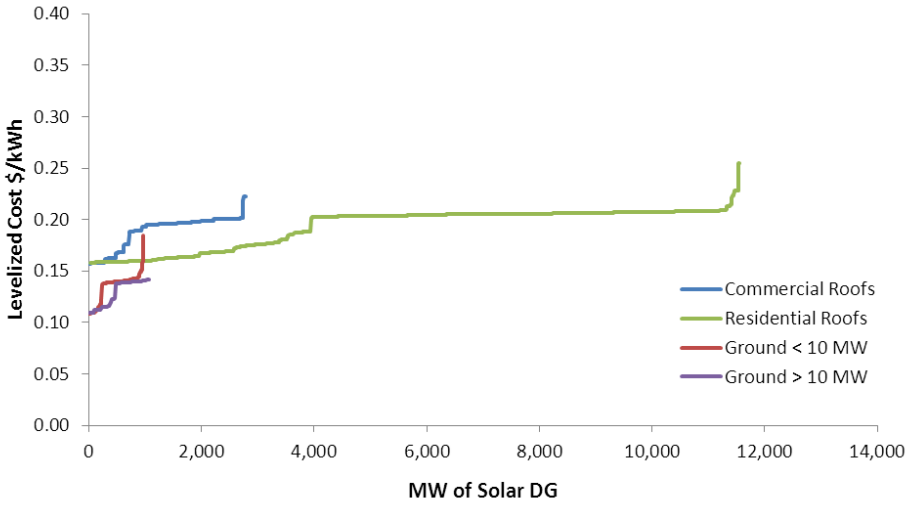
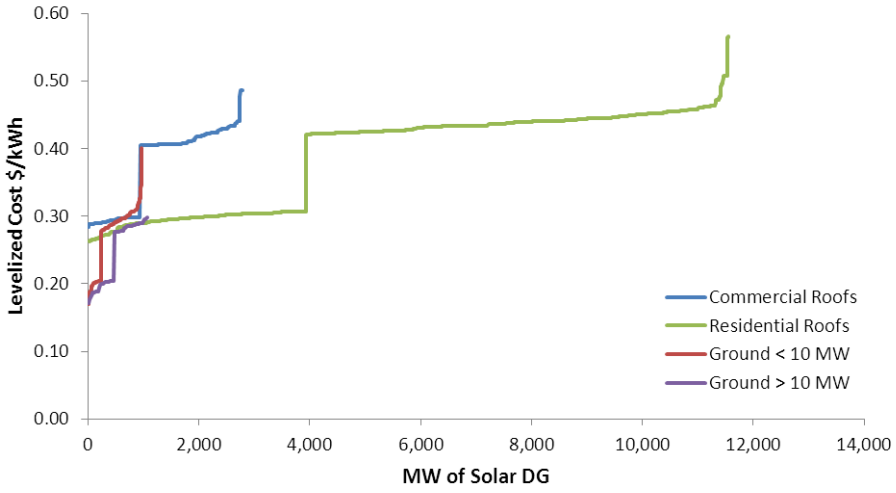


**Figure 38: Supply curves by PV type under the *high rooftop* scenario; High Cost Case**




## 4.2 Sensitivity Analysis

We tested the sensitivity of results to a number of input assumptions:

+ **Interconnection potential criteria**. The calculation of PV interconnection potential is dependent on the criteria by which interconnection potential is determined. For the base case, we used the maximum potential with no backflow and no curtailment. In addition, we tested several variations. The five sensitivities include:
    - 15% of maximum hourly load
    - 30% of maximum hourly load
    - Maximum of 1% curtailment of annual energy output
    - Maximum of 3% curtailment of annual energy output

- Maximum of 5% curtailment of annual energy output

+ **Installation Rate**. A faster installation rate means more PV is installed before presumed expiration of the federal ITC at the end of 2016. We test a high and low installation rate in addition to the base case (see Section 3.2.3).

Table 22 provides summary results across the sensitivities described above for the low cost case, and Table 23 does so for the high cost case. The summary compares the technical potential, the cost, and net cost to ratepayers in 2020.

**Table 22: Sensitivity Results, Low Cost Case**

| Sensitivity | Scenario | Installed MW by 2020 | Cost ($2010, millions) | Net Cost ($2010, millions) |
|---|---|---|---|---|
| Low Cost Base Case (80% progress ratio) | Cost | 15,340 | $4,850 | $1,490 |
| | Net Cost | 15,320 | $4,840 | $1,490 |
| | Roofs First | 16,370 | $5,460 | $2,080 |
| 15% Interconnection | Cost | 6,640 | $1,930 | $367 |
| | Net Cost | 6,640 | $1,930 | $369 |
| | Roofs First | 6,670 | $2,070 | $638 |
| 30% Interconnection | Cost | 11,670 | $3,630 | $1,030 |
| | Net Cost | 11,670 | $3,630 | $1,020 |
| | Roofs First | 12,130 | $4,010 | $1,490 |
| 1% Curtailment | Cost | 16,660 | $5,170 | $1,380 |
| | Net Cost | 16,640 | $5,160 | $1,320 |
| | Roofs First | 16,670 | $5,680 | $2,320 |
| 3% Curtailment | Cost | 16,660 | $5,120 | $1,300 |
| | Net Cost | 16,630 | $5,120 | $1,220 |
| | Roofs First | 16,680 | $5,690 | $2,310 |

| Sensitivity | Scenario | Installed MW by 2020 | Cost ($2010, millions) | Net Cost ($2010, millions) |
|---|---|---|---|---|
| 5% Curtailment | Cost | 16,660 | $5,110 | $1,270 |
| | Net Cost | 16,650 | $5,110 | $1,180 |
| | Roofs First | 16,670 | $5,690 | $2,300 |
| High Timeline | Cost | 15,340 | $4,730 | $1,540 |
| | Net Cost | 15,320 | $4,720 | $1,530 |
| | Roofs First | 16,370 | $5,350 | $2,140 |
| Low Timeline | Cost | 6,660 | $1,890 | $78 |
| | Net Cost | 6,660 | $1,890 | $32 |
| | Roofs First | 6,660 | $2,200 | $666 |

**Table 23: Sensitivity Results, High Cost Case**

| Sensitivity | Scenario | Installed MW by 2020 | Cost ($2010, millions) | Net Cost ($2010, millions) |
|---|---|---|---|---|
| High Cost Base Case (100% progress ratio) | Cost | 15,340 | $9,820 | $6,740 |
| | Net Cost | 15,340 | $9,800 | $6,730 |
| | Roofs First | 16,370 | $11,170 | $8,080 |
| 15% Interconnection | Cost | 6,640 | $3,530 | $2,090 |
| | Net Cost | 6,630 | $3,520 | $2,090 |
| | Roofs First | 6,670 | $3,800 | $2,480 |
| 30% Interconnection | Cost | 11,670 | $7,130 | $4,740 |
| | Net Cost | 11,670 | $7,130 | $4,740 |
| | Roofs First | 12,130 | $7,950 | $5,640 |
| 1% Curtailment | Cost | 16,640 | $10,520 | $7,080 |
| | Net Cost | 16,660 | $10,530 | $7,080 |
| | Roofs First | 16,660 | $11,670 | $8,570 |

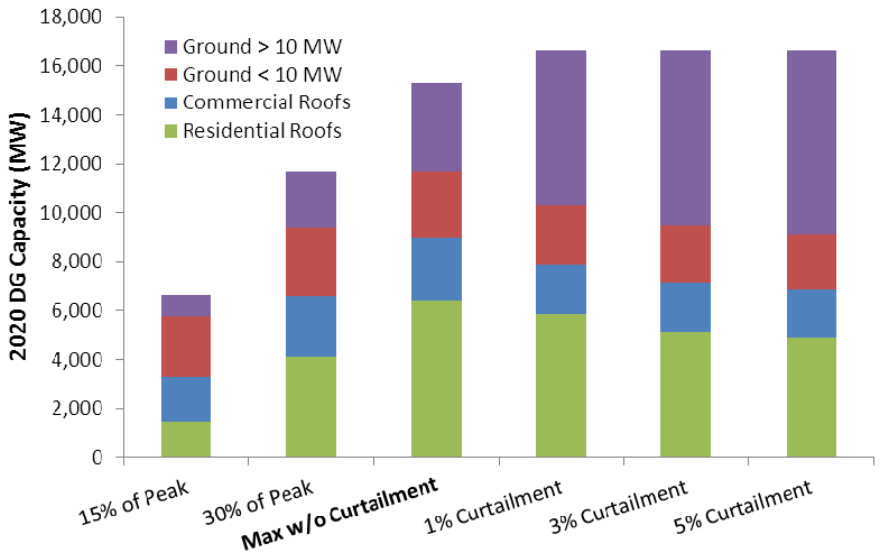
| Sensitivity | Scenario | Installed MW by 2020 | Cost ($2010, millions) | Net Cost ($2010, millions) |
|---|---|---|---|---|
| 3% Curtailment | Cost | 16,680 | $10,450 | $6,970 |
| | Net Cost | 16,660 | $10,430 | $6,960 |
| | Roofs First | 16,680 | $11,690 | $8,580 |
| 5% Curtailment | Cost | 16,670 | $10,390 | $6,900 |
| | Net Cost | 16,640 | $10,370 | $6,880 |
| | Roofs First | 16,660 | $11,670 | $8,560 |
| High Timeline | Cost | 15,340 | $8,990 | $6,070 |
| | Net Cost | 15,340 | $8,970 | $6,060 |
| | Roofs First | 16,370 | $10,270 | $7,330 |
| Low TimeLine | Cost | 6,650 | $3,700 | $2,030 |
| | Net Cost | 6,670 | $3,710 | $2,040 |
| | Roofs First | 6,660 | $4,360 | $2,970 |

Sensitivity results are discussed further in the sections that follow and detailed sensitivity tables are provided in Appendix A.

### 4.2.1 INTERCONNECTION POTENTIAL CRITERIA

A comparison of total interconnection potential is shown Figure 39. This figure differs from Figure 9 in Section 3.2.2 in that Figure 9 presented the individual potential of each market segment (residential roofs, commercial roofs, ground-mount < 10 MW, and ground-mount > 10 MW) separately, assuming only that segment were developed. Figure 39 shows the distributed PV actually selected in the modeling. The total in Figure 39 is lower than the sum of the segments in Figure 9 because installing PV from one segment reduces the amount of capacity available to absorb generation from PV installed in other segments.

**Figure 39: 2020 Technical Capacity Projection under Various Interconnection Potential Criteria and *Least Cost* Scenario; Low Cost Case**




With a 15% of peak load criterion (equivalent to the existing Rule 21 interconnection rule), we identify approximately 6,600 MW of local PV technical potential by 2020, roughly half of the base case estimate (which is based on maximum interconnection without backflow or curtailment). On the other hand, allowing no more than 1% of generation to be curtailed at each substation substantially increases the estimate to more than 16,600 MW.

The proportion of large ground-mounted systems selected increases as one moves from no curtailment to increasing levels of curtailment. In many cases, small amounts of curtailment make it possible to install cheaper large ground-mounted systems where they would otherwise fail the "no backflow" constraint. This can result in a shifting of projects to different areas in the state. For example, significantly less capacity is installed in SDG&E territory under the

5% curtailment case than under the *no backflow* (without curtailment) case. This is because the model selects cheaper generation first and with curtailment allowed there is a much larger quantity of cheaper generation available outside of SDG&E's service territory.

Levelized costs under the various interconnection criteria are shown in Figure 40 and Figure 41. The chart shows the levelized cost and net costs for each interconnection scenario, overlaid on the bars showing total capacity installed. The cost increases from the *15% of peak load* criterion up to the *max without curtailment* criterion because more capacity is installed further along the supply curves, where cost is higher. When curtailment is allowed, costs decrease reflecting the fact that more of the larger, cheaper resources can be installed in lower cost, higher insolation areas.

However, at increasing amounts of curtailment beyond 3%, costs begin to rise slightly due to the lost energy through curtailment. The lost energy payments drive up costs more than the price lowering effect of larger systems. This suggests an optimal level of curtailment, in terms of levelized $/kWh, between 3% and 5%.

**Figure 40: 2020 Levelized Cost under Various Interconnection Potential Criteria and *Least Cost* Scenario; Low Cost Case**

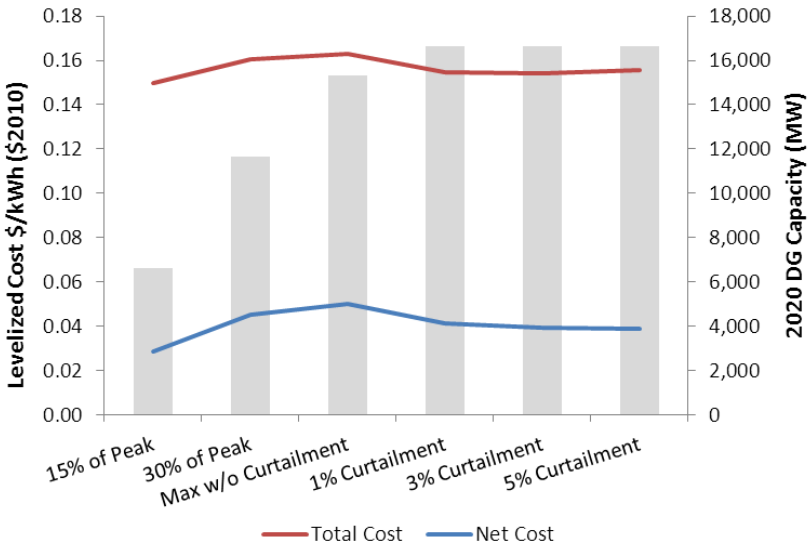
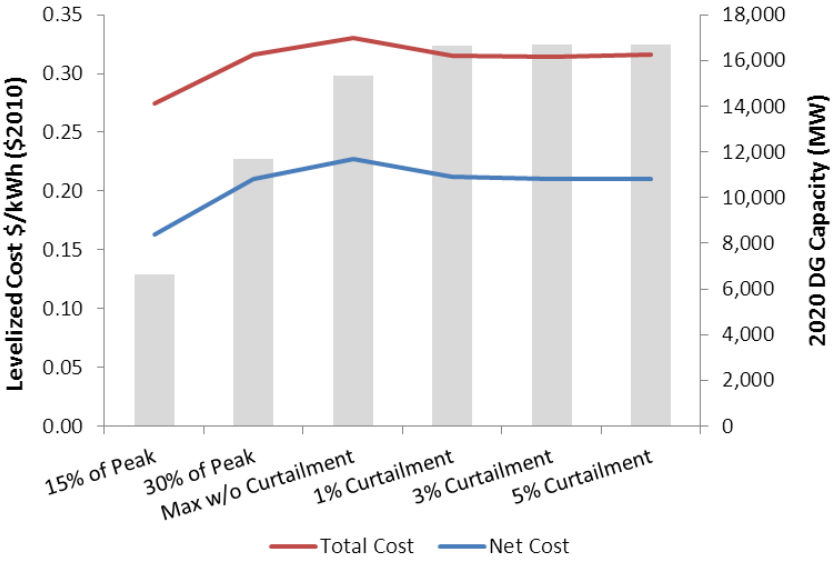



**Figure 41: 2020 Cost under Various Interconnection Potential Criteria and *Least Cost* Scenario; High Cost Case**



### 4.2.2 PV INSTALLATION RATE SENSITIVITY

The final sensitivity evaluates the impact of low and high PV installation rates. Figure 42 provides a comparison of costs under low and high installation rate sensitivities, along with the total capacity installed by 2020. Figure 43 provides the same comparison for the high cost case.

The higher installation rate does not increase the technical potential because it is limited by total interconnection potential rather than the rate of installation.

In both the high and low cost cases, the low installation rate sensitivity shows lower energy costs because higher cost systems that are farther along the cost supply curve have not been developed.

In the low cost case, the high installation rate installs more systems prior to the expiration of the higher ITC, but these systems cost more because costs decline over time. The two effects nearly cancel each other out which results in similar costs and net costs for both the base case and high installation rate sensitivities. In the high cost case, which does not have learning, the high installation rate case has lower costs and net costs because more systems are installed during the period of the higher federal ITC.

**Figure 42: Levelized Cost and Net Cost in 2020 under High and Low Installation Rate, *Least Cost* Scenario; Low Cost Case**

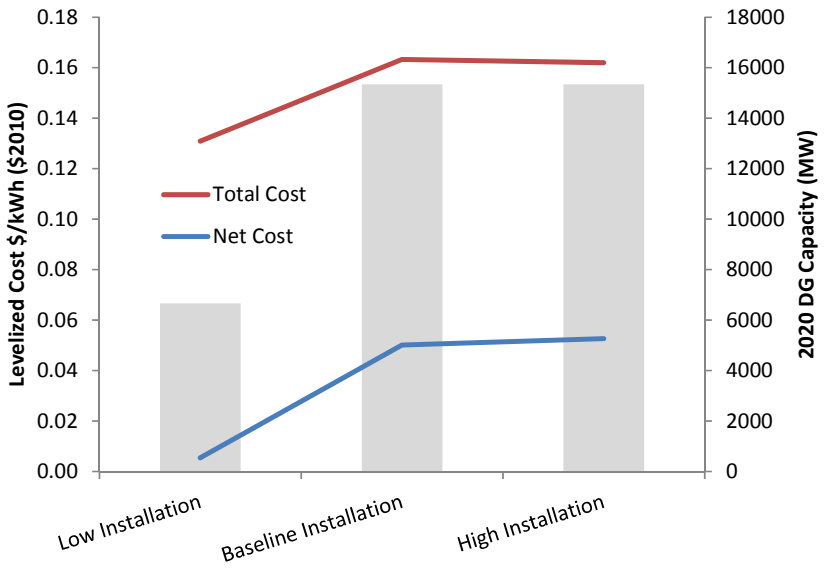
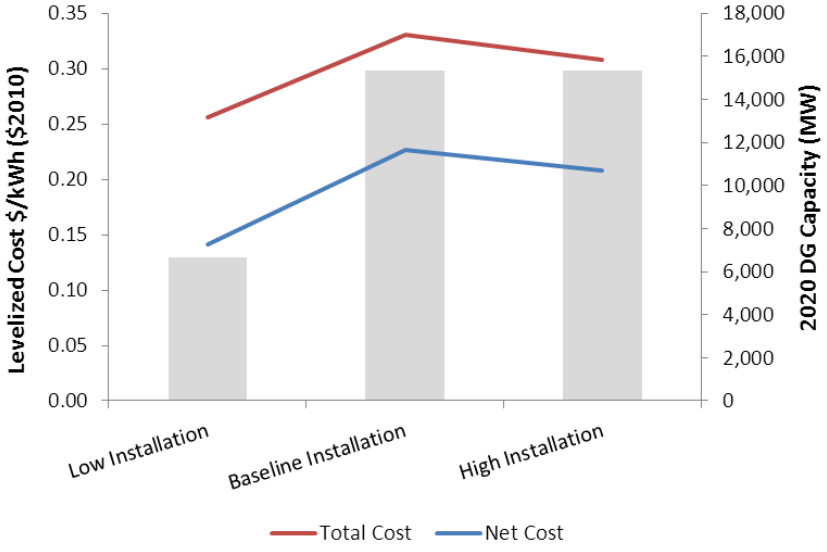



**Figure 43: Levelized Cost and Net Cost in 2020 under High and Low Installation Rate, *Least Cost* Scenario; High Cost Case**



## 4.3 Comparison to LTPP Costs

In the Long-term Procurement Planning (LTPP) proceeding (R.10-05-006)[34] procurement costs were estimated under several cases, including, among others, an All Gas Case, a Trajectory Case, and an Environmentally Constrained Case. The All Gas Case was constructed for cost comparison purposes only and assumes that renewable generation does not increase beyond the existing levels in 2009. The Trajectory and Environmentally Constrained cases both meet the 33% Renewable Portfolio Standard (RPS) and provide a useful comparison point for the LDPV cost estimates in the current study. The Trajectory Case includes renewable resources that are already under contract or under negotiation with California utilities and includes a mix of large and small renewable generators including wind, solar, geothermal, hydro, and biomass. The Environmentally Constrained reflects a scenario where siting of large central station renewables and associated transmission is limited due to environmental constraints and is comprised of a higher proportion of distributed PV (roughly 8,800 MW of distributed PV, compared to roughly 2,800 MW in the Trajectory Case).

The results presented in the LTPP proceeding include the projected 2020 Revenue Requirement in each case, reproduced in the first three columns of Table 24. The *least cost* and *high rooftop* scenarios from the present study are shown in Columns (4) and (5) and Columns (6) and (7). (Because the *least net cost* results are nearly identical to the *least cost* results, we omit the *least net cost* scenario from Table 24 for simplicity).

[34] For analysis, see https://www.pge.com/regulation/LongTermProcure2010-OIR/Testimony/Joint/2011/LongTermProcure2010-OIR_Test_Joint_20110701_212896.pdf

To complete the comparison in Table 24, the *least cost* and *high rooftop* scenarios were calculated on a comparable basis to LTPP. For purposes of using consistent assumptions across analyses, we used the high cost case for the comparison because it makes a "no learning" assumption (no decline in resource costs), which was the same assumption used for all renewable resources in the LTPP analysis. In addition, in order to keep assumptions consistent, we recalculate LDPV costs assuming an extension of the federal investment tax credit through 2020 since this is what the LTPP analysis assumed. To compare the low cost case on the same basis to the LTPP analysis, the LTPP analysis would have to be repeated with assumptions on learning rates across the range of renewable technologies, which is beyond the scope of this study.

In columns (4) and (5) the comparison assumes that local PV resources displace other Trajectory Case renewable resources. In this instance, the revenue requirement is higher than the Trajectory Case by $3,113 million (8.4%) and $4,136 million (11.1%) for the *least cost* and *high rooftop* case, respectively.

### Table 24: Comparison of LDPV with LTPP Cases

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | LTPP All Gas | LTPP Trajectory | LTPP Environmentally Constrained | Least Cost with average LTPP Trajectory | High Rooftop with average LTPP Trajectory | Least Cost + LTPP Trajectory | High Rooftop + LTPP Trajectory |
| 2020 Revenue Requirement (Millions $2010) | $34,548 | $37,280 | $37,809 | $40,394 | $41,416 | $43,031 | $44,063 |
| Δ Revenue Requirement from LTPP Trajectory (Millions $2010) | ($2,732) | $0 | $529 | $3,113 | $4,136 | $5,751 | $6,783 |
| %Δ Revenue Requirement from LTPP Trajectory | -7.3% | 0% | 1.4% | 8.4% | 11.1% | 15.4% | 18.2% |
| RPS % Achieved | 12.7% | 33.0% | 33% | 33.0% | 33.0% | 48.0% | 48.0% |

In columns (6) and (7) the comparison assumes that local PV is procured in addition to the LTPP Trajectory Case renewable resources. In this case, 48% of electricity sales would be met with renewable generation. The annual revenue requirement, compared to the Trajectory Case would be higher by $5,751 million (15.4%) and $6,783 million (18.2%) for the *least cost* and *high rooftop* cases, respectively.

# 5 Conclusion

This report is a preliminary assessment of local distributed PV technical potential in California. Once more solar PV projects achieve commercial operation and actual energy and interconnection costs are known, we will have the information to do more refined assessments of DG deployment barriers, the costs and benefits of the different DG market segments, and overall ratepayer impact.

In addition, further analysis is needed beyond the technical potential estimated in this study, such as analyses of economic and market potential, which will ultimately determine how much local distributed PV can be installed. Actual achievement of the level of LDPV interconnection and associated costs estimated by this study will be dependent on overcoming several potentially significant challenges.

# Appendix A:  Detailed Results

**CONTENTS**

# 80% Learning Curve Results By County

## Least Cost Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 122 | 214 | $43.9 | $0.205 | $19.9 | $0.093 |
| | Commercial Roof | 298 | 493 | $98.6 | $0.200 | $43.7 | $0.089 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.155 | $0.0 | $0.040 |
| | Ground 1-3 MW | 2 | 5 | $0.7 | $0.147 | $0.2 | $0.036 |
| | Ground 3-5 MW | 20 | 44 | $6.3 | $0.142 | $1.4 | $0.031 |
| | Ground 5-10 MW | 53 | 115 | $16.2 | $0.141 | $3.3 | $0.028 |
| | Ground 10-20 MW | 39 | 84 | $11.7 | $0.139 | $2.0 | $0.023 |
| Amador | Residential Roof | 4 | 7 | $1.5 | $0.204 | $0.7 | $0.094 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 9 | 19 | $2.7 | $0.143 | $0.6 | $0.033 |
| | Ground 5-10 MW | 11 | 24 | $3.3 | $0.140 | $0.7 | $0.031 |
| | Ground 10-20 MW | 11 | 23 | $3.2 | $0.142 | $0.4 | $0.019 |
| Butte | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.157 | $0.1 | $0.046 |
| | Ground 1-3 MW | 5 | 10 | $1.6 | $0.151 | $0.4 | $0.038 |
| | Ground 3-5 MW | 28 | 61 | $8.7 | $0.144 | $1.8 | $0.029 |
| | Ground 5-10 MW | 77 | 163 | $23.1 | $0.142 | $4.7 | $0.029 |
| | Ground 10-20 MW | 79 | 166 | $23.2 | $0.140 | $3.8 | $0.023 |
| Calaveras | Residential Roof | 1 | 1 | $0.3 | $0.204 | $0.1 | $0.081 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.152 | $0.1 | $0.040 |
| | Ground 1-3 MW | 7 | 15 | $2.2 | $0.145 | $0.5 | $0.030 |
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.144 | $0.3 | $0.037 |
| | Ground 5-10 MW | 7 | 14 | $2.0 | $0.139 | $0.5 | $0.033 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 13 | $1.9 | $0.151 | $0.5 | $0.040 |
| | Ground 3-5 MW | 11 | 23 | $3.3 | $0.143 | $0.8 | $0.036 |
| | Ground 5-10 MW | 25 | 54 | $7.6 | $0.141 | $1.5 | $0.027 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 437 | 769 | $156.8 | $0.204 | $65.1 | $0.085 |
| | Commercial Roof | 111 | 184 | $36.4 | $0.198 | $14.3 | $0.078 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 8 | 18 | $2.6 | $0.143 | $0.4 | $0.022 |
| | Ground 5-10 MW | 6 | 13 | $1.8 | $0.139 | $0.4 | $0.033 |
| | Ground 10-20 MW | 117 | 250 | $35.2 | $0.141 | $8.3 | $0.033 |
| El Dorado | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.155 | $0.1 | $0.037 |
| | Ground 1-3 MW | 5 | 12 | $1.7 | $0.146 | $0.3 | $0.029 |
| | Ground 3-5 MW | 6 | 13 | $1.9 | $0.141 | $0.3 | $0.024 |
| | Ground 5-10 MW | 31 | 67 | $9.3 | $0.139 | $1.6 | $0.023 |
| | Ground 10-20 MW | 51 | 108 | $15.2 | $0.140 | $2.3 | $0.021 |
| Fresno | Residential Roof | 272 | 484 | $99.4 | $0.205 | $44.4 | $0.092 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 10 | 23 | $3.3 | $0.143 | $0.7 | $0.032 |
| | Ground 3-5 MW | 22 | 49 | $7.0 | $0.141 | $1.6 | $0.032 |
| | Ground 5-10 MW | 138 | 304 | $40.7 | $0.134 | $7.7 | $0.025 |
| | Ground 10-20 MW | 418 | 909 | $121.5 | $0.134 | $18.1 | $0.020 |
| Glenn | Residential Roof | 10 | 17 | $3.4 | $0.206 | $1.5 | $0.088 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 9 | 19 | $2.8 | $0.148 | $0.3 | $0.014 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 19 | $2.6 | $0.141 | $0.4 | $0.019 |
| | Ground 10-20 MW | | | | | | |
| Humboldt | Residential Roof | 11 | 18 | $4.1 | $0.224 | $1.9 | $0.105 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 5 | $0.9 | $0.191 | $0.3 | $0.074 |
| | Ground 1-3 MW | 16 | 26 | $5.1 | $0.194 | $2.1 | $0.079 |
| | Ground 3-5 MW | 10 | 17 | $3.1 | $0.186 | $1.3 | $0.077 |
| | Ground 5-10 MW | 19 | 31 | $5.7 | $0.180 | $2.1 | $0.066 |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.110 | $0.0 | $0.009 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 11 | $1.3 | $0.114 | $0.2 | $0.018 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 73 | 133 | $25.8 | $0.193 | $11.5 | $0.086 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 8 | $0.9 | $0.118 | $0.0 | $0.006 |
| | Ground 1-3 MW | 37 | 85 | $11.6 | $0.136 | $2.6 | $0.031 |
| | Ground 3-5 MW | 69 | 159 | $21.6 | $0.136 | $4.8 | $0.030 |
| | Ground 5-10 MW | 198 | 443 | $53.8 | $0.121 | $6.7 | $0.015 |
| | Ground 10-20 MW | 288 | 633 | $69.4 | $0.110 | ($0.4) | ($0.001) |
| Kings | Residential Roof | 12 | 22 | $4.5 | $0.205 | $2.0 | $0.093 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $0.7 | $0.147 | $0.2 | $0.040 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 21 | 47 | $6.6 | $0.141 | $1.7 | $0.036 |
| | Ground 5-10 MW | 27 | 59 | $8.3 | $0.141 | $1.9 | $0.032 |
| | Ground 10-20 MW | 30 | 66 | $7.2 | $0.109 | ($0.1) | ($0.002) |
| Lake | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.2 | $0.157 | $0.1 | $0.043 |
| | Ground 1-3 MW | 18 | 38 | $5.7 | $0.149 | $1.2 | $0.032 |
| | Ground 3-5 MW | 14 | 31 | $4.4 | $0.143 | $0.9 | $0.030 |
| | Ground 5-10 MW | 8 | 17 | $2.4 | $0.140 | $0.2 | $0.013 |
| | Ground 10-20 MW | | | | | | |
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 1,683 | 3,024 | $572.2 | $0.189 | $247.9 | $0.082 |
| | Commercial Roof | 788 | 1,333 | $232.3 | $0.174 | $84.6 | $0.063 |
| | Ground <= 1 MW | 2 | 6 | $0.7 | $0.120 | $0.1 | $0.014 |
| | Ground 1-3 MW | 9 | 21 | $2.7 | $0.129 | $0.4 | $0.019 |
| | Ground 3-5 MW | 13 | 33 | $3.9 | $0.121 | $0.8 | $0.026 |
| | Ground 5-10 MW | 16 | 38 | $4.4 | $0.114 | ($0.1) | ($0.002) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 295 | 684 | $77.6 | $0.114 | ($5.4) | ($0.008) |
| Madera | Residential Roof | 6 | 10 | $2.0 | $0.205 | $1.0 | $0.098 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.150 | $0.1 | $0.035 |
| | Ground 1-3 MW | 12 | 27 | $3.9 | $0.144 | $0.9 | $0.034 |
| | Ground 3-5 MW | 15 | 34 | $4.7 | $0.141 | $0.9 | $0.026 |
| | Ground 5-10 MW | 26 | 59 | $7.3 | $0.125 | $0.4 | $0.007 |
| | Ground 10-20 MW | 40 | 86 | $12.0 | $0.141 | $3.0 | $0.035 |
| Marin | Residential Roof | 14 | 24 | $5.0 | $0.213 | $2.4 | $0.101 |
| | Commercial Roof | 6 | 9 | $1.8 | $0.212 | $0.9 | $0.103 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.157 | $0.0 | $0.038 |
| | Ground 1-3 MW | 11 | 24 | $3.6 | $0.152 | $0.9 | $0.038 |
| | Ground 3-5 MW | 14 | 30 | $4.3 | $0.145 | $1.0 | $0.035 |
| | Ground 5-10 MW | 34 | 71 | $10.1 | $0.142 | $1.8 | $0.026 |
| | Ground 10-20 MW | 14 | 30 | $4.2 | $0.141 | $1.1 | $0.037 |
| Mariposa | Residential Roof | 1 | 1 | $0.2 | $0.204 | $0.1 | $0.076 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $0.6 | $0.143 | $0.2 | $0.036 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 18 | 39 | $5.5 | $0.141 | $0.8 | $0.019 |
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 1 | 2 | $0.4 | $0.204 | $0.2 | $0.095 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.171 | $0.2 | $0.056 |
| | Ground 1-3 MW | 9 | 19 | $2.9 | $0.154 | $0.8 | $0.041 |
| | Ground 3-5 MW | 7 | 14 | $2.2 | $0.159 | $0.6 | $0.046 |
| | Ground 5-10 MW | 15 | 30 | $4.4 | $0.143 | $0.8 | $0.027 |
| | Ground 10-20 MW | | | | | | |
| Merced | Residential Roof | 13 | 23 | $4.7 | $0.204 | $2.2 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 8 | 18 | $2.6 | $0.146 | $0.6 | $0.037 |
| | Ground 3-5 MW | 29 | 63 | $8.9 | $0.141 | $1.9 | $0.031 |
| | Ground 5-10 MW | 12 | 26 | $3.7 | $0.140 | $0.7 | $0.028 |
| | Ground 10-20 MW | 108 | 233 | $32.7 | $0.141 | $4.5 | $0.019 |
| Mono | Residential Roof | 11 | 20 | $3.8 | $0.189 | $1.8 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.5 | $0.137 | $0.1 | $0.035 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 20 | 34 | $7.2 | $0.208 | $3.3 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 27 | 60 | $8.7 | $0.146 | $2.0 | $0.033 |
| | Ground 3-5 MW | 15 | 34 | $4.6 | $0.134 | $0.4 | $0.012 |
| | Ground 5-10 MW | 82 | 174 | $22.8 | $0.131 | $3.0 | $0.017 |
| | Ground 10-20 MW | 46 | 96 | $13.6 | $0.142 | $2.3 | $0.024 |
| Napa | Residential Roof | 32 | 55 | $11.3 | $0.205 | $4.5 | $0.082 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 14 | $2.1 | $0.152 | $0.5 | $0.039 |
| | Ground 3-5 MW | 8 | 17 | $2.5 | $0.146 | $0.7 | $0.040 |
| | Ground 5-10 MW | 5 | 11 | $1.5 | $0.141 | $0.4 | $0.036 |
| | Ground 10-20 MW | 138 | 287 | $40.5 | $0.141 | $3.8 | $0.013 |
| Nevada | Residential Roof | 2 | 3 | $0.5 | $0.171 | $0.1 | $0.045 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 12 | $1.8 | $0.150 | $0.3 | $0.029 |
| | Ground 3-5 MW | 8 | 18 | $2.5 | $0.142 | $0.5 | $0.030 |
| | Ground 5-10 MW | 30 | 63 | $8.9 | $0.141 | $1.7 | $0.028 |
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 696 | 1,248 | $236.6 | $0.190 | $70.7 | $0.057 |
| | Commercial Roof | 640 | 1,090 | $211.5 | $0.194 | $63.1 | $0.058 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.148 | ($0.0) | ($0.026) |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 13 | 28 | $4.0 | $0.142 | $0.8 | $0.028 |
| | Ground 10-20 MW | 28 | 62 | $8.6 | $0.138 | $2.4 | $0.038 |
| Placer | Residential Roof | 1 | 1 | $0.2 | $0.204 | $0.1 | $0.080 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.2 | $0.150 | $0.0 | $0.044 |
| | Ground 1-3 MW | 12 | 26 | $3.9 | $0.149 | $1.0 | $0.038 |
| | Ground 3-5 MW | 6 | 13 | $1.9 | $0.143 | $0.4 | $0.031 |
| | Ground 5-10 MW | 37 | 79 | $11.2 | $0.141 | $2.1 | $0.027 |
| | Ground 10-20 MW | 169 | 356 | $50.2 | $0.141 | $8.7 | $0.025 |
| Plumas | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 16 | $2.2 | $0.142 | $0.4 | $0.025 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 115 | 212 | $38.4 | $0.181 | $15.4 | $0.072 |
| | Commercial Roof | 43 | 73 | $13.5 | $0.186 | $6.2 | $0.086 |
| | Ground <= 1 MW | 8 | 20 | $2.8 | $0.140 | $0.5 | $0.027 |
| | Ground 1-3 MW | 23 | 57 | $7.0 | $0.124 | $0.4 | $0.008 |
| | Ground 3-5 MW | 8 | 18 | $2.0 | $0.111 | ($0.0) | ($0.001) |
| | Ground 5-10 MW | 77 | 178 | $20.1 | $0.113 | $0.2 | $0.001 |
| | Ground 10-20 MW | 471 | 1,090 | $126.6 | $0.116 | $3.2 | $0.003 |
| Sacramento | Residential Roof | 1 | 2 | $0.4 | $0.205 | $0.2 | $0.077 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.2 | $0.140 | $0.3 | $0.033 |
| | Ground 5-10 MW | 7 | 15 | $2.1 | $0.139 | $0.3 | $0.020 |
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 427 | 783 | $142.9 | $0.183 | $59.5 | $0.076 |
| | Commercial Roof | 203 | 340 | $63.8 | $0.188 | $27.0 | $0.079 |
| | Ground <= 1 MW | 8 | 20 | $2.4 | $0.119 | $0.4 | $0.019 |
| | Ground 1-3 MW | 13 | 33 | $4.0 | $0.123 | $0.7 | $0.020 |
| | Ground 3-5 MW | 12 | 29 | $3.5 | $0.124 | $0.5 | $0.019 |
| | Ground 5-10 MW | 50 | 116 | $13.0 | $0.112 | $0.8 | $0.007 |
| | Ground 10-20 MW | 224 | 527 | $59.2 | $0.112 | $4.1 | $0.008 |
| San Diego | Residential Roof | 847 | 1,518 | $280.4 | $0.185 | $126.3 | $0.083 |
| | Commercial Roof | 142 | 239 | $45.8 | $0.192 | $21.3 | $0.089 |
| | Ground <= 1 MW | 5 | 11 | $1.5 | $0.137 | $0.4 | $0.038 |
| | Ground 1-3 MW | 7 | 16 | $2.1 | $0.132 | $0.5 | $0.034 |
| | Ground 3-5 MW | 17 | 37 | $5.2 | $0.140 | $1.5 | $0.040 |
| | Ground 5-10 MW | 56 | 124 | $14.7 | $0.119 | $1.7 | $0.014 |
| | Ground 10-20 MW | 223 | 487 | $55.9 | $0.115 | $6.8 | $0.014 |
| San Francisco | Residential Roof | 71 | 122 | $25.0 | $0.206 | $11.2 | $0.093 |
| | Commercial Roof | 11 | 18 | $3.7 | $0.201 | $1.6 | $0.086 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 84 | 148 | $30.3 | $0.205 | $13.9 | $0.094 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.1 | $0.155 | $0.0 | $0.039 |
| | Ground 1-3 MW | 8 | 17 | $2.5 | $0.147 | $0.6 | $0.033 |
| | Ground 3-5 MW | 25 | 53 | $7.6 | $0.142 | $1.8 | $0.034 |
| | Ground 5-10 MW | 130 | 281 | $39.5 | $0.141 | $7.7 | $0.027 |
| | Ground 10-20 MW | 141 | 301 | $42.3 | $0.141 | $7.5 | $0.025 |
| San Luis Obispo | Residential Roof | 11 | 20 | $4.0 | $0.200 | $1.9 | $0.093 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $0.7 | $0.144 | $0.2 | $0.032 |
| | Ground 1-3 MW | 9 | 22 | $3.1 | $0.142 | $0.7 | $0.034 |
| | Ground 3-5 MW | 12 | 27 | $3.0 | $0.110 | ($0.1) | ($0.004) |
| | Ground 5-10 MW | 20 | 46 | $5.2 | $0.112 | ($0.1) | ($0.001) |
| | Ground 10-20 MW | 14 | 32 | $3.6 | $0.110 | ($0.1) | ($0.002) |
| San Mateo | Residential Roof | 220 | 367 | $78.5 | $0.214 | $37.3 | $0.102 |
| | Commercial Roof | 104 | 162 | $34.0 | $0.209 | $15.8 | $0.097 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 102 | 183 | $30.3 | $0.165 | $10.9 | $0.060 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.150 | $0.1 | $0.045 |
| | Ground 1-3 MW | 19 | 44 | $6.2 | $0.140 | $1.3 | $0.030 |
| | Ground 3-5 MW | 3 | 8 | $0.9 | $0.111 | $0.0 | $0.004 |
| | Ground 5-10 MW | 34 | 78 | $8.7 | $0.111 | $0.1 | $0.002 |
| | Ground 10-20 MW | 26 | 59 | $6.8 | $0.115 | $0.6 | $0.011 |
| Santa Clara | Residential Roof | 719 | 1,279 | $260.6 | $0.204 | $116.6 | $0.091 |
| | Commercial Roof | 213 | 357 | $70.9 | $0.198 | $31.0 | $0.087 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.144 | $0.3 | $0.032 |
| | Ground 5-10 MW | 38 | 83 | $11.7 | $0.141 | $2.5 | $0.030 |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 3 | 5 | $1.0 | $0.202 | $0.4 | $0.086 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.1 | $0.153 | $0.0 | $0.038 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 7 | 16 | $2.3 | $0.145 | $0.5 | $0.031 |
| | Ground 5-10 MW | 24 | 51 | $7.1 | $0.139 | $1.7 | $0.034 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 30 | 63 | $8.8 | $0.139 | $2.1 | $0.032 |
| Shasta | Residential Roof | 3 | 5 | $1.1 | $0.213 | $0.5 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $0.5 | $0.152 | $0.1 | $0.039 |
| | Ground 1-3 MW | 7 | 14 | $2.2 | $0.153 | $0.5 | $0.035 |
| | Ground 3-5 MW | 12 | 24 | $3.6 | $0.148 | $0.9 | $0.039 |
| | Ground 5-10 MW | 8 | 16 | $2.3 | $0.144 | $0.3 | $0.017 |
| | Ground 10-20 MW | 47 | 97 | $13.9 | $0.143 | $2.2 | $0.023 |
| Sierra | Residential Roof | 1 | 1 | $0.3 | $0.204 | $0.1 | $0.092 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 98 | 171 | $35.0 | $0.205 | $15.5 | $0.091 |
| | Commercial Roof | 0 | 1 | $0.2 | $0.201 | $0.1 | $0.086 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.156 | $0.0 | $0.051 |
| | Ground 1-3 MW | 9 | 20 | $3.0 | $0.152 | $0.8 | $0.039 |
| | Ground 3-5 MW | 12 | 26 | $3.7 | $0.145 | $0.9 | $0.035 |
| | Ground 5-10 MW | 54 | 116 | $16.1 | $0.139 | $3.7 | $0.032 |
| | Ground 10-20 MW | 38 | 82 | $11.4 | $0.139 | $2.4 | $0.029 |
| Sonoma | Residential Roof | 57 | 96 | $20.1 | $0.208 | $9.4 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.7 | $0.170 | $0.2 | $0.056 |
| | Ground 1-3 MW | 11 | 23 | $3.5 | $0.155 | $1.0 | $0.042 |
| | Ground 3-5 MW | 24 | 50 | $7.3 | $0.148 | $1.6 | $0.032 |
| | Ground 5-10 MW | 82 | 169 | $24.3 | $0.143 | $5.0 | $0.029 |
| | Ground 10-20 MW | 63 | 129 | $18.4 | $0.143 | $4.2 | $0.032 |
| Stanislaus | Residential Roof | 1 | 2 | $0.4 | $0.203 | $0.1 | $0.064 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 3 | $0.5 | $0.146 | $0.1 | $0.039 |
| | Ground 3-5 MW | 8 | 17 | $2.5 | $0.142 | $0.5 | $0.028 |
| | Ground 5-10 MW | 21 | 46 | $6.5 | $0.141 | $0.8 | $0.016 |
| | Ground 10-20 MW | 72 | 154 | $21.9 | $0.142 | $3.1 | $0.020 |
| Sutter | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 4 | 8 | $1.3 | $0.151 | $0.4 | $0.042 |
| | Ground 3-5 MW | 13 | 27 | $3.8 | $0.143 | $0.6 | $0.021 |
| | Ground 5-10 MW | 50 | 106 | $15.0 | $0.141 | $1.9 | $0.018 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 23 | 48 | $6.7 | $0.141 | $0.6 | $0.013 |
| Tehama | Residential Roof | 1 | 1 | $0.2 | $0.208 | $0.1 | $0.088 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 11 | 24 | $3.6 | $0.151 | $0.9 | $0.037 |
| | Ground 3-5 MW | 13 | 29 | $4.1 | $0.144 | $1.0 | $0.034 |
| | Ground 5-10 MW | 15 | 31 | $4.5 | $0.142 | $0.9 | $0.029 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.3 | $0.202 | $0.1 | $0.081 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 35 | 63 | $12.9 | $0.205 | $5.3 | $0.085 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.150 | $0.2 | $0.046 |
| | Ground 1-3 MW | 24 | 55 | $7.8 | $0.142 | $1.2 | $0.021 |
| | Ground 3-5 MW | 15 | 33 | $4.6 | $0.140 | $0.8 | $0.025 |
| | Ground 5-10 MW | 54 | 119 | $16.7 | $0.140 | $2.6 | $0.022 |
| | Ground 10-20 MW | 98 | 215 | $28.4 | $0.132 | $4.4 | $0.020 |
| Tuolumne | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $0.7 | $0.145 | $0.2 | $0.038 |
| | Ground 3-5 MW | 3 | 7 | $1.0 | $0.142 | $0.3 | $0.037 |
| | Ground 5-10 MW | 16 | 34 | $4.9 | $0.142 | $1.1 | $0.031 |
| | Ground 10-20 MW | 11 | 24 | $3.4 | $0.138 | $0.9 | $0.036 |
| Ventura | Residential Roof | 199 | 357 | $64.4 | $0.180 | $23.0 | $0.064 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.156 | $0.1 | $0.056 |
| | Ground 1-3 MW | 6 | 12 | $1.8 | $0.149 | $0.6 | $0.050 |
| | Ground 3-5 MW | 8 | 18 | $1.9 | $0.109 | ($0.3) | ($0.017) |
| | Ground 5-10 MW | 24 | 55 | $6.0 | $0.110 | ($1.0) | ($0.018) |
| | Ground 10-20 MW | 190 | 412 | $51.5 | $0.125 | $2.5 | $0.006 |
| Yolo | Residential Roof | 7 | 11 | $2.3 | $0.204 | $1.0 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $0.7 | $0.149 | $0.2 | $0.037 |
| | Ground 3-5 MW | 30 | 65 | $9.2 | $0.142 | $1.8 | $0.028 |
| | Ground 5-10 MW | 29 | 61 | $8.6 | $0.141 | $1.5 | $0.024 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 88 | 187 | $26.2 | $0.140 | $5.0 | $0.027 |
| Yuba | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $0.5 | $0.157 | $0.1 | $0.049 |
| | Ground 1-3 MW | 5 | 10 | $1.6 | $0.150 | $0.4 | $0.041 |
| | Ground 3-5 MW | 7 | 15 | $2.2 | $0.142 | $0.4 | $0.026 |
| | Ground 5-10 MW | 23 | 49 | $6.9 | $0.141 | $1.4 | $0.029 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 15,336 | 29,695 | 4847 | 0.16 | 1489 | 0.05 |

**80% Learning Curve Results By County (cont.)**

## Least Net Cost Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 122 | 212 | $43.0 | $0.203 | $19.2 | $0.091 |
| | Commercial Roof | 298 | 492 | $97.4 | $0.198 | $42.6 | $0.087 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.155 | $0.0 | $0.040 |
| | Ground 1-3 MW | 2 | 5 | $0.7 | $0.147 | $0.2 | $0.036 |
| | Ground 3-5 MW | 20 | 44 | $6.4 | $0.143 | $1.4 | $0.032 |
| | Ground 5-10 MW | 53 | 115 | $16.3 | $0.142 | $3.4 | $0.030 |
| | Ground 10-20 MW | 39 | 83 | $10.3 | $0.124 | $0.7 | $0.008 |
| Amador | Residential Roof | 4 | 7 | $1.5 | $0.205 | $0.7 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 9 | 19 | $2.7 | $0.144 | $0.6 | $0.033 |
| | Ground 5-10 MW | 11 | 24 | $3.3 | $0.141 | $0.7 | $0.031 |
| | Ground 10-20 MW | 11 | 22 | $2.6 | $0.117 | ($0.2) | ($0.007) |
| Butte | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.157 | $0.1 | $0.046 |
| | Ground 1-3 MW | 5 | 10 | $1.6 | $0.151 | $0.4 | $0.038 |
| | Ground 3-5 MW | 28 | 60 | $8.8 | $0.147 | $1.9 | $0.032 |
| | Ground 5-10 MW | 77 | 162 | $22.9 | $0.142 | $4.5 | $0.028 |
| | Ground 10-20 MW | 79 | 162 | $21.8 | $0.134 | $2.7 | $0.017 |
| Calaveras | Residential Roof | 1 | 1 | $0.2 | $0.174 | $0.1 | $0.050 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.152 | $0.1 | $0.040 |
| | Ground 1-3 MW | 7 | 15 | $2.3 | $0.147 | $0.5 | $0.033 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.140 | $0.3 | $0.034 |
| | Ground 5-10 MW | 7 | 14 | $2.0 | $0.139 | $0.5 | $0.033 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 13 | $1.9 | $0.151 | $0.5 | $0.040 |
| | Ground 3-5 MW | 11 | 23 | $3.3 | $0.143 | $0.8 | $0.036 |
| | Ground 5-10 MW | 25 | 53 | $7.7 | $0.145 | $1.7 | $0.031 |
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 437 | 745 | $140.8 | $0.189 | $51.5 | $0.069 |
| | Commercial Roof | 111 | 178 | $34.3 | $0.192 | $12.7 | $0.071 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 8 | 18 | $2.3 | $0.132 | $0.2 | $0.011 |
| | Ground 5-10 MW | 6 | 13 | $1.8 | $0.139 | $0.4 | $0.033 |
| | Ground 10-20 MW | 117 | 252 | $34.8 | $0.138 | $7.8 | $0.031 |
| El Dorado | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.155 | $0.1 | $0.037 |
| | Ground 1-3 MW | 5 | 11 | $1.7 | $0.149 | $0.4 | $0.033 |
| | Ground 3-5 MW | 6 | 13 | $1.9 | $0.146 | $0.4 | $0.030 |
| | Ground 5-10 MW | 31 | 66 | $8.9 | $0.136 | $1.3 | $0.019 |
| | Ground 10-20 MW | 51 | 106 | $12.8 | $0.121 | $0.0 | $0.000 |
| Fresno | Residential Roof | 272 | 478 | $90.9 | $0.190 | $36.4 | $0.076 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 10 | 23 | $3.3 | $0.145 | $0.8 | $0.035 |
| | Ground 3-5 MW | 22 | 50 | $6.9 | $0.140 | $1.5 | $0.031 |
| | Ground 5-10 MW | 138 | 305 | $40.6 | $0.133 | $7.6 | $0.025 |
| | Ground 10-20 MW | 418 | 909 | $116.6 | $0.128 | $13.5 | $0.015 |
| Glenn | Residential Roof | 10 | 16 | $2.8 | $0.174 | $0.9 | $0.055 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 9 | 18 | $2.8 | $0.150 | $0.3 | $0.017 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 18 | $2.1 | $0.118 | ($0.1) | ($0.006) |
| | Ground 10-20 MW | | | | | | |
| Humboldt | Residential Roof | 11 | 18 | $4.1 | $0.224 | $1.9 | $0.105 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 5 | $0.9 | $0.191 | $0.3 | $0.074 |
| | Ground 1-3 MW | 16 | 26 | $5.1 | $0.194 | $2.1 | $0.079 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 10 | 17 | $3.1 | $0.186 | $1.3 | $0.077 |
| | Ground 5-10 MW | 19 | 31 | $5.7 | $0.180 | $2.1 | $0.066 |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.131 | $0.0 | $0.030 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 12 | $1.5 | $0.126 | $0.3 | $0.029 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 73 | 135 | $25.3 | $0.188 | $10.9 | $0.081 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 8 | $0.9 | $0.118 | $0.0 | $0.006 |
| | Ground 1-3 MW | 37 | 86 | $11.8 | $0.137 | $2.7 | $0.031 |
| | Ground 3-5 MW | 69 | 161 | $21.4 | $0.133 | $4.4 | $0.027 |
| | Ground 5-10 MW | 198 | 450 | $59.0 | $0.131 | $11.4 | $0.025 |
| | Ground 10-20 MW | 288 | 641 | $80.0 | $0.125 | $9.5 | $0.015 |
| Kings | Residential Roof | 12 | 22 | $3.8 | $0.175 | $1.4 | $0.062 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $0.7 | $0.147 | $0.2 | $0.040 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 21 | 47 | $6.5 | $0.138 | $1.5 | $0.033 |
| | Ground 5-10 MW | 27 | 59 | $8.2 | $0.139 | $1.7 | $0.030 |
| | Ground 10-20 MW | 30 | 66 | $8.4 | $0.127 | $1.1 | $0.017 |
| Lake | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.2 | $0.157 | $0.1 | $0.043 |
| | Ground 1-3 MW | 18 | 38 | $5.7 | $0.150 | $1.3 | $0.035 |
| | Ground 3-5 MW | 14 | 31 | $4.2 | $0.136 | $0.7 | $0.023 |
| | Ground 5-10 MW | 8 | 17 | $2.0 | $0.121 | ($0.1) | ($0.007) |
| | Ground 10-20 MW | | | | | | |
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 1,683 | 3,053 | $592.3 | $0.194 | $266.2 | $0.087 |
| | Commercial Roof | 788 | 1,345 | $252.6 | $0.188 | $104.4 | $0.078 |
| | Ground <= 1 MW | 2 | 6 | $0.8 | $0.135 | $0.2 | $0.029 |
| | Ground 1-3 MW | 9 | 21 | $2.8 | $0.132 | $0.5 | $0.024 |
| | Ground 3-5 MW | 13 | 34 | $4.0 | $0.115 | $0.6 | $0.017 |
| | Ground 5-10 MW | 16 | 38 | $4.3 | $0.113 | ($0.1) | ($0.003) |
| | Ground 10-20 MW | 295 | 688 | $79.8 | $0.116 | ($3.5) | ($0.005) |
| Madera | Residential Roof | 6 | 10 | $2.0 | $0.205 | $1.0 | $0.098 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.150 | $0.1 | $0.035 |
| | Ground 1-3 MW | 12 | 27 | $3.9 | $0.145 | $0.9 | $0.035 |
| | Ground 3-5 MW | 15 | 33 | $4.8 | $0.146 | $1.0 | $0.031 |
| | Ground 5-10 MW | 26 | 58 | $7.0 | $0.120 | $0.1 | $0.002 |
| | Ground 10-20 MW | 40 | 86 | $11.8 | $0.137 | $2.7 | $0.032 |
| Marin | Residential Roof | 14 | 23 | $5.1 | $0.218 | $2.5 | $0.106 |
| | Commercial Roof | 6 | 9 | $1.9 | $0.213 | $0.9 | $0.104 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.157 | $0.0 | $0.038 |
| | Ground 1-3 MW | 11 | 24 | $3.6 | $0.152 | $0.9 | $0.038 |
| | Ground 3-5 MW | 14 | 30 | $4.3 | $0.146 | $1.1 | $0.036 |
| | Ground 5-10 MW | 34 | 70 | $10.3 | $0.147 | $2.2 | $0.031 |
| | Ground 10-20 MW | 14 | 30 | $4.1 | $0.138 | $1.0 | $0.033 |
| Mariposa | Residential Roof | 1 | 1 | $0.2 | $0.189 | $0.1 | $0.061 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $0.6 | $0.143 | $0.2 | $0.036 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 18 | 38 | $4.4 | $0.115 | ($0.3) | ($0.007) |
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 1 | 2 | $0.4 | $0.204 | $0.2 | $0.095 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.171 | $0.2 | $0.056 |
| | Ground 1-3 MW | 9 | 19 | $2.9 | $0.154 | $0.8 | $0.041 |
| | Ground 3-5 MW | 7 | 14 | $2.2 | $0.159 | $0.6 | $0.046 |
| | Ground 5-10 MW | 15 | 30 | $4.4 | $0.145 | $0.9 | $0.030 |
| | Ground 10-20 MW | | | | | | |
| Merced | Residential Roof | 13 | 23 | $4.7 | $0.205 | $2.2 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 8 | 18 | $2.6 | $0.146 | $0.6 | $0.037 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 29 | 63 | $8.9 | $0.142 | $1.9 | $0.031 |
| | Ground 5-10 MW | 12 | 26 | $3.7 | $0.140 | $0.7 | $0.028 |
| | Ground 10-20 MW | 108 | 228 | $26.2 | $0.115 | ($1.6) | ($0.007) |
| Mono | Residential Roof | 11 | 21 | $4.1 | $0.196 | $2.0 | $0.094 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.140 | $0.2 | $0.038 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 20 | 34 | $7.2 | $0.208 | $3.3 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 27 | 59 | $8.6 | $0.145 | $1.9 | $0.032 |
| | Ground 3-5 MW | 15 | 34 | $4.5 | $0.133 | $0.4 | $0.012 |
| | Ground 5-10 MW | 82 | 174 | $23.6 | $0.135 | $3.8 | $0.022 |
| | Ground 10-20 MW | 46 | 95 | $13.1 | $0.139 | $1.9 | $0.020 |
| Napa | Residential Roof | 32 | 53 | $9.4 | $0.178 | $2.9 | $0.054 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 14 | $2.1 | $0.152 | $0.5 | $0.039 |
| | Ground 3-5 MW | 8 | 17 | $2.5 | $0.146 | $0.7 | $0.040 |
| | Ground 5-10 MW | 5 | 11 | $1.5 | $0.141 | $0.4 | $0.036 |
| | Ground 10-20 MW | 138 | 276 | $40.8 | $0.148 | $5.5 | $0.020 |
| Nevada | Residential Roof | 2 | 3 | $0.5 | $0.197 | $0.2 | $0.074 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 12 | $1.8 | $0.153 | $0.4 | $0.033 |
| | Ground 3-5 MW | 8 | 18 | $2.5 | $0.145 | $0.6 | $0.034 |
| | Ground 5-10 MW | 30 | 63 | $8.5 | $0.136 | $1.4 | $0.022 |
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 714 | 1,253 | $241.0 | $0.192 | $73.5 | $0.059 |
| | Commercial Roof | 621 | 1,036 | $193.8 | $0.187 | $57.3 | $0.055 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.156 | ($0.0) | ($0.015) |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 13 | 28 | $3.5 | $0.123 | $0.3 | $0.010 |
| | Ground 10-20 MW | 28 | 63 | $8.3 | $0.131 | $2.0 | $0.032 |
| Placer | Residential Roof | 1 | 1 | $0.2 | $0.174 | $0.0 | $0.049 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.2 | $0.150 | $0.0 | $0.044 |
| | Ground 1-3 MW | 12 | 26 | $3.9 | $0.150 | $1.0 | $0.039 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 6 | 13 | $1.9 | $0.143 | $0.4 | $0.031 |
| | Ground 5-10 MW | 37 | 78 | $10.3 | $0.131 | $1.3 | $0.017 |
| | Ground 10-20 MW | 169 | 352 | $46.7 | $0.133 | $5.8 | $0.016 |
| Plumas | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 15 | $2.0 | $0.128 | $0.2 | $0.011 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 115 | 216 | $39.5 | $0.183 | $15.9 | $0.073 |
| | Commercial Roof | 43 | 76 | $14.5 | $0.190 | $6.7 | $0.087 |
| | Ground <= 1 MW | 8 | 20 | $2.7 | $0.138 | $0.5 | $0.025 |
| | Ground 1-3 MW | 23 | 56 | $7.3 | $0.130 | $0.8 | $0.015 |
| | Ground 3-5 MW | 8 | 18 | $2.3 | $0.124 | $0.2 | $0.013 |
| | Ground 5-10 MW | 77 | 180 | $21.9 | $0.122 | $1.8 | $0.010 |
| | Ground 10-20 MW | 471 | 1,103 | $126.9 | $0.115 | $1.5 | $0.001 |
| Sacramento | Residential Roof | 1 | 2 | $0.3 | $0.184 | $0.1 | $0.055 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.2 | $0.140 | $0.3 | $0.033 |
| | Ground 5-10 MW | 7 | 15 | $1.7 | $0.113 | ($0.1) | ($0.007) |
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 427 | 796 | $133.7 | $0.168 | $47.6 | $0.060 |
| | Commercial Roof | 203 | 352 | $58.9 | $0.167 | $19.6 | $0.056 |
| | Ground <= 1 MW | 8 | 21 | $2.6 | $0.128 | $0.5 | $0.027 |
| | Ground 1-3 MW | 13 | 34 | $4.1 | $0.121 | $0.6 | $0.017 |
| | Ground 3-5 MW | 12 | 29 | $3.7 | $0.126 | $0.6 | $0.020 |
| | Ground 5-10 MW | 50 | 119 | $13.7 | $0.115 | $1.1 | $0.010 |
| | Ground 10-20 MW | 224 | 540 | $62.2 | $0.115 | $5.0 | $0.009 |
| San Diego | Residential Roof | 847 | 1,552 | $306.8 | $0.198 | $149.2 | $0.096 |
| | Commercial Roof | 142 | 245 | $47.4 | $0.194 | $22.2 | $0.091 |
| | Ground <= 1 MW | 5 | 11 | $1.5 | $0.139 | $0.5 | $0.041 |
| | Ground 1-3 MW | 7 | 16 | $2.1 | $0.133 | $0.6 | $0.035 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 17 | 38 | $5.1 | $0.134 | $1.3 | $0.033 |
| | Ground 5-10 MW | 56 | 126 | $16.5 | $0.131 | $3.4 | $0.027 |
| | Ground 10-20 MW | 223 | 500 | $65.9 | $0.132 | $15.6 | $0.031 |
| San Francisco | Residential Roof | 71 | 121 | $25.3 | $0.210 | $11.7 | $0.097 |
| | Commercial Roof | 11 | 18 | $3.7 | $0.206 | $1.6 | $0.091 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 84 | 147 | $29.9 | $0.203 | $13.5 | $0.092 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.1 | $0.155 | $0.0 | $0.039 |
| | Ground 1-3 MW | 8 | 17 | $2.5 | $0.148 | $0.6 | $0.035 |
| | Ground 3-5 MW | 25 | 53 | $7.6 | $0.142 | $1.8 | $0.034 |
| | Ground 5-10 MW | 130 | 279 | $39.7 | $0.142 | $8.0 | $0.029 |
| | Ground 10-20 MW | 141 | 297 | $39.1 | $0.131 | $4.7 | $0.016 |
| San Luis Obispo | Residential Roof | 11 | 20 | $4.1 | $0.204 | $1.9 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $0.7 | $0.146 | $0.2 | $0.034 |
| | Ground 1-3 MW | 9 | 22 | $3.0 | $0.138 | $0.7 | $0.030 |
| | Ground 3-5 MW | 12 | 27 | $3.2 | $0.116 | $0.1 | $0.003 |
| | Ground 5-10 MW | 20 | 47 | $5.0 | $0.108 | ($0.3) | ($0.006) |
| | Ground 10-20 MW | 14 | 32 | $3.6 | $0.110 | ($0.1) | ($0.002) |
| San Mateo | Residential Roof | 220 | 364 | $76.4 | $0.210 | $35.5 | $0.097 |
| | Commercial Roof | 91 | 142 | $29.1 | $0.205 | $13.1 | $0.092 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 102 | 188 | $38.0 | $0.202 | $18.3 | $0.098 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.150 | $0.1 | $0.045 |
| | Ground 1-3 MW | 19 | 44 | $6.2 | $0.140 | $1.3 | $0.030 |
| | Ground 3-5 MW | 3 | 8 | $1.1 | $0.136 | $0.2 | $0.030 |
| | Ground 5-10 MW | 34 | 79 | $9.2 | $0.117 | $0.6 | $0.008 |
| | Ground 10-20 MW | 26 | 61 | $7.3 | $0.120 | $0.9 | $0.014 |
| Santa Clara | Residential Roof | 719 | 1,253 | $244.6 | $0.195 | $102.8 | $0.082 |
| | Commercial Roof | 213 | 354 | $68.3 | $0.193 | $28.6 | $0.081 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.144 | $0.3 | $0.032 |
| | Ground 5-10 MW | 38 | 83 | $11.7 | $0.141 | $2.5 | $0.030 |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 3 | 5 | $0.8 | $0.167 | $0.2 | $0.049 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.1 | $0.153 | $0.0 | $0.038 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 7 | 16 | $2.3 | $0.145 | $0.5 | $0.031 |
| | Ground 5-10 MW | 24 | 51 | $7.1 | $0.139 | $1.7 | $0.034 |
| | Ground 10-20 MW | 30 | 63 | $8.8 | $0.139 | $2.1 | $0.032 |
| Shasta | Residential Roof | 3 | 5 | $1.1 | $0.213 | $0.5 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $0.5 | $0.152 | $0.1 | $0.039 |
| | Ground 1-3 MW | 7 | 14 | $2.2 | $0.154 | $0.5 | $0.037 |
| | Ground 3-5 MW | 12 | 24 | $3.6 | $0.148 | $0.9 | $0.039 |
| | Ground 5-10 MW | 8 | 15 | $1.9 | $0.123 | ($0.1) | ($0.005) |
| | Ground 10-20 MW | 47 | 95 | $12.5 | $0.131 | $1.0 | $0.011 |
| Sierra | Residential Roof | 1 | 1 | $0.3 | $0.211 | $0.1 | $0.098 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 98 | 168 | $32.6 | $0.193 | $13.2 | $0.079 |
| | Commercial Roof | 0 | 1 | $0.2 | $0.207 | $0.1 | $0.091 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.156 | $0.0 | $0.051 |
| | Ground 1-3 MW | 9 | 20 | $3.0 | $0.152 | $0.8 | $0.039 |
| | Ground 3-5 MW | 12 | 26 | $3.7 | $0.145 | $0.9 | $0.035 |
| | Ground 5-10 MW | 54 | 116 | $16.1 | $0.139 | $3.7 | $0.032 |
| | Ground 10-20 MW | 38 | 82 | $10.7 | $0.131 | $1.7 | $0.020 |
| Sonoma | Residential Roof | 57 | 96 | $20.2 | $0.210 | $9.5 | $0.099 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.7 | $0.170 | $0.2 | $0.056 |
| | Ground 1-3 MW | 11 | 23 | $3.5 | $0.155 | $1.0 | $0.042 |
| | Ground 3-5 MW | 24 | 49 | $7.2 | $0.147 | $1.6 | $0.032 |
| | Ground 5-10 MW | 82 | 168 | $24.5 | $0.146 | $5.4 | $0.032 |
| | Ground 10-20 MW | 63 | 129 | $17.5 | $0.136 | $3.2 | $0.025 |
| Stanislaus | Residential Roof | 1 | 2 | $0.4 | $0.209 | $0.1 | $0.072 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 3 | $0.5 | $0.146 | $0.1 | $0.039 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 8 | 17 | $2.5 | $0.144 | $0.5 | $0.029 |
| | Ground 5-10 MW | 21 | 45 | $5.9 | $0.130 | $0.2 | $0.005 |
| | Ground 10-20 MW | 72 | 151 | $17.5 | $0.116 | ($1.0) | ($0.007) |
| Sutter | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 4 | 8 | $1.3 | $0.151 | $0.4 | $0.042 |
| | Ground 3-5 MW | 13 | 26 | $3.7 | $0.141 | $0.5 | $0.020 |
| | Ground 5-10 MW | 50 | 103 | $12.7 | $0.124 | ($0.1) | ($0.001) |
| | Ground 10-20 MW | 23 | 46 | $5.7 | $0.125 | ($0.2) | ($0.004) |
| Tehama | Residential Roof | 1 | 1 | $0.2 | $0.216 | $0.1 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 11 | 24 | $3.7 | $0.152 | $0.9 | $0.038 |
| | Ground 3-5 MW | 13 | 28 | $4.1 | $0.146 | $1.0 | $0.036 |
| | Ground 5-10 MW | 15 | 31 | $4.5 | $0.143 | $0.9 | $0.030 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.3 | $0.194 | $0.1 | $0.072 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 35 | 60 | $11.0 | $0.181 | $3.7 | $0.061 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.150 | $0.2 | $0.046 |
| | Ground 1-3 MW | 24 | 54 | $7.3 | $0.137 | $0.9 | $0.016 |
| | Ground 3-5 MW | 15 | 33 | $4.4 | $0.136 | $0.7 | $0.021 |
| | Ground 5-10 MW | 54 | 117 | $15.7 | $0.134 | $2.0 | $0.017 |
| | Ground 10-20 MW | 98 | 214 | $28.6 | $0.133 | $4.8 | $0.022 |
| Tuolumne | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $0.7 | $0.145 | $0.2 | $0.038 |
| | Ground 3-5 MW | 3 | 7 | $1.0 | $0.134 | $0.2 | $0.030 |
| | Ground 5-10 MW | 16 | 34 | $4.2 | $0.121 | $0.4 | $0.011 |
| | Ground 10-20 MW | 11 | 25 | $3.3 | $0.131 | $0.7 | $0.029 |
| Ventura | Residential Roof | 199 | 365 | $69.2 | $0.190 | $27.0 | $0.074 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.155 | $0.1 | $0.055 |
| | Ground 1-3 MW | 6 | 12 | $1.8 | $0.149 | $0.6 | $0.050 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 8 | 17 | $2.3 | $0.133 | $0.2 | $0.010 |
| | Ground 5-10 MW | 24 | 54 | $7.1 | $0.131 | $0.4 | $0.007 |
| | Ground 10-20 MW | 190 | 407 | $54.2 | $0.133 | $6.6 | $0.016 |
| Yolo | Residential Roof | 7 | 11 | $2.4 | $0.209 | $1.1 | $0.095 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $0.7 | $0.149 | $0.2 | $0.037 |
| | Ground 3-5 MW | 30 | 64 | $9.3 | $0.146 | $2.1 | $0.032 |
| | Ground 5-10 MW | 29 | 60 | $8.2 | $0.136 | $1.1 | $0.019 |
| | Ground 10-20 MW | 88 | 186 | $26.4 | $0.142 | $5.3 | $0.029 |
| Yuba | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $0.5 | $0.157 | $0.1 | $0.049 |
| | Ground 1-3 MW | 5 | 10 | $1.6 | $0.150 | $0.4 | $0.041 |
| | Ground 3-5 MW | 7 | 15 | $2.2 | $0.146 | $0.5 | $0.030 |
| | Ground 5-10 MW | 23 | 49 | $7.0 | $0.143 | $1.5 | $0.031 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 15,322 | 29,683 | 4841 | 0.16 | 1489 | 0.05 |

**80% Learning Curve Results By County (cont.)**

## High Rooftop Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 239 | 420 | $85.9 | $0.204 | $39.0 | $0.093 |
| | Commercial Roof | 323 | 538 | $106.2 | $0.198 | $46.0 | $0.085 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Amador | Residential Roof | 21 | 37 | $7.6 | $0.204 | $3.3 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 6 | $0.9 | $0.147 | $0.2 | $0.030 |
| | Ground 3-5 MW | 8 | 19 | $2.6 | $0.140 | $0.4 | $0.020 |
| | Ground 5-10 MW | 5 | 12 | $1.6 | $0.139 | $0.4 | $0.037 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Butte | Residential Roof | 174 | 300 | $61.6 | $0.205 | $27.1 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 5 | $0.8 | $0.150 | $0.2 | $0.042 |
| | Ground 3-5 MW | 14 | 29 | $4.2 | $0.144 | $0.9 | $0.032 |
| | Ground 5-10 MW | 14 | 29 | $4.1 | $0.140 | $0.7 | $0.025 |
| | Ground 10-20 MW | 19 | 41 | $5.6 | $0.139 | $0.4 | $0.011 |
| Calaveras | Residential Roof | 10 | 18 | $3.7 | $0.206 | $1.6 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.152 | $0.0 | $0.038 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.140 | $0.3 | $0.034 |
| | Ground 5-10 MW | 7 | 14 | $2.0 | $0.139 | $0.5 | $0.033 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | 23 | 40 | $8.1 | $0.204 | $3.5 | $0.088 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.2 | $0.157 | $0.1 | $0.051 |
| | Ground 1-3 MW | 4 | 8 | $1.2 | $0.150 | $0.3 | $0.042 |
| | Ground 3-5 MW | 8 | 18 | $2.5 | $0.143 | $0.5 | $0.030 |
| | Ground 5-10 MW | 11 | 23 | $3.2 | $0.140 | $0.7 | $0.032 |
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 507 | 891 | $182.2 | $0.204 | $77.5 | $0.087 |
| | Commercial Roof | 111 | 184 | $36.4 | $0.198 | $14.4 | $0.079 |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.154 | $0.1 | $0.047 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.2 | $0.143 | $0.2 | $0.027 |
| | Ground 5-10 MW | 6 | 13 | $1.8 | $0.139 | $0.4 | $0.033 |
| | Ground 10-20 MW | 63 | 135 | $19.0 | $0.141 | $4.7 | $0.035 |
| El Dorado | Residential Roof | 50 | 87 | $17.9 | $0.205 | $7.8 | $0.089 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 11 | $1.6 | $0.147 | $0.4 | $0.035 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 49 | 104 | $14.6 | $0.140 | $2.2 | $0.021 |
| Fresno | Residential Roof | 607 | 1,081 | $221.8 | $0.205 | $100.9 | $0.093 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.2 | $0.149 | $0.1 | $0.036 |
| | Ground 1-3 MW | 5 | 12 | $1.7 | $0.143 | $0.4 | $0.037 |
| | Ground 3-5 MW | 21 | 47 | $6.5 | $0.139 | $1.6 | $0.035 |
| | Ground 5-10 MW | 71 | 156 | $20.0 | $0.128 | $3.1 | $0.020 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 264 | 574 | $75.1 | $0.131 | $8.3 | $0.014 |
| Glenn | Residential Roof | 18 | 31 | $6.3 | $0.205 | $2.5 | $0.080 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.2 | $0.156 | ($0.1) | ($0.078) |
| | Ground 1-3 MW | 3 | 7 | $1.0 | $0.149 | $0.3 | $0.037 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 7 | 15 | $2.2 | $0.141 | $0.3 | $0.019 |
| | Ground 10-20 MW | | | | | | |
| Humboldt | Residential Roof | 37 | 53 | $13.0 | $0.244 | $6.8 | $0.128 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.4 | $0.181 | $0.1 | $0.056 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | 6 | 11 | $2.0 | $0.182 | $0.9 | $0.086 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.115 | $0.0 | $0.015 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 376 | 684 | $121.4 | $0.178 | $46.0 | $0.067 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.5 | $0.143 | $0.1 | $0.038 |
| | Ground 1-3 MW | 26 | 60 | $8.3 | $0.139 | $2.1 | $0.035 |
| | Ground 3-5 MW | 35 | 80 | $10.9 | $0.136 | $2.7 | $0.034 |
| | Ground 5-10 MW | 135 | 300 | $36.2 | $0.121 | $4.1 | $0.014 |
| | Ground 10-20 MW | 153 | 332 | $37.5 | $0.113 | $1.3 | $0.004 |
| Kings | Residential Roof | 79 | 142 | $29.3 | $0.206 | $13.5 | $0.095 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 6 | $0.8 | $0.141 | $0.2 | $0.032 |
| | Ground 3-5 MW | 12 | 27 | $3.7 | $0.140 | $1.0 | $0.037 |
| | Ground 5-10 MW | 11 | 24 | $3.0 | $0.126 | $0.5 | $0.023 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Lake | Residential Roof | 45 | 79 | $16.1 | $0.204 | $6.6 | $0.083 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.153 | $0.0 | $0.045 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.139 | $0.3 | $0.031 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 2,020 | 3,666 | $692.1 | $0.189 | $295.5 | $0.081 |
| | Commercial Roof | 817 | 1,390 | $250.8 | $0.180 | $97.2 | $0.070 |
| | Ground <= 1 MW | 2 | 4 | $0.5 | $0.126 | $0.1 | $0.026 |
| | Ground 1-3 MW | 4 | 9 | $1.2 | $0.133 | ($0.1) | ($0.014) |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 39 | 89 | $10.9 | $0.123 | ($3.1) | ($0.035) |
| Madera | Residential Roof | 80 | 142 | $29.4 | $0.207 | $13.3 | $0.094 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.4 | $0.150 | $0.1 | $0.036 |
| | Ground 1-3 MW | 5 | 12 | $1.7 | $0.143 | $0.4 | $0.034 |
| | Ground 3-5 MW | 12 | 26 | $3.6 | $0.140 | $0.8 | $0.030 |
| | Ground 5-10 MW | 16 | 36 | $5.0 | $0.140 | $1.3 | $0.035 |
| | Ground 10-20 MW | | | | | | |
| Marin | Residential Roof | 100 | 172 | $35.6 | $0.206 | $16.0 | $0.093 |
| | Commercial Roof | 6 | 9 | $1.9 | $0.211 | $0.9 | $0.102 |
| | Ground <= 1 MW | 0 | 1 | $0.2 | $0.163 | $0.0 | $0.043 |
| | Ground 1-3 MW | 2 | 4 | $0.7 | $0.157 | $0.2 | $0.036 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Mariposa | Residential Roof | 25 | 44 | $9.0 | $0.204 | $3.5 | $0.080 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.150 | $0.0 | $0.044 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 41 | 69 | $14.6 | $0.212 | $6.7 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Merced | Residential Roof | 174 | 307 | $63.3 | $0.206 | $26.6 | $0.086 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.153 | $0.1 | $0.047 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 7 | 16 | $2.2 | $0.139 | $0.5 | $0.034 |
| | Ground 5-10 MW | 18 | 39 | $5.4 | $0.139 | $0.8 | $0.020 |
| | Ground 10-20 MW | | | | | | |
| Mono | Residential Roof | 12 | 23 | $4.0 | $0.177 | $1.7 | $0.076 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.2 | $0.120 | $0.0 | $0.023 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 157 | 274 | $54.4 | $0.198 | $22.6 | $0.083 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 12 | 29 | $4.0 | $0.139 | $0.8 | $0.027 |
| | Ground 3-5 MW | 4 | 8 | $0.9 | $0.109 | $0.1 | $0.007 |
| | Ground 5-10 MW | 28 | 60 | $7.3 | $0.121 | $0.2 | $0.004 |
| | Ground 10-20 MW | 13 | 27 | $3.8 | $0.140 | $0.4 | $0.016 |
| Napa | Residential Roof | 133 | 231 | $47.4 | $0.205 | $19.0 | $0.083 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 6 | $0.9 | $0.152 | $0.2 | $0.036 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 71 | 148 | $20.8 | $0.140 | $1.2 | $0.008 |
| Nevada | Residential Roof | 39 | 67 | $13.6 | $0.202 | $5.7 | $0.085 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 1 | 3 | $0.5 | $0.151 | $0.1 | $0.023 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 12 | 26 | $3.6 | $0.141 | $0.8 | $0.033 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 728 | 1,307 | $251.5 | $0.192 | $78.5 | $0.060 |
| | Commercial Roof | 643 | 1,099 | $210.7 | $0.192 | $63.2 | $0.057 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 8 | 18 | $2.6 | $0.142 | $0.8 | $0.043 |
| | Ground 10-20 MW | | | | | | |
| Placer | Residential Roof | 99 | 173 | $35.2 | $0.204 | $15.1 | $0.087 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.157 | $0.0 | $0.053 |
| | Ground 1-3 MW | 5 | 10 | $1.5 | $0.149 | $0.4 | $0.041 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 21 | 45 | $6.3 | $0.139 | $1.2 | $0.026 |
| | Ground 10-20 MW | 119 | 253 | $35.0 | $0.139 | $5.6 | $0.022 |
| Plumas | Residential Roof | 8 | 14 | $2.5 | $0.178 | $0.8 | $0.058 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.2 | $0.142 | $0.0 | $0.021 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 618 | 1,145 | $205.6 | $0.179 | $77.8 | $0.068 |
| | Commercial Roof | 64 | 107 | $19.0 | $0.177 | $8.1 | $0.076 |
| | Ground <= 1 MW | 1 | 4 | $0.4 | $0.110 | ($0.0) | ($0.012) |
| | Ground 1-3 MW | 6 | 13 | $1.8 | $0.139 | $0.4 | $0.028 |
| | Ground 3-5 MW | 8 | 18 | $2.2 | $0.118 | ($0.1) | ($0.007) |
| | Ground 5-10 MW | 29 | 67 | $7.9 | $0.118 | $0.3 | $0.005 |
| | Ground 10-20 MW | 126 | 292 | $34.2 | $0.117 | ($0.1) | ($0.000) |
| Sacramento | Residential Roof | 1 | 2 | $0.4 | $0.205 | $0.2 | $0.078 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | 13 | 23 | $4.8 | $0.205 | $2.1 | $0.089 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 673 | 1,264 | $217.4 | $0.172 | $81.4 | $0.064 |
| | Commercial Roof | 311 | 523 | $95.8 | $0.183 | $39.2 | $0.075 |
| | Ground <= 1 MW | 1 | 4 | $0.4 | $0.112 | $0.0 | $0.005 |
| | Ground 1-3 MW | 6 | 15 | $1.8 | $0.118 | $0.1 | $0.008 |
| | Ground 3-5 MW | 4 | 9 | $1.0 | $0.115 | ($0.1) | ($0.008) |
| | Ground 5-10 MW | 6 | 13 | $1.4 | $0.112 | $0.1 | $0.011 |
| | Ground 10-20 MW | 12 | 30 | $3.4 | $0.113 | $0.8 | $0.026 |
| San Diego | Residential Roof | 1,138 | 2,046 | $371.3 | $0.181 | $163.4 | $0.080 |
| | Commercial Roof | 169 | 286 | $53.1 | $0.186 | $23.7 | $0.083 |
| | Ground <= 1 MW | 2 | 4 | $0.6 | $0.147 | $0.2 | $0.045 |
| | Ground 1-3 MW | 3 | 6 | $0.9 | $0.156 | $0.3 | $0.055 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 6 | 12 | $1.7 | $0.141 | $0.4 | $0.034 |
| | Ground 10-20 MW | 16 | 34 | $3.8 | $0.110 | $0.3 | $0.009 |
| San Francisco | Residential Roof | 71 | 122 | $25.0 | $0.206 | $11.3 | $0.093 |
| | Commercial Roof | 11 | 18 | $3.7 | $0.201 | $1.6 | $0.087 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 380 | 669 | $136.9 | $0.204 | $60.5 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 10 | $1.5 | $0.147 | $0.3 | $0.032 |
| | Ground 3-5 MW | 4 | 9 | $1.3 | $0.139 | $0.2 | $0.024 |
| | Ground 5-10 MW | 31 | 67 | $9.3 | $0.139 | $1.8 | $0.026 |
| | Ground 10-20 MW | 31 | 67 | $9.3 | $0.140 | $1.7 | $0.025 |
| San Luis Obispo | Residential Roof | 89 | 162 | $28.8 | $0.177 | $10.5 | $0.064 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.140 | $0.0 | $0.035 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 3 | 8 | $0.9 | $0.111 | $0.0 | $0.004 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Mateo | Residential Roof | 220 | 367 | $78.5 | $0.214 | $37.6 | $0.102 |
| | Commercial Roof | 104 | 162 | $34.0 | $0.209 | $16.0 | $0.098 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 169 | 307 | $50.1 | $0.163 | $17.3 | $0.057 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.150 | $0.1 | $0.047 |
| | Ground 1-3 MW | 9 | 21 | $3.0 | $0.139 | $0.7 | $0.031 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 22 | $2.5 | $0.116 | $0.2 | $0.008 |
| | Ground 10-20 MW | 11 | 24 | $3.0 | $0.122 | $0.4 | $0.016 |
| Santa Clara | Residential Roof | 759 | 1,346 | $276.6 | $0.205 | $125.6 | $0.093 |
| | Commercial Roof | 225 | 378 | $74.3 | $0.197 | $32.4 | $0.086 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 78 | 136 | $27.8 | $0.204 | $13.0 | $0.095 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Shasta | Residential Roof | 67 | 111 | $23.6 | $0.213 | $10.4 | $0.093 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.160 | $0.1 | $0.034 |
| | Ground 1-3 MW | 1 | 3 | $0.5 | $0.156 | $0.1 | $0.041 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 22 | 45 | $6.5 | $0.143 | $1.0 | $0.022 |
| | Ground 10-20 MW | | | | | | |
| Sierra | Residential Roof | 1 | 1 | $0.3 | $0.204 | $0.1 | $0.093 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 156 | 273 | $56.0 | $0.205 | $26.0 | $0.095 |
| | Commercial Roof | 0 | 1 | $0.2 | $0.197 | $0.1 | $0.082 |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.156 | $0.1 | $0.051 |
| | Ground 1-3 MW | 3 | 6 | $0.9 | $0.147 | $0.2 | $0.031 |
| | Ground 3-5 MW | 4 | 9 | $1.3 | $0.140 | $0.2 | $0.024 |
| | Ground 5-10 MW | 21 | 45 | $6.3 | $0.139 | $1.2 | $0.026 |

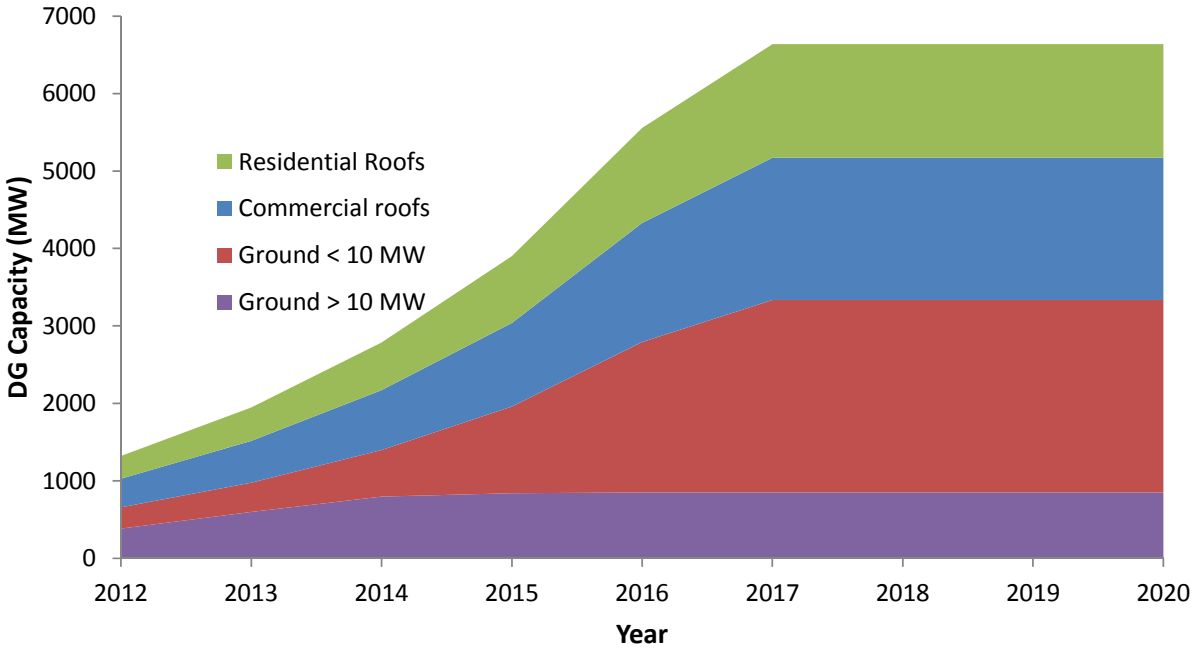
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | 37 | 79 | $11.0 | $0.139 | $2.2 | $0.028 |
| Sonoma | Residential Roof | 251 | 429 | $89.1 | $0.208 | $41.0 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.2 | $0.166 | $0.1 | $0.055 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $1.1 | $0.145 | $0.2 | $0.027 |
| | Ground 5-10 MW | 16 | 34 | $4.8 | $0.141 | $0.8 | $0.025 |
| | Ground 10-20 MW | | | | | | |
| Stanislaus | Residential Roof | 113 | 199 | $40.5 | $0.203 | $16.0 | $0.080 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.2 | $0.153 | $0.1 | $0.047 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 11 | $1.5 | $0.139 | $0.1 | $0.007 |
| | Ground 5-10 MW | 7 | 14 | $2.0 | $0.137 | $0.1 | $0.006 |
| | Ground 10-20 MW | | | | | | |
| Sutter | Residential Roof | 70 | 122 | $24.8 | $0.203 | $9.3 | $0.076 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.158 | $0.0 | $0.031 |
| | Ground 1-3 MW | 4 | 8 | $1.2 | $0.151 | $0.3 | $0.042 |
| | Ground 3-5 MW | 12 | 25 | $3.6 | $0.143 | $0.6 | $0.022 |
| | Ground 5-10 MW | 17 | 36 | $4.9 | $0.139 | $0.4 | $0.012 |
| | Ground 10-20 MW | | | | | | |
| Tehama | Residential Roof | 36 | 62 | $12.8 | $0.207 | $5.9 | $0.096 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 11 | $1.6 | $0.151 | $0.4 | $0.034 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 6 | 13 | $1.7 | $0.138 | $0.3 | $0.022 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.3 | $0.202 | $0.1 | $0.082 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 231 | 414 | $84.8 | $0.205 | $37.1 | $0.090 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $0.5 | $0.151 | $0.1 | $0.027 |
| | Ground 1-3 MW | 16 | 36 | $5.1 | $0.142 | $0.9 | $0.024 |
| | Ground 3-5 MW | 4 | 9 | $1.2 | $0.139 | $0.3 | $0.036 |
| | Ground 5-10 MW | 12 | 27 | $3.8 | $0.140 | $0.4 | $0.017 |

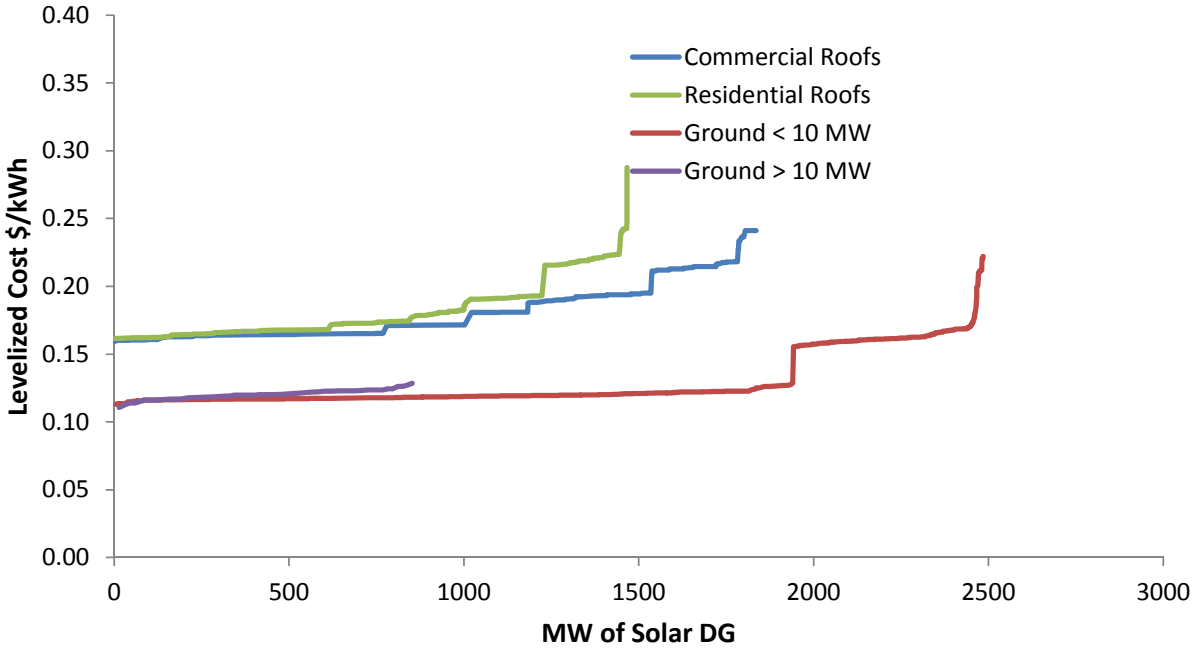
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 10-20 MW | | | | | | |
| Tuolumne | Residential Roof | 35 | 62 | $12.7 | $0.205 | $6.0 | $0.097 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.152 | $0.1 | $0.046 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 3 | 7 | $1.0 | $0.142 | $0.3 | $0.037 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Ventura | Residential Roof | 419 | 756 | $133.1 | $0.176 | $42.7 | $0.056 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $0.7 | $0.140 | $0.0 | $0.005 |
| | Ground 3-5 MW | 9 | 20 | $2.4 | $0.125 | $0.1 | $0.008 |
| | Ground 5-10 MW | 9 | 20 | $2.9 | $0.141 | $0.1 | $0.005 |
| | Ground 10-20 MW | 28 | 60 | $7.6 | $0.127 | $1.2 | $0.021 |
| Yolo | Residential Roof | 123 | 214 | $43.7 | $0.204 | $19.1 | $0.089 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $0.7 | $0.149 | $0.2 | $0.038 |
| | Ground 3-5 MW | 25 | 54 | $7.7 | $0.142 | $1.5 | $0.028 |
| | Ground 5-10 MW | 7 | 15 | $2.1 | $0.140 | $0.5 | $0.030 |
| | Ground 10-20 MW | 20 | 42 | $5.9 | $0.139 | $1.1 | $0.026 |
| Yuba | Residential Roof | 37 | 64 | $13.0 | $0.203 | $5.7 | $0.089 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 1 | 3 | $0.5 | $0.150 | $0.1 | $0.042 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 5 | 11 | $1.5 | $0.141 | $0.4 | $0.034 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 16,366 | 29,804 | 5458 | 0.18 | 2081 | 0.07 |

## 80% Learning Curve Sensitivities

All sensitivities presented are based on the *least cost* scenario unless otherwise noted.

### 15% Interconnection Constraint



**Least Cost Summary Table, 15% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 111 | 189 | $36.9 | $0.195 | $13.4 | $0.071 |
| | | Commercial Roof | 196 | 315 | $60.8 | $0.193 | $21.3 | $0.068 |
| | | Ground < 10 MW | 632 | 1,328 | $176.5 | $0.133 | $17.3 | $0.013 |
| | | Ground 10-20 MW | 42 | 91 | $10.7 | $0.118 | $0.4 | $0.004 |
| | North Central Valley | Residential Roof | 105 | 180 | $35.6 | $0.198 | $12.1 | $0.067 |
| | | Commercial Roof | 237 | 374 | $72.0 | $0.193 | $24.5 | $0.065 |
| | | Ground < 10 MW | 697 | 1,470 | $192.7 | $0.131 | $7.7 | $0.005 |
| | | Ground 10-20 MW | 11 | 24 | $2.9 | $0.122 | $0.4 | $0.017 |
| | South Central Valley | Residential Roof | 98 | 169 | $31.6 | $0.187 | $9.9 | $0.059 |
| | | Commercial Roof | 111 | 179 | $32.6 | $0.182 | $9.2 | $0.051 |
| | | Ground < 10 MW | 363 | 766 | $100.1 | $0.131 | $5.3 | $0.007 |
| | | Ground 10-20 MW | 31 | 64 | $7.6 | $0.119 | $0.1 | $0.001 |
| | Mountain | Residential Roof | 20 | 34 | $6.6 | $0.193 | $2.2 | $0.064 |
| | | Commercial Roof | 11 | 18 | $3.4 | $0.187 | $1.2 | $0.063 |
| | | Ground < 10 MW | 71 | 148 | $19.7 | $0.133 | $1.5 | $0.010 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 2 | $0.3 | $0.120 | $0.0 | $0.016 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 636 | 1,132 | $198.4 | $0.175 | $61.5 | $0.054 |
| | | Commercial Roof | 931 | 1,539 | $269.9 | $0.175 | $72.4 | $0.047 |
| | | Ground < 10 MW | 366 | 832 | $100.9 | $0.121 | $3.4 | $0.004 |
| | | Ground 10-20 MW | 571 | 1,290 | $155.0 | $0.120 | $1.9 | $0.001 |
| | South Central Valley | Residential Roof | 137 | 251 | $45.3 | $0.180 | $17.2 | $0.069 |
| | | Commercial Roof | 144 | 238 | $41.4 | $0.174 | $7.9 | $0.033 |
| | | Ground < 10 MW | 138 | 321 | $38.4 | $0.120 | $0.3 | $0.001 |
| | | Ground 10-20 MW | 48 | 102 | $12.1 | $0.118 | ($0.3) | ($0.003) |
| | Desert | Residential Roof | 24 | 43 | $7.5 | $0.176 | $2.6 | $0.061 |
| | | Commercial Roof | 35 | 59 | $9.9 | $0.168 | $2.5 | $0.043 |
| | | Ground < 10 MW | 45 | 107 | $13.0 | $0.122 | ($0.2) | ($0.002) |
| | | Ground 10-20 MW | 32 | 70 | $8.8 | $0.126 | $1.4 | $0.020 |
| | Mountain | Residential Roof | 32 | 59 | $10.2 | $0.174 | $3.7 | $0.064 |
| | | Commercial Roof | 29 | 48 | $8.9 | $0.187 | $3.3 | $0.069 |
| | | Ground < 10 MW | 34 | 78 | $9.5 | $0.121 | $0.7 | $0.009 |
| | | Ground 10-20 MW | 26 | 56 | $6.7 | $0.119 | $0.6 | $0.011 |
| SDGE | South Coast | Residential Roof | 300 | 529 | $96.1 | $0.182 | $37.8 | $0.071 |
| | | Commercial Roof | 141 | 232 | $42.6 | $0.184 | $17.0 | $0.073 |
| | | Ground < 10 MW | 134 | 290 | $35.0 | $0.121 | $3.3 | $0.011 |
| | | Ground 10-20 MW | 90 | 194 | $23.3 | $0.120 | $2.8 | $0.014 |
| | South Central Valley | Residential Roof | 3 | 7 | $1.2 | $0.182 | $0.6 | $0.085 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 4 | $0.4 | $0.119 | $0.1 | $0.020 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.121 | $0.1 | $0.022 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,638 | 12,836 | 1925 | 0.15 | 367 | 0.03 |

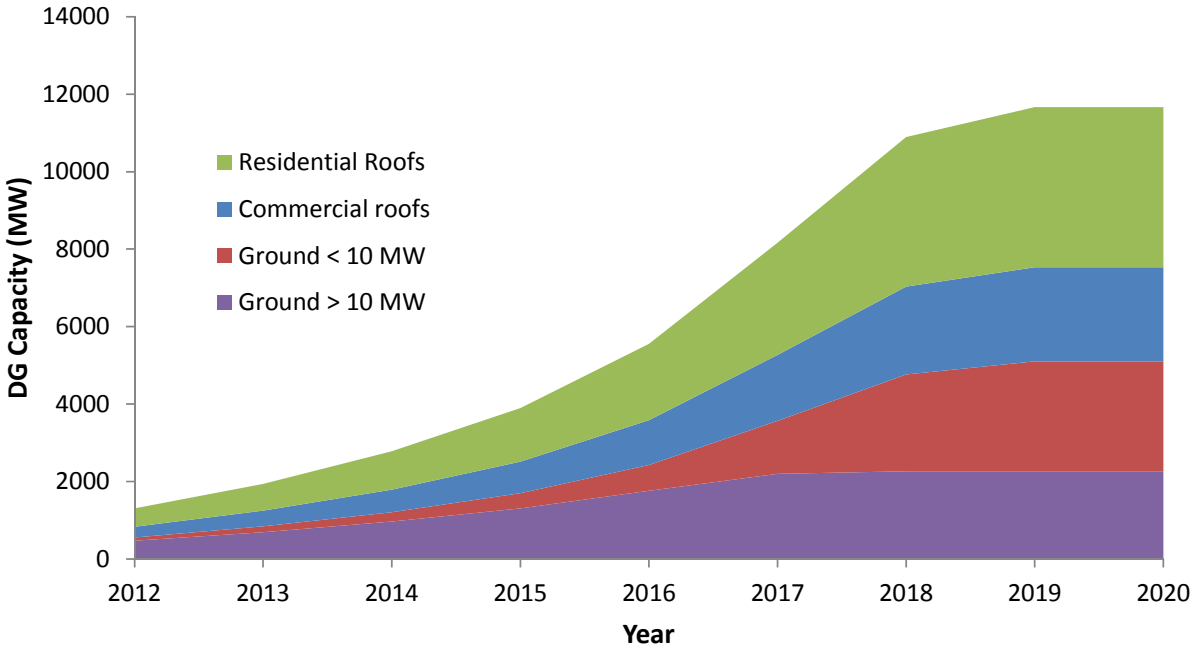
**Least Net Cost Summary Table, 15% Interconnection Constraint**

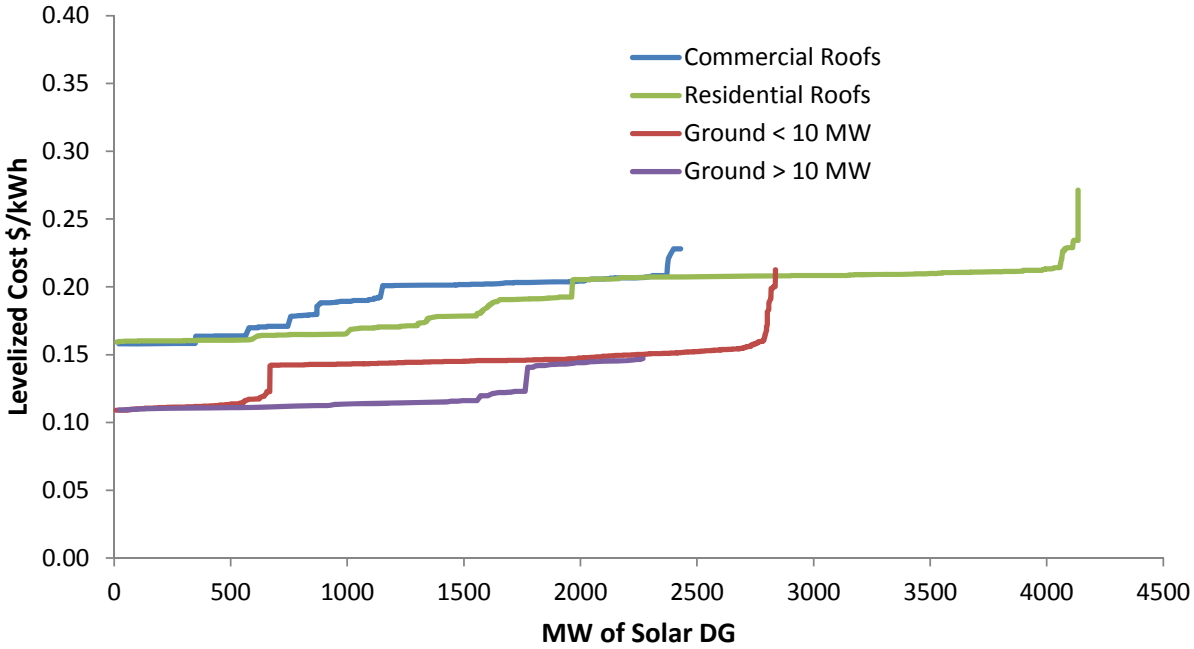
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 111 | 188 | $33.9 | $0.181 | $10.7 | $0.057 |
| | | Commercial Roof | 196 | 304 | $56.3 | $0.185 | $18.4 | $0.060 |
| | | Ground < 10 MW | 632 | 1,328 | $180.3 | $0.136 | $21.0 | $0.016 |
| | | Ground 10-20 MW | 42 | 91 | $10.4 | $0.114 | ($0.0) | ($0.000) |
| | North Central Valley | Residential Roof | 105 | 176 | $33.9 | $0.193 | $11.6 | $0.066 |
| | | Commercial Roof | 237 | 371 | $70.4 | $0.190 | $23.9 | $0.064 |
| | | Ground < 10 MW | 697 | 1,456 | $192.6 | $0.132 | $11.6 | $0.008 |
| | | Ground 10-20 MW | 11 | 25 | $2.6 | $0.107 | ($0.1) | ($0.003) |
| | South Central Valley | Residential Roof | 98 | 165 | $29.8 | $0.180 | $9.1 | $0.055 |
| | | Commercial Roof | 111 | 176 | $32.9 | $0.187 | $10.5 | $0.060 |
| | | Ground < 10 MW | 363 | 760 | $99.2 | $0.131 | $5.9 | $0.008 |
| | | Ground 10-20 MW | 31 | 64 | $7.7 | $0.120 | $0.2 | $0.003 |
| | Mountain | Residential Roof | 20 | 34 | $6.0 | $0.176 | $1.6 | $0.048 |
| | | Commercial Roof | 11 | 18 | $3.1 | $0.169 | $0.8 | $0.045 |
| | | Ground < 10 MW | 71 | 147 | $19.5 | $0.133 | $1.6 | $0.011 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 2 | $0.3 | $0.140 | $0.1 | $0.033 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 676 | 1,203 | $216.1 | $0.180 | $65.6 | $0.054 |
| | | Commercial Roof | 891 | 1,479 | $261.7 | $0.177 | $76.4 | $0.052 |
| | | Ground < 10 MW | 366 | 837 | $101.0 | $0.121 | $2.4 | $0.003 |
| | | Ground 10-20 MW | 571 | 1,296 | $153.1 | $0.118 | ($1.4) | ($0.001) |
| | South Central Valley | Residential Roof | 137 | 252 | $44.6 | $0.177 | $16.1 | $0.064 |
| | | Commercial Roof | 144 | 238 | $43.0 | $0.181 | $9.8 | $0.041 |
| | | Ground < 10 MW | 138 | 321 | $39.2 | $0.122 | $1.2 | $0.004 |
| | | Ground 10-20 MW | 48 | 102 | $12.4 | $0.121 | $0.2 | $0.002 |
| | Desert | Residential Roof | 24 | 42 | $7.6 | $0.179 | $2.7 | $0.064 |
| | | Commercial Roof | 35 | 58 | $10.4 | $0.180 | $3.4 | $0.058 |
| | | Ground < 10 MW | 45 | 107 | $13.1 | $0.123 | ($0.0) | ($0.000) |
| | | Ground 10-20 MW | 32 | 71 | $8.1 | $0.115 | $0.3 | $0.005 |
| | Mountain | Residential Roof | 32 | 59 | $9.9 | $0.169 | $3.4 | $0.057 |
| | | Commercial Roof | 29 | 48 | $8.4 | $0.175 | $2.7 | $0.056 |
| | | Ground < 10 MW | 34 | 80 | $9.2 | $0.116 | $0.1 | $0.001 |
| | | Ground 10-20 MW | 26 | 57 | $6.4 | $0.112 | $0.1 | $0.002 |
| SDGE | South Coast | Residential Roof | 300 | 537 | $99.1 | $0.185 | $39.0 | $0.073 |
| | | Commercial Roof | 141 | 238 | $42.9 | $0.181 | $15.8 | $0.067 |
| | | Ground < 10 MW | 134 | 294 | $36.6 | $0.125 | $4.0 | $0.014 |
| | | Ground 10-20 MW | 90 | 199 | $21.6 | $0.109 | ($0.1) | ($0.001) |
| | South Central Valley | Residential Roof | 3 | 7 | $1.1 | $0.158 | $0.4 | $0.057 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 4 | $0.5 | $0.138 | $0.1 | $0.035 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.134 | $0.1 | $0.030 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,638 | 12,838 | 1926 | 0.15 | 369 | 0.03 |

**High Rooftop Summary Table, 15% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 640 | 1,086 | $203.1 | $0.187 | $69.6 | $0.064 |
| | | Commercial Roof | 219 | 352 | $67.4 | $0.192 | $23.3 | $0.066 |
| | | Ground < 10 MW | 122 | 261 | $34.5 | $0.132 | $4.3 | $0.016 |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 686 | 1,173 | $218.1 | $0.186 | $67.0 | $0.057 |
| | | Commercial Roof | 256 | 408 | $78.6 | $0.193 | $26.7 | $0.065 |
| | | Ground < 10 MW | 109 | 234 | $29.4 | $0.126 | $0.6 | $0.003 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 454 | 780 | $145.5 | $0.187 | $46.3 | $0.059 |
| | | Commercial Roof | 121 | 197 | $38.7 | $0.196 | $12.9 | $0.065 |
| | | Ground < 10 MW | 38 | 81 | $11.2 | $0.137 | $1.5 | $0.018 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 88 | 150 | $28.6 | $0.191 | $9.6 | $0.064 |
| | | Commercial Roof | 11 | 18 | $3.4 | $0.187 | $1.2 | $0.063 |
| | | Ground < 10 MW | 3 | 7 | $0.8 | $0.125 | $0.0 | $0.002 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 1 | 2 | $0.4 | $0.188 | $0.2 | $0.087 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,354 | 2,448 | $434.4 | $0.177 | $139.0 | $0.057 |
| | | Commercial Roof | 1,089 | 1,809 | $315.1 | $0.174 | $86.5 | $0.048 |
| | | Ground < 10 MW | 67 | 153 | $19.4 | $0.127 | ($0.7) | ($0.005) |
| | | Ground 10-20 MW | 12 | 28 | $3.4 | $0.124 | $0.2 | $0.007 |
| | South Central Valley | Residential Roof | 274 | 505 | $88.6 | $0.175 | $29.5 | $0.058 |
| | | Commercial Roof | 186 | 309 | $53.1 | $0.172 | $10.7 | $0.035 |
| | | Ground < 10 MW | 7 | 16 | $2.0 | $0.121 | $0.1 | $0.006 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 82 | 150 | $26.7 | $0.178 | $8.8 | $0.059 |
| | | Commercial Roof | 49 | 82 | $14.0 | $0.171 | $4.0 | $0.049 |
| | | Ground < 10 MW | 5 | 13 | $1.5 | $0.114 | ($0.0) | ($0.001) |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 65 | 120 | $21.0 | $0.176 | $7.7 | $0.064 |
| | | Commercial Roof | 54 | 89 | $16.4 | $0.185 | $6.2 | $0.069 |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.124 | $0.1 | $0.021 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 481 | 848 | $153.6 | $0.181 | $60.6 | $0.072 |
| | | Commercial Roof | 178 | 294 | $53.0 | $0.181 | $20.5 | $0.070 |
| | | Ground < 10 MW | 7 | 15 | $2.1 | $0.137 | $0.5 | $0.031 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 5 | 9 | $1.7 | $0.181 | $0.8 | $0.083 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 3 | $0.6 | $0.181 | $0.3 | $0.082 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,668 | 11,643 | 2067 | 0.18 | 638 | 0.05 |

## 30% Interconnection Constraint



**Least Cost Summary Table, 30% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 405 | 703 | $144.9 | $0.206 | $65.3 | $0.093 |
| | | Commercial Roof | 255 | 416 | $85.4 | $0.205 | $37.3 | $0.090 |
| | | Ground < 10 MW | 870 | 1,859 | $269.3 | $0.145 | $62.3 | $0.034 |
| | | Ground 10-20 MW | 230 | 487 | $65.8 | $0.135 | $12.3 | $0.025 |
| | North Central Valley | Residential Roof | 396 | 684 | $144.0 | $0.211 | $62.2 | $0.091 |
| | | Commercial Roof | 295 | 477 | $99.0 | $0.208 | $43.0 | $0.090 |
| | | Ground < 10 MW | 923 | 1,976 | $279.9 | $0.142 | $45.6 | $0.023 |
| | | Ground 10-20 MW | 310 | 661 | $83.6 | $0.127 | $6.4 | $0.010 |
| | South Central Valley | Residential Roof | 284 | 497 | $104.0 | $0.209 | $44.9 | $0.090 |
| | | Commercial Roof | 134 | 219 | $45.0 | $0.205 | $19.0 | $0.086 |
| | | Ground < 10 MW | 430 | 919 | $130.4 | $0.142 | $23.3 | $0.025 |
| | | Ground 10-20 MW | 203 | 434 | $55.3 | $0.128 | $5.7 | $0.013 |
| | Mountain | Residential Roof | 40 | 70 | $14.7 | $0.212 | $6.4 | $0.092 |
| | | Commercial Roof | 14 | 24 | $4.8 | $0.204 | $2.1 | $0.088 |
| | | Ground < 10 MW | 91 | 194 | $28.2 | $0.146 | $5.9 | $0.030 |
| | | Ground 10-20 MW | 38 | 82 | $9.0 | $0.111 | ($0.3) | ($0.004) |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.5 | $0.110 | $0.1 | $0.011 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,788 | 3,215 | $589.7 | $0.183 | $215.4 | $0.067 |
| | | Commercial Roof | 1,281 | 2,154 | $393.2 | $0.183 | $131.2 | $0.061 |
| | | Ground < 10 MW | 273 | 629 | $77.6 | $0.123 | $5.0 | $0.008 |
| | | Ground 10-20 MW | 1,015 | 2,310 | $268.4 | $0.116 | $0.8 | $0.000 |
| | South Central Valley | Residential Roof | 313 | 570 | $104.5 | $0.183 | $41.6 | $0.073 |
| | | Commercial Roof | 189 | 318 | $55.7 | $0.175 | $8.8 | $0.028 |
| | | Ground < 10 MW | 89 | 209 | $26.5 | $0.126 | $2.5 | $0.012 |
| | | Ground 10-20 MW | 161 | 373 | $42.7 | $0.114 | $0.6 | $0.002 |
| | Desert | Residential Roof | 113 | 203 | $39.5 | $0.195 | $17.1 | $0.084 |
| | | Commercial Roof | 49 | 83 | $15.5 | $0.187 | $6.0 | $0.072 |
| | | Ground < 10 MW | 41 | 97 | $11.7 | $0.121 | $0.4 | $0.004 |
| | | Ground 10-20 MW | 29 | 68 | $8.0 | $0.119 | ($0.3) | ($0.005) |
| | Mountain | Residential Roof | 88 | 163 | $29.5 | $0.181 | $12.2 | $0.075 |
| | | Commercial Roof | 59 | 99 | $17.3 | $0.175 | $6.2 | $0.062 |
| | | Ground < 10 MW | 30 | 68 | $7.8 | $0.114 | $0.3 | $0.004 |
| | | Ground 10-20 MW | 45 | 98 | $11.0 | $0.112 | $0.8 | $0.008 |
| SDGE | South Coast | Residential Roof | 704 | 1,255 | $234.9 | $0.187 | $104.3 | $0.083 |
| | | Commercial Roof | 153 | 255 | $46.9 | $0.184 | $20.1 | $0.079 |
| | | Ground < 10 MW | 85 | 187 | $23.1 | $0.123 | $3.4 | $0.018 |
| | | Ground 10-20 MW | 237 | 516 | $59.7 | $0.116 | $6.7 | $0.013 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.182 | $0.6 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.4 | $0.111 | $0.1 | $0.015 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.114 | $0.1 | $0.018 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 11,668 | 22,592 | 3629 | 0.16 | 1025 | 0.05 |

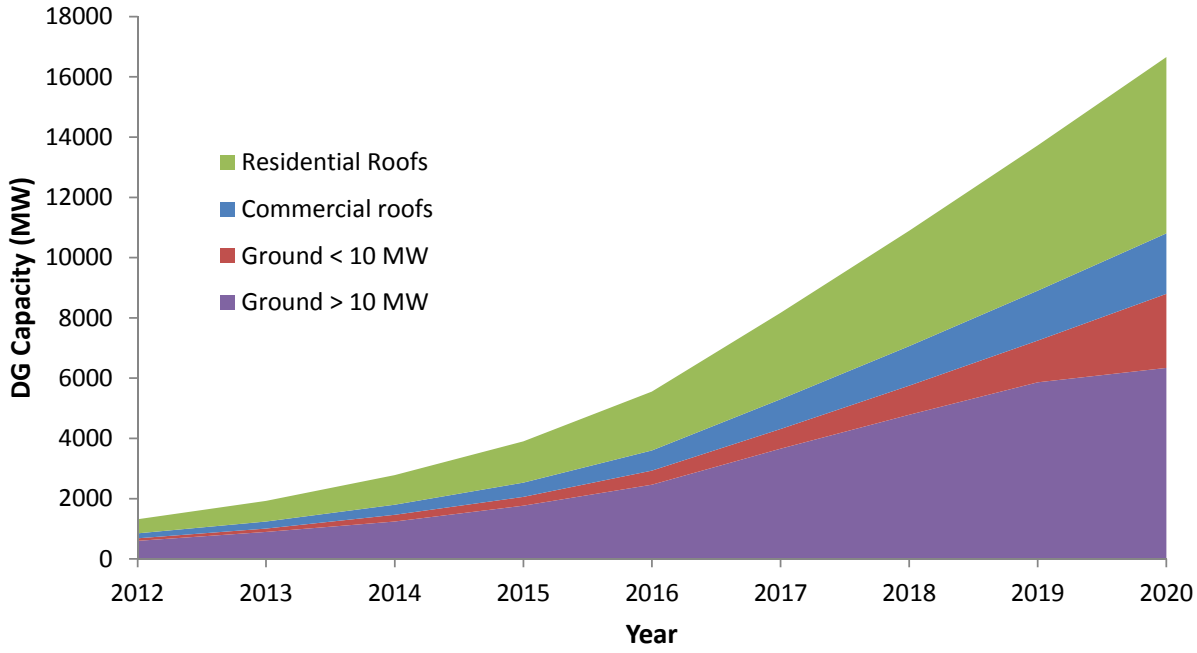
**Least Net Cost Summary Table, 30% Interconnection Constraint**

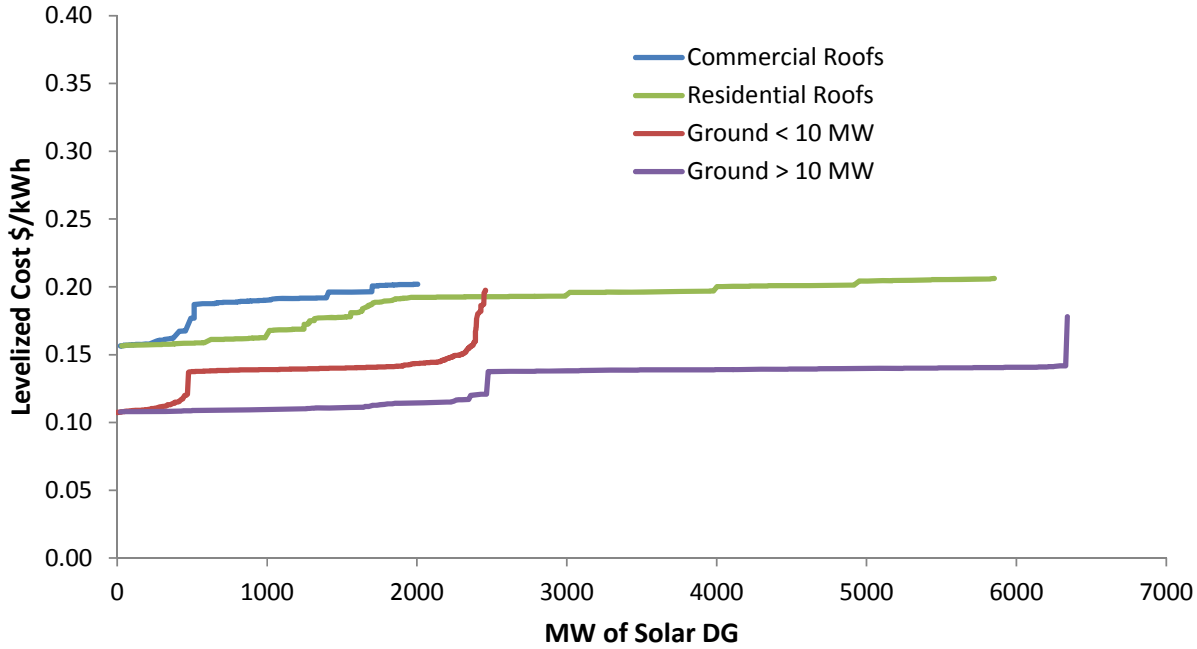
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 405 | 700 | $144.4 | $0.206 | $65.1 | $0.093 |
| | | Commercial Roof | 255 | 414 | $82.0 | $0.198 | $34.1 | $0.082 |
| | | Ground < 10 MW | 870 | 1,863 | $267.4 | $0.144 | $60.0 | $0.032 |
| | | Ground 10-20 MW | 230 | 489 | $67.7 | $0.139 | $14.0 | $0.029 |
| | North Central Valley | Residential Roof | 396 | 666 | $130.2 | $0.195 | $50.7 | $0.076 |
| | | Commercial Roof | 295 | 471 | $92.9 | $0.197 | $37.6 | $0.080 |
| | | Ground < 10 MW | 923 | 1,954 | $261.8 | $0.134 | $30.6 | $0.016 |
| | | Ground 10-20 MW | 310 | 655 | $78.9 | $0.120 | $2.4 | $0.004 |
| | South Central Valley | Residential Roof | 284 | 487 | $87.5 | $0.180 | $29.6 | $0.061 |
| | | Commercial Roof | 134 | 216 | $41.0 | $0.189 | $15.3 | $0.071 |
| | | Ground < 10 MW | 430 | 912 | $121.3 | $0.133 | $15.1 | $0.017 |
| | | Ground 10-20 MW | 203 | 433 | $53.2 | $0.123 | $3.7 | $0.009 |
| | Mountain | Residential Roof | 40 | 68 | $12.4 | $0.182 | $4.3 | $0.063 |
| | | Commercial Roof | 14 | 24 | $4.9 | $0.208 | $2.2 | $0.093 |
| | | Ground < 10 MW | 91 | 193 | $28.0 | $0.145 | $5.7 | $0.030 |
| | | Ground 10-20 MW | 38 | 82 | $9.0 | $0.111 | ($0.3) | ($0.004) |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.7 | $0.136 | $0.2 | $0.036 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,832 | 3,294 | $618.8 | $0.188 | $230.5 | $0.070 |
| | | Commercial Roof | 1,236 | 2,088 | $385.3 | $0.185 | $137.7 | $0.066 |
| | | Ground < 10 MW | 273 | 631 | $79.7 | $0.126 | $7.2 | $0.011 |
| | | Ground 10-20 MW | 1,015 | 2,325 | $282.5 | $0.121 | $13.2 | $0.006 |
| | South Central Valley | Residential Roof | 302 | 553 | $102.5 | $0.185 | $41.4 | $0.075 |
| | | Commercial Roof | 200 | 332 | $62.9 | $0.190 | $15.5 | $0.047 |
| | | Ground < 10 MW | 89 | 210 | $25.3 | $0.121 | $1.2 | $0.006 |
| | | Ground 10-20 MW | 161 | 374 | $44.3 | $0.118 | $2.0 | $0.005 |
| | Desert | Residential Roof | 109 | 197 | $34.7 | $0.176 | $12.8 | $0.065 |
| | | Commercial Roof | 53 | 89 | $14.8 | $0.167 | $4.6 | $0.052 |
| | | Ground < 10 MW | 41 | 97 | $11.7 | $0.121 | $0.5 | $0.005 |
| | | Ground 10-20 MW | 29 | 68 | $8.0 | $0.119 | ($0.3) | ($0.005) |
| | Mountain | Residential Roof | 88 | 165 | $28.6 | $0.173 | $10.9 | $0.066 |
| | | Commercial Roof | 59 | 101 | $16.8 | $0.167 | $5.4 | $0.053 |
| | | Ground < 10 MW | 30 | 69 | $9.0 | $0.130 | $1.4 | $0.021 |
| | | Ground 10-20 MW | 45 | 101 | $11.9 | $0.118 | $1.3 | $0.013 |
| SDGE | South Coast | Residential Roof | 704 | 1,279 | $255.4 | $0.200 | $121.7 | $0.095 |
| | | Commercial Roof | 153 | 262 | $51.8 | $0.198 | $24.1 | $0.092 |
| | | Ground < 10 MW | 85 | 190 | $25.8 | $0.136 | $5.8 | $0.031 |
| | | Ground 10-20 MW | 237 | 528 | $71.1 | $0.135 | $16.6 | $0.032 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.1 | $0.145 | $0.3 | $0.047 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.133 | $0.1 | $0.036 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.7 | $0.130 | $0.2 | $0.032 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 11,667 | 22,598 | 3626 | 0.16 | 1025 | 0.05 |

**High Rooftop Summary Table, 30% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,214 | 2,091 | $434.5 | $0.208 | $197.5 | $0.094 |
| | | Commercial Roof | 278 | 456 | $93.0 | $0.204 | $40.4 | $0.089 |
| | | Ground < 10 MW | 238 | 522 | $72.6 | $0.139 | $16.2 | $0.031 |
| | | Ground 10-20 MW | 82 | 174 | $23.5 | $0.135 | $4.5 | $0.026 |
| | North Central Valley | Residential Roof | 1,394 | 2,421 | $499.4 | $0.206 | $210.0 | $0.087 |
| | | Commercial Roof | 315 | 510 | $105.5 | $0.207 | $46.0 | $0.090 |
| | | Ground < 10 MW | 207 | 453 | $62.0 | $0.137 | $8.8 | $0.019 |
| | | Ground 10-20 MW | 67 | 142 | $18.8 | $0.132 | $1.8 | $0.013 |
| | South Central Valley | Residential Roof | 887 | 1,544 | $318.1 | $0.206 | $134.6 | $0.087 |
| | | Commercial Roof | 135 | 223 | $45.4 | $0.204 | $19.0 | $0.085 |
| | | Ground < 10 MW | 86 | 190 | $25.3 | $0.133 | $4.0 | $0.021 |
| | | Ground 10-20 MW | 10 | 22 | $2.5 | $0.112 | $0.1 | $0.004 |
| | Mountain | Residential Roof | 166 | 288 | $60.9 | $0.212 | $27.0 | $0.094 |
| | | Commercial Roof | 14 | 24 | $4.8 | $0.204 | $2.1 | $0.089 |
| | | Ground < 10 MW | 7 | 16 | $2.0 | $0.122 | $0.1 | $0.007 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 2 | 4 | $0.7 | $0.188 | $0.3 | $0.091 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,888 | 5,252 | $945.5 | $0.180 | $336.5 | $0.064 |
| | | Commercial Roof | 1,428 | 2,408 | $438.3 | $0.182 | $148.0 | $0.061 |
| | | Ground < 10 MW | 94 | 213 | $26.4 | $0.124 | $1.5 | $0.007 |
| | | Ground 10-20 MW | 150 | 348 | $40.4 | $0.116 | ($4.3) | ($0.012) |
| | South Central Valley | Residential Roof | 590 | 1,084 | $194.0 | $0.179 | $71.0 | $0.065 |
| | | Commercial Roof | 182 | 307 | $56.6 | $0.184 | $11.0 | $0.036 |
| | | Ground < 10 MW | 6 | 14 | $2.1 | $0.145 | $0.3 | $0.018 |
| | | Ground 10-20 MW | 10 | 25 | $2.8 | $0.113 | $0.6 | $0.025 |
| | Desert | Residential Roof | 190 | 348 | $64.6 | $0.185 | $24.8 | $0.071 |
| | | Commercial Roof | 44 | 75 | $14.6 | $0.195 | $6.0 | $0.080 |
| | | Ground < 10 MW | 6 | 16 | $1.8 | $0.115 | $0.1 | $0.004 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 113 | 207 | $37.4 | $0.181 | $15.6 | $0.075 |
| | | Commercial Roof | 98 | 164 | $28.7 | $0.175 | $10.6 | $0.064 |
| | | Ground < 10 MW | 16 | 39 | $4.5 | $0.116 | $0.1 | $0.002 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 990 | 1,774 | $320.1 | $0.180 | $135.2 | $0.076 |
| | | Commercial Roof | 183 | 306 | $54.6 | $0.178 | $22.4 | $0.073 |
| | | Ground < 10 MW | 24 | 53 | $6.5 | $0.124 | $1.0 | $0.020 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 6 | 11 | $2.0 | $0.180 | $0.9 | $0.087 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $0.9 | $0.181 | $0.4 | $0.086 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 12,125 | 21,731 | 4011 | 0.18 | 1494 | 0.07 |

## 1% Curtailment Interconnection Constraint



**Least Cost Summary Table, 1% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 52 | 95 | $18.8 | $0.198 | $8.7 | $0.092 |
| | | Commercial Roof | 2 | 4 | $0.7 | $0.192 | $0.3 | $0.079 |
| | | Ground < 10 MW | 855 | 1,843 | $258.3 | $0.140 | $57.6 | $0.031 |
| | | Ground 10-20 MW | 1,028 | 2,194 | $297.7 | $0.136 | $61.7 | $0.028 |
| | North Central Valley | Residential Roof | 49 | 90 | $17.6 | $0.195 | $7.4 | $0.082 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 563 | 1,202 | $165.8 | $0.138 | $28.6 | $0.024 |
| | | Ground 10-20 MW | 2,411 | 5,152 | $688.6 | $0.134 | $74.4 | $0.014 |
| | South Central Valley | Residential Roof | 56 | 102 | $20.3 | $0.200 | $8.9 | $0.088 |
| | | Commercial Roof | 3 | 4 | $0.8 | $0.191 | $0.3 | $0.078 |
| | | Ground < 10 MW | 440 | 952 | $133.4 | $0.140 | $25.7 | $0.027 |
| | | Ground 10-20 MW | 546 | 1,171 | $156.6 | $0.134 | $23.9 | $0.020 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 105 | 224 | $31.8 | $0.142 | $6.8 | $0.030 |
| | | Ground 10-20 MW | 82 | 176 | $24.7 | $0.140 | $4.8 | $0.027 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $1.1 | $0.110 | $0.1 | $0.012 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,631 | 6,645 | $1,263.7 | $0.190 | $499.2 | $0.075 |
| | | Commercial Roof | 1,523 | 2,607 | $487.1 | $0.187 | $187.3 | $0.072 |
| | | Ground < 10 MW | 269 | 631 | $77.1 | $0.122 | $7.0 | $0.011 |
| | | Ground 10-20 MW | 1,525 | 3,490 | $403.5 | $0.116 | $3.8 | $0.001 |
| | South Central Valley | Residential Roof | 594 | 1,090 | $206.6 | $0.190 | $79.1 | $0.073 |
| | | Commercial Roof | 201 | 346 | $64.3 | $0.186 | $14.8 | $0.043 |
| | | Ground < 10 MW | 99 | 233 | $29.2 | $0.126 | $4.0 | $0.017 |
| | | Ground 10-20 MW | 260 | 614 | $73.6 | $0.120 | $7.0 | $0.011 |
| | Desert | Residential Roof | 278 | 510 | $95.1 | $0.186 | $38.4 | $0.075 |
| | | Commercial Roof | 13 | 22 | $4.1 | $0.191 | $1.8 | $0.083 |
| | | Ground < 10 MW | 27 | 64 | $7.6 | $0.120 | $0.1 | $0.001 |
| | | Ground 10-20 MW | 76 | 183 | $20.9 | $0.114 | ($1.3) | ($0.007) |
| | Mountain | Residential Roof | 201 | 374 | $68.1 | $0.182 | $28.6 | $0.077 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Commercial Roof | 124 | 212 | $37.3 | $0.176 | $14.0 | $0.066 |
| | | Ground < 10 MW | 28 | 65 | $7.4 | $0.113 | $0.7 | $0.011 |
| | | Ground 10-20 MW | 52 | 115 | $15.0 | $0.130 | $2.7 | $0.024 |
| SDGE | South Coast | Residential Roof | 988 | 1,805 | $330.7 | $0.183 | $147.2 | $0.082 |
| | | Commercial Roof | 139 | 238 | $42.7 | $0.179 | $18.1 | $0.076 |
| | | Ground < 10 MW | 60 | 131 | $17.5 | $0.134 | $4.3 | $0.033 |
| | | Ground 10-20 MW | 358 | 785 | $96.9 | $0.123 | $17.0 | $0.022 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.182 | $0.6 | $0.090 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $1.2 | $0.117 | $0.2 | $0.022 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 9 | $1.0 | $0.109 | $0.1 | $0.014 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,656 | 33,404 | 5168 | 0.15 | 1384 | 0.04 |

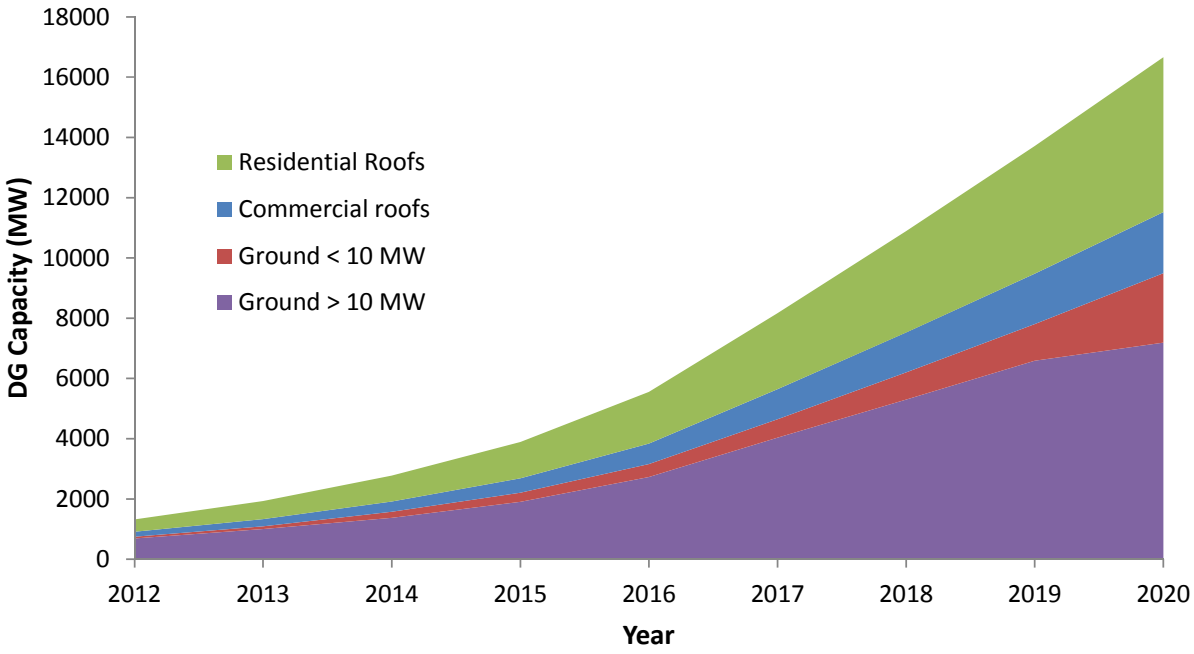
**Least Net Cost Summary Table, 1% Curtailment Interconnection Constraint**

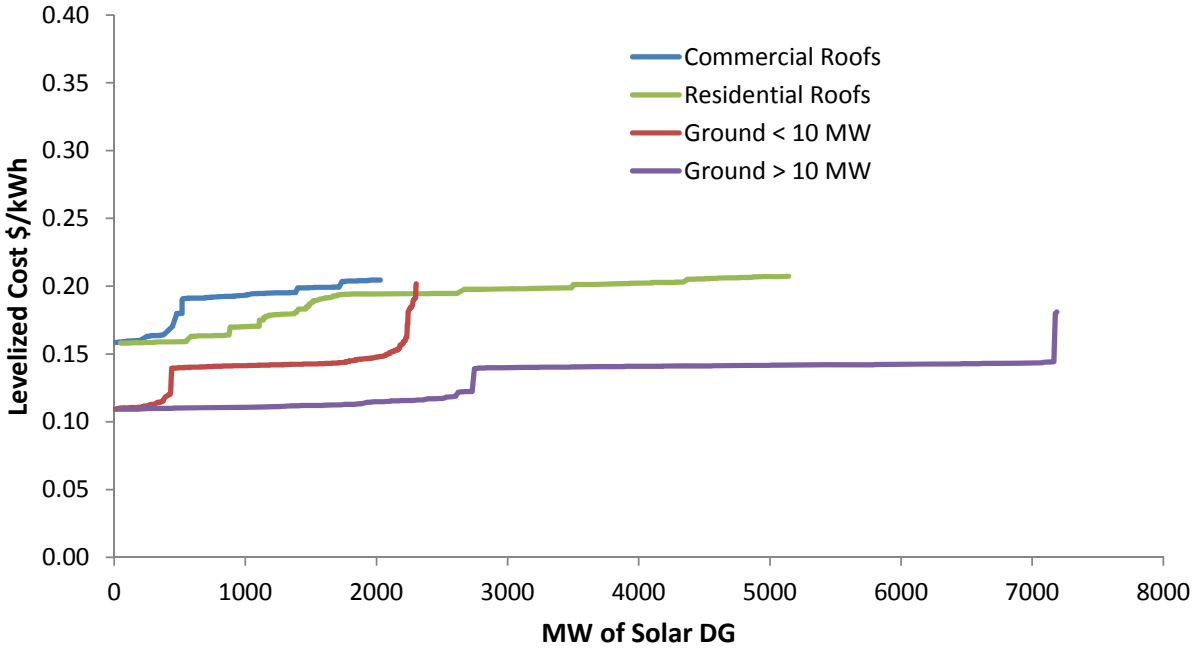
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 199 | 353 | $70.3 | $0.199 | $29.1 | $0.083 |
| | | Commercial Roof | 57 | 94 | $18.5 | $0.196 | $7.1 | $0.076 |
| | | Ground < 10 MW | 855 | 1,850 | $258.6 | $0.140 | $57.3 | $0.031 |
| | | Ground 10-20 MW | 1,028 | 2,213 | $299.2 | $0.135 | $61.5 | $0.028 |
| | North Central Valley | Residential Roof | 1,062 | 1,841 | $352.5 | $0.191 | $126.1 | $0.069 |
| | | Commercial Roof | 124 | 202 | $38.5 | $0.190 | $13.8 | $0.068 |
| | | Ground < 10 MW | 563 | 1,197 | $168.4 | $0.141 | $31.9 | $0.027 |
| | | Ground 10-20 MW | 2,411 | 5,075 | $659.8 | $0.130 | $53.7 | $0.011 |
| | South Central Valley | Residential Roof | 470 | 829 | $166.6 | $0.201 | $69.0 | $0.083 |
| | | Commercial Roof | 94 | 153 | $31.1 | $0.204 | $12.6 | $0.082 |
| | | Ground < 10 MW | 440 | 948 | $132.4 | $0.140 | $25.1 | $0.026 |
| | | Ground 10-20 MW | 546 | 1,169 | $158.2 | $0.135 | $25.6 | $0.022 |
| | Mountain | Residential Roof | 54 | 96 | $19.4 | $0.202 | $8.4 | $0.087 |
| | | Commercial Roof | 22 | 37 | $7.1 | $0.194 | $3.0 | $0.083 |
| | | Ground < 10 MW | 105 | 223 | $32.0 | $0.144 | $7.2 | $0.032 |
| | | Ground 10-20 MW | 82 | 176 | $24.7 | $0.141 | $4.8 | $0.028 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $1.3 | $0.127 | $0.3 | $0.030 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,914 | 5,321 | $1,004.8 | $0.189 | $365.3 | $0.069 |
| | | Commercial Roof | 1,335 | 2,287 | $422.8 | $0.185 | $158.4 | $0.069 |
| | | Ground < 10 MW | 269 | 638 | $79.4 | $0.124 | $8.5 | $0.013 |
| | | Ground 10-20 MW | 1,525 | 3,523 | $418.2 | $0.119 | $16.0 | $0.005 |
| | South Central Valley | Residential Roof | 418 | 757 | $143.2 | $0.189 | $45.8 | $0.060 |
| | | Commercial Roof | 182 | 303 | $56.7 | $0.187 | $12.7 | $0.042 |
| | | Ground < 10 MW | 99 | 236 | $28.8 | $0.122 | $3.0 | $0.013 |
| | | Ground 10-20 MW | 260 | 622 | $70.2 | $0.113 | $2.0 | $0.003 |
| | Desert | Residential Roof | 253 | 465 | $93.1 | $0.200 | $41.0 | $0.088 |
| | | Commercial Roof | 13 | 22 | $3.7 | $0.164 | $1.2 | $0.055 |
| | | Ground < 10 MW | 27 | 63 | $8.0 | $0.127 | $0.6 | $0.009 |
| | | Ground 10-20 MW | 76 | 182 | $21.3 | $0.117 | ($0.6) | ($0.003) |
| | Mountain | Residential Roof | 157 | 298 | $55.2 | $0.185 | $23.1 | $0.077 |
| | | Commercial Roof | 119 | 206 | $39.7 | $0.192 | $17.0 | $0.083 |
| | | Ground < 10 MW | 28 | 67 | $8.8 | $0.130 | $1.9 | $0.029 |
| | | Ground 10-20 MW | 52 | 117 | $14.9 | $0.128 | $2.6 | $0.022 |
| SDGE | South Coast | Residential Roof | 311 | 590 | $111.3 | $0.189 | $50.3 | $0.085 |
| | | Commercial Roof | 57 | 101 | $18.8 | $0.187 | $8.4 | $0.084 |
| | | Ground < 10 MW | 60 | 133 | $18.1 | $0.136 | $4.7 | $0.035 |
| | | Ground 10-20 MW | 358 | 806 | $104.3 | $0.129 | $22.5 | $0.028 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.4 | $0.187 | $0.7 | $0.092 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $1.3 | $0.126 | $0.3 | $0.031 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $1.2 | $0.124 | $0.3 | $0.029 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,642 | 33,231 | 5164 | 0.16 | 1323 | 0.04 |

**High Rooftop Summary Table, 1% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,681 | 2,984 | $601.5 | $0.202 | $274.7 | $0.092 |
| | | Commercial Roof | 262 | 435 | $86.1 | $0.198 | $37.6 | $0.086 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 2,087 | 3,709 | $731.8 | $0.197 | $295.4 | $0.080 |
| | | Commercial Roof | 304 | 506 | $100.1 | $0.198 | $42.2 | $0.083 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,205 | 2,137 | $423.4 | $0.198 | $178.6 | $0.084 |
| | | Commercial Roof | 119 | 197 | $38.9 | $0.197 | $15.7 | $0.080 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 210 | 373 | $75.1 | $0.201 | $33.3 | $0.089 |
| | | Commercial Roof | 22 | 36 | $7.2 | $0.198 | $3.2 | $0.088 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 4 | 8 | $1.4 | $0.175 | $0.6 | $0.077 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 5,440 | 9,877 | $1,858.1 | $0.188 | $727.8 | $0.074 |
| | | Commercial Roof | 1,654 | 2,805 | $524.5 | $0.187 | $204.2 | $0.073 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,035 | 1,893 | $356.9 | $0.189 | $135.8 | $0.072 |
| | | Commercial Roof | 171 | 292 | $55.3 | $0.190 | $12.3 | $0.042 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 399 | 729 | $139.0 | $0.191 | $56.7 | $0.078 |
| | | Commercial Roof | 13 | 22 | $3.9 | $0.179 | $1.6 | $0.072 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 259 | 474 | $89.1 | $0.188 | $39.4 | $0.083 |
| | | Commercial Roof | 122 | 207 | $35.1 | $0.170 | $12.3 | $0.060 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,512 | 2,729 | $503.0 | $0.184 | $224.7 | $0.082 |
| | | Commercial Roof | 158 | 268 | $47.9 | $0.179 | $20.3 | $0.076 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 7 | 13 | $2.4 | $0.181 | $1.1 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 4 | 8 | $1.5 | $0.183 | $0.7 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,669 | 29,703 | 5682 | 0.19 | 2318 | 0.08 |

## 3% Curtailment Interconnection Constraint



**Least Cost Summary Table, 3% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 50 | 90 | $17.6 | $0.195 | $7.8 | $0.087 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 801 | 1,691 | $240.2 | $0.142 | $52.0 | $0.031 |
| | | Ground 10-20 MW | 1,261 | 2,649 | $366.6 | $0.138 | $76.1 | $0.029 |
| | North Central Valley | Residential Roof | 37 | 67 | $12.7 | $0.189 | $5.0 | $0.074 |
| | | Commercial Roof | 30 | 50 | $9.7 | $0.193 | $4.4 | $0.087 |
| | | Ground < 10 MW | 514 | 1,075 | $153.0 | $0.142 | $26.4 | $0.025 |
| | | Ground 10-20 MW | 2,726 | 5,727 | $778.8 | $0.136 | $86.7 | $0.015 |
| | South Central Valley | Residential Roof | 58 | 105 | $20.5 | $0.196 | $8.5 | $0.082 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 427 | 907 | $128.9 | $0.142 | $24.5 | $0.027 |
| | | Ground 10-20 MW | 629 | 1,331 | $178.0 | $0.134 | $24.8 | $0.019 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 87 | 183 | $26.3 | $0.144 | $5.6 | $0.031 |
| | | Ground 10-20 MW | 113 | 237 | $33.6 | $0.142 | $6.6 | $0.028 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $1.3 | $0.112 | $0.1 | $0.012 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,182 | 5,779 | $1,099.4 | $0.190 | $416.6 | $0.072 |
| | | Commercial Roof | 1,546 | 2,606 | $494.4 | $0.190 | $191.6 | $0.074 |
| | | Ground < 10 MW | 251 | 580 | $70.8 | $0.122 | $4.5 | $0.008 |
| | | Ground 10-20 MW | 1,641 | 3,714 | $434.3 | $0.117 | $5.5 | $0.001 |
| | South Central Valley | Residential Roof | 536 | 978 | $188.1 | $0.192 | $76.1 | $0.078 |
| | | Commercial Roof | 170 | 287 | $54.7 | $0.191 | $12.1 | $0.042 |
| | | Ground < 10 MW | 101 | 231 | $29.3 | $0.127 | $3.7 | $0.016 |
| | | Ground 10-20 MW | 305 | 709 | $86.4 | $0.122 | $8.2 | $0.012 |
| | Desert | Residential Roof | 177 | 322 | $57.6 | $0.179 | $21.6 | $0.067 |
| | | Commercial Roof | 13 | 21 | $4.1 | $0.195 | $1.8 | $0.086 |
| | | Ground < 10 MW | 28 | 65 | $8.0 | $0.124 | $0.2 | $0.003 |
| | | Ground 10-20 MW | 84 | 199 | $23.1 | $0.116 | ($1.4) | ($0.007) |
| | Mountain | Residential Roof | 214 | 394 | $72.4 | $0.184 | $29.6 | $0.075 |
| | | Commercial Roof | 132 | 222 | $39.9 | $0.180 | $15.1 | $0.068 |
| | | Ground < 10 MW | 25 | 57 | $6.4 | $0.113 | $0.6 | $0.011 |
| | | Ground 10-20 MW | 56 | 122 | $16.4 | $0.134 | $3.3 | $0.027 |
| SDGE | South Coast | Residential Roof | 884 | 1,604 | $306.3 | $0.191 | $141.1 | $0.088 |
| | | Commercial Roof | 139 | 233 | $42.6 | $0.182 | $18.2 | $0.078 |
| | | Ground < 10 MW | 56 | 122 | $16.8 | $0.138 | $4.3 | $0.035 |
| | | Ground 10-20 MW | 372 | 802 | $100.2 | $0.125 | $17.2 | $0.022 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.185 | $0.6 | $0.091 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $1.3 | $0.111 | $0.2 | $0.015 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 11 | $1.2 | $0.110 | $0.2 | $0.014 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 16,662 | 33,197 | 5122 | 0.15 | 1299 | 0.04 |

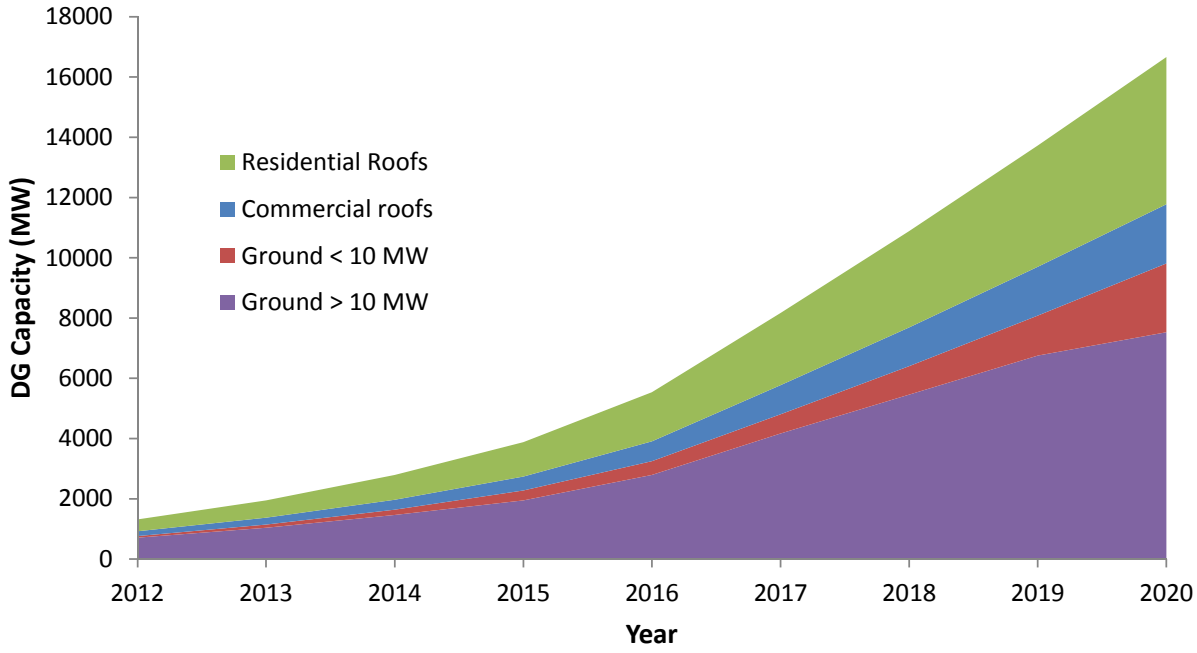
**Least Net Cost Summary Table, 3% Curtailment Interconnection Constraint**

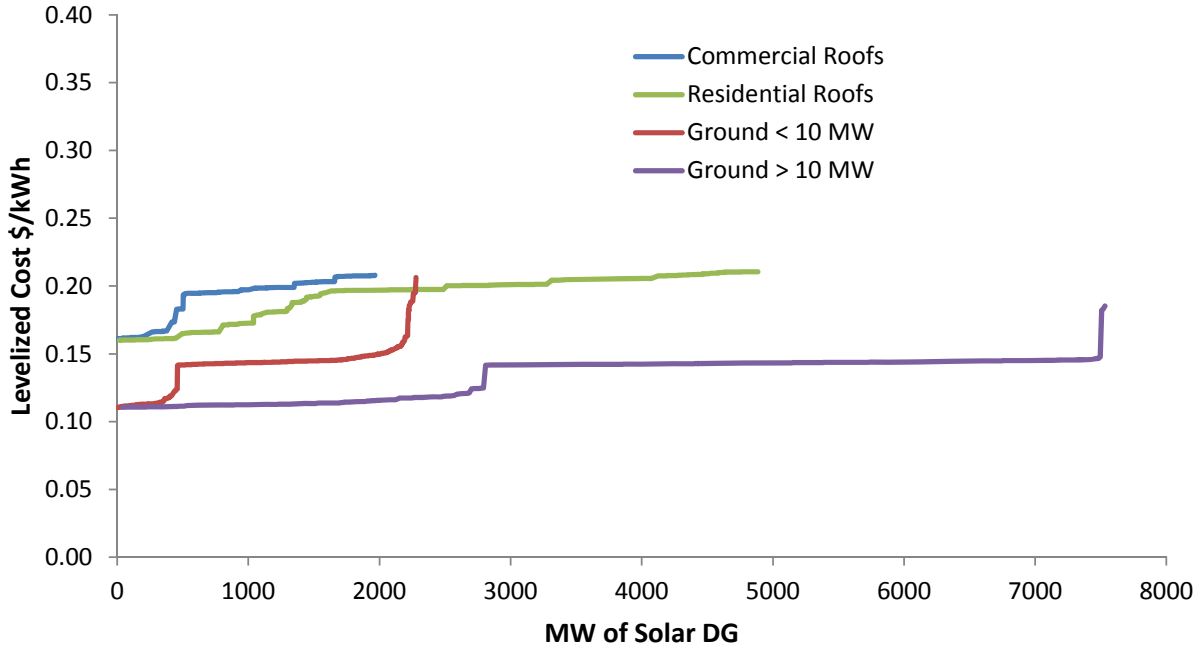
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 165 | 286 | $56.9 | $0.199 | $21.6 | $0.075 |
| | | Commercial Roof | 59 | 97 | $19.4 | $0.200 | $7.7 | $0.079 |
| | | Ground < 10 MW | 801 | 1,696 | $241.8 | $0.143 | $53.1 | $0.031 |
| | | Ground 10-20 MW | 1,261 | 2,668 | $367.4 | $0.138 | $75.2 | $0.028 |
| | North Central Valley | Residential Roof | 1,043 | 1,796 | $353.9 | $0.197 | $128.3 | $0.071 |
| | | Commercial Roof | 119 | 191 | $36.7 | $0.193 | $13.1 | $0.069 |
| | | Ground < 10 MW | 514 | 1,067 | $152.0 | $0.142 | $26.7 | $0.025 |
| | | Ground 10-20 MW | 2,726 | 5,646 | $752.2 | $0.133 | $69.1 | $0.012 |
| | South Central Valley | Residential Roof | 343 | 597 | $121.0 | $0.203 | $48.2 | $0.081 |
| | | Commercial Roof | 101 | 163 | $33.3 | $0.205 | $13.2 | $0.081 |
| | | Ground < 10 MW | 427 | 903 | $128.0 | $0.142 | $23.9 | $0.027 |
| | | Ground 10-20 MW | 629 | 1,329 | $181.5 | $0.137 | $28.5 | $0.021 |
| | Mountain | Residential Roof | 61 | 109 | $21.7 | $0.199 | $9.1 | $0.083 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 87 | 182 | $26.4 | $0.145 | $5.8 | $0.032 |
| | | Ground 10-20 MW | 113 | 236 | $33.8 | $0.143 | $6.7 | $0.029 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $1.5 | $0.129 | $0.4 | $0.030 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,611 | 4,704 | $900.6 | $0.191 | $309.8 | $0.066 |
| | | Commercial Roof | 1,220 | 2,060 | $386.6 | $0.188 | $141.4 | $0.069 |
| | | Ground < 10 MW | 251 | 585 | $73.7 | $0.126 | $7.0 | $0.012 |
| | | Ground 10-20 MW | 1,641 | 3,754 | $447.6 | $0.119 | $14.9 | $0.004 |
| | South Central Valley | Residential Roof | 491 | 876 | $164.5 | $0.188 | $47.7 | $0.054 |
| | | Commercial Roof | 146 | 238 | $44.8 | $0.188 | $7.7 | $0.032 |
| | | Ground < 10 MW | 101 | 233 | $29.9 | $0.128 | $3.9 | $0.017 |
| | | Ground 10-20 MW | 305 | 719 | $82.4 | $0.115 | $2.4 | $0.003 |
| | Desert | Residential Roof | 275 | 502 | $99.6 | $0.198 | $42.5 | $0.085 |
| | | Commercial Roof | 8 | 15 | $2.3 | $0.156 | $0.6 | $0.042 |
| | | Ground < 10 MW | 28 | 64 | $8.3 | $0.131 | $0.7 | $0.011 |
| | | Ground 10-20 MW | 84 | 198 | $23.6 | $0.119 | ($0.6) | ($0.003) |
| | Mountain | Residential Roof | 197 | 371 | $71.1 | $0.192 | $30.5 | $0.082 |
| | | Commercial Roof | 112 | 192 | $37.5 | $0.195 | $16.1 | $0.084 |
| | | Ground < 10 MW | 25 | 59 | $7.7 | $0.131 | $1.7 | $0.029 |
| | | Ground 10-20 MW | 56 | 125 | $16.1 | $0.129 | $2.8 | $0.023 |
| SDGE | South Coast | Residential Roof | 144 | 274 | $51.5 | $0.188 | $22.8 | $0.083 |
| | | Commercial Roof | 39 | 69 | $12.9 | $0.188 | $5.7 | $0.083 |
| | | Ground < 10 MW | 56 | 124 | $16.9 | $0.136 | $4.1 | $0.033 |
| | | Ground 10-20 MW | 372 | 824 | $108.2 | $0.131 | $23.2 | $0.028 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.4 | $0.185 | $0.6 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 13 | $1.6 | $0.127 | $0.4 | $0.030 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 11 | $1.4 | $0.126 | $0.3 | $0.029 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 16,630 | 32,992 | 5118 | 0.16 | 1217 | 0.04 |

**High Rooftop Summary Table, 3% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,395 | 2,457 | $497.2 | $0.202 | $224.6 | $0.091 |
| | | Commercial Roof | 206 | 337 | $67.4 | $0.200 | $28.8 | $0.085 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 1,783 | 3,144 | $624.7 | $0.199 | $248.8 | $0.079 |
| | | Commercial Roof | 280 | 463 | $92.0 | $0.199 | $38.6 | $0.083 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 985 | 1,731 | $347.4 | $0.201 | $145.3 | $0.084 |
| | | Commercial Roof | 89 | 145 | $29.0 | $0.199 | $11.7 | $0.081 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 212 | 372 | $75.6 | $0.203 | $33.2 | $0.089 |
| | | Commercial Roof | 22 | 36 | $7.2 | $0.198 | $3.1 | $0.085 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 5 | 10 | $1.7 | $0.179 | $0.8 | $0.078 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 6,138 | 10,999 | $2,112.8 | $0.192 | $840.2 | $0.076 |
| | | Commercial Roof | 1,656 | 2,768 | $526.8 | $0.190 | $205.1 | $0.074 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,164 | 2,102 | $403.2 | $0.192 | $151.4 | $0.072 |
| | | Commercial Roof | 163 | 272 | $51.7 | $0.190 | $10.5 | $0.039 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 414 | 747 | $143.0 | $0.191 | $56.9 | $0.076 |
| | | Commercial Roof | 13 | 21 | $4.2 | $0.197 | $1.9 | $0.088 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 303 | 546 | $103.0 | $0.189 | $44.6 | $0.082 |
| | | Commercial Roof | 130 | 216 | $38.0 | $0.176 | $14.1 | $0.065 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,553 | 2,772 | $509.8 | $0.184 | $223.1 | $0.080 |
| | | Commercial Roof | 156 | 261 | $47.7 | $0.183 | $20.5 | $0.079 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 7 | 14 | $2.5 | $0.183 | $1.2 | $0.089 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 5 | 9 | $1.7 | $0.185 | $0.8 | $0.089 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 16,678 | 29,423 | 5687 | 0.19 | 2305 | 0.08 |

## 5% Curtailment Interconnection Constraint



## Least Cost Summary Table, 5% Curtailment Interconnection Constraint

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 13 | 22 | $4.1 | $0.185 | $1.6 | $0.070 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 805 | 1,674 | $241.1 | $0.144 | $51.9 | $0.031 |
| | | Ground 10-20 MW | 1,346 | 2,785 | $391.9 | $0.141 | $81.6 | $0.029 |
| | North Central Valley | Residential Roof | 25 | 45 | $8.2 | $0.183 | $2.8 | $0.062 |
| | | Commercial Roof | 31 | 51 | $10.1 | $0.199 | $3.8 | $0.075 |
| | | Ground < 10 MW | 516 | 1,064 | $152.4 | $0.143 | $25.3 | $0.024 |
| | | Ground 10-20 MW | 2,816 | 5,841 | $803.6 | $0.138 | $90.1 | $0.015 |
| | South Central Valley | Residential Roof | 65 | 116 | $22.5 | $0.194 | $9.0 | $0.077 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 407 | 857 | $122.1 | $0.143 | $22.0 | $0.026 |
| | | Ground 10-20 MW | 701 | 1,449 | $198.9 | $0.137 | $28.4 | $0.020 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 88 | 184 | $26.3 | $0.143 | $5.3 | $0.029 |
| | | Ground 10-20 MW | 115 | 237 | $34.0 | $0.143 | $6.8 | $0.029 |
| SCE | North Coast | Residential Roof | 0 | 0 | $0.1 | $0.181 | $0.0 | $0.079 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $1.3 | $0.114 | $0.2 | $0.014 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,986 | 5,353 | $1,028.4 | $0.192 | $388.7 | $0.073 |
| | | Commercial Roof | 1,499 | 2,481 | $478.8 | $0.193 | $184.5 | $0.074 |
| | | Ground < 10 MW | 226 | 515 | $64.3 | $0.125 | $4.8 | $0.009 |
| | | Ground 10-20 MW | 1,717 | 3,832 | $458.7 | $0.120 | $8.6 | $0.002 |
| | South Central Valley | Residential Roof | 544 | 982 | $189.6 | $0.193 | $76.1 | $0.077 |
| | | Commercial Roof | 159 | 265 | $52.2 | $0.197 | $11.5 | $0.044 |
| | | Ground < 10 MW | 108 | 242 | $31.4 | $0.130 | $4.0 | $0.017 |
| | | Ground 10-20 MW | 322 | 736 | $91.3 | $0.124 | $8.9 | $0.012 |
| | Desert | Residential Roof | 182 | 328 | $62.4 | $0.190 | $25.1 | $0.077 |
| | | Commercial Roof | 13 | 21 | $4.2 | $0.198 | $1.8 | $0.088 |
| | | Ground < 10 MW | 26 | 60 | $7.4 | $0.123 | ($0.1) | ($0.002) |
| | | Ground 10-20 MW | 87 | 203 | $24.4 | $0.120 | ($0.7) | ($0.003) |
| | Mountain | Residential Roof | 186 | 337 | $62.6 | $0.185 | $25.6 | $0.076 |
| | | Commercial Roof | 139 | 230 | $41.1 | $0.179 | $15.0 | $0.065 |
| | | Ground < 10 MW | 25 | 58 | $7.3 | $0.126 | $1.3 | $0.023 |
| | | Ground 10-20 MW | 61 | 130 | $17.5 | $0.135 | $3.2 | $0.025 |
| SDGE | South Coast | Residential Roof | 881 | 1,575 | $311.1 | $0.198 | $145.7 | $0.093 |
| | | Commercial Roof | 126 | 208 | $38.6 | $0.185 | $16.4 | $0.079 |
| | | Ground < 10 MW | 62 | 134 | $17.6 | $0.131 | $3.6 | $0.027 |
| | | Ground 10-20 MW | 368 | 780 | $96.0 | $0.123 | $13.9 | $0.018 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.186 | $0.6 | $0.092 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 6 | 14 | $1.7 | $0.125 | $0.4 | $0.026 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $1.3 | $0.113 | $0.2 | $0.015 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,662 | 32,837 | 5106 | 0.16 | 1268 | 0.04 |

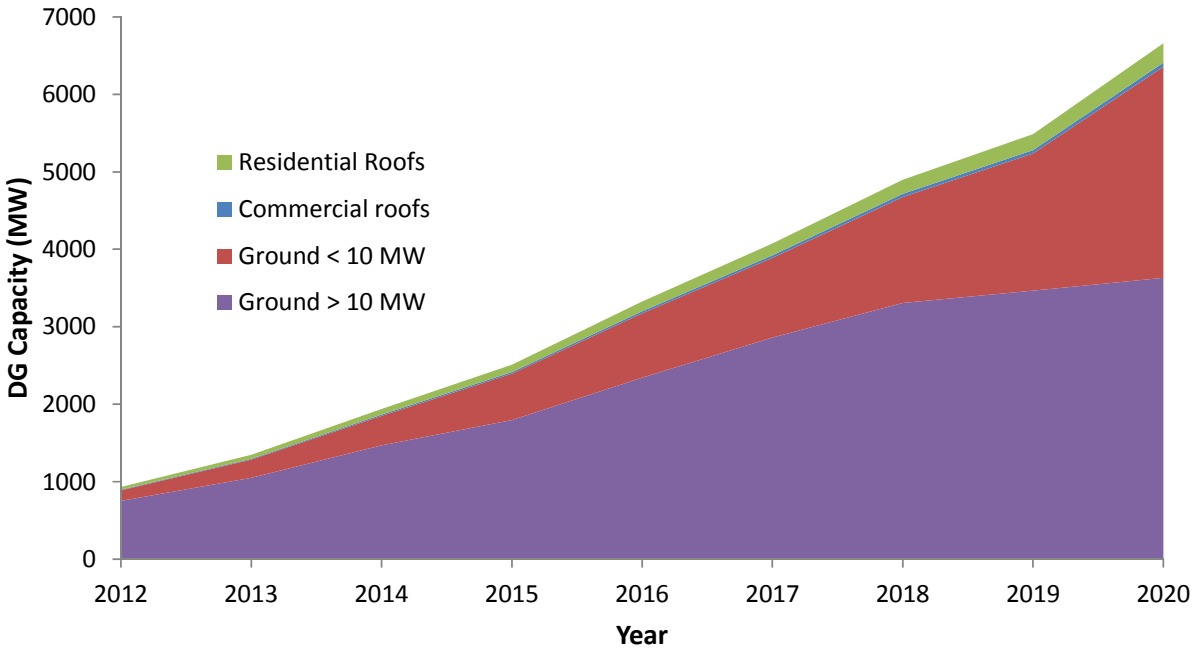
**Least Net Cost Summary Table, 5% Curtailment Interconnection Constraint**

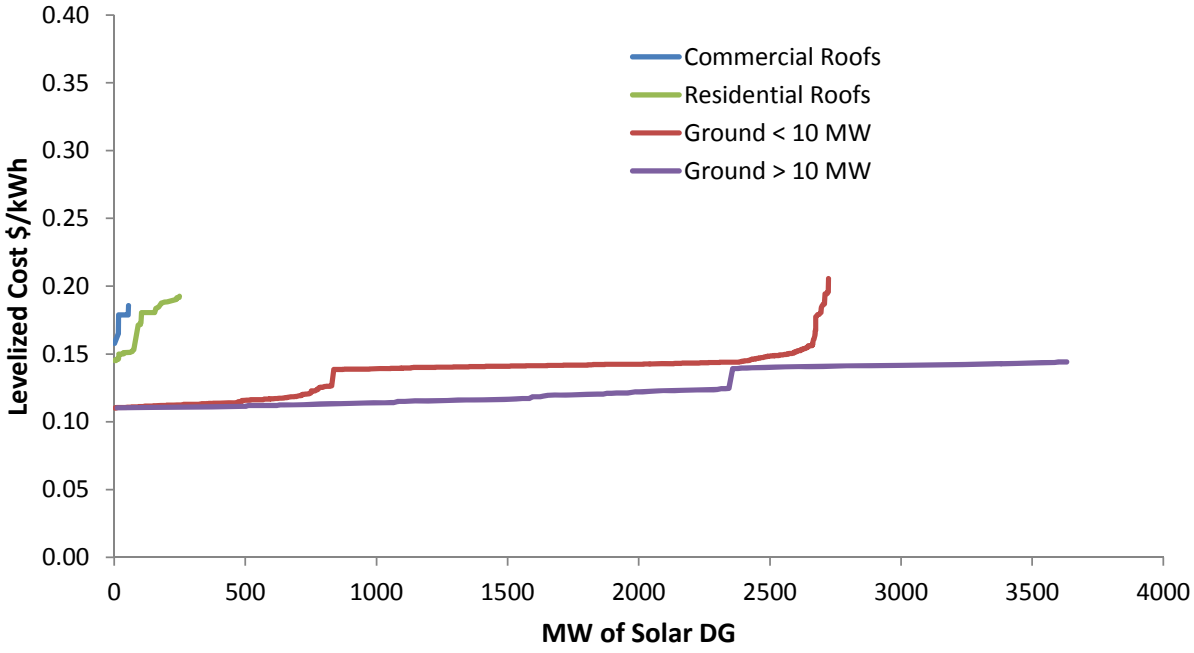
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 182 | 311 | $62.6 | $0.201 | $23.4 | $0.075 |
| | | Commercial Roof | 64 | 103 | $21.0 | $0.204 | $8.2 | $0.080 |
| | | Ground < 10 MW | 805 | 1,680 | $242.0 | $0.144 | $52.3 | $0.031 |
| | | Ground 10-20 MW | 1,346 | 2,807 | $391.6 | $0.140 | $79.6 | $0.028 |
| | North Central Valley | Residential Roof | 1,002 | 1,716 | $344.5 | $0.201 | $126.5 | $0.074 |
| | | Commercial Roof | 128 | 204 | $41.9 | $0.205 | $16.3 | $0.080 |
| | | Ground < 10 MW | 516 | 1,057 | $152.3 | $0.144 | $26.4 | $0.025 |
| | | Ground 10-20 MW | 2,816 | 5,762 | $778.2 | $0.135 | $73.6 | $0.013 |
| | South Central Valley | Residential Roof | 266 | 458 | $92.9 | $0.203 | $36.0 | $0.079 |
| | | Commercial Roof | 104 | 164 | $33.8 | $0.205 | $13.1 | $0.079 |
| | | Ground < 10 MW | 407 | 854 | $122.9 | $0.144 | $23.2 | $0.027 |
| | | Ground 10-20 MW | 701 | 1,442 | $201.0 | $0.139 | $31.0 | $0.021 |
| | Mountain | Residential Roof | 68 | 119 | $24.1 | $0.202 | $10.1 | $0.084 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 88 | 184 | $26.8 | $0.146 | $5.8 | $0.032 |
| | | Ground 10-20 MW | 115 | 236 | $34.1 | $0.144 | $7.0 | $0.029 |
| SCE | North Coast | Residential Roof | 0 | 0 | $0.1 | $0.190 | $0.0 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $1.5 | $0.130 | $0.3 | $0.029 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,649 | 4,707 | $912.7 | $0.194 | $307.9 | $0.065 |
| | | Commercial Roof | 974 | 1,613 | $308.4 | $0.191 | $107.2 | $0.066 |
| | | Ground < 10 MW | 226 | 519 | $66.6 | $0.128 | $6.9 | $0.013 |
| | | Ground 10-20 MW | 1,717 | 3,866 | $467.6 | $0.121 | $14.4 | $0.004 |
| | South Central Valley | Residential Roof | 530 | 931 | $180.3 | $0.194 | $52.1 | $0.056 |
| | | Commercial Roof | 136 | 217 | $40.8 | $0.188 | $5.5 | $0.025 |
| | | Ground < 10 MW | 108 | 245 | $32.0 | $0.130 | $4.1 | $0.017 |
| | | Ground 10-20 MW | 322 | 746 | $86.7 | $0.116 | $2.3 | $0.003 |
| | Desert | Residential Roof | 291 | 523 | $104.6 | $0.200 | $43.8 | $0.084 |
| | | Commercial Roof | 8 | 15 | $2.9 | $0.199 | $1.2 | $0.085 |
| | | Ground < 10 MW | 26 | 60 | $7.8 | $0.131 | $0.5 | $0.008 |
| | | Ground 10-20 MW | 87 | 203 | $24.4 | $0.120 | ($0.6) | ($0.003) |
| | Mountain | Residential Roof | 217 | 403 | $77.8 | $0.193 | $33.0 | $0.082 |
| | | Commercial Roof | 118 | 199 | $39.5 | $0.198 | $16.9 | $0.085 |
| | | Ground < 10 MW | 25 | 60 | $7.9 | $0.132 | $1.7 | $0.028 |
| | | Ground 10-20 MW | 61 | 132 | $17.4 | $0.132 | $3.0 | $0.023 |
| SDGE | South Coast | Residential Roof | 73 | 136 | $25.9 | $0.190 | $11.0 | $0.081 |
| | | Commercial Roof | 24 | 42 | $8.0 | $0.190 | $3.5 | $0.083 |
| | | Ground < 10 MW | 62 | 138 | $18.8 | $0.136 | $4.5 | $0.033 |
| | | Ground 10-20 MW | 368 | 803 | $107.1 | $0.133 | $22.8 | $0.028 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.4 | $0.186 | $0.6 | $0.088 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 6 | 14 | $1.9 | $0.130 | $0.4 | $0.031 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $1.6 | $0.129 | $0.4 | $0.030 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,649 | 32,700 | 5113 | 0.16 | 1176 | 0.04 |

**High Rooftop Summary Table, 5% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,283 | 2,230 | $454.3 | $0.204 | $201.4 | $0.090 |
| | | Commercial Roof | 143 | 232 | $46.8 | $0.202 | $19.7 | $0.085 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 1,745 | 3,044 | $623.1 | $0.205 | $256.1 | $0.084 |
| | | Commercial Roof | 223 | 364 | $73.2 | $0.201 | $30.9 | $0.085 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 860 | 1,495 | $303.8 | $0.203 | $126.7 | $0.085 |
| | | Commercial Roof | 78 | 126 | $25.5 | $0.202 | $10.3 | $0.082 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 220 | 384 | $78.6 | $0.205 | $34.3 | $0.089 |
| | | Commercial Roof | 22 | 35 | $7.2 | $0.203 | $3.1 | $0.087 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 6 | 10 | $1.9 | $0.181 | $0.8 | $0.079 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 6,408 | 11,316 | $2,202.0 | $0.195 | $870.6 | $0.077 |
| | | Commercial Roof | 1,659 | 2,725 | $528.0 | $0.194 | $205.7 | $0.075 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,230 | 2,185 | $426.3 | $0.195 | $158.2 | $0.072 |
| | | Commercial Roof | 159 | 262 | $52.7 | $0.201 | $12.3 | $0.047 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 424 | 755 | $144.9 | $0.192 | $56.0 | $0.074 |
| | | Commercial Roof | 13 | 21 | $3.9 | $0.183 | $1.6 | $0.074 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 318 | 565 | $107.6 | $0.190 | $46.2 | $0.082 |
| | | Commercial Roof | 131 | 214 | $37.7 | $0.176 | $13.4 | $0.063 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,573 | 2,766 | $516.8 | $0.187 | $225.5 | $0.082 |
| | | Commercial Roof | 157 | 258 | $47.9 | $0.185 | $20.4 | $0.079 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 8 | 14 | $2.6 | $0.185 | $1.3 | $0.090 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 5 | 10 | $1.9 | $0.189 | $0.9 | $0.091 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,666 | 29,013 | 5687 | 0.20 | 2295 | 0.08 |

## Low Adoption Rate



**Least Cost Summary Table, Low Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 851 | 1,838 | $254.2 | $0.138 | $26.2 | $0.014 |
| | | Ground 10-20 MW | 469 | 991 | $131.5 | $0.133 | $10.8 | $0.011 |
| | North Central Valley | Residential Roof | 1 | 2 | $0.4 | $0.188 | $0.1 | $0.059 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 848 | 1,819 | $246.4 | $0.135 | $9.3 | $0.005 |
| | | Ground 10-20 MW | 1,278 | 2,723 | $350.4 | $0.129 | ($12.1) | ($0.004) |
| | South Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 415 | 896 | $122.8 | $0.137 | $7.3 | $0.008 |
| | | Ground 10-20 MW | 273 | 581 | $75.1 | $0.129 | $2.3 | $0.004 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 101 | 216 | $30.5 | $0.141 | $2.8 | $0.013 |
| | | Ground 10-20 MW | 35 | 75 | $8.3 | $0.111 | ($1.1) | ($0.015) |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.7 | $0.110 | $0.0 | $0.002 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 135 | 266 | $47.5 | $0.179 | $14.3 | $0.054 |
| | | Commercial Roof | 40 | 73 | $12.9 | $0.178 | $3.9 | $0.053 |
| | | Ground < 10 MW | 273 | 627 | $78.0 | $0.124 | $1.6 | $0.003 |
| | | Ground 10-20 MW | 1,074 | 2,430 | $291.3 | $0.120 | ($6.5) | ($0.003) |
| | South Central Valley | Residential Roof | 51 | 102 | $16.4 | $0.161 | $4.3 | $0.042 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 74 | 173 | $22.4 | $0.130 | $1.7 | $0.010 |
| | | Ground 10-20 MW | 173 | 401 | $46.2 | $0.115 | ($2.0) | ($0.005) |
| | Desert | Residential Roof | 9 | 18 | $2.9 | $0.160 | $0.8 | $0.041 |
| | | Commercial Roof | 13 | 23 | $3.8 | $0.164 | $1.0 | $0.043 |
| | | Ground < 10 MW | 41 | 98 | $12.0 | $0.123 | ($0.1) | ($0.001) |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.7) | ($0.011) |
| | Mountain | Residential Roof | 39 | 77 | $13.3 | $0.172 | $4.5 | $0.059 |
| | | Commercial Roof | 1 | 1 | $0.2 | $0.158 | $0.0 | $0.032 |
| | | Ground < 10 MW | 29 | 68 | $8.0 | $0.118 | $0.1 | $0.002 |
| | | Ground 10-20 MW | 50 | 109 | $12.7 | $0.117 | $0.6 | $0.005 |
| SDGE | South Coast | Residential Roof | 10 | 19 | $3.6 | $0.188 | $1.4 | $0.075 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 85 | 188 | $23.4 | $0.124 | $1.8 | $0.010 |
| | | Ground 10-20 MW | 252 | 543 | $64.7 | $0.119 | $4.7 | $0.009 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.1 | $0.145 | $0.3 | $0.039 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.4 | $0.114 | $0.0 | $0.012 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.121 | $0.1 | $0.020 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,659 | 14,448 | 1890 | 0.13 | 77 | 0.01 |

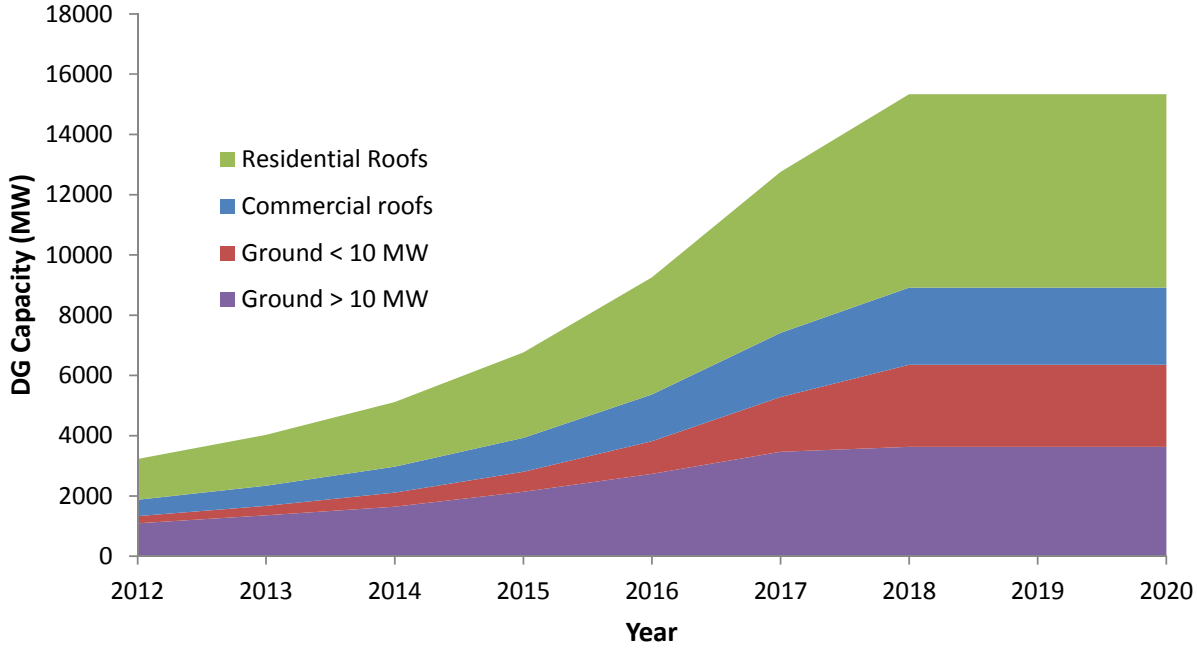
**Least Net Cost Summary Table, Low Adoption Rate**

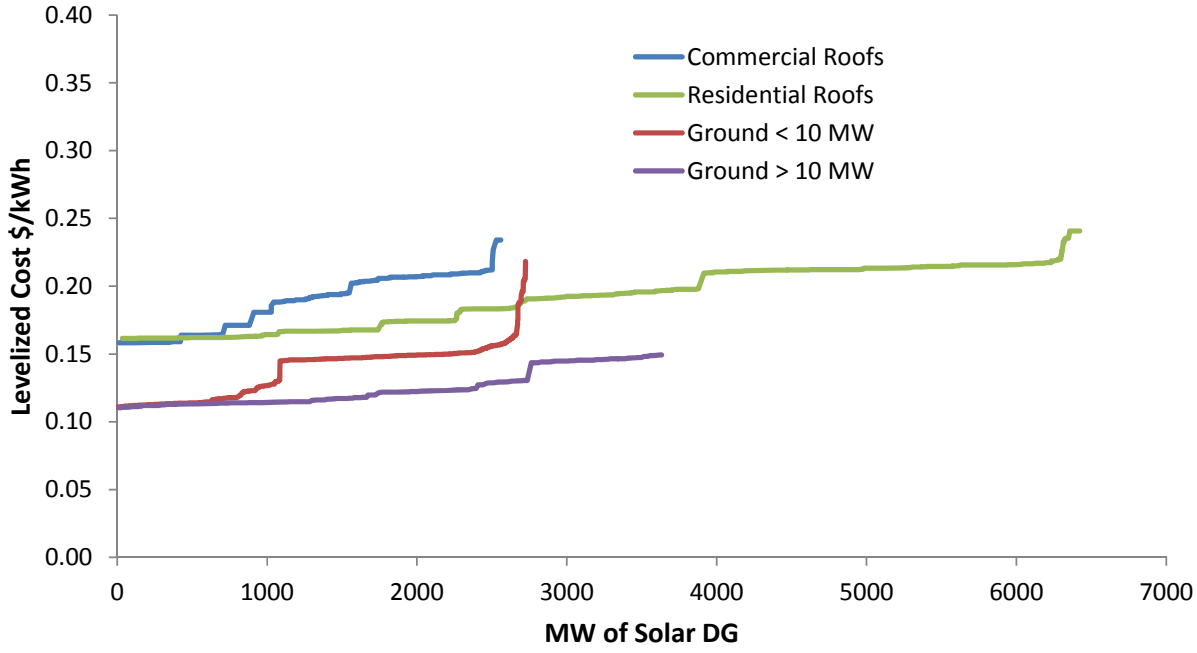
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 793 | 1,732 | $237.5 | $0.137 | $22.2 | $0.013 |
| | | Ground 10-20 MW | 469 | 1,004 | $138.4 | $0.138 | $15.3 | $0.015 |
| | North Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 808 | 1,726 | $227.8 | $0.132 | $4.6 | $0.003 |
| | | Ground 10-20 MW | 1,278 | 2,671 | $326.3 | $0.122 | ($23.7) | ($0.009) |
| | South Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 393 | 847 | $111.9 | $0.132 | $3.0 | $0.004 |
| | | Ground 10-20 MW | 273 | 582 | $74.0 | $0.127 | $1.1 | $0.002 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 92 | 196 | $28.2 | $0.143 | $3.1 | $0.016 |
| | | Ground 10-20 MW | 35 | 75 | $8.3 | $0.111 | ($1.1) | ($0.015) |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.8 | $0.129 | $0.1 | $0.019 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 239 | 432 | $79.2 | $0.183 | ($2.4) | ($0.006) |
| | | Commercial Roof | 93 | 158 | $29.5 | $0.187 | ($1.1) | ($0.007) |
| | | Ground < 10 MW | 265 | 618 | $78.5 | $0.127 | $2.5 | $0.004 |
| | | Ground 10-20 MW | 1,074 | 2,461 | $300.5 | $0.122 | ($4.3) | ($0.002) |
| | South Central Valley | Residential Roof | 47 | 86 | $16.8 | $0.194 | $1.3 | $0.015 |
| | | Commercial Roof | 94 | 160 | $29.7 | $0.186 | ($0.9) | ($0.005) |
| | | Ground < 10 MW | 71 | 167 | $20.5 | $0.123 | $0.1 | $0.001 |
| | | Ground 10-20 MW | 173 | 402 | $48.2 | $0.120 | ($0.1) | ($0.000) |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 38 | 90 | $11.3 | $0.125 | $0.0 | $0.000 |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.7) | ($0.011) |
| | Mountain | Residential Roof | 2 | 5 | $0.8 | $0.171 | $0.1 | $0.027 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 29 | 70 | $9.0 | $0.129 | $0.7 | $0.010 |
| | | Ground 10-20 MW | 50 | 114 | $14.8 | $0.130 | $1.6 | $0.014 |
| SDGE | South Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 72 | 165 | $21.5 | $0.130 | $2.2 | $0.013 |
| | | Ground 10-20 MW | 235 | 533 | $69.0 | $0.130 | $8.1 | $0.015 |
| | South Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.127 | $0.1 | $0.020 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.124 | $0.1 | $0.015 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,658 | 14,379 | 1892 | 0.13 | 32 | 0.00 |

**High Rooftop Summary Table, Low Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 103 | 191 | $36.0 | $0.188 | $12.8 | $0.067 |
| | North Central Valley | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 265 | 490 | $92.7 | $0.189 | $31.3 | $0.064 |
| | South Central Valley | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 119 | 220 | $40.4 | $0.184 | $11.7 | $0.053 |
| | Mountain | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 4 | 8 | $1.4 | $0.179 | $0.4 | $0.052 |
| SCE | North Coast | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 3 | 6 | $1.0 | $0.174 | $0.4 | $0.067 |
| | South Coast | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 2,651<br>1,452 | 4,938<br>2,481 | $892.8<br>$451.3 | $0.181<br>$0.182 | $259.9<br>$129.5 | $0.053<br>$0.052 |
| | South Central Valley | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 515<br>183 | 971<br>313 | $177.0<br>$58.7 | $0.182<br>$0.187 | $55.7<br>$8.3 | $0.057<br>$0.026 |
| | Desert | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 185<br>32 | 345<br>54 | $61.5<br>$10.1 | $0.178<br>$0.187 | $18.6<br>$3.3 | $0.054<br>$0.062 |
| | Mountain | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 116<br>107 | 218<br>180 | $38.7<br>$32.0 | $0.177<br>$0.178 | $13.3<br>$10.5 | $0.061<br>$0.058 |
| SDGE | South Coast | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 764<br>152 | 1,411<br>260 | $254.1<br>$47.0 | $0.180<br>$0.181 | $92.3<br>$17.0 | $0.065<br>$0.065 |
| | South Central Valley | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 6 | 11 | $2.0 | $0.180 | $0.9 | $0.081 |
| | Desert | Residential Roof<br>Commercial Roof<br>Ground < 10 MW<br>Ground 10-20 MW | 2 | 5 | $0.9 | $0.181 | $0.4 | $0.080 |
| | Totals | | 6,658 | 12,102 | 2198 | 0.18 | 666 | 0.06 |

## High Adoption Rate



**Least Cost Summary Table, High Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,454 | $307.2 | $0.211 | $152.7 | $0.105 |
| | | Commercial Roof | 257 | 418 | $87.1 | $0.208 | $41.7 | $0.100 |
| | | Ground < 10 MW | 851 | 1,809 | $252.3 | $0.139 | $61.7 | $0.034 |
| | | Ground 10-20 MW | 469 | 983 | $125.7 | $0.128 | $24.1 | $0.024 |
| | North Central Valley | Residential Roof | 1,026 | 1,765 | $376.8 | $0.213 | $173.2 | $0.098 |
| | | Commercial Roof | 310 | 499 | $105.3 | $0.211 | $49.9 | $0.100 |
| | | Ground < 10 MW | 848 | 1,793 | $250.9 | $0.140 | $50.5 | $0.028 |
| | | Ground 10-20 MW | 1,278 | 2,696 | $340.2 | $0.126 | $29.5 | $0.011 |
| | South Central Valley | Residential Roof | 404 | 702 | $148.3 | $0.211 | $70.4 | $0.100 |
| | | Commercial Roof | 154 | 251 | $52.5 | $0.209 | $24.6 | $0.098 |
| | | Ground < 10 MW | 415 | 882 | $124.0 | $0.140 | $26.5 | $0.030 |
| | | Ground 10-20 MW | 273 | 575 | $74.8 | $0.130 | $13.0 | $0.023 |
| | Mountain | Residential Roof | 64 | 110 | $23.7 | $0.215 | $11.4 | $0.103 |
| | | Commercial Roof | 21 | 35 | $7.3 | $0.209 | $3.5 | $0.101 |
| | | Ground < 10 MW | 101 | 212 | $29.5 | $0.139 | $6.3 | $0.030 |
| | | Ground 10-20 MW | 35 | 74 | $8.5 | $0.115 | $0.5 | $0.006 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.7 | $0.114 | $0.1 | $0.021 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,350 | $775.1 | $0.178 | $297.0 | $0.068 |
| | | Commercial Roof | 1,358 | 2,266 | $403.3 | $0.178 | $147.0 | $0.065 |
| | | Ground < 10 MW | 273 | 623 | $77.0 | $0.124 | $9.7 | $0.016 |
| | | Ground 10-20 MW | 1,074 | 2,419 | $297.2 | $0.123 | $30.8 | $0.013 |
| | South Central Valley | Residential Roof | 417 | 745 | $133.8 | $0.180 | $53.1 | $0.071 |
| | | Commercial Roof | 200 | 334 | $57.9 | $0.174 | $11.2 | $0.034 |
| | | Ground < 10 MW | 74 | 171 | $22.1 | $0.129 | $4.0 | $0.023 |
| | | Ground 10-20 MW | 173 | 400 | $46.8 | $0.117 | $3.8 | $0.009 |
| | Desert | Residential Roof | 177 | 315 | $55.2 | $0.175 | $22.0 | $0.070 |
| | | Commercial Roof | 37 | 61 | $10.7 | $0.174 | $4.1 | $0.067 |
| | | Ground < 10 MW | 41 | 97 | $12.2 | $0.126 | $1.5 | $0.015 |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.1) | ($0.001) |
| | Mountain | Residential Roof | 128 | 234 | $41.8 | $0.179 | $18.3 | $0.078 |
| | | Commercial Roof | 67 | 111 | $20.3 | $0.183 | $8.7 | $0.079 |
| | | Ground < 10 MW | 29 | 67 | $8.2 | $0.122 | $1.3 | $0.020 |
| | | Ground 10-20 MW | 50 | 108 | $13.1 | $0.121 | $2.7 | $0.025 |
| SDGE | South Coast | Residential Roof | 909 | 1,577 | $291.9 | $0.185 | $138.8 | $0.088 |
| | | Commercial Roof | 154 | 255 | $48.3 | $0.190 | $23.2 | $0.091 |
| | | Ground < 10 MW | 85 | 187 | $22.8 | $0.122 | $4.1 | $0.022 |
| | | Ground 10-20 MW | 252 | 538 | $66.5 | $0.124 | $14.9 | $0.028 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.3 | $0.182 | $0.7 | $0.093 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.119 | $0.1 | $0.029 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.6 | $0.130 | $0.2 | $0.042 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 15,336 | 29,208 | 4730 | 0.16 | 1537 | 0.05 |

**Least Net Cost Summary Table, High Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,449 | $295.3 | $0.204 | $141.5 | $0.098 |
| | | Commercial Roof | 257 | 416 | $84.7 | $0.204 | $39.6 | $0.095 |
| | | Ground < 10 MW | 851 | 1,815 | $259.4 | $0.143 | $68.1 | $0.038 |
| | | Ground 10-20 MW | 469 | 990 | $139.6 | $0.141 | $37.2 | $0.038 |
| | North Central Valley | Residential Roof | 1,026 | 1,693 | $337.3 | $0.199 | $144.0 | $0.085 |
| | | Commercial Roof | 297 | 474 | $93.7 | $0.198 | $41.1 | $0.087 |
| | | Ground < 10 MW | 848 | 1,778 | $238.5 | $0.134 | $40.3 | $0.023 |
| | | Ground 10-20 MW | 1,278 | 2,653 | $328.8 | $0.124 | $25.3 | $0.010 |
| | South Central Valley | Residential Roof | 404 | 689 | $130.4 | $0.189 | $54.1 | $0.079 |
| | | Commercial Roof | 154 | 249 | $47.6 | $0.191 | $20.0 | $0.081 |
| | | Ground < 10 MW | 415 | 878 | $114.8 | $0.131 | $17.9 | $0.020 |
| | | Ground 10-20 MW | 273 | 576 | $71.8 | $0.125 | $10.0 | $0.017 |
| | Mountain | Residential Roof | 64 | 109 | $19.5 | $0.179 | $7.3 | $0.068 |
| | | Commercial Roof | 21 | 35 | $7.3 | $0.209 | $3.5 | $0.101 |
| | | Ground < 10 MW | 101 | 211 | $27.3 | $0.129 | $4.3 | $0.020 |
| | | Ground 10-20 MW | 35 | 75 | $8.4 | $0.113 | $0.3 | $0.005 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $0.8 | $0.136 | $0.3 | $0.041 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,483 | 4,427 | $823.5 | $0.186 | $333.8 | $0.075 |
| | | Commercial Roof | 1,328 | 2,224 | $402.4 | $0.181 | $154.9 | $0.070 |
| | | Ground < 10 MW | 273 | 628 | $78.1 | $0.124 | $10.1 | $0.016 |
| | | Ground 10-20 MW | 1,074 | 2,444 | $298.9 | $0.122 | $28.7 | $0.012 |
| | South Central Valley | Residential Roof | 414 | 746 | $138.7 | $0.186 | $57.7 | $0.077 |
| | | Commercial Roof | 202 | 333 | $63.6 | $0.191 | $17.8 | $0.054 |
| | | Ground < 10 MW | 74 | 172 | $21.5 | $0.125 | $3.2 | $0.019 |
| | | Ground 10-20 MW | 173 | 400 | $46.9 | $0.117 | $3.9 | $0.010 |
| | Desert | Residential Roof | 168 | 297 | $54.5 | $0.183 | $23.3 | $0.078 |
| | | Commercial Roof | 46 | 77 | $13.6 | $0.176 | $5.3 | $0.068 |
| | | Ground < 10 MW | 41 | 97 | $12.1 | $0.124 | $1.3 | $0.013 |
| | | Ground 10-20 MW | 29 | 69 | $8.2 | $0.119 | ($0.1) | ($0.001) |
| | Mountain | Residential Roof | 128 | 236 | $42.9 | $0.182 | $19.1 | $0.081 |
| | | Commercial Roof | 67 | 113 | $19.5 | $0.172 | $7.5 | $0.066 |
| | | Ground < 10 MW | 29 | 69 | $8.7 | $0.126 | $1.5 | $0.022 |
| | | Ground 10-20 MW | 50 | 112 | $13.6 | $0.122 | $2.5 | $0.023 |
| SDGE | South Coast | Residential Roof | 909 | 1,637 | $317.0 | $0.194 | $155.6 | $0.095 |
| | | Commercial Roof | 154 | 261 | $50.9 | $0.195 | $24.9 | $0.095 |
| | | Ground < 10 MW | 85 | 190 | $26.1 | $0.138 | $7.2 | $0.038 |
| | | Ground 10-20 MW | 252 | 555 | $74.2 | $0.134 | $20.1 | $0.036 |
| | South Central Valley | Residential Roof | 4 | 7 | $1.2 | $0.168 | $0.5 | $0.077 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.5 | $0.133 | $0.2 | $0.041 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $0.7 | $0.134 | $0.2 | $0.041 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 15,322 | 29,200 | 4723 | 0.16 | 1534 | 0.05 |

## High Rooftop Summary Table, High Adoption Rate

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,780 | 3,071 | $638.0 | $0.208 | $311.9 | $0.102 |
| | | Commercial Roof | 278 | 452 | $94.1 | $0.208 | $45.3 | $0.100 |
| | | Ground < 10 MW | 315 | 682 | $93.1 | $0.137 | $23.8 | $0.035 |
| | | Ground 10-20 MW | 210 | 441 | $58.1 | $0.132 | $13.0 | $0.029 |
| | North Central Valley | Residential Roof | 2,450 | 4,220 | $874.0 | $0.207 | $390.7 | $0.093 |
| | | Commercial Roof | 359 | 579 | $121.6 | $0.210 | $57.6 | $0.099 |
| | | Ground < 10 MW | 373 | 796 | $109.2 | $0.137 | $19.0 | $0.024 |
| | | Ground 10-20 MW | 599 | 1,267 | $162.0 | $0.128 | $15.7 | $0.012 |
| | South Central Valley | Residential Roof | 1,097 | 1,899 | $394.3 | $0.208 | $182.7 | $0.096 |
| | | Commercial Roof | 122 | 199 | $41.1 | $0.206 | $18.6 | $0.093 |
| | | Ground < 10 MW | 110 | 238 | $32.1 | $0.134 | $6.9 | $0.029 |
| | | Ground 10-20 MW | 41 | 88 | $11.6 | $0.133 | $2.7 | $0.031 |
| | Mountain | Residential Roof | 214 | 369 | $77.2 | $0.209 | $36.4 | $0.099 |
| | | Commercial Roof | 21 | 35 | $7.2 | $0.203 | $3.4 | $0.095 |
| | | Ground < 10 MW | 13 | 28 | $3.7 | $0.133 | $0.7 | $0.024 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 3 | 6 | $1.1 | $0.188 | $0.6 | $0.096 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,644 | 6,538 | $1,160.5 | $0.177 | $443.4 | $0.068 |
| | | Commercial Roof | 1,499 | 2,510 | $451.8 | $0.180 | $171.7 | $0.068 |
| | | Ground < 10 MW | 96 | 217 | $27.1 | $0.125 | $2.3 | $0.011 |
| | | Ground 10-20 MW | 193 | 438 | $54.2 | $0.124 | $1.7 | $0.004 |
| | South Central Valley | Residential Roof | 708 | 1,285 | $226.6 | $0.176 | $86.2 | $0.067 |
| | | Commercial Roof | 184 | 309 | $54.3 | $0.176 | $10.5 | $0.034 |
| | | Ground < 10 MW | 9 | 21 | $2.9 | $0.139 | $0.4 | $0.021 |
| | | Ground 10-20 MW | 12 | 30 | $3.4 | $0.113 | $0.9 | $0.029 |
| | Desert | Residential Roof | 261 | 471 | $84.1 | $0.179 | $33.2 | $0.071 |
| | | Commercial Roof | 32 | 53 | $9.1 | $0.171 | $3.4 | $0.063 |
| | | Ground < 10 MW | 6 | 16 | $1.8 | $0.115 | $0.1 | $0.008 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 167 | 304 | $53.1 | $0.175 | $23.0 | $0.076 |
| | | Commercial Roof | 107 | 178 | $32.1 | $0.181 | $13.7 | $0.077 |
| | | Ground < 10 MW | 16 | 39 | $4.8 | $0.125 | $0.7 | $0.018 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,221 | 2,152 | $395.4 | $0.184 | $186.6 | $0.087 |
| | | Commercial Roof | 183 | 303 | $56.6 | $0.187 | $26.8 | $0.088 |
| | | Ground < 10 MW | 18 | 40 | $4.9 | $0.123 | $1.0 | $0.024 |
| | | Ground 10-20 MW | 16 | 34 | $4.0 | $0.118 | $0.7 | $0.022 |
| | South Central Valley | Residential Roof | 6 | 11 | $2.0 | $0.180 | $1.0 | $0.091 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $0.9 | $0.181 | $0.4 | $0.091 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,366 | 29,325 | 5348 | 0.18 | 2137 | 0.07 |

# 100% Learning Curve Results By County

## Least Cost Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 122 | 214 | $97.2 | $0.455 | $74.2 | $0.347 |
| | Commercial Roof | 298 | 493 | $214.9 | $0.436 | $161.7 | $0.328 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.344 | $0.0 | $0.237 |
| | Ground 1-3 MW | 2 | 5 | $1.5 | $0.323 | $1.0 | $0.217 |
| | Ground 3-5 MW | 20 | 44 | $13.8 | $0.309 | $9.1 | $0.204 |
| | Ground 5-10 MW | 53 | 115 | $34.3 | $0.298 | $22.1 | $0.192 |
| | Ground 10-20 MW | 39 | 84 | $24.5 | $0.292 | $15.5 | $0.185 |
| Amador | Residential Roof | 4 | 7 | $3.2 | $0.448 | $2.5 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 9 | 19 | $5.8 | $0.310 | $3.9 | $0.205 |
| | Ground 5-10 MW | 11 | 24 | $7.1 | $0.299 | $4.6 | $0.194 |
| | Ground 10-20 MW | 11 | 23 | $6.6 | $0.290 | $4.2 | $0.184 |
| Butte | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.8 | $0.349 | $0.5 | $0.243 |
| | Ground 1-3 MW | 5 | 10 | $3.5 | $0.331 | $2.4 | $0.226 |
| | Ground 3-5 MW | 28 | 61 | $19.3 | $0.317 | $12.8 | $0.211 |
| | Ground 5-10 MW | 77 | 163 | $49.8 | $0.306 | $32.6 | $0.200 |
| | Ground 10-20 MW | 79 | 166 | $49.7 | $0.300 | $32.1 | $0.194 |
| Calaveras | Residential Roof | 1 | 1 | $0.6 | $0.448 | $0.5 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.338 | $0.5 | $0.233 |
| | Ground 1-3 MW | 7 | 15 | $4.9 | $0.319 | $3.3 | $0.212 |
| | Ground 3-5 MW | 4 | 8 | $2.4 | $0.310 | $1.6 | $0.207 |
| | Ground 5-10 MW | 7 | 14 | $4.3 | $0.299 | $2.8 | $0.195 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 13 | $4.2 | $0.332 | $2.9 | $0.226 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 11 | 23 | $7.3 | $0.315 | $4.9 | $0.211 |
| | Ground 5-10 MW | 25 | 54 | $16.3 | $0.303 | $10.6 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 437 | 769 | $346.9 | $0.451 | $263.5 | $0.343 |
| | Commercial Roof | 111 | 184 | $80.2 | $0.437 | $60.1 | $0.327 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 8 | 18 | $5.6 | $0.312 | $3.7 | $0.205 |
| | Ground 5-10 MW | 6 | 13 | $3.8 | $0.300 | $2.5 | $0.197 |
| | Ground 10-20 MW | 117 | 250 | $73.1 | $0.293 | $47.1 | $0.188 |
| El Dorado | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.343 | $0.5 | $0.238 |
| | Ground 1-3 MW | 5 | 12 | $3.7 | $0.321 | $2.5 | $0.215 |
| | Ground 3-5 MW | 6 | 13 | $4.2 | $0.308 | $2.7 | $0.203 |
| | Ground 5-10 MW | 31 | 67 | $20.1 | $0.300 | $13.0 | $0.195 |
| | Ground 10-20 MW | 51 | 108 | $32.0 | $0.295 | $20.5 | $0.189 |
| Fresno | Residential Roof | 272 | 484 | $212.9 | $0.440 | $161.4 | $0.334 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 10 | 23 | $7.2 | $0.316 | $4.8 | $0.211 |
| | Ground 3-5 MW | 22 | 50 | $14.9 | $0.300 | $9.8 | $0.197 |
| | Ground 5-10 MW | 138 | 303 | $82.5 | $0.272 | $51.2 | $0.169 |
| | Ground 10-20 MW | 418 | 910 | $247.4 | $0.272 | $152.1 | $0.167 |
| Glenn | Residential Roof | 10 | 15 | $6.7 | $0.455 | $5.1 | $0.346 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 9 | 19 | $6.1 | $0.327 | $4.1 | $0.220 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 19 | $5.6 | $0.304 | $3.7 | $0.197 |
| | Ground 10-20 MW | | | | | | |
| Humboldt | Residential Roof | 11 | 18 | $9.1 | $0.504 | $7.1 | $0.391 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 5 | $2.0 | $0.423 | $1.5 | $0.312 |
| | Ground 1-3 MW | 16 | 26 | $11.1 | $0.424 | $8.3 | $0.315 |
| | Ground 3-5 MW | 10 | 17 | $6.9 | $0.409 | $5.1 | $0.302 |
| | Ground 5-10 MW | 19 | 31 | $12.4 | $0.393 | $9.0 | $0.285 |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

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|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.208 | $0.0 | $0.109 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 11 | $2.1 | $0.192 | $1.1 | $0.099 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 73 | 133 | $51.4 | $0.385 | $37.7 | $0.283 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 8 | $1.8 | $0.230 | $1.0 | $0.133 |
| | Ground 1-3 MW | 37 | 85 | $24.4 | $0.286 | $15.9 | $0.186 |
| | Ground 3-5 MW | 69 | 159 | $43.7 | $0.274 | $27.8 | $0.175 |
| | Ground 5-10 MW | 198 | 443 | $102.3 | $0.231 | $57.5 | $0.130 |
| | Ground 10-20 MW | 288 | 633 | $131.9 | $0.208 | $66.6 | $0.105 |
| Kings | Residential Roof | 12 | 22 | $9.4 | $0.429 | $7.1 | $0.323 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $1.5 | $0.328 | $1.0 | $0.225 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 21 | 47 | $13.9 | $0.298 | $9.2 | $0.196 |
| | Ground 5-10 MW | 27 | 59 | $16.9 | $0.288 | $10.8 | $0.185 |
| | Ground 10-20 MW | 30 | 66 | $13.8 | $0.210 | $7.0 | $0.106 |
| Lake | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.5 | $0.348 | $0.4 | $0.241 |
| | Ground 1-3 MW | 18 | 38 | $12.5 | $0.327 | $8.4 | $0.220 |
| | Ground 3-5 MW | 14 | 31 | $9.6 | $0.311 | $6.3 | $0.206 |
| | Ground 5-10 MW | 8 | 17 | $5.2 | $0.302 | $3.4 | $0.195 |
| | Ground 10-20 MW | | | | | | |
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 1,683 | 3,025 | $1,151.9 | $0.381 | $836.6 | $0.277 |
| | Commercial Roof | 788 | 1,333 | $455.0 | $0.341 | $314.6 | $0.236 |
| | Ground <= 1 MW | 2 | 6 | $1.5 | $0.239 | $0.9 | $0.142 |
| | Ground 1-3 MW | 9 | 21 | $5.3 | $0.258 | $3.3 | $0.160 |

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|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 13 | 33 | $6.2 | $0.189 | $3.2 | $0.097 |
| | Ground 5-10 MW | 16 | 38 | $7.2 | $0.189 | $3.6 | $0.093 |
| | Ground 10-20 MW | 295 | 685 | $134.2 | $0.196 | $67.6 | $0.099 |
| Madera | Residential Roof | 6 | 10 | $4.3 | $0.440 | $3.3 | $0.335 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.334 | $0.5 | $0.229 |
| | Ground 1-3 MW | 12 | 27 | $8.5 | $0.316 | $5.7 | $0.213 |
| | Ground 3-5 MW | 15 | 34 | $10.2 | $0.305 | $6.7 | $0.200 |
| | Ground 5-10 MW | 26 | 58 | $13.5 | $0.231 | $7.3 | $0.125 |
| | Ground 10-20 MW | 40 | 86 | $24.6 | $0.288 | $15.8 | $0.185 |
| Marin | Residential Roof | 14 | 24 | $11.2 | $0.474 | $8.7 | $0.367 |
| | Commercial Roof | 6 | 9 | $4.1 | $0.468 | $3.1 | $0.362 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.349 | $0.0 | $0.241 |
| | Ground 1-3 MW | 11 | 24 | $7.9 | $0.334 | $5.4 | $0.226 |
| | Ground 3-5 MW | 14 | 30 | $9.5 | $0.320 | $6.4 | $0.213 |
| | Ground 5-10 MW | 34 | 71 | $21.9 | $0.307 | $14.2 | $0.199 |
| | Ground 10-20 MW | 14 | 30 | $8.8 | $0.297 | $5.7 | $0.193 |
| Mariposa | Residential Roof | 1 | 1 | $0.4 | $0.437 | $0.3 | $0.328 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $1.4 | $0.314 | $0.9 | $0.211 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 18 | 39 | $11.2 | $0.288 | $7.1 | $0.182 |
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 1 | 2 | $1.0 | $0.461 | $0.8 | $0.353 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.3 | $0.378 | $0.9 | $0.271 |
| | Ground 1-3 MW | 9 | 19 | $6.4 | $0.339 | $4.4 | $0.231 |
| | Ground 3-5 MW | 7 | 14 | $4.8 | $0.350 | $3.4 | $0.243 |
| | Ground 5-10 MW | 15 | 30 | $9.5 | $0.312 | $6.2 | $0.204 |
| | Ground 10-20 MW | | | | | | |
| Merced | Residential Roof | 13 | 23 | $10.2 | $0.447 | $7.8 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 8 | 18 | $5.7 | $0.321 | $3.9 | $0.217 |
| | Ground 3-5 MW | 29 | 63 | $19.3 | $0.306 | $12.7 | $0.202 |
| | Ground 5-10 MW | 12 | 26 | $7.7 | $0.293 | $5.0 | $0.189 |
| | Ground 10-20 MW | 108 | 233 | $66.9 | $0.287 | $42.1 | $0.181 |
| Mono | Residential Roof | 11 | 20 | $6.0 | $0.300 | $4.0 | $0.201 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.2 | $0.291 | $0.8 | $0.190 |
| | Ground 1-3 MW | | | | | | |

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|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 20 | 34 | $16.1 | $0.467 | $12.4 | $0.360 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 27 | 60 | $18.8 | $0.316 | $12.7 | $0.212 |
| | Ground 3-5 MW | 15 | 34 | $9.5 | $0.276 | $5.9 | $0.171 |
| | Ground 5-10 MW | 82 | 174 | $47.5 | $0.273 | $29.1 | $0.167 |
| | Ground 10-20 MW | 46 | 96 | $29.0 | $0.302 | $18.8 | $0.196 |
| Napa | Residential Roof | 32 | 55 | $25.5 | $0.463 | $19.3 | $0.351 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 14 | $4.7 | $0.335 | $3.2 | $0.228 |
| | Ground 3-5 MW | 8 | 17 | $5.4 | $0.323 | $3.7 | $0.218 |
| | Ground 5-10 MW | 5 | 11 | $3.3 | $0.311 | $2.2 | $0.206 |
| | Ground 10-20 MW | 138 | 287 | $87.2 | $0.304 | $55.9 | $0.195 |
| Nevada | Residential Roof | 2 | 3 | $0.8 | $0.309 | $0.5 | $0.199 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 12 | $4.0 | $0.329 | $2.7 | $0.222 |
| | Ground 3-5 MW | 8 | 18 | $5.5 | $0.314 | $3.7 | $0.208 |
| | Ground 5-10 MW | 30 | 63 | $19.2 | $0.303 | $12.5 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 696 | 1,248 | $492.5 | $0.395 | $363.7 | $0.291 |
| | Commercial Roof | 640 | 1,090 | $436.1 | $0.400 | $322.3 | $0.296 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.329 | $0.0 | $0.228 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 13 | 28 | $8.2 | $0.289 | $5.3 | $0.187 |
| | Ground 10-20 MW | 28 | 62 | $17.5 | $0.283 | $11.3 | $0.183 |
| Placer | Residential Roof | 1 | 1 | $0.5 | $0.458 | $0.4 | $0.349 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.4 | $0.334 | $0.3 | $0.230 |
| | Ground 1-3 MW | 12 | 26 | $8.6 | $0.328 | $5.8 | $0.223 |
| | Ground 3-5 MW | 6 | 13 | $4.1 | $0.312 | $2.8 | $0.207 |
| | Ground 5-10 MW | 37 | 79 | $24.1 | $0.304 | $15.8 | $0.199 |
| | Ground 10-20 MW | 169 | 356 | $105.5 | $0.297 | $68.0 | $0.191 |
| Plumas | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 16 | $4.7 | $0.301 | $3.0 | $0.195 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 115 | 212 | $62.7 | $0.296 | $42.0 | $0.198 |
| | Commercial Roof | 43 | 73 | $21.6 | $0.298 | $14.4 | $0.198 |
| | Ground <= 1 MW | 8 | 20 | $6.0 | $0.301 | $4.1 | $0.204 |
| | Ground 1-3 MW | 23 | 57 | $13.9 | $0.244 | $8.4 | $0.148 |
| | Ground 3-5 MW | 8 | 18 | $3.6 | $0.201 | $1.9 | $0.105 |
| | Ground 5-10 MW | 77 | 177 | $35.0 | $0.198 | $17.9 | $0.101 |
| | Ground 10-20 MW | 471 | 1,090 | $210.6 | $0.193 | $107.1 | $0.098 |
| Sacramento | Residential Roof | 1 | 2 | $0.9 | $0.451 | $0.7 | $0.341 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.6 | $0.303 | $1.7 | $0.199 |
| | Ground 5-10 MW | 7 | 15 | $4.4 | $0.292 | $2.8 | $0.185 |
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 427 | 783 | $232.4 | $0.297 | $155.1 | $0.198 |
| | Commercial Roof | 203 | 340 | $100.9 | $0.297 | $66.4 | $0.195 |
| | Ground <= 1 MW | 8 | 20 | $4.6 | $0.228 | $2.7 | $0.133 |
| | Ground 1-3 MW | 13 | 33 | $7.4 | $0.225 | $4.3 | $0.131 |
| | Ground 3-5 MW | 12 | 29 | $6.2 | $0.218 | $3.5 | $0.123 |
| | Ground 5-10 MW | 50 | 116 | $22.7 | $0.195 | $11.4 | $0.098 |
| | Ground 10-20 MW | 224 | 527 | $100.4 | $0.191 | $49.6 | $0.094 |
| San Diego | Residential Roof | 847 | 1,518 | $558.1 | $0.368 | $404.6 | $0.267 |
| | Commercial Roof | 142 | 239 | $91.2 | $0.382 | $66.6 | $0.279 |
| | Ground <= 1 MW | 5 | 11 | $3.2 | $0.291 | $2.1 | $0.193 |
| | Ground 1-3 MW | 7 | 16 | $4.2 | $0.270 | $2.7 | $0.173 |
| | Ground 3-5 MW | 17 | 37 | $11.0 | $0.295 | $7.3 | $0.195 |
| | Ground 5-10 MW | 56 | 123 | $29.1 | $0.236 | $16.7 | $0.135 |
| | Ground 10-20 MW | 223 | 489 | $113.0 | $0.231 | $64.1 | $0.131 |
| San Francisco | Residential Roof | 71 | 122 | $56.4 | $0.465 | $43.1 | $0.355 |
| | Commercial Roof | 11 | 18 | $8.2 | $0.446 | $6.1 | $0.336 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 84 | 148 | $66.7 | $0.451 | $50.9 | $0.344 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.3 | $0.344 | $0.2 | $0.237 |
| | Ground 1-3 MW | 8 | 17 | $5.5 | $0.324 | $3.7 | $0.217 |
| | Ground 3-5 MW | 25 | 53 | $16.6 | $0.311 | $11.0 | $0.206 |
| | Ground 5-10 MW | 130 | 281 | $83.9 | $0.298 | $54.1 | $0.192 |
| | Ground 10-20 MW | 141 | 301 | $87.8 | $0.292 | $55.9 | $0.186 |
| San Luis Obispo | Residential Roof | 11 | 20 | $8.6 | $0.433 | $6.6 | $0.332 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $1.6 | $0.320 | $1.1 | $0.216 |
| | Ground 1-3 MW | 9 | 22 | $6.6 | $0.302 | $4.4 | $0.201 |
| | Ground 3-5 MW | 12 | 27 | $5.6 | $0.206 | $2.8 | $0.102 |
| | Ground 5-10 MW | 20 | 46 | $9.4 | $0.202 | $4.5 | $0.098 |
| | Ground 10-20 MW | 14 | 32 | $6.4 | $0.197 | $3.0 | $0.094 |
| San Mateo | Residential Roof | 220 | 367 | $175.5 | $0.478 | $136.3 | $0.371 |
| | Commercial Roof | 104 | 162 | $75.2 | $0.463 | $57.9 | $0.356 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 102 | 183 | $56.9 | $0.310 | $37.5 | $0.205 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.8 | $0.333 | $0.5 | $0.229 |
| | Ground 1-3 MW | 19 | 44 | $13.1 | $0.296 | $8.6 | $0.193 |
| | Ground 3-5 MW | 3 | 8 | $1.7 | $0.206 | $0.8 | $0.105 |
| | Ground 5-10 MW | 34 | 78 | $15.9 | $0.203 | $7.8 | $0.100 |
| | Ground 10-20 MW | 26 | 59 | $11.9 | $0.201 | $5.9 | $0.100 |
| Santa Clara | Residential Roof | 719 | 1,279 | $567.8 | $0.444 | $430.1 | $0.336 |
| | Commercial Roof | 213 | 357 | $152.7 | $0.427 | $114.2 | $0.320 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.319 | $1.7 | $0.212 |
| | Ground 5-10 MW | 38 | 83 | $24.6 | $0.297 | $15.9 | $0.192 |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 3 | 5 | $2.2 | $0.446 | $1.7 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.3 | $0.341 | $0.2 | $0.234 |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 7 | 16 | $4.9 | $0.318 | $3.3 | $0.211 |
| | Ground 5-10 MW | 24 | 51 | $15.4 | $0.299 | $10.0 | $0.195 |
| | Ground 10-20 MW | 30 | 63 | $19.1 | $0.300 | $12.4 | $0.196 |
| Shasta | Residential Roof | 3 | 5 | $2.5 | $0.480 | $1.9 | $0.370 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $1.1 | $0.338 | $0.7 | $0.232 |
| | Ground 1-3 MW | 7 | 14 | $4.8 | $0.337 | $3.2 | $0.229 |
| | Ground 3-5 MW | 12 | 24 | $7.8 | $0.327 | $5.3 | $0.221 |
| | Ground 5-10 MW | 8 | 16 | $5.1 | $0.317 | $3.3 | $0.207 |
| | Ground 10-20 MW | 47 | 97 | $29.8 | $0.308 | $19.4 | $0.200 |
| Sierra | Residential Roof | 1 | 1 | $0.5 | $0.438 | $0.4 | $0.331 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 98 | 171 | $77.4 | $0.453 | $59.0 | $0.345 |
| | Commercial Roof | 0 | 1 | $0.3 | $0.437 | $0.3 | $0.328 |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.346 | $0.1 | $0.242 |
| | Ground 1-3 MW | 9 | 20 | $6.5 | $0.333 | $4.4 | $0.227 |
| | Ground 3-5 MW | 12 | 26 | $8.2 | $0.320 | $5.5 | $0.214 |
| | Ground 5-10 MW | 54 | 116 | $34.7 | $0.300 | $22.6 | $0.196 |
| | Ground 10-20 MW | 38 | 82 | $24.0 | $0.293 | $15.4 | $0.188 |
| Sonoma | Residential Roof | 57 | 96 | $45.3 | $0.470 | $34.8 | $0.361 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.7 | $0.377 | $1.2 | $0.269 |
| | Ground 1-3 MW | 11 | 23 | $7.8 | $0.341 | $5.3 | $0.233 |
| | Ground 3-5 MW | 24 | 50 | $16.2 | $0.326 | $10.8 | $0.219 |
| | Ground 5-10 MW | 82 | 169 | $53.2 | $0.314 | $34.9 | $0.206 |
| | Ground 10-20 MW | 63 | 129 | $39.7 | $0.308 | $26.0 | $0.201 |
| Stanislaus | Residential Roof | 1 | 2 | $0.9 | $0.447 | $0.6 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 3 | $1.1 | $0.321 | $0.8 | $0.217 |
| | Ground 3-5 MW | 8 | 17 | $5.3 | $0.307 | $3.5 | $0.203 |
| | Ground 5-10 MW | 21 | 46 | $13.7 | $0.296 | $8.9 | $0.191 |
| | Ground 10-20 MW | 72 | 154 | $44.7 | $0.290 | $28.2 | $0.183 |
| Sutter | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 4 | 8 | $2.8 | $0.331 | $1.9 | $0.227 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 13 | 27 | $8.5 | $0.316 | $5.6 | $0.210 |
| | Ground 5-10 MW | 50 | 106 | $32.3 | $0.304 | $21.0 | $0.198 |
| | Ground 10-20 MW | 23 | 48 | $14.2 | $0.296 | $9.0 | $0.189 |
| Tehama | Residential Roof | 1 | 1 | $0.5 | $0.468 | $0.4 | $0.359 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 11 | 24 | $8.0 | $0.333 | $5.5 | $0.226 |
| | Ground 3-5 MW | 13 | 29 | $9.1 | $0.319 | $6.1 | $0.214 |
| | Ground 5-10 MW | 15 | 31 | $9.6 | $0.306 | $6.3 | $0.200 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.8 | $0.457 | $0.6 | $0.346 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 35 | 63 | $27.6 | $0.439 | $20.8 | $0.331 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.2 | $0.333 | $0.8 | $0.231 |
| | Ground 1-3 MW | 24 | 55 | $17.2 | $0.313 | $11.6 | $0.210 |
| | Ground 3-5 MW | 15 | 33 | $10.0 | $0.301 | $6.6 | $0.199 |
| | Ground 5-10 MW | 54 | 119 | $34.5 | $0.291 | $22.2 | $0.187 |
| | Ground 10-20 MW | 98 | 215 | $57.4 | $0.268 | $35.3 | $0.165 |
| Tuolumne | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $1.5 | $0.319 | $1.0 | $0.215 |
| | Ground 3-5 MW | 3 | 7 | $2.1 | $0.291 | $1.3 | $0.188 |
| | Ground 5-10 MW | 16 | 34 | $9.9 | $0.290 | $6.4 | $0.185 |
| | Ground 10-20 MW | 11 | 24 | $6.9 | $0.283 | $4.4 | $0.180 |
| Ventura | Residential Roof | 199 | 357 | $109.0 | $0.305 | $72.6 | $0.203 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.346 | $0.5 | $0.248 |
| | Ground 1-3 MW | 6 | 12 | $3.9 | $0.328 | $2.7 | $0.230 |
| | Ground 3-5 MW | 8 | 18 | $3.7 | $0.209 | $1.9 | $0.109 |
| | Ground 5-10 MW | 24 | 54 | $11.1 | $0.205 | $5.6 | $0.103 |
| | Ground 10-20 MW | 190 | 412 | $103.3 | $0.251 | $61.5 | $0.149 |
| Yolo | Residential Roof | 7 | 11 | $5.2 | $0.459 | $4.0 | $0.351 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $1.5 | $0.327 | $1.0 | $0.223 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 30 | 65 | $20.3 | $0.315 | $13.5 | $0.208 |
| | Ground 5-10 MW | 29 | 61 | $18.6 | $0.303 | $12.1 | $0.197 |
| | Ground 10-20 MW | 88 | 187 | $55.1 | $0.294 | $35.2 | $0.188 |
| Yuba | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $1.1 | $0.350 | $0.8 | $0.245 |
| | Ground 1-3 MW | 5 | 10 | $3.4 | $0.329 | $2.3 | $0.225 |
| | Ground 3-5 MW | 7 | 15 | $4.8 | $0.315 | $3.2 | $0.209 |
| | Ground 5-10 MW | 23 | 49 | $14.9 | $0.304 | $9.8 | $0.199 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 15,336 | 29,695 | 9820 | 0.33 | 6741 | 0.23 |

**100% Learning Curve Results By County (cont.)**

## Least Net Cost Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 122 | 214 | $97.2 | $0.455 | $74.2 | $0.347 |
| | Commercial Roof | 298 | 493 | $215.1 | $0.436 | $161.8 | $0.328 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.344 | $0.0 | $0.237 |
| | Ground 1-3 MW | 2 | 5 | $1.5 | $0.323 | $1.0 | $0.217 |
| | Ground 3-5 MW | 20 | 44 | $13.7 | $0.309 | $9.0 | $0.204 |
| | Ground 5-10 MW | 53 | 115 | $34.3 | $0.298 | $22.1 | $0.192 |
| | Ground 10-20 MW | 39 | 83 | $24.3 | $0.292 | $15.3 | $0.184 |
| Amador | Residential Roof | 4 | 7 | $3.2 | $0.448 | $2.5 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 9 | 19 | $5.8 | $0.310 | $3.9 | $0.205 |
| | Ground 5-10 MW | 11 | 24 | $7.1 | $0.299 | $4.6 | $0.194 |
| | Ground 10-20 MW | 11 | 23 | $6.6 | $0.290 | $4.2 | $0.184 |
| Butte | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.8 | $0.349 | $0.5 | $0.243 |
| | Ground 1-3 MW | 5 | 10 | $3.5 | $0.331 | $2.4 | $0.226 |
| | Ground 3-5 MW | 28 | 61 | $19.3 | $0.317 | $12.8 | $0.211 |
| | Ground 5-10 MW | 77 | 163 | $49.8 | $0.306 | $32.6 | $0.200 |
| | Ground 10-20 MW | 79 | 165 | $49.5 | $0.300 | $32.0 | $0.194 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Calaveras | Residential Roof | 1 | 1 | $0.6 | $0.448 | $0.5 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.338 | $0.5 | $0.233 |
| | Ground 1-3 MW | 7 | 15 | $4.9 | $0.319 | $3.3 | $0.212 |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.310 | $1.6 | $0.206 |
| | Ground 5-10 MW | 7 | 14 | $4.3 | $0.299 | $2.8 | $0.195 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 13 | $4.2 | $0.332 | $2.9 | $0.226 |
| | Ground 3-5 MW | 11 | 23 | $7.3 | $0.315 | $4.9 | $0.211 |
| | Ground 5-10 MW | 25 | 54 | $16.3 | $0.303 | $10.6 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 437 | 768 | $346.6 | $0.451 | $263.3 | $0.343 |
| | Commercial Roof | 111 | 183 | $79.9 | $0.437 | $59.9 | $0.327 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 8 | 18 | $5.6 | $0.312 | $3.7 | $0.205 |
| | Ground 5-10 MW | 6 | 13 | $3.8 | $0.300 | $2.5 | $0.197 |
| | Ground 10-20 MW | 117 | 250 | $73.3 | $0.293 | $47.2 | $0.189 |
| El Dorado | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.343 | $0.5 | $0.238 |
| | Ground 1-3 MW | 5 | 12 | $3.7 | $0.321 | $2.5 | $0.215 |
| | Ground 3-5 MW | 6 | 13 | $4.1 | $0.308 | $2.7 | $0.203 |
| | Ground 5-10 MW | 31 | 67 | $20.0 | $0.300 | $13.0 | $0.195 |
| | Ground 10-20 MW | 51 | 108 | $32.0 | $0.295 | $20.5 | $0.189 |
| Fresno | Residential Roof | 272 | 484 | $212.9 | $0.440 | $161.4 | $0.334 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 10 | 23 | $7.2 | $0.316 | $4.8 | $0.211 |
| | Ground 3-5 MW | 22 | 50 | $14.9 | $0.300 | $9.8 | $0.197 |
| | Ground 5-10 MW | 138 | 304 | $83.6 | $0.275 | $52.3 | $0.172 |
| | Ground 10-20 MW | 418 | 905 | $220.6 | $0.244 | $125.7 | $0.139 |
| Glenn | Residential Roof | 10 | 17 | $7.6 | $0.455 | $5.8 | $0.347 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 9 | 19 | $6.1 | $0.327 | $4.1 | $0.220 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 19 | $5.6 | $0.304 | $3.7 | $0.197 |
| | Ground 10-20 MW | | | | | | |

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|---|---|---|---|---|---|---|---|
| Humboldt | Residential Roof | 11 | 18 | $9.1 | $0.504 | $7.1 | $0.391 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 5 | $2.0 | $0.423 | $1.5 | $0.312 |
| | Ground 1-3 MW | 16 | 26 | $11.1 | $0.424 | $8.3 | $0.315 |
| | Ground 3-5 MW | 10 | 17 | $6.9 | $0.409 | $5.1 | $0.302 |
| | Ground 5-10 MW | 19 | 31 | $12.4 | $0.393 | $9.0 | $0.285 |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.279 | $0.0 | $0.180 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 11 | $2.1 | $0.192 | $1.1 | $0.097 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 73 | 133 | $51.4 | $0.385 | $37.7 | $0.283 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 3 | 8 | $2.1 | $0.263 | $1.3 | $0.166 |
| | Ground 1-3 MW | 37 | 86 | $24.9 | $0.290 | $16.3 | $0.190 |
| | Ground 3-5 MW | 69 | 160 | $43.9 | $0.274 | $27.9 | $0.175 |
| | Ground 5-10 MW | 198 | 444 | $111.1 | $0.250 | $66.1 | $0.149 |
| | Ground 10-20 MW | 288 | 632 | $135.7 | $0.215 | $70.5 | $0.112 |
| Kings | Residential Roof | 12 | 22 | $7.6 | $0.350 | $5.3 | $0.243 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $1.5 | $0.328 | $1.0 | $0.225 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 21 | 47 | $14.0 | $0.298 | $9.2 | $0.196 |
| | Ground 5-10 MW | 27 | 59 | $16.9 | $0.288 | $10.9 | $0.185 |
| | Ground 10-20 MW | 30 | 66 | $13.7 | $0.210 | $6.9 | $0.106 |
| Lake | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.5 | $0.348 | $0.4 | $0.241 |
| | Ground 1-3 MW | 18 | 38 | $12.5 | $0.327 | $8.4 | $0.220 |
| | Ground 3-5 MW | 14 | 31 | $9.6 | $0.311 | $6.4 | $0.205 |
| | Ground 5-10 MW | 8 | 17 | $5.2 | $0.302 | $3.4 | $0.195 |
| | Ground 10-20 MW | | | | | | |

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|---|---|---|---|---|---|---|---|
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 1,683 | 3,022 | $1,122.3 | $0.371 | $807.4 | $0.267 |
| | Commercial Roof | 788 | 1,332 | $472.1 | $0.354 | $331.9 | $0.249 |
| | Ground <= 1 MW | 2 | 6 | $1.8 | $0.286 | $1.2 | $0.188 |
| | Ground 1-3 MW | 9 | 21 | $5.3 | $0.257 | $3.3 | $0.160 |
| | Ground 3-5 MW | 13 | 33 | $6.2 | $0.189 | $3.2 | $0.096 |
| | Ground 5-10 MW | 16 | 38 | $7.2 | $0.189 | $3.6 | $0.093 |
| | Ground 10-20 MW | 295 | 684 | $134.1 | $0.196 | $67.7 | $0.099 |
| Madera | Residential Roof | 6 | 10 | $4.3 | $0.440 | $3.3 | $0.335 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.334 | $0.5 | $0.229 |
| | Ground 1-3 MW | 12 | 27 | $8.5 | $0.316 | $5.7 | $0.213 |
| | Ground 3-5 MW | 15 | 34 | $10.2 | $0.305 | $6.7 | $0.200 |
| | Ground 5-10 MW | 26 | 58 | $13.4 | $0.231 | $7.3 | $0.125 |
| | Ground 10-20 MW | 40 | 86 | $24.6 | $0.288 | $15.8 | $0.185 |
| Marin | Residential Roof | 14 | 24 | $11.2 | $0.474 | $8.7 | $0.367 |
| | Commercial Roof | 6 | 9 | $4.1 | $0.468 | $3.1 | $0.362 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.349 | $0.0 | $0.241 |
| | Ground 1-3 MW | 11 | 24 | $7.9 | $0.334 | $5.4 | $0.226 |
| | Ground 3-5 MW | 14 | 30 | $9.5 | $0.320 | $6.4 | $0.213 |
| | Ground 5-10 MW | 34 | 71 | $21.9 | $0.307 | $14.2 | $0.200 |
| | Ground 10-20 MW | 14 | 30 | $8.8 | $0.297 | $5.7 | $0.193 |
| Mariposa | Residential Roof | 1 | 1 | $0.3 | $0.321 | $0.2 | $0.211 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $1.4 | $0.314 | $0.9 | $0.211 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 18 | 38 | $8.2 | $0.213 | $4.1 | $0.107 |
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 1 | 2 | $1.0 | $0.461 | $0.8 | $0.353 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.3 | $0.378 | $0.9 | $0.271 |
| | Ground 1-3 MW | 9 | 19 | $6.4 | $0.339 | $4.4 | $0.231 |
| | Ground 3-5 MW | 7 | 14 | $4.8 | $0.350 | $3.4 | $0.243 |
| | Ground 5-10 MW | 15 | 30 | $9.5 | $0.312 | $6.2 | $0.204 |
| | Ground 10-20 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Merced | Residential Roof | 13 | 23 | $10.2 | $0.447 | $7.8 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 8 | 18 | $5.7 | $0.321 | $3.9 | $0.217 |
| | Ground 3-5 MW | 29 | 63 | $19.3 | $0.306 | $12.7 | $0.202 |
| | Ground 5-10 MW | 12 | 26 | $7.7 | $0.293 | $5.0 | $0.189 |
| | Ground 10-20 MW | 108 | 232 | $64.6 | $0.278 | $39.8 | $0.171 |
| Mono | Residential Roof | 11 | 20 | $6.0 | $0.300 | $4.0 | $0.201 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.3 | $0.311 | $0.9 | $0.210 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 20 | 34 | $16.1 | $0.467 | $12.4 | $0.360 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 27 | 60 | $18.9 | $0.316 | $12.7 | $0.212 |
| | Ground 3-5 MW | 15 | 34 | $8.1 | $0.235 | $4.5 | $0.130 |
| | Ground 5-10 MW | 82 | 174 | $47.5 | $0.273 | $29.1 | $0.167 |
| | Ground 10-20 MW | 46 | 96 | $29.0 | $0.302 | $18.8 | $0.196 |
| Napa | Residential Roof | 32 | 55 | $25.5 | $0.463 | $19.3 | $0.351 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 14 | $4.7 | $0.335 | $3.2 | $0.228 |
| | Ground 3-5 MW | 8 | 17 | $5.4 | $0.323 | $3.7 | $0.218 |
| | Ground 5-10 MW | 5 | 11 | $3.3 | $0.311 | $2.2 | $0.206 |
| | Ground 10-20 MW | 138 | 286 | $86.9 | $0.304 | $55.7 | $0.195 |
| Nevada | Residential Roof | 2 | 3 | $0.8 | $0.309 | $0.5 | $0.202 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 6 | 12 | $4.0 | $0.329 | $2.7 | $0.222 |
| | Ground 3-5 MW | 8 | 18 | $5.5 | $0.314 | $3.7 | $0.208 |
| | Ground 5-10 MW | 30 | 63 | $19.1 | $0.303 | $12.5 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 696 | 1,208 | $476.7 | $0.395 | $352.1 | $0.292 |
| | Commercial Roof | 640 | 1,089 | $419.3 | $0.385 | $305.4 | $0.280 |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.329 | $0.0 | $0.228 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 13 | 29 | $8.3 | $0.289 | $5.3 | $0.187 |
| | Ground 10-20 MW | 28 | 62 | $17.5 | $0.283 | $11.3 | $0.183 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Placer | Residential Roof | 1 | 1 | $0.5 | $0.451 | $0.4 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.4 | $0.334 | $0.3 | $0.230 |
| | Ground 1-3 MW | 12 | 26 | $8.6 | $0.328 | $5.8 | $0.223 |
| | Ground 3-5 MW | 6 | 13 | $4.1 | $0.312 | $2.8 | $0.207 |
| | Ground 5-10 MW | 37 | 79 | $24.1 | $0.304 | $15.8 | $0.199 |
| | Ground 10-20 MW | 169 | 356 | $105.5 | $0.297 | $68.0 | $0.191 |
| Plumas | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 7 | 16 | $4.7 | $0.301 | $3.0 | $0.195 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 115 | 212 | $62.8 | $0.296 | $42.1 | $0.198 |
| | Commercial Roof | 43 | 73 | $21.7 | $0.298 | $14.4 | $0.197 |
| | Ground <= 1 MW | 8 | 20 | $6.1 | $0.303 | $4.2 | $0.206 |
| | Ground 1-3 MW | 23 | 57 | $15.3 | $0.266 | $9.7 | $0.170 |
| | Ground 3-5 MW | 8 | 18 | $3.6 | $0.201 | $1.9 | $0.105 |
| | Ground 5-10 MW | 77 | 178 | $35.1 | $0.198 | $17.8 | $0.100 |
| | Ground 10-20 MW | 471 | 1,094 | $211.3 | $0.193 | $107.1 | $0.098 |
| Sacramento | Residential Roof | 1 | 2 | $0.9 | $0.451 | $0.7 | $0.341 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.6 | $0.303 | $1.7 | $0.199 |
| | Ground 5-10 MW | 7 | 15 | $4.3 | $0.292 | $2.7 | $0.185 |
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 427 | 782 | $232.2 | $0.297 | $155.0 | $0.198 |
| | Commercial Roof | 203 | 340 | $100.9 | $0.297 | $66.4 | $0.195 |
| | Ground <= 1 MW | 8 | 20 | $5.4 | $0.266 | $3.5 | $0.171 |
| | Ground 1-3 MW | 13 | 33 | $7.5 | $0.225 | $4.3 | $0.130 |
| | Ground 3-5 MW | 12 | 29 | $6.2 | $0.218 | $3.5 | $0.124 |
| | Ground 5-10 MW | 50 | 116 | $22.7 | $0.195 | $11.4 | $0.098 |
| | Ground 10-20 MW | 224 | 528 | $100.5 | $0.191 | $49.6 | $0.094 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| San Diego | Residential Roof | 847 | 1,527 | $590.3 | $0.387 | $435.8 | $0.285 |
| | Commercial Roof | 142 | 240 | $93.1 | $0.387 | $68.4 | $0.285 |
| | Ground <= 1 MW | 5 | 11 | $3.4 | $0.309 | $2.3 | $0.210 |
| | Ground 1-3 MW | 7 | 16 | $4.2 | $0.270 | $2.7 | $0.172 |
| | Ground 3-5 MW | 17 | 38 | $11.1 | $0.295 | $7.4 | $0.195 |
| | Ground 5-10 MW | 56 | 124 | $30.6 | $0.246 | $18.2 | $0.146 |
| | Ground 10-20 MW | 223 | 492 | $124.8 | $0.254 | $75.7 | $0.154 |
| San Francisco | Residential Roof | 71 | 122 | $56.4 | $0.465 | $43.1 | $0.355 |
| | Commercial Roof | 11 | 18 | $8.2 | $0.446 | $6.1 | $0.336 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 84 | 148 | $66.7 | $0.451 | $50.9 | $0.344 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.3 | $0.344 | $0.2 | $0.237 |
| | Ground 1-3 MW | 8 | 17 | $5.5 | $0.324 | $3.7 | $0.217 |
| | Ground 3-5 MW | 25 | 53 | $16.6 | $0.311 | $11.0 | $0.206 |
| | Ground 5-10 MW | 130 | 280 | $83.6 | $0.298 | $53.9 | $0.192 |
| | Ground 10-20 MW | 141 | 300 | $87.6 | $0.292 | $55.8 | $0.186 |
| San Luis Obispo | Residential Roof | 11 | 20 | $8.6 | $0.433 | $6.6 | $0.332 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 5 | $1.6 | $0.320 | $1.1 | $0.216 |
| | Ground 1-3 MW | 9 | 22 | $6.6 | $0.302 | $4.4 | $0.201 |
| | Ground 3-5 MW | 12 | 27 | $5.5 | $0.206 | $2.7 | $0.102 |
| | Ground 5-10 MW | 20 | 46 | $9.3 | $0.202 | $4.5 | $0.099 |
| | Ground 10-20 MW | 14 | 32 | $6.2 | $0.197 | $3.1 | $0.097 |
| San Mateo | Residential Roof | 220 | 367 | $175.5 | $0.478 | $136.3 | $0.371 |
| | Commercial Roof | 105 | 164 | $76.1 | $0.463 | $58.6 | $0.357 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 102 | 182 | $56.4 | $0.310 | $37.3 | $0.205 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.8 | $0.333 | $0.5 | $0.229 |
| | Ground 1-3 MW | 19 | 44 | $13.1 | $0.296 | $8.6 | $0.193 |
| | Ground 3-5 MW | 3 | 8 | $1.7 | $0.206 | $0.8 | $0.105 |
| | Ground 5-10 MW | 34 | 77 | $15.7 | $0.203 | $7.8 | $0.101 |
| | Ground 10-20 MW | 26 | 59 | $11.9 | $0.201 | $5.9 | $0.100 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Santa Clara | Residential Roof | 719 | 1,275 | $566.3 | $0.444 | $428.8 | $0.336 |
| | Commercial Roof | 213 | 357 | $152.7 | $0.427 | $114.3 | $0.320 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.319 | $1.7 | $0.212 |
| | Ground 5-10 MW | 38 | 83 | $24.6 | $0.297 | $15.9 | $0.192 |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 3 | 5 | $2.2 | $0.446 | $1.7 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 1 | $0.3 | $0.341 | $0.2 | $0.234 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 7 | 16 | $4.9 | $0.318 | $3.3 | $0.211 |
| | Ground 5-10 MW | 24 | 51 | $15.3 | $0.299 | $10.0 | $0.195 |
| | Ground 10-20 MW | 30 | 63 | $19.1 | $0.300 | $12.4 | $0.196 |
| Shasta | Residential Roof | 3 | 5 | $2.5 | $0.480 | $1.9 | $0.370 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $1.1 | $0.338 | $0.7 | $0.232 |
| | Ground 1-3 MW | 7 | 14 | $4.8 | $0.337 | $3.2 | $0.229 |
| | Ground 3-5 MW | 12 | 24 | $7.8 | $0.327 | $5.3 | $0.221 |
| | Ground 5-10 MW | 8 | 16 | $5.1 | $0.317 | $3.3 | $0.207 |
| | Ground 10-20 MW | 47 | 97 | $29.8 | $0.308 | $19.4 | $0.200 |
| Sierra | Residential Roof | 1 | 1 | $0.5 | $0.438 | $0.4 | $0.331 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 98 | 171 | $77.4 | $0.453 | $59.0 | $0.345 |
| | Commercial Roof | 0 | 1 | $0.3 | $0.437 | $0.3 | $0.328 |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.346 | $0.1 | $0.242 |
| | Ground 1-3 MW | 9 | 20 | $6.5 | $0.333 | $4.4 | $0.227 |
| | Ground 3-5 MW | 12 | 26 | $8.2 | $0.320 | $5.5 | $0.214 |
| | Ground 5-10 MW | 54 | 116 | $34.7 | $0.300 | $22.6 | $0.196 |
| | Ground 10-20 MW | 38 | 82 | $23.9 | $0.293 | $15.3 | $0.188 |
| Sonoma | Residential Roof | 57 | 96 | $45.3 | $0.470 | $34.8 | $0.361 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.7 | $0.377 | $1.2 | $0.269 |
| | Ground 1-3 MW | 11 | 23 | $7.8 | $0.341 | $5.3 | $0.233 |
| | Ground 3-5 MW | 24 | 50 | $16.2 | $0.326 | $10.8 | $0.219 |
| | Ground 5-10 MW | 82 | 169 | $53.0 | $0.314 | $34.8 | $0.206 |
| | Ground 10-20 MW | 63 | 129 | $39.7 | $0.308 | $26.0 | $0.201 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stanislaus | Residential Roof | 1 | 2 | $0.9 | $0.447 | $0.6 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 3 | $1.1 | $0.321 | $0.8 | $0.217 |
| | Ground 3-5 MW | 8 | 17 | $5.3 | $0.307 | $3.5 | $0.203 |
| | Ground 5-10 MW | 21 | 46 | $13.7 | $0.296 | $8.9 | $0.191 |
| | Ground 10-20 MW | 72 | 154 | $44.7 | $0.290 | $28.2 | $0.183 |
| Sutter | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 4 | 8 | $2.8 | $0.331 | $1.9 | $0.227 |
| | Ground 3-5 MW | 13 | 27 | $8.5 | $0.316 | $5.6 | $0.210 |
| | Ground 5-10 MW | 50 | 106 | $32.3 | $0.304 | $21.0 | $0.198 |
| | Ground 10-20 MW | 23 | 48 | $14.2 | $0.296 | $9.0 | $0.189 |
| Tehama | Residential Roof | 1 | 1 | $0.5 | $0.468 | $0.4 | $0.359 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 11 | 24 | $8.0 | $0.333 | $5.5 | $0.226 |
| | Ground 3-5 MW | 13 | 29 | $9.1 | $0.319 | $6.1 | $0.214 |
| | Ground 5-10 MW | 15 | 31 | $9.6 | $0.306 | $6.3 | $0.200 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.8 | $0.457 | $0.6 | $0.347 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 35 | 63 | $27.5 | $0.439 | $20.7 | $0.331 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.2 | $0.333 | $0.8 | $0.231 |
| | Ground 1-3 MW | 24 | 55 | $17.2 | $0.313 | $11.6 | $0.210 |
| | Ground 3-5 MW | 15 | 33 | $10.0 | $0.301 | $6.6 | $0.199 |
| | Ground 5-10 MW | 54 | 119 | $34.7 | $0.291 | $22.4 | $0.187 |
| | Ground 10-20 MW | 98 | 215 | $57.4 | $0.268 | $35.3 | $0.165 |
| Tuolumne | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $1.5 | $0.319 | $1.0 | $0.215 |
| | Ground 3-5 MW | 3 | 7 | $2.1 | $0.291 | $1.4 | $0.188 |
| | Ground 5-10 MW | 16 | 34 | $10.0 | $0.290 | $6.4 | $0.185 |
| | Ground 10-20 MW | 11 | 24 | $6.9 | $0.283 | $4.4 | $0.180 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ventura | Residential Roof | 199 | 357 | $108.8 | $0.305 | $72.5 | $0.203 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.346 | $0.5 | $0.248 |
| | Ground 1-3 MW | 6 | 12 | $3.9 | $0.328 | $2.7 | $0.230 |
| | Ground 3-5 MW | 8 | 18 | $5.0 | $0.284 | $3.3 | $0.184 |
| | Ground 5-10 MW | 24 | 54 | $11.1 | $0.205 | $5.6 | $0.103 |
| | Ground 10-20 MW | 190 | 412 | $103.5 | $0.251 | $61.6 | $0.149 |
| Yolo | Residential Roof | 7 | 11 | $5.2 | $0.459 | $4.0 | $0.351 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $1.5 | $0.327 | $1.0 | $0.223 |
| | Ground 3-5 MW | 30 | 65 | $20.3 | $0.315 | $13.5 | $0.208 |
| | Ground 5-10 MW | 29 | 61 | $18.6 | $0.303 | $12.1 | $0.197 |
| | Ground 10-20 MW | 88 | 187 | $55.1 | $0.294 | $35.2 | $0.188 |
| Yuba | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 3 | $1.1 | $0.350 | $0.8 | $0.245 |
| | Ground 1-3 MW | 5 | 10 | $3.4 | $0.329 | $2.3 | $0.225 |
| | Ground 3-5 MW | 7 | 15 | $4.8 | $0.315 | $3.2 | $0.209 |
| | Ground 5-10 MW | 23 | 49 | $14.9 | $0.304 | $9.8 | $0.199 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 15,338 | 29,657 | 9804 | 0.33 | 6729 | 0.23 |

**100% Learning Curve Results By County (cont.)**

## High Rooftop Scenario

| County | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | $M | $/kWh | $M | $/kWh |
| Alameda | Residential Roof | 239 | 420 | $189.5 | $0.451 | $144.6 | $0.344 |
| | Commercial Roof | 323 | 538 | $234.2 | $0.435 | $176.2 | $0.328 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Amador | Residential Roof | 21 | 37 | $16.7 | $0.450 | $12.7 | $0.344 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 6 | $2.0 | $0.323 | $1.3 | $0.216 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 8 | 19 | $5.7 | $0.309 | $3.8 | $0.202 |
| | Ground 5-10 MW | 5 | 12 | $3.5 | $0.300 | $2.3 | $0.197 |
| | Ground 10-20 MW | | | | | | |
| Butte | Residential Roof | 174 | 300 | $139.0 | $0.463 | $106.7 | $0.356 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 5 | $1.8 | $0.329 | $1.2 | $0.225 |
| | Ground 3-5 MW | 14 | 29 | $9.3 | $0.318 | $6.2 | $0.213 |
| | Ground 5-10 MW | 14 | 29 | $8.9 | $0.305 | $5.8 | $0.199 |
| | Ground 10-20 MW | 19 | 41 | $12.1 | $0.299 | $7.8 | $0.193 |
| Calaveras | Residential Roof | 10 | 18 | $8.1 | $0.446 | $6.2 | $0.338 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.338 | $0.1 | $0.232 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.310 | $1.6 | $0.207 |
| | Ground 5-10 MW | 7 | 14 | $4.3 | $0.299 | $2.8 | $0.196 |
| | Ground 10-20 MW | | | | | | |
| Colusa | Residential Roof | 23 | 40 | $18.3 | $0.460 | $14.0 | $0.352 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.5 | $0.349 | $0.3 | $0.245 |
| | Ground 1-3 MW | 4 | 8 | $2.7 | $0.329 | $1.9 | $0.225 |
| | Ground 3-5 MW | 8 | 18 | $5.6 | $0.316 | $3.7 | $0.210 |
| | Ground 5-10 MW | 11 | 23 | $6.9 | $0.302 | $4.5 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Contra Costa | Residential Roof | 507 | 891 | $402.2 | $0.451 | $306.3 | $0.344 |
| | Commercial Roof | 111 | 184 | $80.2 | $0.437 | $60.2 | $0.328 |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.341 | $0.5 | $0.238 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.7 | $0.316 | $1.8 | $0.210 |
| | Ground 5-10 MW | 6 | 13 | $3.8 | $0.300 | $2.5 | $0.197 |
| | Ground 10-20 MW | 63 | 135 | $39.4 | $0.291 | $25.5 | $0.188 |
| El Dorado | Residential Roof | 50 | 87 | $39.5 | $0.454 | $30.2 | $0.347 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 11 | $3.6 | $0.323 | $2.4 | $0.219 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 49 | 104 | $30.7 | $0.295 | $19.8 | $0.190 |
| Fresno | Residential Roof | 607 | 1,081 | $475.3 | $0.440 | $361.0 | $0.334 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.331 | $0.4 | $0.226 |
| | Ground 1-3 MW | 5 | 12 | $3.8 | $0.314 | $2.6 | $0.212 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 21 | 47 | $14.0 | $0.300 | $9.2 | $0.198 |
| | Ground 5-10 MW | 71 | 156 | $40.6 | $0.261 | $24.5 | $0.158 |
| | Ground 10-20 MW | 264 | 574 | $150.3 | $0.262 | $90.0 | $0.157 |
| Glenn | Residential Roof | 18 | 31 | $14.0 | $0.456 | $10.7 | $0.349 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.4 | $0.346 | $0.3 | $0.239 |
| | Ground 1-3 MW | 3 | 7 | $2.3 | $0.327 | $1.5 | $0.222 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 7 | 15 | $4.7 | $0.304 | $3.0 | $0.197 |
| | Ground 10-20 MW | | | | | | |
| Humboldt | Residential Roof | 37 | 53 | $29.2 | $0.548 | $23.3 | $0.438 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $1.0 | $0.400 | $0.7 | $0.287 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Imperial | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Inyo | Residential Roof | 6 | 11 | $3.1 | $0.287 | $2.1 | $0.191 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.208 | $0.0 | $0.109 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Kern | Residential Roof | 376 | 684 | $239.4 | $0.350 | $168.5 | $0.246 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.1 | $0.317 | $0.8 | $0.216 |
| | Ground 1-3 MW | 26 | 60 | $18.1 | $0.302 | $12.0 | $0.202 |
| | Ground 3-5 MW | 35 | 80 | $22.5 | $0.282 | $14.5 | $0.182 |
| | Ground 5-10 MW | 135 | 299 | $69.0 | $0.230 | $38.7 | $0.129 |
| | Ground 10-20 MW | 153 | 333 | $69.7 | $0.209 | $35.5 | $0.106 |
| Kings | Residential Roof | 79 | 142 | $61.3 | $0.433 | $46.4 | $0.327 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 6 | $1.7 | $0.311 | $1.2 | $0.209 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 12 | 27 | $8.0 | $0.299 | $5.3 | $0.198 |
| | Ground 5-10 MW | 11 | 24 | $6.0 | $0.252 | $3.6 | $0.150 |
| | Ground 10-20 MW | | | | | | |
| Lake | Residential Roof | 45 | 79 | $36.2 | $0.458 | $27.6 | $0.350 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.2 | $0.341 | $0.1 | $0.237 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.308 | $1.7 | $0.204 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Lassen | Residential Roof | | | | | | |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Los Angeles | Residential Roof | 2,020 | 3,666 | $1,372.8 | $0.374 | $995.4 | $0.272 |
| | Commercial Roof | 817 | 1,390 | $501.4 | $0.361 | $355.7 | $0.256 |
| | Ground <= 1 MW | 2 | 4 | $1.2 | $0.275 | $0.8 | $0.178 |
| | Ground 1-3 MW | 4 | 9 | $2.3 | $0.259 | $1.4 | $0.161 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 39 | 89 | $17.3 | $0.195 | $8.7 | $0.098 |
| Madera | Residential Roof | 80 | 142 | $62.5 | $0.440 | $47.5 | $0.334 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.8 | $0.334 | $0.6 | $0.230 |
| | Ground 1-3 MW | 5 | 12 | $3.7 | $0.316 | $2.5 | $0.213 |
| | Ground 3-5 MW | 12 | 26 | $7.7 | $0.301 | $5.1 | $0.198 |
| | Ground 5-10 MW | 16 | 36 | $10.5 | $0.294 | $6.9 | $0.192 |
| | Ground 10-20 MW | | | | | | |
| Marin | Residential Roof | 100 | 172 | $79.2 | $0.460 | $60.6 | $0.352 |
| | Commercial Roof | 6 | 9 | $4.1 | $0.468 | $3.2 | $0.362 |
| | Ground <= 1 MW | 0 | 1 | $0.4 | $0.362 | $0.3 | $0.253 |
| | Ground 1-3 MW | 2 | 4 | $1.5 | $0.345 | $1.0 | $0.235 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Mariposa | Residential Roof | 25 | 44 | $19.4 | $0.438 | $14.6 | $0.330 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.0 | $0.333 | $0.0 | $0.231 |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Mendocino | Residential Roof | 41 | 69 | $32.8 | $0.478 | $25.3 | $0.369 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Merced | Residential Roof | 174 | 307 | $136.6 | $0.444 | $103.6 | $0.337 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.341 | $0.4 | $0.238 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 7 | 16 | $4.8 | $0.305 | $3.2 | $0.203 |
| | Ground 5-10 MW | 18 | 39 | $11.5 | $0.295 | $7.4 | $0.190 |
| | Ground 10-20 MW | | | | | | |
| Mono | Residential Roof | 12 | 23 | $7.1 | $0.313 | $4.8 | $0.212 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.3 | $0.227 | $0.2 | $0.132 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Monterey | Residential Roof | 157 | 274 | $118.8 | $0.433 | $89.5 | $0.326 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 12 | 29 | $8.7 | $0.302 | $5.7 | $0.199 |
| | Ground 3-5 MW | 4 | 8 | $1.8 | $0.210 | $0.9 | $0.108 |
| | Ground 5-10 MW | 28 | 60 | $14.4 | $0.240 | $8.1 | $0.135 |
| | Ground 10-20 MW | 13 | 27 | $8.0 | $0.293 | $5.0 | $0.186 |
| Napa | Residential Roof | 133 | 231 | $106.8 | $0.463 | $81.3 | $0.352 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 3 | 6 | $2.0 | $0.333 | $1.3 | $0.227 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | 71 | 148 | $45.1 | $0.304 | $29.0 | $0.195 |
| Nevada | Residential Roof | 39 | 67 | $30.5 | $0.453 | $23.2 | $0.345 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 1 | 3 | $1.0 | $0.333 | $0.7 | $0.225 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 12 | 26 | $7.8 | $0.304 | $5.1 | $0.200 |
| | Ground 10-20 MW | | | | | | |
| Orange | Residential Roof | 728 | 1,307 | $524.5 | $0.401 | $390.2 | $0.299 |
| | Commercial Roof | 643 | 1,100 | $439.8 | $0.400 | $325.7 | $0.296 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 8 | 18 | $5.3 | $0.289 | $3.5 | $0.190 |
| | Ground 10-20 MW | | | | | | |
| Placer | Residential Roof | 99 | 173 | $79.4 | $0.459 | $60.8 | $0.352 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.348 | $0.1 | $0.245 |
| | Ground 1-3 MW | 5 | 10 | $3.3 | $0.329 | $2.3 | $0.225 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 21 | 45 | $13.7 | $0.304 | $9.0 | $0.200 |
| | Ground 10-20 MW | 119 | 253 | $75.0 | $0.297 | $48.5 | $0.192 |
| Plumas | Residential Roof | 8 | 14 | $5.0 | $0.357 | $3.5 | $0.249 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.4 | $0.317 | $0.3 | $0.210 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Riverside | Residential Roof | 618 | 1,145 | $337.5 | $0.295 | $226.5 | $0.198 |
| | Commercial Roof | 64 | 107 | $32.0 | $0.298 | $21.1 | $0.196 |
| | Ground <= 1 MW | 1 | 4 | $1.0 | $0.276 | $0.7 | $0.180 |
| | Ground 1-3 MW | 6 | 13 | $3.9 | $0.293 | $2.6 | $0.195 |
| | Ground 3-5 MW | 8 | 18 | $3.7 | $0.198 | $1.9 | $0.102 |
| | Ground 5-10 MW | 29 | 67 | $13.1 | $0.197 | $6.8 | $0.101 |
| | Ground 10-20 MW | 126 | 292 | $56.1 | $0.192 | $28.5 | $0.098 |
| Sacramento | Residential Roof | 1 | 2 | $0.9 | $0.451 | $0.7 | $0.342 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Benito | Residential Roof | 13 | 23 | $10.2 | $0.439 | $7.7 | $0.332 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Bernardino | Residential Roof | 673 | 1,264 | $369.5 | $0.292 | $244.6 | $0.194 |
| | Commercial Roof | 311 | 523 | $155.7 | $0.298 | $102.2 | $0.195 |
| | Ground <= 1 MW | 1 | 4 | $0.8 | $0.230 | $0.5 | $0.135 |
| | Ground 1-3 MW | 6 | 15 | $2.9 | $0.194 | $1.5 | $0.102 |
| | Ground 3-5 MW | 4 | 9 | $1.7 | $0.193 | $0.8 | $0.097 |
| | Ground 5-10 MW | 6 | 13 | $2.6 | $0.208 | $1.4 | $0.108 |
| | Ground 10-20 MW | 12 | 30 | $5.4 | $0.179 | $2.8 | $0.092 |
| San Diego | Residential Roof | 1,138 | 2,046 | $741.1 | $0.362 | $534.4 | $0.261 |
| | Commercial Roof | 169 | 286 | $106.6 | $0.373 | $77.3 | $0.270 |
| | Ground <= 1 MW | 2 | 4 | $1.3 | $0.327 | $0.9 | $0.226 |
| | Ground 1-3 MW | 3 | 6 | $1.9 | $0.343 | $1.4 | $0.242 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 6 | 12 | $3.5 | $0.288 | $2.3 | $0.187 |
| | Ground 10-20 MW | 16 | 34 | $7.3 | $0.212 | $3.8 | $0.111 |
| San Francisco | Residential Roof | 71 | 122 | $56.4 | $0.465 | $43.2 | $0.355 |
| | Commercial Roof | 11 | 18 | $8.2 | $0.446 | $6.1 | $0.336 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Joaquin | Residential Roof | 380 | 669 | $301.5 | $0.450 | $229.9 | $0.343 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 10 | $3.3 | $0.323 | $2.2 | $0.217 |
| | Ground 3-5 MW | 4 | 9 | $2.9 | $0.308 | $1.9 | $0.202 |
| | Ground 5-10 MW | 31 | 67 | $20.1 | $0.299 | $13.1 | $0.194 |
| | Ground 10-20 MW | 31 | 67 | $19.5 | $0.292 | $12.5 | $0.187 |
| San Luis Obispo | Residential Roof | 89 | 162 | $52.4 | $0.323 | $35.4 | $0.218 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.306 | $0.0 | $0.204 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 3 | 8 | $1.6 | $0.206 | $0.8 | $0.104 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| San Mateo | Residential Roof | 220 | 361 | $172.8 | $0.478 | $134.5 | $0.372 |
| | Commercial Roof | 104 | 162 | $75.2 | $0.463 | $58.0 | $0.357 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Barbara | Residential Roof | 169 | 307 | $94.7 | $0.309 | $62.5 | $0.204 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.334 | $0.4 | $0.231 |
| | Ground 1-3 MW | 9 | 21 | $6.3 | $0.294 | $4.1 | $0.192 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 9 | 22 | $4.2 | $0.196 | $2.0 | $0.095 |
| | Ground 10-20 MW | 11 | 24 | $4.7 | $0.194 | $2.3 | $0.095 |
| Santa Clara | Residential Roof | 759 | 1,346 | $597.7 | $0.444 | $453.4 | $0.337 |
| | Commercial Roof | 225 | 378 | $161.7 | $0.428 | $121.3 | $0.321 |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Santa Cruz | Residential Roof | 78 | 136 | $61.9 | $0.454 | $47.5 | $0.348 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Shasta | Residential Roof | 67 | 111 | $53.2 | $0.479 | $41.1 | $0.370 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.6 | $0.355 | $0.4 | $0.246 |
| | Ground 1-3 MW | 1 | 3 | $1.0 | $0.343 | $0.7 | $0.236 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 22 | 45 | $14.3 | $0.315 | $9.4 | $0.207 |
| | Ground 10-20 MW | | | | | | |
| Sierra | Residential Roof | 1 | 1 | $0.5 | $0.438 | $0.4 | $0.332 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Solano | Residential Roof | 156 | 273 | $124.0 | $0.454 | $94.9 | $0.347 |
| | Commercial Roof | 0 | 1 | $0.3 | $0.437 | $0.3 | $0.328 |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.347 | $0.5 | $0.244 |
| | Ground 1-3 MW | 3 | 6 | $2.0 | $0.324 | $1.3 | $0.218 |

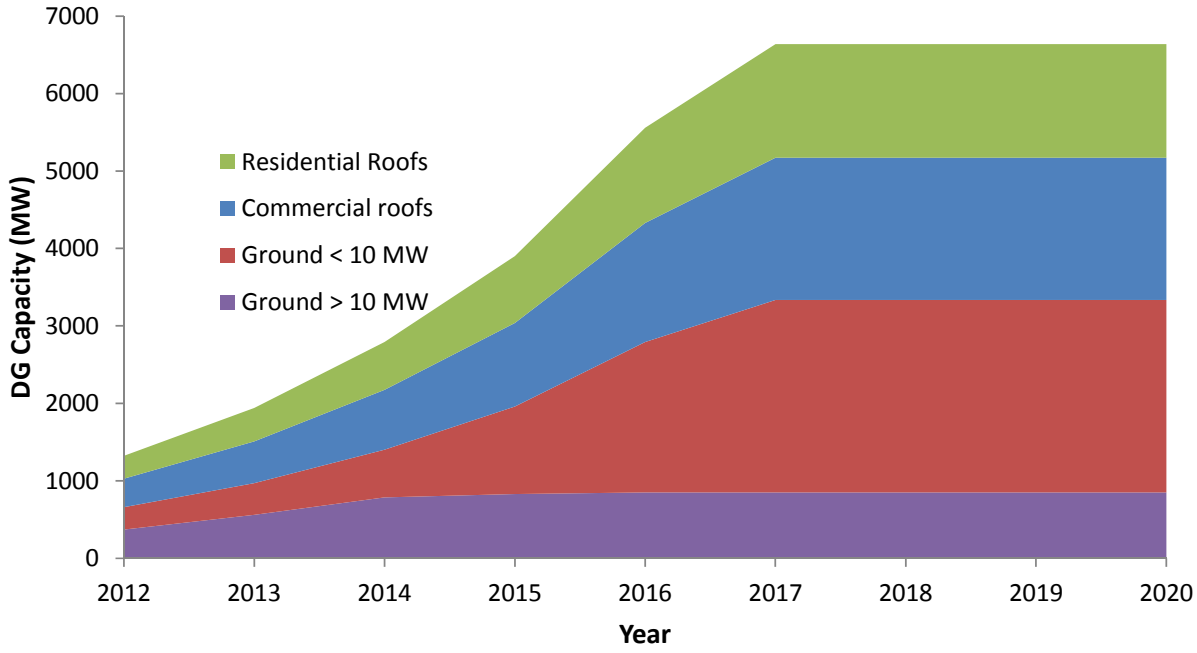
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 4 | 9 | $2.9 | $0.310 | $1.9 | $0.204 |
| | Ground 5-10 MW | 21 | 45 | $13.6 | $0.299 | $8.8 | $0.194 |
| | Ground 10-20 MW | 37 | 79 | $23.2 | $0.293 | $14.9 | $0.188 |
| Sonoma | Residential Roof | 251 | 429 | $201.0 | $0.469 | $154.6 | $0.361 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 1 | $0.5 | $0.369 | $0.3 | $0.262 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 4 | 8 | $2.5 | $0.320 | $1.7 | $0.211 |
| | Ground 5-10 MW | 16 | 34 | $10.5 | $0.311 | $6.8 | $0.203 |
| | Ground 10-20 MW | | | | | | |
| Stanislaus | Residential Roof | 113 | 199 | $89.2 | $0.448 | $67.7 | $0.340 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.5 | $0.340 | $0.4 | $0.237 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 5 | 11 | $3.4 | $0.307 | $2.2 | $0.202 |
| | Ground 5-10 MW | 7 | 14 | $4.3 | $0.296 | $2.8 | $0.191 |
| | Ground 10-20 MW | | | | | | |
| Sutter | Residential Roof | 70 | 122 | $56.0 | $0.458 | $42.7 | $0.350 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 0 | 0 | $0.1 | $0.350 | $0.1 | $0.243 |
| | Ground 1-3 MW | 4 | 8 | $2.7 | $0.331 | $1.8 | $0.227 |
| | Ground 3-5 MW | 12 | 25 | $7.9 | $0.316 | $5.2 | $0.210 |
| | Ground 5-10 MW | 17 | 36 | $10.8 | $0.305 | $7.0 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Tehama | Residential Roof | 36 | 62 | $28.9 | $0.468 | $22.3 | $0.361 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 5 | 11 | $3.6 | $0.333 | $2.5 | $0.226 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 6 | 13 | $3.8 | $0.304 | $2.5 | $0.198 |
| | Ground 10-20 MW | | | | | | |
| Trinity | Residential Roof | 1 | 2 | $0.8 | $0.457 | $0.6 | $0.347 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Tulare | Residential Roof | 231 | 414 | $181.1 | $0.438 | $137.7 | $0.333 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 2 | 4 | $1.2 | $0.335 | $0.8 | $0.232 |
| | Ground 1-3 MW | 16 | 36 | $11.3 | $0.313 | $7.6 | $0.211 |

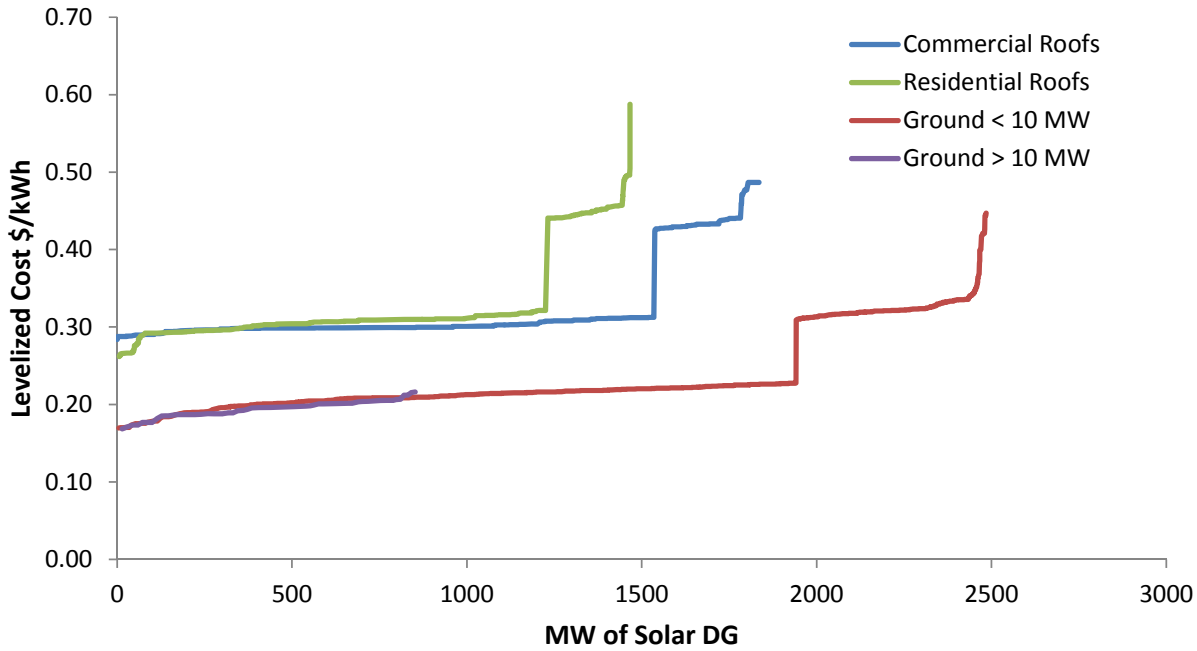
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ground 3-5 MW | 4 | 9 | $2.6 | $0.301 | $1.7 | $0.200 |
| | Ground 5-10 MW | 12 | 27 | $7.8 | $0.290 | $5.0 | $0.187 |
| | Ground 10-20 MW | | | | | | |
| Tuolumne | Residential Roof | 35 | 62 | $27.2 | $0.440 | $20.7 | $0.335 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | 1 | 2 | $0.7 | $0.338 | $0.5 | $0.235 |
| | Ground 1-3 MW | | | | | | |
| | Ground 3-5 MW | 3 | 7 | $2.1 | $0.291 | $1.3 | $0.188 |
| | Ground 5-10 MW | | | | | | |
| | Ground 10-20 MW | | | | | | |
| Ventura | Residential Roof | 419 | 756 | $259.7 | $0.343 | $181.8 | $0.240 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 5 | $1.5 | $0.308 | $1.0 | $0.205 |
| | Ground 3-5 MW | 9 | 20 | $5.0 | $0.255 | $3.0 | $0.154 |
| | Ground 5-10 MW | 9 | 20 | $5.9 | $0.287 | $3.7 | $0.184 |
| | Ground 10-20 MW | 28 | 60 | $14.8 | $0.248 | $8.8 | $0.147 |
| Yolo | Residential Roof | 123 | 214 | $97.8 | $0.456 | $74.7 | $0.348 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 2 | 4 | $1.5 | $0.327 | $1.0 | $0.223 |
| | Ground 3-5 MW | 25 | 54 | $17.1 | $0.314 | $11.4 | $0.209 |
| | Ground 5-10 MW | 7 | 15 | $4.6 | $0.302 | $3.0 | $0.199 |
| | Ground 10-20 MW | 20 | 42 | $12.5 | $0.293 | $8.0 | $0.188 |
| Yuba | Residential Roof | 37 | 64 | $29.3 | $0.458 | $22.5 | $0.352 |
| | Commercial Roof | | | | | | |
| | Ground <= 1 MW | | | | | | |
| | Ground 1-3 MW | 1 | 3 | $1.0 | $0.329 | $0.7 | $0.226 |
| | Ground 3-5 MW | | | | | | |
| | Ground 5-10 MW | 5 | 11 | $3.3 | $0.304 | $2.2 | $0.201 |
| | Ground 10-20 MW | | | | | | |
| | Totals | 16,366 | 29,798 | 11175 | 0.38 | 8076 | 0.27 |

## 100% Learning Curve Sensitivities

All sensitivities presented are based on the *least cost* scenario unless otherwise noted.

### 15% Interconnection Constraint



**Least Cost Summary Table, 15% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 111 | 189 | $74.8 | $0.396 | $52.0 | $0.275 |
| | | Commercial Roof | 196 | 315 | $122.1 | $0.388 | $83.8 | $0.266 |
| | | Ground < 10 MW | 632 | 1,328 | $344.3 | $0.259 | $190.7 | $0.144 |
| | | Ground 10-20 MW | 42 | 91 | $19.1 | $0.210 | $9.2 | $0.101 |
| | North Central Valley | Residential Roof | 105 | 176 | $68.7 | $0.390 | $47.2 | $0.268 |
| | | Commercial Roof | 237 | 376 | $145.4 | $0.387 | $99.5 | $0.264 |
| | | Ground < 10 MW | 697 | 1,470 | $373.1 | $0.254 | $201.8 | $0.137 |
| | | Ground 10-20 MW | 11 | 24 | $4.9 | $0.207 | $2.4 | $0.102 |
| | South Central Valley | Residential Roof | 98 | 169 | $65.1 | $0.385 | $44.6 | $0.264 |
| | | Commercial Roof | 111 | 179 | $64.6 | $0.360 | $42.6 | $0.237 |
| | | Ground < 10 MW | 363 | 765 | $192.9 | $0.252 | $104.1 | $0.136 |
| | | Ground 10-20 MW | 31 | 65 | $14.3 | $0.221 | $6.8 | $0.106 |
| | Mountain | Residential Roof | 20 | 34 | $13.4 | $0.391 | $9.2 | $0.269 |
| | | Commercial Roof | 11 | 18 | $6.9 | $0.375 | $4.6 | $0.253 |
| | | Ground < 10 MW | 71 | 148 | $37.7 | $0.255 | $20.5 | $0.139 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 2 | $0.5 | $0.212 | $0.3 | $0.111 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 636 | 1,132 | $353.0 | $0.312 | $227.6 | $0.201 |
| | | Commercial Roof | 931 | 1,540 | $471.4 | $0.306 | $298.3 | $0.194 |
| | | Ground < 10 MW | 366 | 832 | $171.3 | $0.206 | $85.4 | $0.103 |
| | | Ground 10-20 MW | 571 | 1,291 | $254.6 | $0.197 | $122.7 | $0.095 |
| | South Central Valley | Residential Roof | 137 | 251 | $76.9 | $0.306 | $50.2 | $0.200 |
| | | Commercial Roof | 144 | 238 | $73.0 | $0.307 | $46.2 | $0.194 |
| | | Ground < 10 MW | 138 | 321 | $65.3 | $0.203 | $32.3 | $0.101 |
| | | Ground 10-20 MW | 48 | 102 | $21.5 | $0.210 | $10.3 | $0.101 |
| | Desert | Residential Roof | 24 | 43 | $13.7 | $0.322 | $8.9 | $0.210 |
| | | Commercial Roof | 35 | 59 | $18.1 | $0.308 | $11.3 | $0.193 |
| | | Ground < 10 MW | 45 | 107 | $21.1 | $0.198 | $10.6 | $0.099 |
| | | Ground 10-20 MW | 32 | 70 | $14.0 | $0.200 | $6.8 | $0.097 |
| | Mountain | Residential Roof | 32 | 59 | $17.6 | $0.301 | $11.3 | $0.193 |
| | | Commercial Roof | 29 | 48 | $14.6 | $0.305 | $9.3 | $0.196 |
| | | Ground < 10 MW | 34 | 78 | $15.8 | $0.203 | $7.8 | $0.100 |
| | | Ground 10-20 MW | 26 | 56 | $11.6 | $0.207 | $5.6 | $0.101 |
| SDGE | South Coast | Residential Roof | 300 | 529 | $180.0 | $0.340 | $122.0 | $0.231 |
| | | Commercial Roof | 141 | 232 | $76.0 | $0.327 | $50.4 | $0.217 |
| | | Ground < 10 MW | 134 | 289 | $63.7 | $0.220 | $32.7 | $0.113 |
| | | Ground 10-20 MW | 90 | 195 | $40.6 | $0.209 | $20.1 | $0.103 |
| | South Central Valley | Residential Roof | 3 | 7 | $1.9 | $0.286 | $1.2 | $0.189 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 4 | $0.8 | $0.212 | $0.4 | $0.112 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.8 | $0.203 | $0.4 | $0.105 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,638 | 12,834 | 3525 | 0.27 | 2091 | 0.16 |

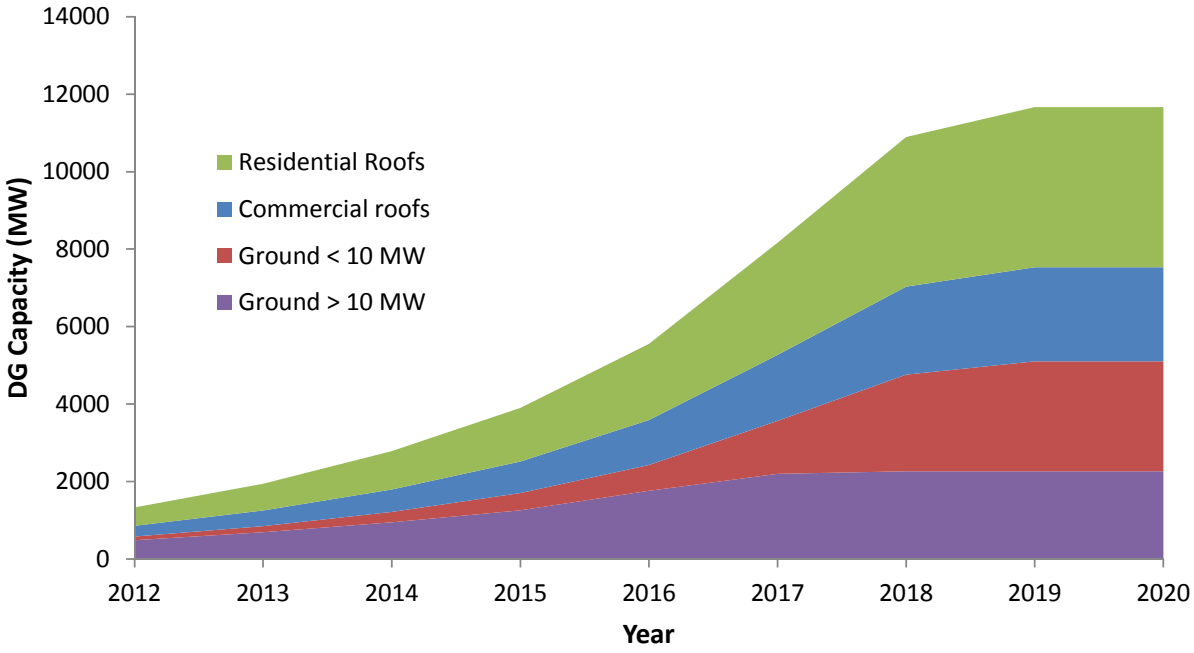
**Least Net Cost Summary Table, 15% Interconnection Constraint**

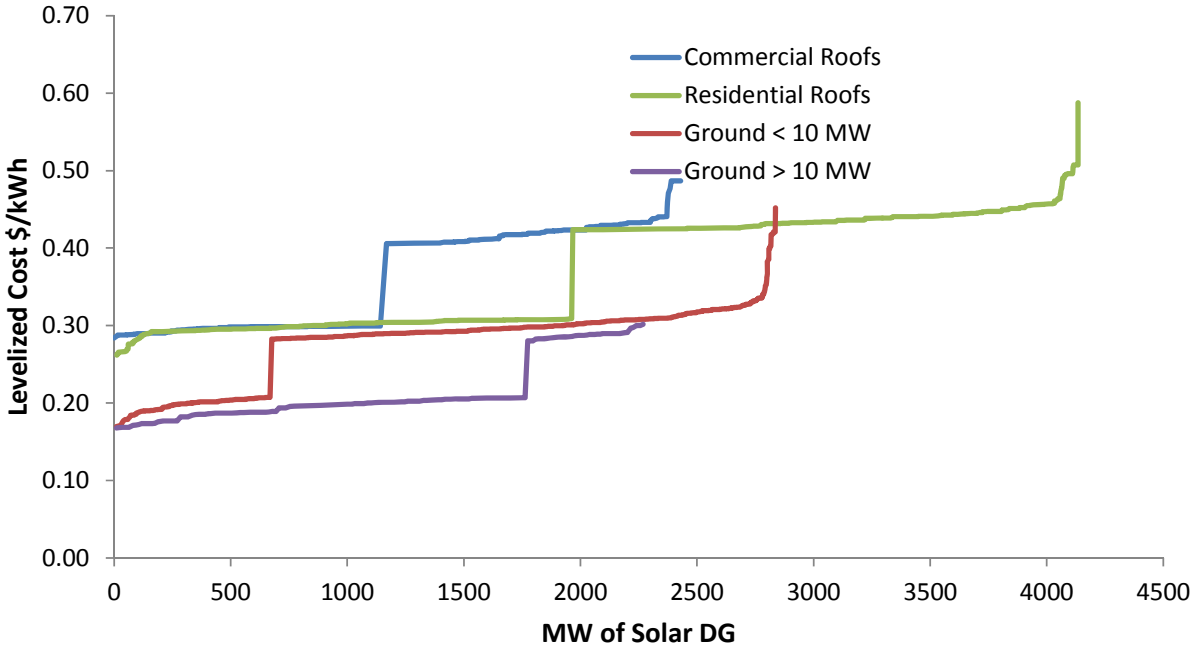
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 111 | 189 | $74.8 | $0.396 | $52.0 | $0.275 |
| | | Commercial Roof | 196 | 313 | $120.6 | $0.386 | $82.5 | $0.264 |
| | | Ground < 10 MW | 632 | 1,328 | $344.2 | $0.259 | $190.5 | $0.143 |
| | | Ground 10-20 MW | 42 | 91 | $19.1 | $0.210 | $9.2 | $0.101 |
| | North Central Valley | Residential Roof | 105 | 180 | $69.7 | $0.388 | $47.8 | $0.266 |
| | | Commercial Roof | 228 | 363 | $134.8 | $0.371 | $90.5 | $0.249 |
| | | Ground < 10 MW | 697 | 1,468 | $368.6 | $0.251 | $197.9 | $0.135 |
| | | Ground 10-20 MW | 11 | 24 | $5.0 | $0.207 | $2.4 | $0.100 |
| | South Central Valley | Residential Roof | 98 | 168 | $59.2 | $0.352 | $38.9 | $0.231 |
| | | Commercial Roof | 111 | 179 | $61.8 | $0.345 | $39.8 | $0.223 |
| | | Ground < 10 MW | 363 | 764 | $189.4 | $0.248 | $100.9 | $0.132 |
| | | Ground 10-20 MW | 31 | 64 | $14.2 | $0.221 | $6.8 | $0.106 |
| | Mountain | Residential Roof | 20 | 34 | $13.4 | $0.391 | $9.2 | $0.269 |
| | | Commercial Roof | 11 | 18 | $5.9 | $0.321 | $3.6 | $0.199 |
| | | Ground < 10 MW | 71 | 148 | $37.7 | $0.255 | $20.5 | $0.139 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 2 | $0.5 | $0.212 | $0.3 | $0.108 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 636 | 1,131 | $357.9 | $0.316 | $232.8 | $0.206 |
| | | Commercial Roof | 931 | 1,539 | $479.1 | $0.311 | $306.1 | $0.199 |
| | | Ground < 10 MW | 366 | 834 | $172.5 | $0.207 | $86.1 | $0.103 |
| | | Ground 10-20 MW | 571 | 1,289 | $254.3 | $0.197 | $122.9 | $0.095 |
| | South Central Valley | Residential Roof | 137 | 251 | $76.8 | $0.306 | $50.1 | $0.200 |
| | | Commercial Roof | 144 | 238 | $74.1 | $0.311 | $47.3 | $0.199 |
| | | Ground < 10 MW | 138 | 322 | $66.9 | $0.208 | $33.8 | $0.105 |
| | | Ground 10-20 MW | 48 | 102 | $21.5 | $0.210 | $10.3 | $0.101 |
| | Desert | Residential Roof | 24 | 42 | $13.6 | $0.322 | $8.9 | $0.211 |
| | | Commercial Roof | 35 | 58 | $17.9 | $0.308 | $11.3 | $0.194 |
| | | Ground < 10 MW | 45 | 107 | $21.6 | $0.202 | $11.0 | $0.103 |
| | | Ground 10-20 MW | 32 | 70 | $14.0 | $0.200 | $6.8 | $0.097 |
| | Mountain | Residential Roof | 32 | 59 | $17.7 | $0.301 | $11.4 | $0.193 |
| | | Commercial Roof | 29 | 48 | $14.8 | $0.305 | $9.3 | $0.193 |
| | | Ground < 10 MW | 34 | 78 | $16.0 | $0.204 | $7.9 | $0.101 |
| | | Ground 10-20 MW | 26 | 56 | $11.6 | $0.207 | $5.7 | $0.102 |
| SDGE | South Coast | Residential Roof | 300 | 531 | $182.6 | $0.344 | $124.1 | $0.234 |
| | | Commercial Roof | 141 | 234 | $76.5 | $0.327 | $50.4 | $0.216 |
| | | Ground < 10 MW | 134 | 291 | $68.6 | $0.236 | $37.2 | $0.128 |
| | | Ground 10-20 MW | 90 | 195 | $40.8 | $0.209 | $20.0 | $0.102 |
| | South Central Valley | Residential Roof | 3 | 7 | $1.9 | $0.286 | $1.2 | $0.189 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 1 | 4 | $0.8 | $0.212 | $0.4 | $0.110 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.8 | $0.203 | $0.4 | $0.103 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,630 | 12,824 | 3521 | 0.27 | 2089 | 0.16 |

**High Rooftop Summary Table, 15% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 640 | 1,089 | $405.6 | $0.373 | $275.9 | $0.253 |
| | | Commercial Roof | 219 | 352 | $135.3 | $0.385 | $92.5 | $0.263 |
| | | Ground < 10 MW | 122 | 261 | $66.1 | $0.253 | $36.6 | $0.140 |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 686 | 1,173 | $430.7 | $0.367 | $290.0 | $0.247 |
| | | Commercial Roof | 256 | 408 | $157.6 | $0.386 | $107.7 | $0.264 |
| | | Ground < 10 MW | 109 | 234 | $55.0 | $0.236 | $28.4 | $0.122 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 454 | 780 | $286.4 | $0.367 | $193.0 | $0.248 |
| | | Commercial Roof | 121 | 197 | $78.2 | $0.396 | $53.9 | $0.273 |
| | | Ground < 10 MW | 38 | 81 | $21.0 | $0.258 | $11.9 | $0.146 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 88 | 150 | $57.5 | $0.384 | $39.5 | $0.264 |
| | | Commercial Roof | 11 | 18 | $6.9 | $0.375 | $4.7 | $0.253 |
| | | Ground < 10 MW | 3 | 7 | $1.6 | $0.241 | $0.8 | $0.127 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 1 | 2 | $0.6 | $0.296 | $0.4 | $0.196 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,354 | 2,448 | $744.7 | $0.304 | $480.9 | $0.196 |
| | | Commercial Roof | 1,089 | 1,809 | $552.1 | $0.305 | $349.2 | $0.193 |
| | | Ground < 10 MW | 67 | 153 | $31.6 | $0.206 | $16.0 | $0.104 |
| | | Ground 10-20 MW | 12 | 28 | $5.4 | $0.196 | $2.7 | $0.096 |
| | South Central Valley | Residential Roof | 274 | 505 | $150.8 | $0.299 | $97.0 | $0.192 |
| | | Commercial Roof | 186 | 309 | $94.5 | $0.306 | $59.7 | $0.193 |
| | | Ground < 10 MW | 7 | 16 | $3.4 | $0.209 | $1.8 | $0.108 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 82 | 150 | $44.9 | $0.299 | $29.0 | $0.193 |
| | | Commercial Roof | 49 | 82 | $24.8 | $0.304 | $15.6 | $0.191 |
| | | Ground < 10 MW | 5 | 13 | $2.3 | $0.178 | $1.0 | $0.080 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 65 | 120 | $36.0 | $0.301 | $23.3 | $0.195 |
| | | Commercial Roof | 54 | 89 | $26.8 | $0.302 | $17.1 | $0.192 |
| | | Ground < 10 MW | 2 | 5 | $1.1 | $0.209 | $0.5 | $0.107 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 481 | 848 | $281.0 | $0.332 | $188.8 | $0.223 |
| | | Commercial Roof | 178 | 294 | $94.6 | $0.322 | $62.3 | $0.212 |
| | | Ground < 10 MW | 7 | 15 | $3.7 | $0.244 | $2.1 | $0.138 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 5 | 9 | $2.6 | $0.284 | $1.7 | $0.187 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 3 | $0.9 | $0.285 | $0.6 | $0.186 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,668 | 11,646 | 3804 | 0.33 | 2485 | 0.21 |

## 30% Interconnection Constraint



**Least Cost Summary Table, 30% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 405 | 703 | $310.8 | $0.442 | $233.3 | $0.332 |
| | | Commercial Roof | 255 | 416 | $181.7 | $0.436 | $135.1 | $0.325 |
| | | Ground < 10 MW | 870 | 1,859 | $559.3 | $0.301 | $359.8 | $0.194 |
| | | Ground 10-20 MW | 230 | 487 | $132.6 | $0.272 | $80.6 | $0.165 |
| | North Central Valley | Residential Roof | 396 | 685 | $310.9 | $0.454 | $234.2 | $0.342 |
| | | Commercial Roof | 295 | 477 | $210.4 | $0.441 | $157.0 | $0.329 |
| | | Ground < 10 MW | 923 | 1,975 | $577.9 | $0.293 | $363.3 | $0.184 |
| | | Ground 10-20 MW | 310 | 661 | $166.3 | $0.252 | $94.8 | $0.143 |
| | South Central Valley | Residential Roof | 284 | 497 | $222.4 | $0.448 | $166.8 | $0.336 |
| | | Commercial Roof | 134 | 219 | $95.2 | $0.434 | $70.5 | $0.321 |
| | | Ground < 10 MW | 430 | 919 | $269.1 | $0.293 | $169.4 | $0.184 |
| | | Ground 10-20 MW | 203 | 434 | $109.5 | $0.252 | $62.7 | $0.144 |
| | Mountain | Residential Roof | 40 | 70 | $31.7 | $0.456 | $23.9 | $0.344 |
| | | Commercial Roof | 14 | 24 | $10.3 | $0.431 | $7.6 | $0.319 |
| | | Ground < 10 MW | 91 | 194 | $58.9 | $0.305 | $38.0 | $0.196 |
| | | Ground 10-20 MW | 38 | 82 | $17.5 | $0.214 | $8.7 | $0.106 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.212 | $0.6 | $0.114 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,788 | 3,215 | $1,125.0 | $0.350 | $786.5 | $0.245 |
| | | Commercial Roof | 1,281 | 2,154 | $741.3 | $0.344 | $511.1 | $0.237 |
| | | Ground < 10 MW | 273 | 629 | $143.1 | $0.228 | $80.0 | $0.127 |
| | | Ground 10-20 MW | 1,015 | 2,310 | $462.8 | $0.200 | $234.7 | $0.102 |
| | South Central Valley | Residential Roof | 313 | 570 | $194.2 | $0.341 | $135.3 | $0.237 |
| | | Commercial Roof | 189 | 318 | $107.8 | $0.339 | $73.6 | $0.232 |
| | | Ground < 10 MW | 89 | 209 | $48.8 | $0.234 | $28.2 | $0.135 |
| | | Ground 10-20 MW | 161 | 374 | $74.7 | $0.200 | $37.6 | $0.101 |
| | Desert | Residential Roof | 113 | 203 | $74.2 | $0.366 | $52.9 | $0.261 |
| | | Commercial Roof | 49 | 83 | $28.9 | $0.350 | $20.1 | $0.243 |
| | | Ground < 10 MW | 41 | 97 | $20.8 | $0.215 | $11.4 | $0.118 |
| | | Ground 10-20 MW | 29 | 68 | $12.8 | $0.188 | $6.4 | $0.094 |
| | Mountain | Residential Roof | 88 | 163 | $52.5 | $0.323 | $36.0 | $0.221 |
| | | Commercial Roof | 59 | 99 | $30.1 | $0.304 | $19.6 | $0.198 |
| | | Ground < 10 MW | 30 | 68 | $13.9 | $0.205 | $7.1 | $0.105 |
| | | Ground 10-20 MW | 45 | 98 | $20.4 | $0.208 | $10.4 | $0.105 |
| SDGE | South Coast | Residential Roof | 704 | 1,255 | $463.4 | $0.369 | $333.4 | $0.266 |
| | | Commercial Roof | 153 | 255 | $89.3 | $0.350 | $62.5 | $0.245 |
| | | Ground < 10 MW | 85 | 187 | $45.2 | $0.242 | $26.1 | $0.140 |
| | | Ground 10-20 MW | 237 | 516 | $113.6 | $0.220 | $60.9 | $0.118 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.193 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.9 | $0.234 | $0.5 | $0.138 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.107 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 11,668 | 22,593 | 7132 | 0.32 | 4742 | 0.21 |

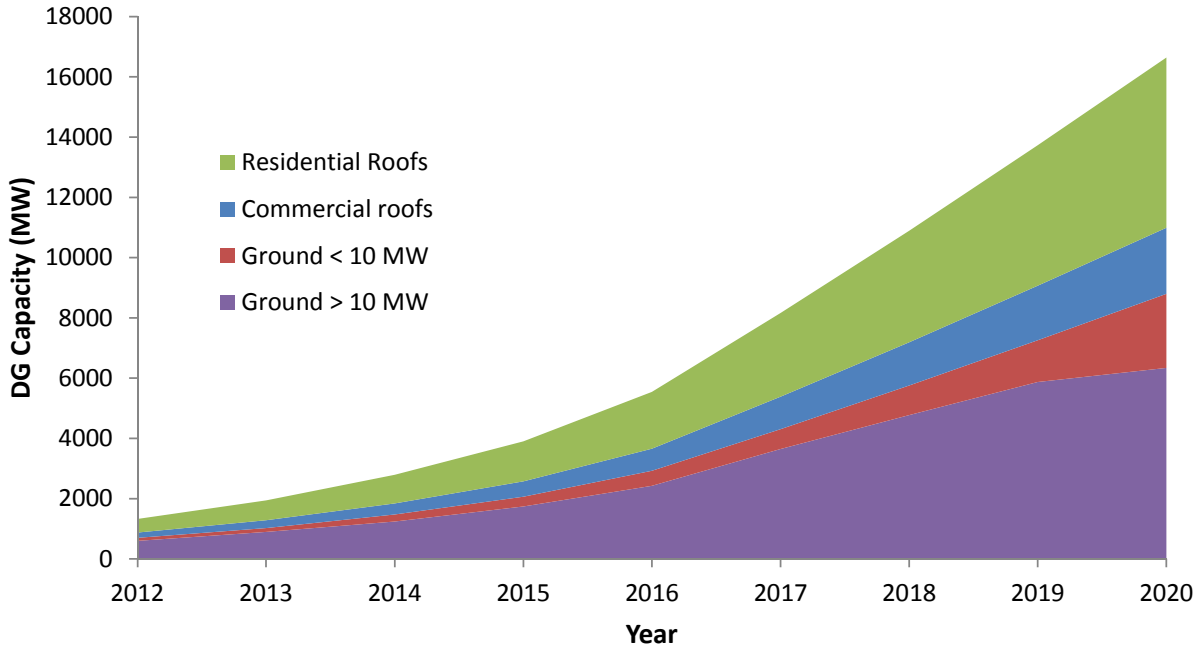
**Least Net Cost Summary Table, 30% Interconnection Constraint**

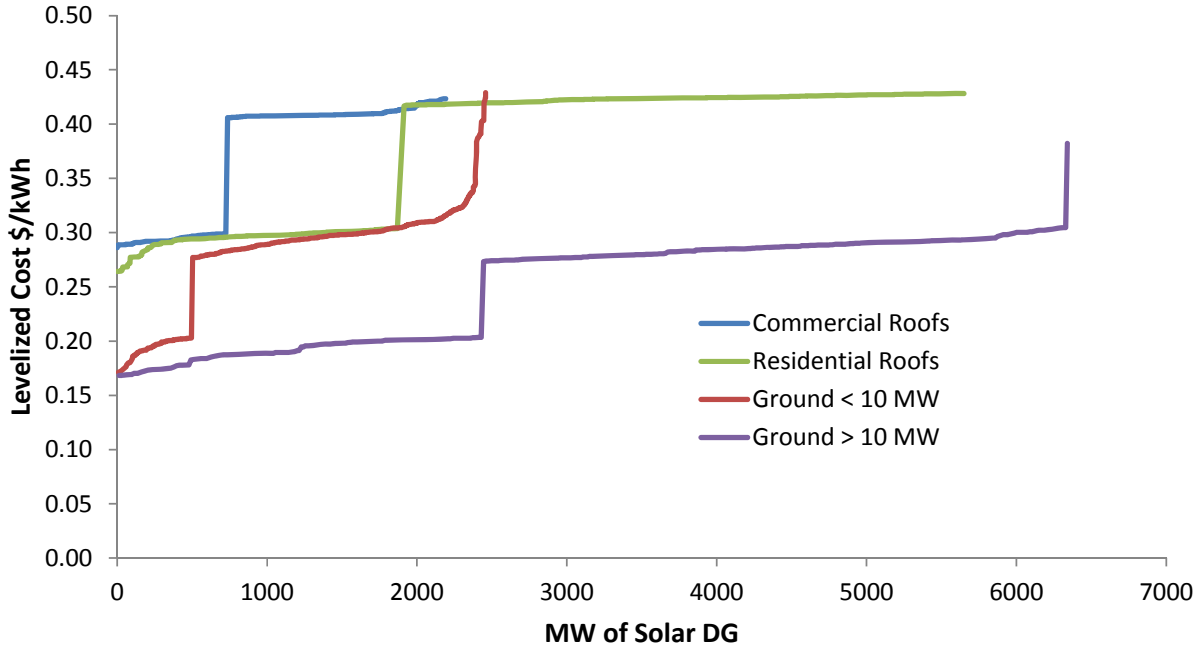
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 405 | 693 | $312.4 | $0.451 | $236.1 | $0.341 |
| | | Commercial Roof | 255 | 416 | $181.5 | $0.436 | $135.0 | $0.325 |
| | | Ground < 10 MW | 870 | 1,860 | $559.7 | $0.301 | $360.1 | $0.194 |
| | | Ground 10-20 MW | 230 | 488 | $136.2 | $0.279 | $84.1 | $0.172 |
| | North Central Valley | Residential Roof | 396 | 685 | $309.7 | $0.452 | $233.0 | $0.340 |
| | | Commercial Roof | 295 | 477 | $210.3 | $0.441 | $156.9 | $0.329 |
| | | Ground < 10 MW | 923 | 1,971 | $564.3 | $0.286 | $350.3 | $0.178 |
| | | Ground 10-20 MW | 310 | 659 | $160.7 | $0.244 | $89.4 | $0.136 |
| | South Central Valley | Residential Roof | 284 | 496 | $222.0 | $0.448 | $166.5 | $0.336 |
| | | Commercial Roof | 134 | 219 | $95.2 | $0.434 | $70.4 | $0.321 |
| | | Ground < 10 MW | 430 | 918 | $268.0 | $0.292 | $168.5 | $0.184 |
| | | Ground 10-20 MW | 203 | 433 | $109.3 | $0.252 | $62.7 | $0.145 |
| | Mountain | Residential Roof | 40 | 70 | $31.7 | $0.456 | $23.9 | $0.344 |
| | | Commercial Roof | 14 | 24 | $10.3 | $0.431 | $7.6 | $0.319 |
| | | Ground < 10 MW | 91 | 194 | $58.9 | $0.305 | $38.0 | $0.196 |
| | | Ground 10-20 MW | 38 | 82 | $17.5 | $0.214 | $8.7 | $0.106 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.4 | $0.286 | $0.9 | $0.188 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 1,788 | 3,212 | $1,110.5 | $0.346 | $772.5 | $0.240 |
| | | Commercial Roof | 1,281 | 2,152 | $730.2 | $0.339 | $500.3 | $0.232 |
| | | Ground < 10 MW | 273 | 630 | $143.2 | $0.227 | $80.0 | $0.127 |
| | | Ground 10-20 MW | 1,015 | 2,313 | $463.4 | $0.200 | $234.9 | $0.102 |
| | South Central Valley | Residential Roof | 313 | 570 | $192.4 | $0.338 | $133.4 | $0.234 |
| | | Commercial Roof | 189 | 317 | $108.1 | $0.340 | $73.9 | $0.233 |
| | | Ground < 10 MW | 89 | 210 | $49.4 | $0.236 | $28.6 | $0.137 |
| | | Ground 10-20 MW | 161 | 373 | $74.5 | $0.200 | $37.6 | $0.101 |
| | Desert | Residential Roof | 113 | 202 | $65.6 | $0.325 | $44.3 | $0.219 |
| | | Commercial Roof | 49 | 82 | $24.9 | $0.304 | $16.2 | $0.197 |
| | | Ground < 10 MW | 41 | 97 | $21.5 | $0.221 | $12.0 | $0.124 |
| | | Ground 10-20 MW | 29 | 68 | $12.8 | $0.188 | $6.4 | $0.094 |
| | Mountain | Residential Roof | 88 | 163 | $52.5 | $0.323 | $36.0 | $0.221 |
| | | Commercial Roof | 59 | 100 | $34.0 | $0.341 | $23.5 | $0.235 |
| | | Ground < 10 MW | 30 | 68 | $14.2 | $0.209 | $7.4 | $0.109 |
| | | Ground 10-20 MW | 45 | 99 | $23.6 | $0.239 | $13.5 | $0.136 |
| SDGE | South Coast | Residential Roof | 704 | 1,262 | $482.5 | $0.382 | $351.6 | $0.279 |
| | | Commercial Roof | 153 | 258 | $99.6 | $0.386 | $72.5 | $0.281 |
| | | Ground < 10 MW | 85 | 188 | $48.2 | $0.257 | $29.0 | $0.154 |
| | | Ground 10-20 MW | 237 | 518 | $120.9 | $0.233 | $68.0 | $0.131 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.193 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $1.1 | $0.283 | $0.8 | $0.187 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.106 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 11,668 | 22,583 | 7125 | 0.32 | 4736 | 0.21 |

**High Rooftop Summary Table, 30% Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,214 | 2,102 | $930.1 | $0.442 | $699.2 | $0.333 |
| | | Commercial Roof | 278 | 456 | $199.1 | $0.436 | $148.3 | $0.325 |
| | | Ground < 10 MW | 238 | 522 | $150.0 | $0.287 | $95.0 | $0.182 |
| | | Ground 10-20 MW | 82 | 174 | $47.1 | $0.270 | $28.6 | $0.164 |
| | North Central Valley | Residential Roof | 1,394 | 2,418 | $1,055.0 | $0.436 | $786.5 | $0.325 |
| | | Commercial Roof | 315 | 510 | $224.8 | $0.440 | $167.8 | $0.329 |
| | | Ground < 10 MW | 207 | 453 | $127.2 | $0.281 | $78.6 | $0.173 |
| | | Ground 10-20 MW | 67 | 142 | $37.8 | $0.266 | $22.4 | $0.157 |
| | South Central Valley | Residential Roof | 887 | 1,544 | $669.8 | $0.434 | $498.2 | $0.323 |
| | | Commercial Roof | 135 | 223 | $96.6 | $0.434 | $71.6 | $0.321 |
| | | Ground < 10 MW | 86 | 190 | $51.6 | $0.272 | $31.5 | $0.166 |
| | | Ground 10-20 MW | 10 | 22 | $4.6 | $0.210 | $2.3 | $0.106 |
| | Mountain | Residential Roof | 166 | 288 | $129.5 | $0.450 | $97.6 | $0.339 |
| | | Commercial Roof | 14 | 24 | $10.3 | $0.431 | $7.6 | $0.319 |
| | | Ground < 10 MW | 7 | 16 | $4.0 | $0.243 | $2.2 | $0.137 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 2 | 4 | $1.1 | $0.296 | $0.8 | $0.200 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,888 | 5,252 | $1,757.8 | $0.335 | $1,213.5 | $0.231 |
| | | Commercial Roof | 1,428 | 2,408 | $831.1 | $0.345 | $574.5 | $0.239 |
| | | Ground < 10 MW | 94 | 213 | $50.6 | $0.237 | $29.0 | $0.136 |
| | | Ground 10-20 MW | 150 | 348 | $67.1 | $0.193 | $33.5 | $0.096 |
| | South Central Valley | Residential Roof | 590 | 1,084 | $358.1 | $0.330 | $246.6 | $0.227 |
| | | Commercial Roof | 182 | 307 | $111.5 | $0.363 | $78.5 | $0.256 |
| | | Ground < 10 MW | 6 | 14 | $4.4 | $0.306 | $2.9 | $0.202 |
| | | Ground 10-20 MW | 10 | 25 | $4.5 | $0.179 | $2.3 | $0.091 |
| | Desert | Residential Roof | 190 | 348 | $117.5 | $0.337 | $81.7 | $0.235 |
| | | Commercial Roof | 44 | 75 | $28.4 | $0.379 | $20.4 | $0.272 |
| | | Ground < 10 MW | 6 | 16 | $2.9 | $0.184 | $1.4 | $0.089 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 113 | 207 | $69.9 | $0.337 | $48.6 | $0.235 |
| | | Commercial Roof | 98 | 164 | $49.4 | $0.302 | $32.2 | $0.196 |
| | | Ground < 10 MW | 16 | 39 | $7.6 | $0.195 | $3.8 | $0.099 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 990 | 1,774 | $633.0 | $0.357 | $449.3 | $0.253 |
| | | Commercial Roof | 183 | 306 | $104.6 | $0.342 | $72.5 | $0.237 |
| | | Ground < 10 MW | 24 | 53 | $13.0 | $0.248 | $7.6 | $0.145 |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 6 | 11 | $3.1 | $0.284 | $2.1 | $0.190 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $1.3 | $0.285 | $0.9 | $0.190 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 12,125 | 21,739 | 7954 | 0.37 | 5640 | 0.26 |

## 1% Curtailment Interconnection Constraint



## Least Cost Summary Table, 1% Curtailment Interconnection Constraint

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 52 | 95 | $40.3 | $0.424 | $30.5 | $0.321 |
| | | Commercial Roof | 51 | 86 | $37.0 | $0.428 | $27.6 | $0.320 |
| | | Ground < 10 MW | 855 | 1,842 | $551.2 | $0.299 | $359.1 | $0.195 |
| | | Ground 10-20 MW | 1,028 | 2,195 | $627.7 | $0.286 | $399.5 | $0.182 |
| | North Central Valley | Residential Roof | 49 | 90 | $37.2 | $0.412 | $27.6 | $0.306 |
| | | Commercial Roof | 105 | 178 | $76.1 | $0.428 | $56.8 | $0.320 |
| | | Ground < 10 MW | 563 | 1,201 | $354.2 | $0.295 | $227.4 | $0.189 |
| | | Ground 10-20 MW | 2,411 | 5,152 | $1,439.1 | $0.279 | $890.9 | $0.173 |
| | South Central Valley | Residential Roof | 56 | 102 | $40.6 | $0.399 | $29.9 | $0.294 |
| | | Commercial Roof | 13 | 22 | $9.5 | $0.429 | $7.0 | $0.319 |
| | | Ground < 10 MW | 440 | 952 | $284.9 | $0.299 | $184.8 | $0.194 |
| | | Ground 10-20 MW | 546 | 1,171 | $326.0 | $0.278 | $202.6 | $0.173 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | 22 | 37 | $15.9 | $0.431 | $11.9 | $0.324 |
| | | Ground < 10 MW | 105 | 224 | $68.9 | $0.307 | $45.3 | $0.202 |
| | | Ground 10-20 MW | 82 | 176 | $51.3 | $0.292 | $32.8 | $0.186 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $2.0 | $0.203 | $1.0 | $0.107 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,572 | 6,543 | $2,576.3 | $0.394 | $1,900.8 | $0.291 |
| | | Commercial Roof | 1,523 | 2,600 | $983.1 | $0.378 | $711.7 | $0.274 |
| | | Ground < 10 MW | 269 | 631 | $144.6 | $0.229 | $82.8 | $0.131 |
| | | Ground 10-20 MW | 1,525 | 3,491 | $720.3 | $0.206 | $378.3 | $0.108 |
| | South Central Valley | Residential Roof | 577 | 1,060 | $412.8 | $0.389 | $304.0 | $0.287 |
| | | Commercial Roof | 201 | 345 | $132.3 | $0.384 | $96.1 | $0.279 |
| | | Ground < 10 MW | 99 | 233 | $55.5 | $0.239 | $33.0 | $0.142 |
| | | Ground 10-20 MW | 260 | 614 | $129.6 | $0.211 | $70.5 | $0.115 |
| | Desert | Residential Roof | 278 | 510 | $194.6 | $0.382 | $141.6 | $0.278 |
| | | Commercial Roof | 13 | 21 | $6.4 | $0.299 | $4.2 | $0.197 |
| | | Ground < 10 MW | 27 | 63 | $14.7 | $0.232 | $8.6 | $0.135 |
| | | Ground 10-20 MW | 76 | 183 | $34.0 | $0.186 | $16.8 | $0.092 |
| | Mountain | Residential Roof | 201 | 374 | $133.7 | $0.358 | $96.0 | $0.257 |
| | | Commercial Roof | 124 | 211 | $72.6 | $0.344 | $50.3 | $0.239 |
| | | Ground < 10 MW | 28 | 65 | $13.5 | $0.208 | $7.1 | $0.109 |
| | | Ground 10-20 MW | 52 | 115 | $29.7 | $0.259 | $18.3 | $0.160 |
| SDGE | South Coast | Residential Roof | 861 | 1,575 | $585.0 | $0.371 | $425.5 | $0.270 |
| | | Commercial Roof | 139 | 238 | $87.1 | $0.366 | $62.6 | $0.263 |
| | | Ground < 10 MW | 60 | 131 | $36.8 | $0.280 | $23.6 | $0.180 |
| | | Ground 10-20 MW | 358 | 785 | $192.1 | $0.245 | $113.4 | $0.144 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.287 | $1.4 | $0.194 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $2.2 | $0.224 | $1.3 | $0.130 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 9 | $1.8 | $0.194 | $0.9 | $0.100 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,640 | 33,344 | 10522 | 0.32 | 7084 | 0.21 |

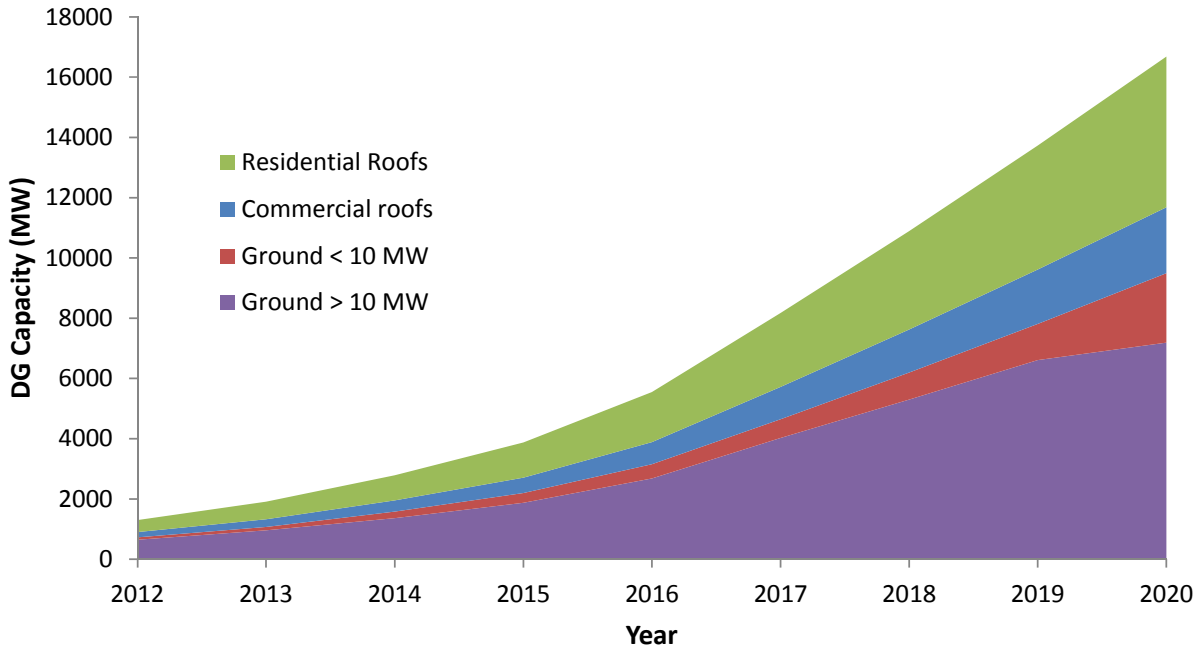
**Least Net Cost Summary Table, 1% Curtailment Interconnection Constraint**

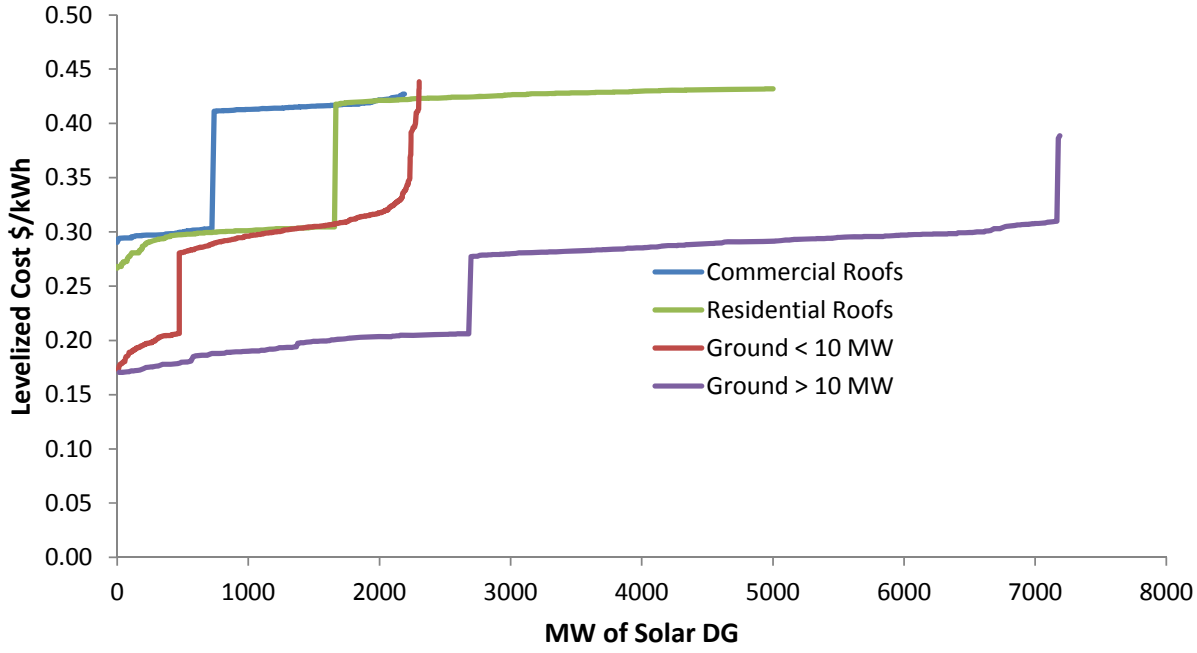
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 52 | 96 | $40.1 | $0.420 | $30.3 | $0.317 |
| | | Commercial Roof | 65 | 110 | $47.3 | $0.429 | $35.4 | $0.321 |
| | | Ground < 10 MW | 855 | 1,845 | $553.1 | $0.300 | $360.8 | $0.196 |
| | | Ground 10-20 MW | 1,028 | 2,196 | $632.4 | $0.288 | $404.1 | $0.184 |
| | North Central Valley | Residential Roof | 70 | 128 | $53.7 | $0.420 | $40.2 | $0.314 |
| | | Commercial Roof | 117 | 198 | $85.0 | $0.429 | $63.4 | $0.320 |
| | | Ground < 10 MW | 563 | 1,201 | $358.3 | $0.298 | $231.5 | $0.193 |
| | | Ground 10-20 MW | 2,411 | 5,137 | $1,411.4 | $0.275 | $864.7 | $0.168 |
| | South Central Valley | Residential Roof | 56 | 102 | $40.7 | $0.399 | $30.0 | $0.294 |
| | | Commercial Roof | 39 | 65 | $28.2 | $0.432 | $21.0 | $0.322 |
| | | Ground < 10 MW | 440 | 952 | $284.0 | $0.298 | $183.9 | $0.193 |
| | | Ground 10-20 MW | 546 | 1,170 | $322.8 | $0.276 | $199.6 | $0.171 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | 22 | 37 | $15.9 | $0.431 | $11.9 | $0.324 |
| | | Ground < 10 MW | 105 | 224 | $67.9 | $0.303 | $44.3 | $0.198 |
| | | Ground 10-20 MW | 82 | 176 | $51.3 | $0.292 | $32.8 | $0.186 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $2.0 | $0.203 | $1.0 | $0.107 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,614 | 6,613 | $2,582.7 | $0.391 | $1,898.7 | $0.287 |
| | | Commercial Roof | 1,523 | 2,598 | $973.9 | $0.375 | $702.4 | $0.270 |
| | | Ground < 10 MW | 269 | 633 | $147.5 | $0.233 | $85.5 | $0.135 |
| | | Ground 10-20 MW | 1,525 | 3,497 | $727.1 | $0.208 | $384.3 | $0.110 |
| | South Central Valley | Residential Roof | 579 | 1,064 | $415.1 | $0.390 | $305.6 | $0.287 |
| | | Commercial Roof | 201 | 343 | $134.0 | $0.390 | $98.0 | $0.285 |
| | | Ground < 10 MW | 99 | 234 | $56.8 | $0.243 | $34.1 | $0.146 |
| | | Ground 10-20 MW | 260 | 614 | $129.7 | $0.211 | $70.5 | $0.115 |
| | Desert | Residential Roof | 278 | 509 | $194.0 | $0.381 | $141.2 | $0.278 |
| | | Commercial Roof | 13 | 22 | $7.1 | $0.331 | $4.9 | $0.228 |
| | | Ground < 10 MW | 27 | 64 | $15.8 | $0.246 | $9.5 | $0.149 |
| | | Ground 10-20 MW | 76 | 183 | $34.0 | $0.186 | $16.8 | $0.092 |
| | Mountain | Residential Roof | 194 | 360 | $127.9 | $0.355 | $91.6 | $0.254 |
| | | Commercial Roof | 124 | 211 | $72.5 | $0.344 | $50.4 | $0.240 |
| | | Ground < 10 MW | 28 | 65 | $13.8 | $0.211 | $7.3 | $0.112 |
| | | Ground 10-20 MW | 52 | 116 | $29.9 | $0.259 | $18.5 | $0.160 |
| SDGE | South Coast | Residential Roof | 766 | 1,410 | $537.0 | $0.381 | $394.3 | $0.280 |
| | | Commercial Roof | 139 | 239 | $89.4 | $0.374 | $64.8 | $0.271 |
| | | Ground < 10 MW | 60 | 132 | $39.3 | $0.298 | $26.0 | $0.197 |
| | | Ground 10-20 MW | 358 | 788 | $200.2 | $0.254 | $121.2 | $0.154 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.287 | $1.4 | $0.194 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $2.6 | $0.256 | $1.6 | $0.161 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 9 | $1.8 | $0.194 | $0.9 | $0.099 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,655 | 33,366 | 10528 | 0.32 | 7084 | 0.21 |

**High Rooftop Summary Table, 1% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,664 | 2,954 | $1,310.8 | $0.444 | $997.9 | $0.338 |
| | | Commercial Roof | 278 | 460 | $201.1 | $0.438 | $151.7 | $0.330 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 2,080 | 3,697 | $1,596.4 | $0.432 | $1,197.6 | $0.324 |
| | | Commercial Roof | 318 | 529 | $230.2 | $0.435 | $172.8 | $0.327 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,194 | 2,117 | $920.7 | $0.435 | $693.2 | $0.327 |
| | | Commercial Roof | 119 | 197 | $86.0 | $0.437 | $64.5 | $0.327 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 210 | 373 | $166.0 | $0.445 | $126.2 | $0.338 |
| | | Commercial Roof | 22 | 36 | $15.7 | $0.431 | $11.8 | $0.324 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 4 | 8 | $2.4 | $0.298 | $1.6 | $0.201 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 5,440 | 9,878 | $3,665.4 | $0.371 | $2,653.1 | $0.269 |
| | | Commercial Roof | 1,654 | 2,803 | $1,035.6 | $0.369 | $743.5 | $0.265 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,035 | 1,894 | $697.2 | $0.368 | $504.3 | $0.266 |
| | | Commercial Roof | 171 | 291 | $113.4 | $0.389 | $82.9 | $0.284 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 399 | 729 | $265.4 | $0.364 | $191.2 | $0.262 |
| | | Commercial Roof | 13 | 22 | $6.6 | $0.302 | $4.4 | $0.200 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 259 | 474 | $174.1 | $0.367 | $126.1 | $0.266 |
| | | Commercial Roof | 122 | 207 | $65.8 | $0.318 | $44.0 | $0.213 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,482 | 2,677 | $994.2 | $0.371 | $722.9 | $0.270 |
| | | Commercial Roof | 185 | 312 | $112.8 | $0.362 | $80.8 | $0.259 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 7 | 13 | $3.7 | $0.284 | $2.5 | $0.192 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 4 | 8 | $2.4 | $0.288 | $1.6 | $0.193 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,660 | 29,680 | 11666 | 0.39 | 8575 | 0.29 |

## 3% Curtailment Interconnection Constraint



**Least Cost Summary Table, 3% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 50 | 90 | $38.4 | $0.425 | $29.0 | $0.321 |
| | | Commercial Roof | 27 | 46 | $19.9 | $0.434 | $14.8 | $0.324 |
| | | Ground < 10 MW | 801 | 1,690 | $513.6 | $0.304 | $333.7 | $0.197 |
| | | Ground 10-20 MW | 1,261 | 2,649 | $773.6 | $0.292 | $492.9 | $0.186 |
| | North Central Valley | Residential Roof | 37 | 67 | $27.1 | $0.405 | $19.9 | $0.298 |
| | | Commercial Roof | 97 | 164 | $70.8 | $0.431 | $52.9 | $0.322 |
| | | Ground < 10 MW | 514 | 1,074 | $323.6 | $0.301 | $207.7 | $0.193 |
| | | Ground 10-20 MW | 2,726 | 5,727 | $1,628.5 | $0.284 | $1,008.9 | $0.176 |
| | South Central Valley | Residential Roof | 58 | 105 | $42.8 | $0.407 | $31.6 | $0.300 |
| | | Commercial Roof | 4 | 8 | $3.3 | $0.432 | $2.4 | $0.322 |
| | | Ground < 10 MW | 427 | 907 | $276.7 | $0.305 | $179.6 | $0.198 |
| | | Ground 10-20 MW | 629 | 1,331 | $369.1 | $0.277 | $226.8 | $0.170 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 87 | 183 | $57.0 | $0.312 | $37.5 | $0.205 |
| | | Ground 10-20 MW | 113 | 237 | $70.7 | $0.299 | $45.4 | $0.192 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $2.3 | $0.207 | $1.2 | $0.109 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,105 | 5,646 | $2,212.9 | $0.392 | $1,623.3 | $0.288 |
| | | Commercial Roof | 1,595 | 2,683 | $1,041.6 | $0.388 | $756.6 | $0.282 |
| | | Ground < 10 MW | 251 | 579 | $132.9 | $0.230 | $75.4 | $0.130 |
| | | Ground 10-20 MW | 1,641 | 3,717 | $772.0 | $0.208 | $403.4 | $0.109 |
| | South Central Valley | Residential Roof | 496 | 906 | $360.6 | $0.398 | $266.3 | $0.294 |
| | | Commercial Roof | 177 | 299 | $117.2 | $0.392 | $85.3 | $0.285 |
| | | Ground < 10 MW | 101 | 230 | $56.5 | $0.245 | $33.7 | $0.146 |
| | | Ground 10-20 MW | 305 | 709 | $152.5 | $0.215 | $83.1 | $0.117 |
| | Desert | Residential Roof | 177 | 322 | $113.1 | $0.351 | $79.6 | $0.247 |
| | | Commercial Roof | 13 | 21 | $7.2 | $0.342 | $5.0 | $0.238 |
| | | Ground < 10 MW | 28 | 65 | $15.3 | $0.237 | $8.9 | $0.138 |
| | | Ground 10-20 MW | 84 | 199 | $37.6 | $0.189 | $18.6 | $0.094 |
| | Mountain | Residential Roof | 214 | 394 | $143.3 | $0.363 | $102.7 | $0.260 |
| | | Commercial Roof | 132 | 222 | $73.1 | $0.330 | $49.3 | $0.223 |
| | | Ground < 10 MW | 25 | 57 | $11.9 | $0.210 | $6.3 | $0.110 |
| | | Ground 10-20 MW | 56 | 122 | $32.1 | $0.263 | $19.9 | $0.163 |
| SDGE | South Coast | Residential Roof | 860 | 1,561 | $620.3 | $0.398 | $460.2 | $0.295 |
| | | Commercial Roof | 144 | 241 | $86.5 | $0.359 | $61.4 | $0.255 |
| | | Ground < 10 MW | 56 | 122 | $34.8 | $0.286 | $22.3 | $0.184 |
| | | Ground 10-20 MW | 372 | 802 | $201.1 | $0.251 | $119.4 | $0.149 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.292 | $1.4 | $0.198 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $2.5 | $0.207 | $1.3 | $0.111 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 10 | $2.0 | $0.196 | $1.1 | $0.101 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 16,682 | 33,215 | 10447 | 0.31 | 6969 | 0.21 |

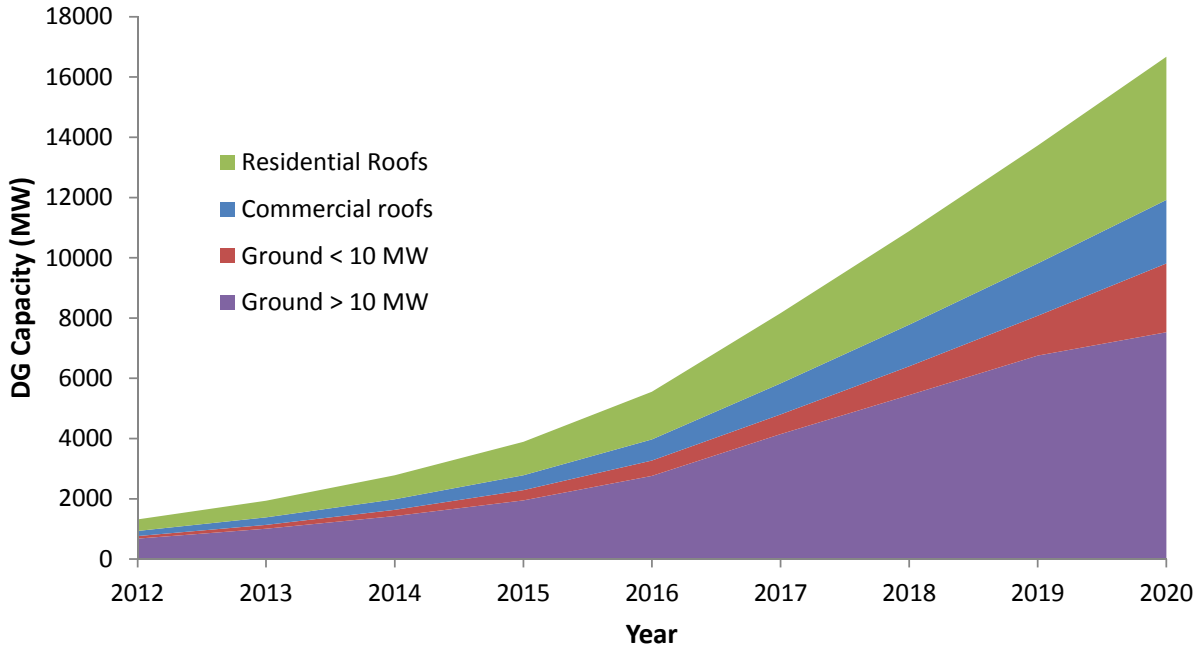
**Least Net Cost Summary Table, 3% Curtailment Interconnection Constraint**

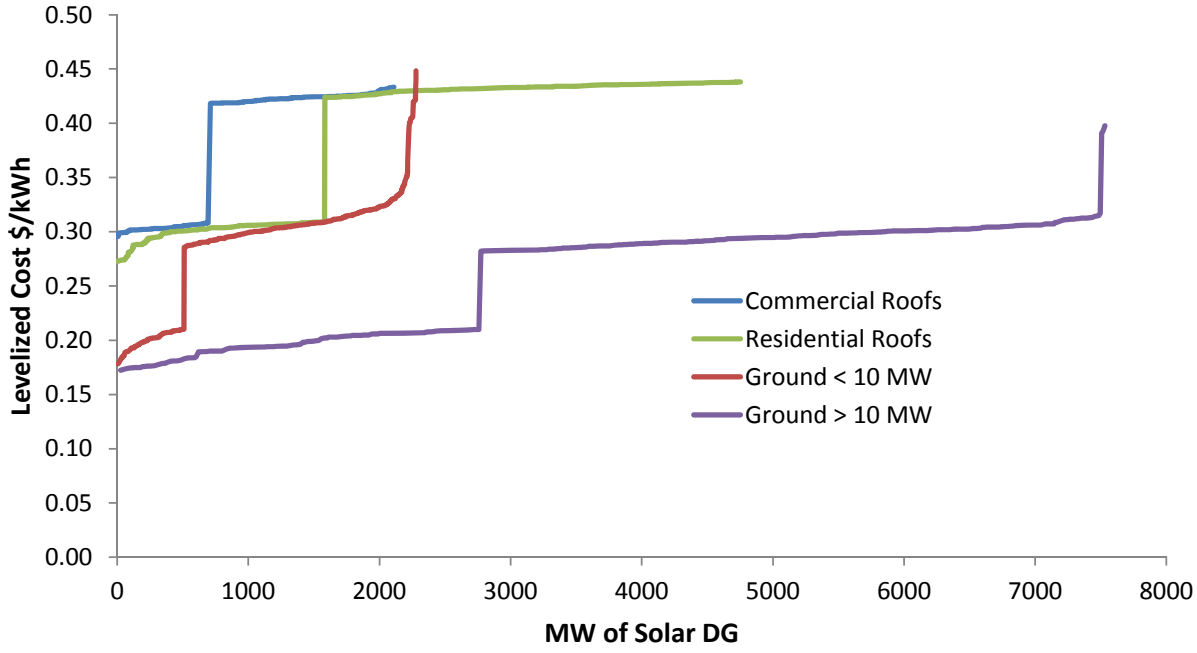
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 55 | 101 | $42.3 | $0.420 | $31.7 | $0.314 |
| | | Commercial Roof | 27 | 46 | $19.9 | $0.434 | $14.8 | $0.324 |
| | | Ground < 10 MW | 801 | 1,692 | $515.2 | $0.305 | $335.2 | $0.198 |
| | | Ground 10-20 MW | 1,261 | 2,650 | $771.0 | $0.291 | $490.2 | $0.185 |
| | North Central Valley | Residential Roof | 47 | 85 | $35.2 | $0.413 | $26.1 | $0.307 |
| | | Commercial Roof | 108 | 182 | $78.5 | $0.431 | $58.7 | $0.323 |
| | | Ground < 10 MW | 514 | 1,074 | $327.0 | $0.305 | $211.1 | $0.197 |
| | | Ground 10-20 MW | 2,726 | 5,708 | $1,600.3 | $0.280 | $982.8 | $0.172 |
| | South Central Valley | Residential Roof | 75 | 134 | $55.7 | $0.415 | $41.3 | $0.308 |
| | | Commercial Roof | 5 | 8 | $3.3 | $0.432 | $2.5 | $0.322 |
| | | Ground < 10 MW | 427 | 907 | $273.8 | $0.302 | $176.8 | $0.195 |
| | | Ground 10-20 MW | 629 | 1,329 | $373.8 | $0.281 | $231.7 | $0.174 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 87 | 183 | $57.1 | $0.312 | $37.5 | $0.205 |
| | | Ground 10-20 MW | 113 | 237 | $70.7 | $0.299 | $45.4 | $0.192 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $2.4 | $0.207 | $1.2 | $0.109 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,207 | 5,821 | $2,279.0 | $0.392 | $1,669.1 | $0.287 |
| | | Commercial Roof | 1,583 | 2,664 | $1,022.0 | $0.384 | $738.6 | $0.277 |
| | | Ground < 10 MW | 251 | 582 | $136.2 | $0.234 | $78.4 | $0.135 |
| | | Ground 10-20 MW | 1,641 | 3,725 | $781.7 | $0.210 | $411.9 | $0.111 |
| | South Central Valley | Residential Roof | 480 | 877 | $342.9 | $0.391 | $251.4 | $0.287 |
| | | Commercial Roof | 177 | 299 | $119.7 | $0.400 | $87.7 | $0.293 |
| | | Ground < 10 MW | 101 | 231 | $57.9 | $0.250 | $34.9 | $0.151 |
| | | Ground 10-20 MW | 305 | 709 | $152.5 | $0.215 | $83.0 | $0.117 |
| | Desert | Residential Roof | 241 | 438 | $164.0 | $0.375 | $118.0 | $0.270 |
| | | Commercial Roof | 13 | 21 | $7.2 | $0.342 | $5.0 | $0.237 |
| | | Ground < 10 MW | 28 | 65 | $15.9 | $0.245 | $9.5 | $0.146 |
| | | Ground 10-20 MW | 84 | 199 | $37.6 | $0.189 | $18.6 | $0.094 |
| | Mountain | Residential Roof | 192 | 353 | $125.0 | $0.354 | $88.7 | $0.251 |
| | | Commercial Roof | 132 | 219 | $75.7 | $0.345 | $52.6 | $0.240 |
| | | Ground < 10 MW | 25 | 57 | $12.0 | $0.211 | $6.4 | $0.112 |
| | | Ground 10-20 MW | 56 | 123 | $32.4 | $0.263 | $20.1 | $0.164 |
| SDGE | South Coast | Residential Roof | 683 | 1,246 | $502.2 | $0.403 | $374.6 | $0.301 |
| | | Commercial Roof | 138 | 233 | $88.8 | $0.380 | $64.3 | $0.275 |
| | | Ground < 10 MW | 56 | 122 | $36.5 | $0.299 | $24.0 | $0.196 |
| | | Ground 10-20 MW | 372 | 806 | $209.8 | $0.260 | $127.8 | $0.158 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.292 | $1.4 | $0.198 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $3.1 | $0.257 | $2.0 | $0.161 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 4 | 11 | $2.1 | $0.196 | $1.1 | $0.100 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,659 | 33,168 | 10432 | 0.31 | 6956 | 0.21 |

**High Rooftop Summary Table, 3% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,382 | 2,436 | $1,089.1 | $0.447 | $827.3 | $0.340 |
| | | Commercial Roof | 257 | 419 | $186.2 | $0.445 | $140.3 | $0.335 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 1,734 | 3,060 | $1,336.9 | $0.437 | $1,002.8 | $0.328 |
| | | Commercial Roof | 306 | 505 | $221.4 | $0.439 | $166.2 | $0.329 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 972 | 1,708 | $755.3 | $0.442 | $568.8 | $0.333 |
| | | Commercial Roof | 115 | 189 | $83.8 | $0.444 | $62.8 | $0.333 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 184 | 324 | $145.3 | $0.449 | $110.3 | $0.341 |
| | | Commercial Roof | 22 | 36 | $15.9 | $0.441 | $11.9 | $0.331 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 5 | 10 | $2.9 | $0.304 | $2.0 | $0.205 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 6,137 | 11,000 | $4,212.7 | $0.383 | $3,067.2 | $0.279 |
| | | Commercial Roof | 1,656 | 2,765 | $1,043.1 | $0.377 | $750.1 | $0.271 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,164 | 2,102 | $802.8 | $0.382 | $584.9 | $0.278 |
| | | Commercial Roof | 163 | 272 | $106.0 | $0.390 | $77.1 | $0.283 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 414 | 747 | $273.1 | $0.365 | $195.9 | $0.262 |
| | | Commercial Roof | 13 | 21 | $7.4 | $0.344 | $5.1 | $0.240 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 303 | 546 | $204.5 | $0.374 | $148.1 | $0.271 |
| | | Commercial Roof | 130 | 216 | $69.1 | $0.320 | $46.1 | $0.214 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,553 | 2,773 | $1,031.5 | $0.372 | $746.5 | $0.269 |
| | | Commercial Roof | 158 | 263 | $93.4 | $0.355 | $66.1 | $0.252 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 7 | 14 | $4.0 | $0.288 | $2.7 | $0.194 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 5 | 9 | $2.7 | $0.291 | $1.8 | $0.195 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,680 | 29,414 | 11687 | 0.40 | 8584 | 0.29 |

## 5% Curtailment Interconnection Constraint



## Least Cost Summary Table, 5% Curtailment Interconnection Constraint

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 13 | 22 | $8.5 | $0.377 | $6.0 | $0.268 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 805 | 1,673 | $514.2 | $0.307 | $333.7 | $0.200 |
| | | Ground 10-20 MW | 1,346 | 2,786 | $827.0 | $0.297 | $527.0 | $0.189 |
| | North Central Valley | Residential Roof | 25 | 45 | $16.5 | $0.369 | $11.6 | $0.259 |
| | | Commercial Roof | 43 | 72 | $31.3 | $0.434 | $23.3 | $0.323 |
| | | Ground < 10 MW | 516 | 1,064 | $323.5 | $0.304 | $207.0 | $0.195 |
| | | Ground 10-20 MW | 2,816 | 5,842 | $1,679.3 | $0.287 | $1,039.7 | $0.178 |
| | South Central Valley | Residential Roof | 65 | 116 | $48.3 | $0.417 | $35.7 | $0.308 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 407 | 857 | $260.8 | $0.304 | $167.7 | $0.196 |
| | | Ground 10-20 MW | 701 | 1,449 | $415.9 | $0.287 | $257.7 | $0.178 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 88 | 183 | $55.9 | $0.305 | $36.2 | $0.198 |
| | | Ground 10-20 MW | 115 | 237 | $71.7 | $0.303 | $46.2 | $0.195 |
| SCE | North Coast | Residential Roof | 0 | 0 | $0.1 | $0.308 | $0.1 | $0.207 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $2.3 | $0.203 | $1.2 | $0.104 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,872 | 5,152 | $2,026.0 | $0.393 | $1,480.6 | $0.287 |
| | | Commercial Roof | 1,601 | 2,646 | $1,043.1 | $0.394 | $756.6 | $0.286 |
| | | Ground < 10 MW | 226 | 513 | $119.7 | $0.233 | $67.9 | $0.132 |
| | | Ground 10-20 MW | 1,717 | 3,833 | $821.4 | $0.214 | $435.3 | $0.114 |
| | South Central Valley | Residential Roof | 524 | 946 | $380.9 | $0.403 | $281.1 | $0.297 |
| | | Commercial Roof | 166 | 275 | $113.2 | $0.411 | $83.3 | $0.303 |
| | | Ground < 10 MW | 108 | 242 | $60.0 | $0.248 | $35.6 | $0.147 |
| | | Ground 10-20 MW | 322 | 736 | $160.8 | $0.218 | $87.7 | $0.119 |
| | Desert | Residential Roof | 182 | 328 | $126.6 | $0.386 | $91.9 | $0.280 |
| | | Commercial Roof | 13 | 21 | $6.4 | $0.307 | $4.2 | $0.202 |
| | | Ground < 10 MW | 26 | 60 | $14.0 | $0.233 | $8.0 | $0.133 |
| | | Ground 10-20 MW | 87 | 204 | $38.8 | $0.191 | $19.2 | $0.094 |
| | Mountain | Residential Roof | 186 | 337 | $119.4 | $0.354 | $84.3 | $0.250 |
| | | Commercial Roof | 139 | 229 | $80.1 | $0.350 | $55.1 | $0.241 |
| | | Ground < 10 MW | 25 | 57 | $12.1 | $0.212 | $6.4 | $0.112 |
| | | Ground 10-20 MW | 61 | 130 | $34.7 | $0.267 | $21.4 | $0.165 |
| SDGE | South Coast | Residential Roof | 881 | 1,578 | $652.3 | $0.413 | $487.4 | $0.309 |
| | | Commercial Roof | 147 | 243 | $92.8 | $0.383 | $67.0 | $0.276 |
| | | Ground < 10 MW | 62 | 134 | $34.8 | $0.259 | $20.9 | $0.156 |
| | | Ground 10-20 MW | 368 | 780 | $188.9 | $0.242 | $108.1 | $0.139 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.293 | $1.4 | $0.199 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 6 | 14 | $3.4 | $0.247 | $2.0 | $0.149 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $2.3 | $0.201 | $1.2 | $0.103 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,672 | 32,834 | 10389 | 0.32 | 6900 | 0.21 |

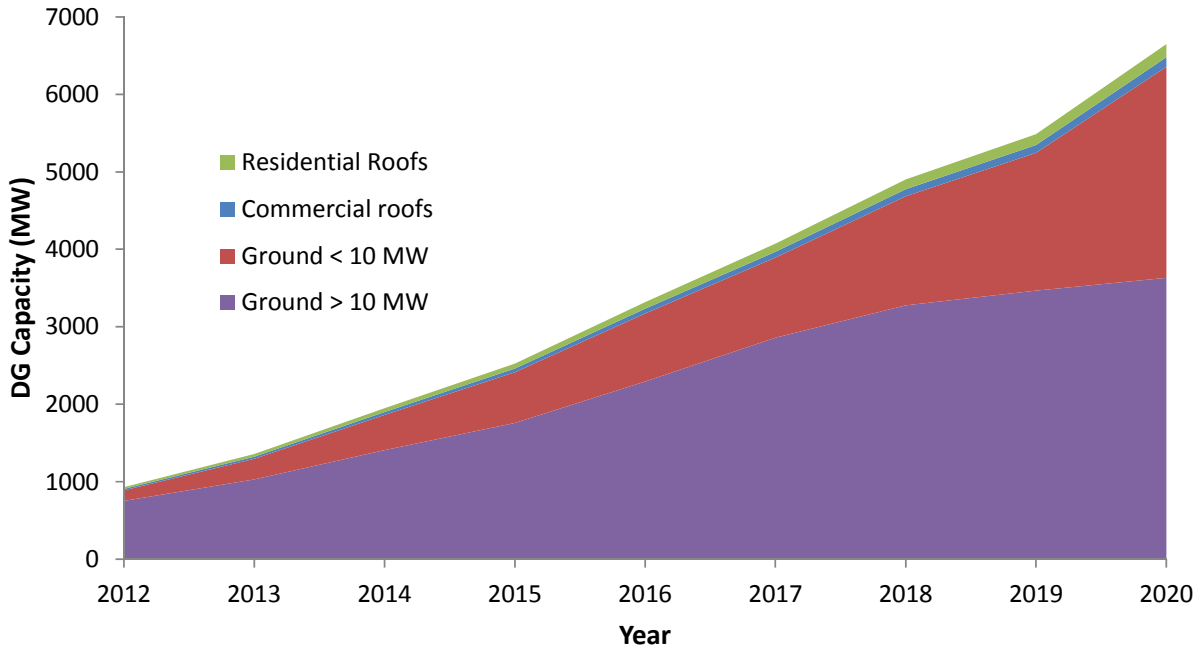
**Least Net Cost Summary Table, 5% Curtailment Interconnection Constraint**

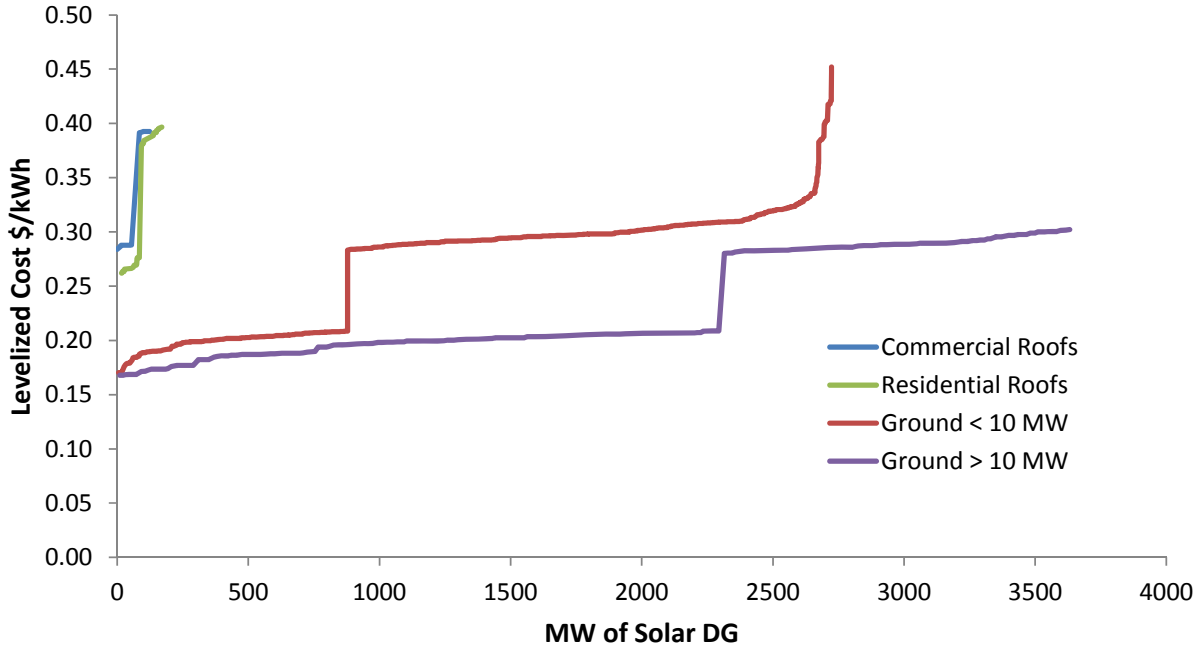
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 21 | 37 | $14.4 | $0.391 | $10.3 | $0.280 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 805 | 1,675 | $516.0 | $0.308 | $335.4 | $0.200 |
| | | Ground 10-20 MW | 1,346 | 2,790 | $832.1 | $0.298 | $531.8 | $0.191 |
| | North Central Valley | Residential Roof | 242 | 431 | $189.9 | $0.441 | $141.8 | $0.329 |
| | | Commercial Roof | 64 | 105 | $45.9 | $0.437 | $34.1 | $0.325 |
| | | Ground < 10 MW | 516 | 1,063 | $327.0 | $0.308 | $210.7 | $0.198 |
| | | Ground 10-20 MW | 2,816 | 5,825 | $1,648.6 | $0.283 | $1,010.8 | $0.174 |
| | South Central Valley | Residential Roof | 65 | 115 | $48.1 | $0.417 | $35.6 | $0.309 |
| | | Commercial Roof | 5 | 8 | $3.3 | $0.443 | $2.5 | $0.330 |
| | | Ground < 10 MW | 407 | 857 | $257.6 | $0.301 | $164.5 | $0.192 |
| | | Ground 10-20 MW | 701 | 1,445 | $419.7 | $0.290 | $261.9 | $0.181 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 88 | 184 | $56.1 | $0.305 | $36.3 | $0.198 |
| | | Ground 10-20 MW | 115 | 237 | $71.8 | $0.303 | $46.3 | $0.195 |
| SCE | North Coast | Residential Roof | 0 | 0 | $0.1 | $0.308 | $0.1 | $0.206 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 11 | $2.3 | $0.203 | $1.2 | $0.104 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,890 | 5,177 | $2,038.1 | $0.394 | $1,488.0 | $0.287 |
| | | Commercial Roof | 1,575 | 2,604 | $1,020.8 | $0.392 | $738.7 | $0.284 |
| | | Ground < 10 MW | 226 | 516 | $121.4 | $0.235 | $69.2 | $0.134 |
| | | Ground 10-20 MW | 1,717 | 3,836 | $811.1 | $0.211 | $424.3 | $0.111 |
| | South Central Valley | Residential Roof | 471 | 849 | $340.4 | $0.401 | $250.3 | $0.295 |
| | | Commercial Roof | 166 | 275 | $113.5 | $0.413 | $83.7 | $0.304 |
| | | Ground < 10 MW | 108 | 243 | $61.6 | $0.253 | $37.0 | $0.152 |
| | | Ground 10-20 MW | 322 | 737 | $161.1 | $0.218 | $87.8 | $0.119 |
| | Desert | Residential Roof | 131 | 234 | $74.8 | $0.320 | $50.1 | $0.214 |
| | | Commercial Roof | 13 | 21 | $6.4 | $0.307 | $4.2 | $0.202 |
| | | Ground < 10 MW | 26 | 61 | $14.7 | $0.241 | $8.6 | $0.141 |
| | | Ground 10-20 MW | 87 | 204 | $38.8 | $0.191 | $19.2 | $0.094 |
| | Mountain | Residential Roof | 186 | 338 | $118.9 | $0.352 | $83.8 | $0.248 |
| | | Commercial Roof | 139 | 227 | $79.8 | $0.351 | $55.1 | $0.242 |
| | | Ground < 10 MW | 25 | 57 | $12.3 | $0.214 | $6.5 | $0.114 |
| | | Ground 10-20 MW | 61 | 131 | $35.0 | $0.268 | $21.7 | $0.166 |
| SDGE | South Coast | Residential Roof | 715 | 1,287 | $535.7 | $0.416 | $401.1 | $0.312 |
| | | Commercial Roof | 141 | 235 | $92.1 | $0.392 | $67.1 | $0.285 |
| | | Ground < 10 MW | 62 | 135 | $40.5 | $0.299 | $26.5 | $0.196 |
| | | Ground 10-20 MW | 368 | 785 | $210.2 | $0.268 | $128.9 | $0.164 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.293 | $1.4 | $0.199 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 6 | 14 | $3.7 | $0.264 | $2.3 | $0.166 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 5 | 12 | $2.3 | $0.201 | $1.2 | $0.102 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,639 | 32,770 | 10368 | 0.32 | 6880 | 0.21 |

**High Rooftop Summary Table, 5% Curtailment Interconnection Constraint**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,259 | 2,188 | $991.5 | $0.453 | $751.8 | $0.344 |
| | | Commercial Roof | 215 | 345 | $155.9 | $0.452 | $117.3 | $0.340 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 1,682 | 2,940 | $1,304.3 | $0.444 | $980.9 | $0.334 |
| | | Commercial Roof | 296 | 479 | $213.5 | $0.446 | $160.2 | $0.335 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 763 | 1,328 | $593.1 | $0.447 | $445.9 | $0.336 |
| | | Commercial Roof | 115 | 184 | $83.4 | $0.452 | $62.5 | $0.339 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 220 | 385 | $175.1 | $0.455 | $132.9 | $0.346 |
| | | Commercial Roof | 22 | 35 | $15.9 | $0.450 | $11.9 | $0.338 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 6 | 10 | $3.2 | $0.308 | $2.1 | $0.208 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 6,408 | 11,320 | $4,414.4 | $0.390 | $3,214.7 | $0.284 |
| | | Commercial Roof | 1,659 | 2,720 | $1,044.2 | $0.384 | $750.7 | $0.276 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 1,225 | 2,177 | $847.4 | $0.389 | $617.6 | $0.284 |
| | | Commercial Roof | 159 | 261 | $107.2 | $0.410 | $78.9 | $0.302 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 424 | 755 | $280.5 | $0.372 | $200.9 | $0.266 |
| | | Commercial Roof | 13 | 21 | $6.6 | $0.310 | $4.4 | $0.205 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 318 | 565 | $210.7 | $0.373 | $151.7 | $0.268 |
| | | Commercial Roof | 131 | 214 | $69.7 | $0.326 | $46.4 | $0.217 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,573 | 2,767 | $1,049.1 | $0.379 | $759.7 | $0.275 |
| | | Commercial Roof | 158 | 259 | $94.1 | $0.364 | $66.7 | $0.258 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 8 | 14 | $4.1 | $0.291 | $2.8 | $0.196 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 5 | 10 | $3.0 | $0.298 | $2.0 | $0.199 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,659 | 28,978 | 11667 | 0.40 | 8562 | 0.30 |

## Low Adoption Rate



**Least Cost Summary Table, Low Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 851 | 1,837 | $538.6 | $0.293 | $318.7 | $0.174 |
| | | Ground 10-20 MW | 469 | 993 | $274.0 | $0.276 | $155.5 | $0.157 |
| | North Central Valley | Residential Roof | 1 | 2 | $1.0 | $0.403 | $0.7 | $0.281 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 848 | 1,817 | $513.0 | $0.282 | $293.7 | $0.162 |
| | | Ground 10-20 MW | 1,278 | 2,724 | $704.0 | $0.258 | $376.0 | $0.138 |
| | South Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 415 | 895 | $256.2 | $0.286 | $148.4 | $0.166 |
| | | Ground 10-20 MW | 273 | 581 | $150.7 | $0.259 | $81.6 | $0.140 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 101 | 216 | $65.4 | $0.303 | $39.2 | $0.181 |
| | | Ground 10-20 MW | 35 | 75 | $16.0 | $0.214 | $7.2 | $0.096 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.3 | $0.212 | $0.6 | $0.107 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 72 | 145 | $52.1 | $0.361 | $36.2 | $0.251 |
| | | Commercial Roof | 109 | 194 | $70.1 | $0.362 | $47.3 | $0.244 |
| | | Ground < 10 MW | 273 | 627 | $136.5 | $0.218 | $69.0 | $0.110 |
| | | Ground 10-20 MW | 1,074 | 2,431 | $490.4 | $0.202 | $234.7 | $0.097 |
| | South Central Valley | Residential Roof | 36 | 74 | $20.5 | $0.275 | $12.4 | $0.167 |
| | | Commercial Roof | 1 | 1 | $0.6 | $0.399 | $0.4 | $0.285 |
| | | Ground < 10 MW | 74 | 173 | $42.2 | $0.244 | $23.6 | $0.137 |
| | | Ground 10-20 MW | 173 | 401 | $79.6 | $0.198 | $37.2 | $0.093 |
| | Desert | Residential Roof | 9 | 19 | $5.8 | $0.311 | $3.7 | $0.198 |
| | | Commercial Roof | 13 | 23 | $6.7 | $0.295 | $4.2 | $0.185 |
| | | Ground < 10 MW | 41 | 98 | $21.1 | $0.216 | $10.9 | $0.111 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.1 | $0.089 |
| | Mountain | Residential Roof | 37 | 75 | $24.5 | $0.328 | $16.5 | $0.221 |
| | | Commercial Roof | 1 | 1 | $0.4 | $0.295 | $0.3 | $0.186 |
| | | Ground < 10 MW | 29 | 67 | $13.8 | $0.205 | $6.6 | $0.098 |
| | | Ground 10-20 MW | 50 | 109 | $22.7 | $0.208 | $10.7 | $0.098 |
| SDGE | South Coast | Residential Roof | 10 | 20 | $7.9 | $0.404 | $5.7 | $0.290 |
| | | Commercial Roof | 0 | 0 | $0.0 | $0.296 | $0.0 | $0.180 |
| | | Ground < 10 MW | 85 | 188 | $45.0 | $0.239 | $24.0 | $0.128 |
| | | Ground 10-20 MW | 252 | 543 | $120.0 | $0.221 | $60.2 | $0.111 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.9 | $0.389 | $2.1 | $0.282 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.9 | $0.234 | $0.5 | $0.132 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.102 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,649 | 14,418 | 3698 | 0.26 | 2035 | 0.14 |

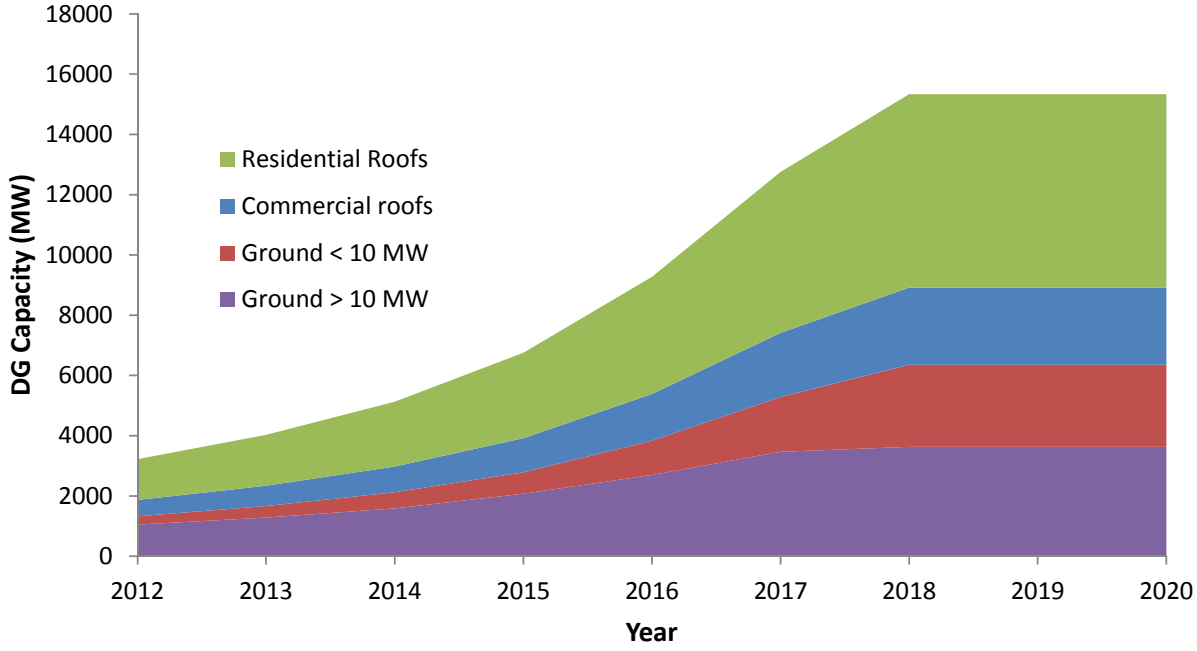
**Least Net Cost Summary Table, Low Adoption Rate**

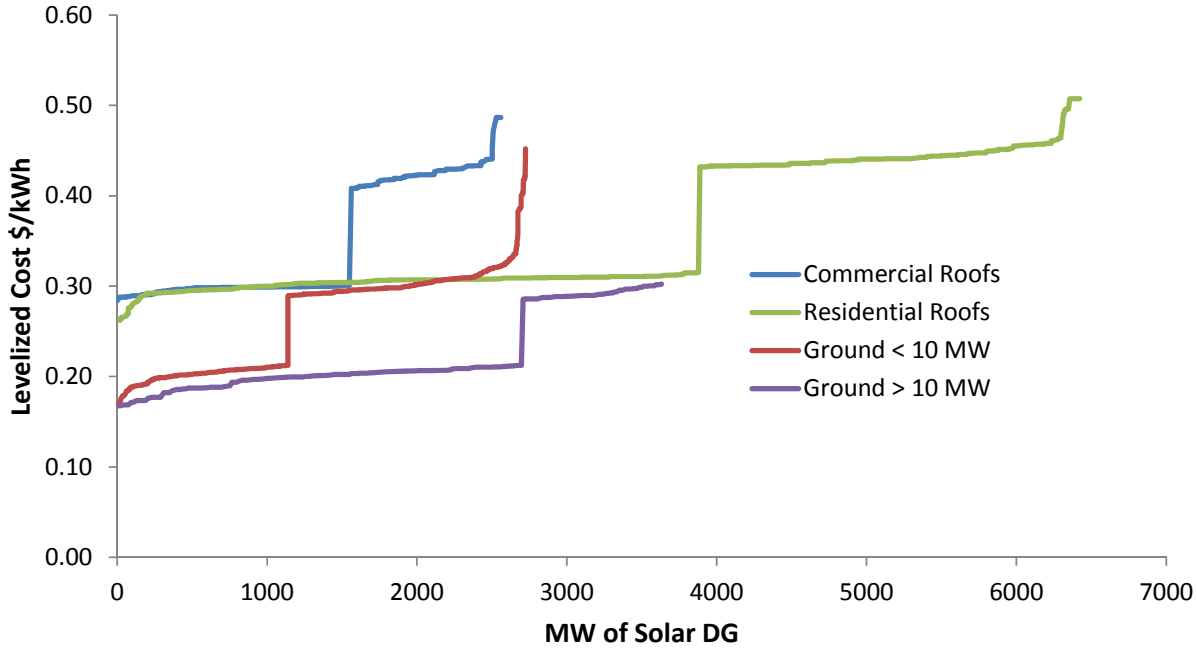
| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 851 | 1,840 | $542.0 | $0.295 | $321.6 | $0.175 |
| | | Ground 10-20 MW | 469 | 994 | $278.3 | $0.280 | $159.6 | $0.161 |
| | North Central Valley | Residential Roof | 1 | 2 | $1.0 | $0.403 | $0.7 | $0.282 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 848 | 1,817 | $516.2 | $0.284 | $297.1 | $0.164 |
| | | Ground 10-20 MW | 1,278 | 2,703 | $663.0 | $0.245 | $339.5 | $0.126 |
| | South Central Valley | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 415 | 894 | $256.2 | $0.286 | $148.5 | $0.166 |
| | | Ground 10-20 MW | 273 | 578 | $150.0 | $0.260 | $81.5 | $0.141 |
| | Mountain | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 101 | 216 | $64.5 | $0.299 | $38.4 | $0.178 |
| | | Ground 10-20 MW | 35 | 74 | $15.9 | $0.214 | $7.2 | $0.097 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.8 | $0.286 | $1.1 | $0.177 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 62 | 126 | $45.1 | $0.357 | $31.2 | $0.247 |
| | | Commercial Roof | 141 | 250 | $92.9 | $0.372 | $63.5 | $0.254 |
| | | Ground < 10 MW | 273 | 630 | $145.0 | $0.230 | $76.7 | $0.122 |
| | | Ground 10-20 MW | 1,074 | 2,435 | $491.5 | $0.202 | $234.6 | $0.096 |
| | South Central Valley | Residential Roof | 36 | 75 | $20.7 | $0.277 | $12.6 | $0.169 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 74 | 174 | $42.8 | $0.246 | $24.0 | $0.138 |
| | | Ground 10-20 MW | 173 | 402 | $79.7 | $0.199 | $37.2 | $0.093 |
| | Desert | Residential Roof | 9 | 19 | $7.3 | $0.389 | $5.2 | $0.276 |
| | | Commercial Roof | 13 | 23 | $6.8 | $0.295 | $4.2 | $0.180 |
| | | Ground < 10 MW | 41 | 98 | $22.1 | $0.224 | $11.7 | $0.119 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.1 | $0.089 |
| | Mountain | Residential Roof | 37 | 75 | $24.5 | $0.328 | $16.6 | $0.222 |
| | | Commercial Roof | 5 | 9 | $2.9 | $0.313 | $1.8 | $0.197 |
| | | Ground < 10 MW | 29 | 68 | $14.2 | $0.210 | $7.0 | $0.103 |
| | | Ground 10-20 MW | 50 | 110 | $26.8 | $0.244 | $14.6 | $0.133 |
| SDGE | South Coast | Residential Roof | | | | | | |
| | | Commercial Roof | 0 | 0 | $0.0 | $0.398 | $0.0 | $0.281 |
| | | Ground < 10 MW | 85 | 191 | $49.2 | $0.258 | $27.6 | $0.145 |
| | | Ground 10-20 MW | 252 | 550 | $132.8 | $0.242 | $71.4 | $0.130 |
| | South Central Valley | Residential Roof | 4 | 8 | $2.9 | $0.389 | $2.1 | $0.281 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $1.2 | $0.283 | $0.7 | $0.177 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.098 |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,666 | 14,447 | 3712 | 0.26 | 2044 | 0.14 |

**High Rooftop Summary Table, Low Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 102 | 190 | $78.4 | $0.412 | $55.8 | $0.293 |
| | | Commercial Roof | 32 | 55 | $23.5 | $0.425 | $16.5 | $0.299 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | North Central Valley | Residential Roof | 265 | 491 | $194.7 | $0.396 | $136.1 | $0.277 |
| | | Commercial Roof | 58 | 99 | $42.0 | $0.425 | $29.4 | $0.297 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 119 | 220 | $83.5 | $0.380 | $56.9 | $0.259 |
| | | Commercial Roof | 5 | 8 | $3.3 | $0.424 | $2.3 | $0.297 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 4 | 8 | $3.1 | $0.387 | $2.1 | $0.266 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 3 | 6 | $1.7 | $0.296 | $1.1 | $0.191 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,580 | 4,809 | $1,711.3 | $0.356 | $1,165.0 | $0.242 |
| | | Commercial Roof | 1,464 | 2,495 | $888.5 | $0.356 | $595.4 | $0.239 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 484 | 915 | $318.8 | $0.348 | $216.4 | $0.236 |
| | | Commercial Roof | 183 | 313 | $119.4 | $0.381 | $82.2 | $0.262 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 185 | 346 | $115.4 | $0.334 | $76.8 | $0.222 |
| | | Commercial Roof | 32 | 54 | $19.6 | $0.365 | $13.3 | $0.247 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 116 | 219 | $74.0 | $0.338 | $49.6 | $0.227 |
| | | Commercial Roof | 107 | 179 | $56.9 | $0.317 | $36.3 | $0.202 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 764 | 1,413 | $528.6 | $0.374 | $367.3 | $0.260 |
| | | Commercial Roof | 153 | 261 | $92.7 | $0.355 | $62.6 | $0.240 |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Central Valley | Residential Roof | 6 | 11 | $3.1 | $0.284 | $2.0 | $0.184 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $1.3 | $0.285 | $0.9 | $0.184 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 6,664 | 12,097 | 4360 | 0.36 | 2968 | 0.25 |

## High Adoption Rate



**Least Cost Summary Table, High Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,453 | $642.7 | $0.442 | $492.3 | $0.339 |
| | | Commercial Roof | 257 | 418 | $182.5 | $0.437 | $138.7 | $0.332 |
| | | Ground < 10 MW | 851 | 1,808 | $504.7 | $0.279 | $322.2 | $0.178 |
| | | Ground 10-20 MW | 469 | 983 | $249.6 | $0.254 | $150.6 | $0.153 |
| | North Central Valley | Residential Roof | 1,026 | 1,765 | $789.1 | $0.447 | $602.5 | $0.341 |
| | | Commercial Roof | 310 | 499 | $219.9 | $0.441 | $167.3 | $0.335 |
| | | Ground < 10 MW | 848 | 1,791 | $500.0 | $0.279 | $317.0 | $0.177 |
| | | Ground 10-20 MW | 1,278 | 2,698 | $661.4 | $0.245 | $384.8 | $0.143 |
| | South Central Valley | Residential Roof | 404 | 702 | $311.6 | $0.444 | $237.9 | $0.339 |
| | | Commercial Roof | 154 | 251 | $109.0 | $0.434 | $82.4 | $0.328 |
| | | Ground < 10 MW | 415 | 882 | $248.5 | $0.282 | $158.5 | $0.180 |
| | | Ground 10-20 MW | 273 | 575 | $144.7 | $0.252 | $86.6 | $0.151 |
| | Mountain | Residential Roof | 64 | 110 | $49.7 | $0.451 | $38.1 | $0.346 |
| | | Commercial Roof | 21 | 35 | $15.1 | $0.430 | $11.4 | $0.325 |
| | | Ground < 10 MW | 101 | 212 | $60.3 | $0.284 | $38.6 | $0.182 |
| | | Ground 10-20 MW | 35 | 75 | $16.0 | $0.214 | $8.4 | $0.113 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.3 | $0.212 | $0.7 | $0.120 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,350 | $1,383.9 | $0.318 | $954.0 | $0.219 |
| | | Commercial Roof | 1,358 | 2,266 | $726.4 | $0.321 | $499.4 | $0.220 |
| | | Ground < 10 MW | 273 | 622 | $133.4 | $0.214 | $75.0 | $0.120 |
| | | Ground 10-20 MW | 1,074 | 2,421 | $488.3 | $0.202 | $263.7 | $0.109 |
| | South Central Valley | Residential Roof | 417 | 745 | $235.7 | $0.317 | $162.9 | $0.219 |
| | | Commercial Roof | 200 | 334 | $106.4 | $0.319 | $72.8 | $0.218 |
| | | Ground < 10 MW | 74 | 171 | $40.1 | $0.235 | $24.2 | $0.141 |
| | | Ground 10-20 MW | 173 | 400 | $79.4 | $0.198 | $42.1 | $0.105 |
| | Desert | Residential Roof | 177 | 315 | $100.3 | $0.319 | $68.9 | $0.219 |
| | | Commercial Roof | 37 | 61 | $18.6 | $0.303 | $12.5 | $0.203 |
| | | Ground < 10 MW | 41 | 97 | $20.9 | $0.215 | $12.0 | $0.124 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.8 | $0.098 |
| | Mountain | Residential Roof | 128 | 234 | $70.4 | $0.301 | $48.1 | $0.205 |
| | | Commercial Roof | 67 | 111 | $33.7 | $0.304 | $22.7 | $0.205 |
| | | Ground < 10 MW | 29 | 67 | $13.5 | $0.202 | $7.3 | $0.109 |
| | | Ground 10-20 MW | 50 | 108 | $22.5 | $0.208 | $12.2 | $0.113 |
| SDGE | South Coast | Residential Roof | 909 | 1,597 | $541.5 | $0.339 | $386.9 | $0.242 |
| | | Commercial Roof | 154 | 255 | $89.6 | $0.352 | $64.5 | $0.253 |
| | | Ground < 10 MW | 85 | 186 | $43.2 | $0.232 | $25.3 | $0.135 |
| | | Ground 10-20 MW | 252 | 539 | $119.1 | $0.221 | $67.6 | $0.125 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.197 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.8 | $0.211 | $0.5 | $0.120 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.115 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 15,336 | 29,227 | 8990 | 0.31 | 6069 | 0.21 |

**Least Net Cost Summary Table, High Adoption Rate**

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 840 | 1,455 | $638.1 | $0.439 | $487.5 | $0.335 |
| | | Commercial Roof | 257 | 418 | $182.5 | $0.437 | $138.6 | $0.332 |
| | | Ground < 10 MW | 851 | 1,811 | $517.5 | $0.286 | $334.7 | $0.185 |
| | | Ground 10-20 MW | 469 | 984 | $252.1 | $0.256 | $153.0 | $0.156 |
| | North Central Valley | Residential Roof | 1,026 | 1,758 | $730.9 | $0.416 | $545.0 | $0.310 |
| | | Commercial Roof | 312 | 500 | $215.1 | $0.430 | $162.4 | $0.325 |
| | | Ground < 10 MW | 848 | 1,789 | $498.3 | $0.278 | $315.6 | $0.176 |
| | | Ground 10-20 MW | 1,278 | 2,686 | $639.6 | $0.238 | $364.8 | $0.136 |
| | South Central Valley | Residential Roof | 404 | 699 | $295.9 | $0.423 | $222.5 | $0.318 |
| | | Commercial Roof | 154 | 251 | $109.0 | $0.434 | $82.4 | $0.328 |
| | | Ground < 10 MW | 415 | 881 | $244.8 | $0.278 | $155.0 | $0.176 |
| | | Ground 10-20 MW | 273 | 575 | $149.1 | $0.260 | $91.1 | $0.159 |
| | Mountain | Residential Roof | 64 | 110 | $49.5 | $0.451 | $38.0 | $0.346 |
| | | Commercial Roof | 21 | 35 | $15.1 | $0.430 | $11.4 | $0.325 |
| | | Ground < 10 MW | 101 | 212 | $60.3 | $0.284 | $38.6 | $0.182 |
| | | Ground 10-20 MW | 35 | 74 | $15.9 | $0.214 | $8.4 | $0.113 |
| SCE | North Coast | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 3 | 6 | $1.8 | $0.286 | $1.2 | $0.193 |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 2,454 | 4,307 | $1,404.2 | $0.326 | $978.8 | $0.227 |
| | | Commercial Roof | 1,358 | 2,265 | $728.2 | $0.322 | $501.5 | $0.221 |
| | | Ground < 10 MW | 273 | 624 | $135.4 | $0.217 | $76.6 | $0.123 |
| | | Ground 10-20 MW | 1,074 | 2,422 | $488.5 | $0.202 | $263.6 | $0.109 |
| | South Central Valley | Residential Roof | 417 | 746 | $236.4 | $0.317 | $163.5 | $0.219 |
| | | Commercial Roof | 200 | 333 | $108.8 | $0.327 | $75.3 | $0.226 |
| | | Ground < 10 MW | 74 | 171 | $40.9 | $0.238 | $24.8 | $0.145 |
| | | Ground 10-20 MW | 173 | 400 | $79.4 | $0.198 | $42.1 | $0.105 |
| | Desert | Residential Roof | 177 | 313 | $101.9 | $0.326 | $70.8 | $0.226 |
| | | Commercial Roof | 37 | 61 | $18.5 | $0.303 | $12.4 | $0.203 |
| | | Ground < 10 MW | 41 | 97 | $21.0 | $0.215 | $12.0 | $0.124 |
| | | Ground 10-20 MW | 29 | 69 | $13.0 | $0.188 | $6.8 | $0.098 |
| | Mountain | Residential Roof | 128 | 234 | $70.5 | $0.301 | $48.1 | $0.205 |
| | | Commercial Roof | 67 | 112 | $34.1 | $0.304 | $22.9 | $0.204 |
| | | Ground < 10 MW | 29 | 67 | $13.8 | $0.205 | $7.5 | $0.111 |
| | | Ground 10-20 MW | 50 | 109 | $22.6 | $0.208 | $12.3 | $0.113 |
| SDGE | South Coast | Residential Roof | 909 | 1,608 | $577.9 | $0.360 | $421.8 | $0.262 |
| | | Commercial Roof | 154 | 256 | $91.9 | $0.358 | $66.5 | $0.259 |
| | | Ground < 10 MW | 85 | 188 | $45.8 | $0.244 | $27.7 | $0.148 |
| | | Ground 10-20 MW | 252 | 544 | $120.1 | $0.221 | $67.8 | $0.125 |
| | South Central Valley | Residential Roof | 4 | 7 | $2.0 | $0.286 | $1.4 | $0.197 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 4 | $0.9 | $0.234 | $0.6 | $0.142 |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | | | | | | |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | 2 | 5 | $1.0 | $0.203 | $0.5 | $0.112 |
| | | Ground 10-20 MW | | | | | | |
| | Totals | | 15,338 | 29,190 | 8972 | 0.31 | 6056 | 0.21 |

## High Rooftop Summary Table, High Adoption Rate

| Utility | Climate Zone | Type | MW | GWh | Cost ($2010) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost in 2020 | | Net Cost in 2020 | |
| | | | | | $M | $/kWh | $M | $/kWh |
| PGE | North Coast | Residential Roof | 1,780 | 3,072 | $1,343.9 | $0.437 | $1,027.7 | $0.335 |
| | | Commercial Roof | 278 | 452 | $197.4 | $0.436 | $150.3 | $0.332 |
| | | Ground < 10 MW | 315 | 681 | $183.1 | $0.269 | $115.9 | $0.170 |
| | | Ground 10-20 MW | 210 | 442 | $112.3 | $0.254 | $68.4 | $0.155 |
| | North Central Valley | Residential Roof | 2,450 | 4,215 | $1,792.3 | $0.425 | $1,351.8 | $0.321 |
| | | Commercial Roof | 359 | 579 | $254.4 | $0.439 | $193.7 | $0.335 |
| | | Ground < 10 MW | 373 | 795 | $216.8 | $0.273 | $136.0 | $0.171 |
| | | Ground 10-20 MW | 599 | 1,269 | $311.5 | $0.245 | $182.5 | $0.144 |
| | South Central Valley | Residential Roof | 1,097 | 1,899 | $814.2 | $0.429 | $616.5 | $0.325 |
| | | Commercial Roof | 122 | 199 | $86.6 | $0.434 | $65.6 | $0.329 |
| | | Ground < 10 MW | 110 | 237 | $62.8 | $0.265 | $39.4 | $0.166 |
| | | Ground 10-20 MW | 41 | 88 | $20.9 | $0.239 | $12.4 | $0.141 |
| | Mountain | Residential Roof | 214 | 369 | $161.4 | $0.437 | $123.1 | $0.333 |
| | | Commercial Roof | 21 | 35 | $15.2 | $0.430 | $11.5 | $0.326 |
| | | Ground < 10 MW | 13 | 27 | $7.5 | $0.272 | $4.7 | $0.171 |
| | | Ground 10-20 MW | | | | | | |
| SCE | North Coast | Residential Roof | 3 | 6 | $1.7 | $0.296 | $1.2 | $0.205 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | South Coast | Residential Roof | 3,644 | 6,538 | $2,043.7 | $0.313 | $1,407.1 | $0.215 |
| | | Commercial Roof | 1,499 | 2,510 | $825.7 | $0.329 | $575.3 | $0.229 |
| | | Ground < 10 MW | 96 | 217 | $48.2 | $0.222 | $27.6 | $0.127 |
| | | Ground 10-20 MW | 193 | 438 | $87.7 | $0.200 | $47.6 | $0.109 |
| | South Central Valley | Residential Roof | 708 | 1,285 | $400.8 | $0.312 | $276.2 | $0.215 |
| | | Commercial Roof | 184 | 309 | $102.6 | $0.332 | $71.6 | $0.231 |
| | | Ground < 10 MW | 9 | 21 | $5.8 | $0.270 | $3.7 | $0.174 |
| | | Ground 10-20 MW | 12 | 30 | $5.4 | $0.179 | $2.9 | $0.095 |
| | Desert | Residential Roof | 261 | 471 | $147.1 | $0.312 | $101.3 | $0.215 |
| | | Commercial Roof | 32 | 53 | $16.3 | $0.304 | $10.9 | $0.204 |
| | | Ground < 10 MW | 6 | 16 | $2.9 | $0.184 | $1.5 | $0.094 |
| | | Ground 10-20 MW | | | | | | |
| | Mountain | Residential Roof | 167 | 304 | $92.5 | $0.305 | $63.4 | $0.209 |
| | | Commercial Roof | 107 | 178 | $53.5 | $0.301 | $36.0 | $0.203 |
| | | Ground < 10 MW | 16 | 39 | $7.5 | $0.195 | $4.1 | $0.105 |
| | | Ground 10-20 MW | | | | | | |
| SDGE | South Coast | Residential Roof | 1,221 | 2,152 | $724.2 | $0.337 | $516.6 | $0.240 |
| | | Commercial Roof | 183 | 303 | $104.4 | $0.344 | $74.7 | $0.246 |
| | | Ground < 10 MW | 18 | 40 | $9.6 | $0.243 | $5.8 | $0.147 |
| | | Ground 10-20 MW | 16 | 34 | $7.2 | $0.212 | $3.9 | $0.115 |
| | South Central Valley | Residential Roof | 6 | 11 | $3.1 | $0.284 | $2.1 | $0.195 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | Desert | Residential Roof | 2 | 5 | $1.3 | $0.285 | $0.9 | $0.195 |
| | | Commercial Roof | | | | | | |
| | | Ground < 10 MW | | | | | | |
| | | Ground 10-20 MW | | | | | | |
| | | Totals | 16,366 | 29,321 | 10272 | 0.35 | 7334 | 0.25 |

# Appendix B: Additional Methodological Details

# Additional Methodological Detail Regarding Potential Analysis

This appendix provides additional detail on our method for evaluating the local potential for distributed PV at the substation level. The appendix covers the following issues:

- Development of substation load profiles and PV output profiles for assessing potential for PV development
- Assignment of PV sites to substations

## PV Output and Substation Load Profiles

### PV OUTPUT PROFILES

PV output profiles are necessary to determine the amount of PV that can be placed on any given substation under a no backflow criterion. Also, the PV capacity factor is used in calculating the cost and net cost of the PV systems. PV output profiles were developed through simulation for each substation location in horizontal, fixed tilt, and tracking orientation by Clean Power Research (CPR). CPR developed PV output profiles for 797 locations in California.

### SUBSTATION LOAD PROFILES

In response to a CPUC data request, each IOU provided their readily available interval load data for distribution substations and feeders. While not comprehensive, the data was sufficient to develop an hourly min, max, and mean load (8760 X 3) for each substation or feeder for 2010. In addition, peak load was provided for all substations.

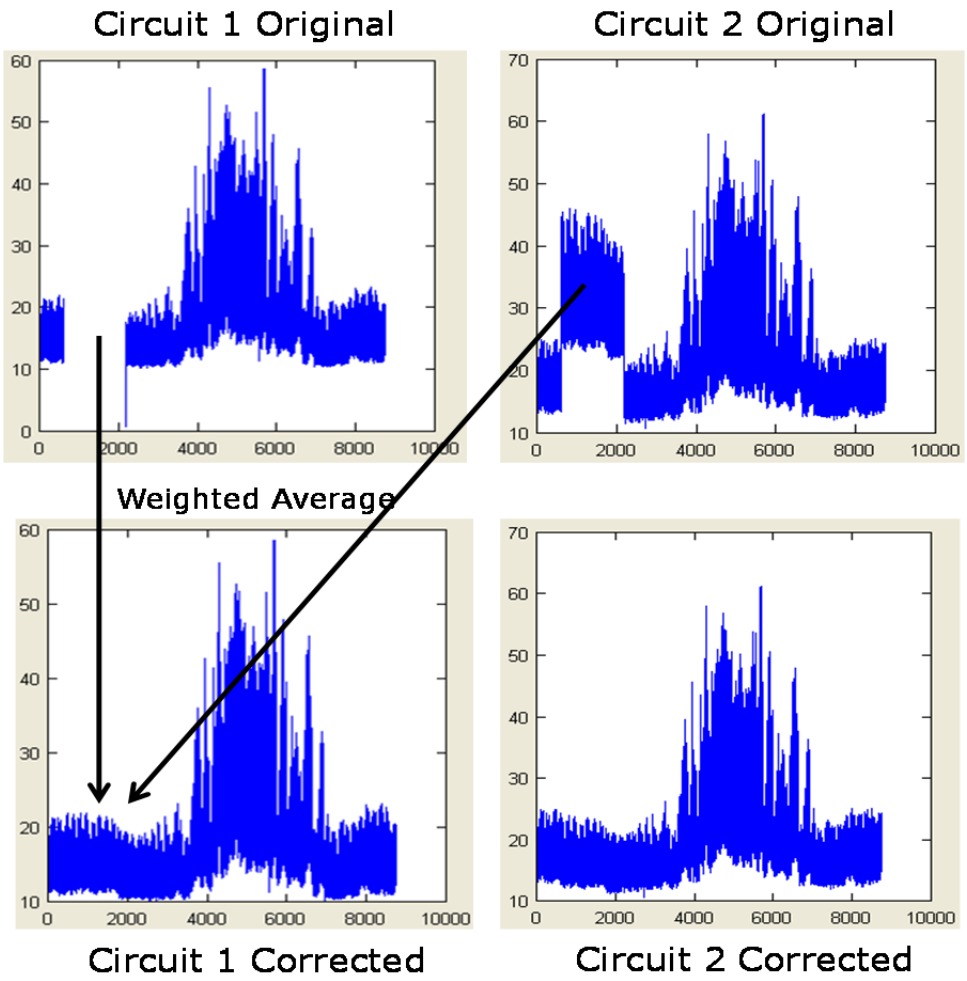
| Utility | # of Substations | # with Peak Load Values | # with 8760 Load Curves |
|---|---|---|---|
| PGE | 1,019 | 1,019 | 24 |
| SCE | 680 | 677 | 400 |
| SDGE | 105 | 101 | 20 |
| *Total* | *1,804* | *1,797* | *444* |

Two key steps were necessary to adapt the provided substation data to develop estimated 8760 load profiles for each substation. First, we cleaned the data to correct for missing data, outliers, and other obvious anomalies, such as shifting of load from one substation to another. Second, we assigned representative substation profiles to substations for which hourly load data was not available based on regression analysis that considered the type of land-use (residential, commercial, industrial, agricultural) in the surrounding area.

### *Cleaning of Substation Load Profile Data*

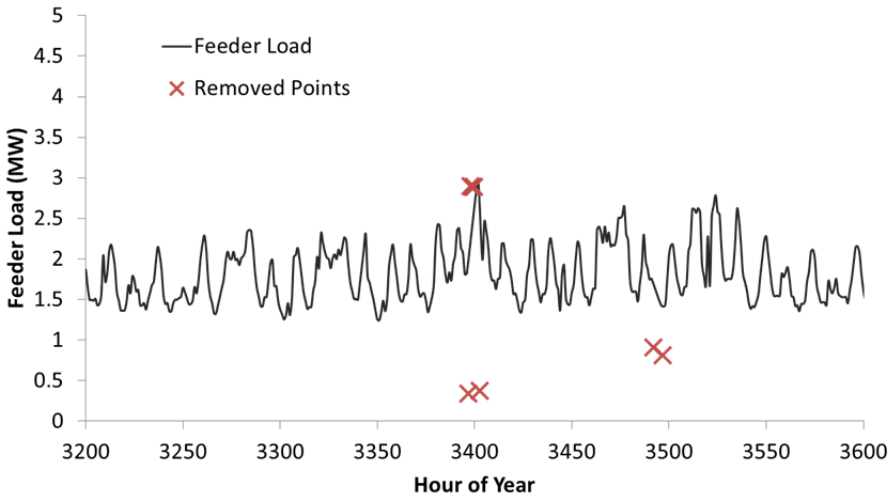
Not all of the provided hourly substation load profiles were suitable for determining available DG capacity; in some cases data were missing or required cleaning. In cases where load from one feeder was obviously shifted to another, we move the load back to the original feeder (see Figure 1).

**Figure 1: Reassignment of load shifted between feeders**




In some cases, very high or very low readings were observed that were incongruous with the rest of the data. We removed from the data any outliers we deemed to be erroneous measurements (see Figure 2).

**Figure 2: Removal of measurement errors**




We removed an hourly reading if it met one of the following conditions:

- >1.8 times the maximum of the same hour in the week ahead/prior
- <0.55 times the minimum of the same hour in the week ahead/prior
- <0.1 MW

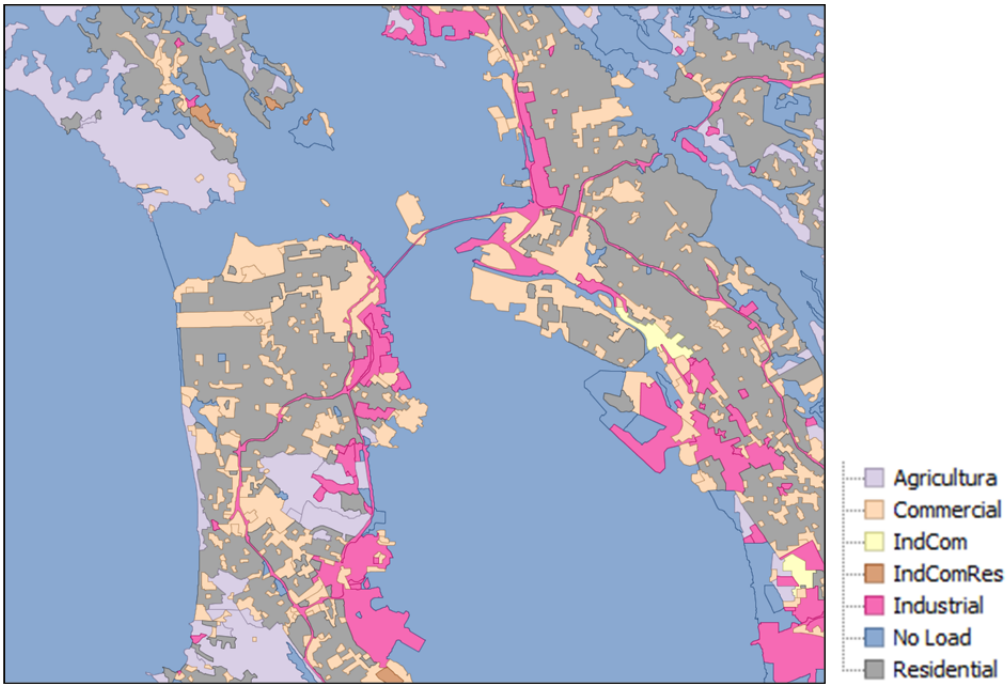
Finally, we estimated minimum hourly load based on the average load provided in the clean shapes. Only PG&E provided minimum (and maximum and mean) load for each hour of the year for each of their readings. We used the PG&E data to develop an hourly distribution of the difference between average and minimum load. We then used this distribution to apply a de-rating factor of 3-standard deviations on hourly load profiles from SCE and SDG&E. We can be reasonably confident that the resulting hourly load profiles for SCE and SDG&E are a fair representation of minimum load.

### *Assignment of Substation Load Profiles*

To determine the available capacity for DG at each substation, we assigned an hourly load shape to those substations for which hourly load data were not provided. We did this by assigning representative substation load profiles to other substations with similar land use characteristics.

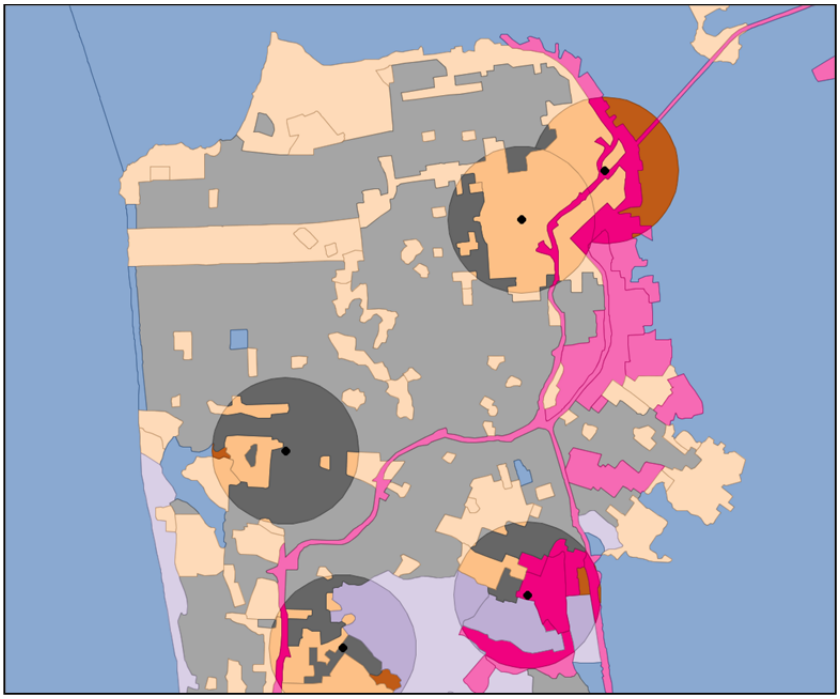
We first create four land use categories (residential, commercial, industrial, and agricultural) from 37 categories in the USGS's California land use map (see Figure 3).

**Figure 3: Land use mapping for San Francisco Bay Area**




We then determine the amount of land of each type within reach of the substation (see Figure 4). In the absence of a more detailed mapping, we define a proxy for the area within reach of the substation based on a circle.

**Figure 4: Illustration of land within reach of substations**



For each substation for which we have an annual load shape, we regress the total kWh against the area of each land use type to find the relative energy density of each:

$$Total\ kWh = \beta_{res}A_{res} + \beta_{\text{com}}A_{\text{com}} + \beta_{\text{ind}}A_{\text{ind}} + \beta_{\text{agr}}A_{\text{agr}}$$

Where:

A = land area

res = residential land use type

com = commercial land use type

ind = industrial land use type

agr = agricultural land use type

The relative energy density of each land use type is useful for assigning load shapes to substations based on the most similar substation for which we have hourly data, as described below.

For each substation without hourly load profile, we estimate the percentage contribution to load from each land use type, based on the regression results:

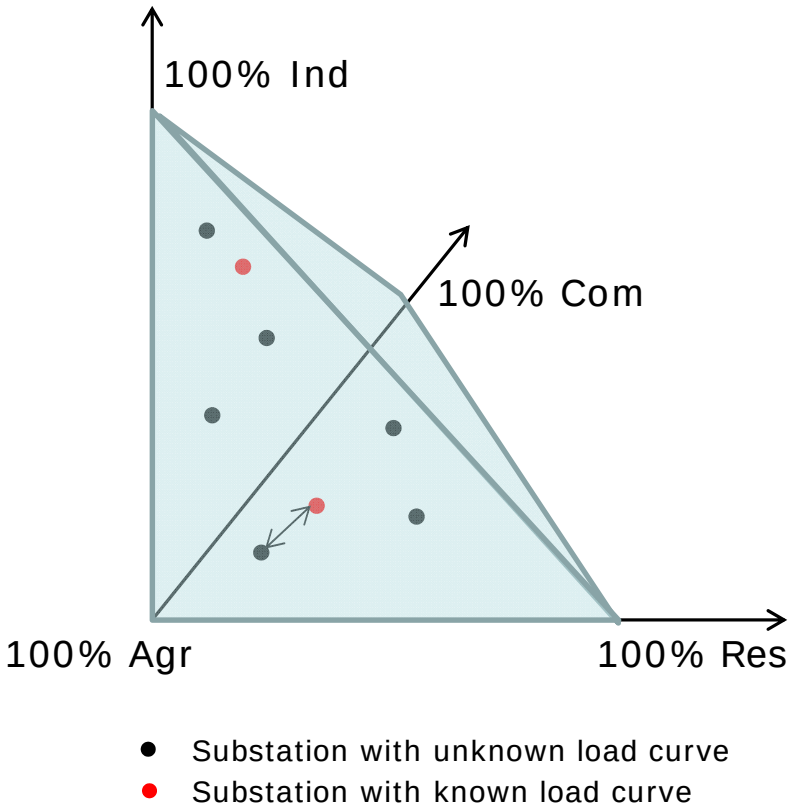
$$Res\ Contribution = \frac{Area \times \beta_{res}}{\sum_i Area_i \beta_i}$$

$$Com\ Contribution = \frac{Area \times \beta_{com}}{\sum_i Area_i \beta_i}$$

$$Ind\ Contribution = \frac{Area \times \beta_{ind}}{\sum_i Area_i \beta_i}$$

Finally, we match, by climate zone, the substations with unknown load shapes to those with known load shapes. We plot all substations in 3 dimensions where each axis represents the percentage contribution to substation load. Substations with unknown load shapes are assigned the load shape of the substation closest to it in this percentage contribution space (see Figure 5).

**Figure 5: Illustration of substation load shape assignment based on minimum Euclidean distance**



## Assignment of PV Sites to Substations

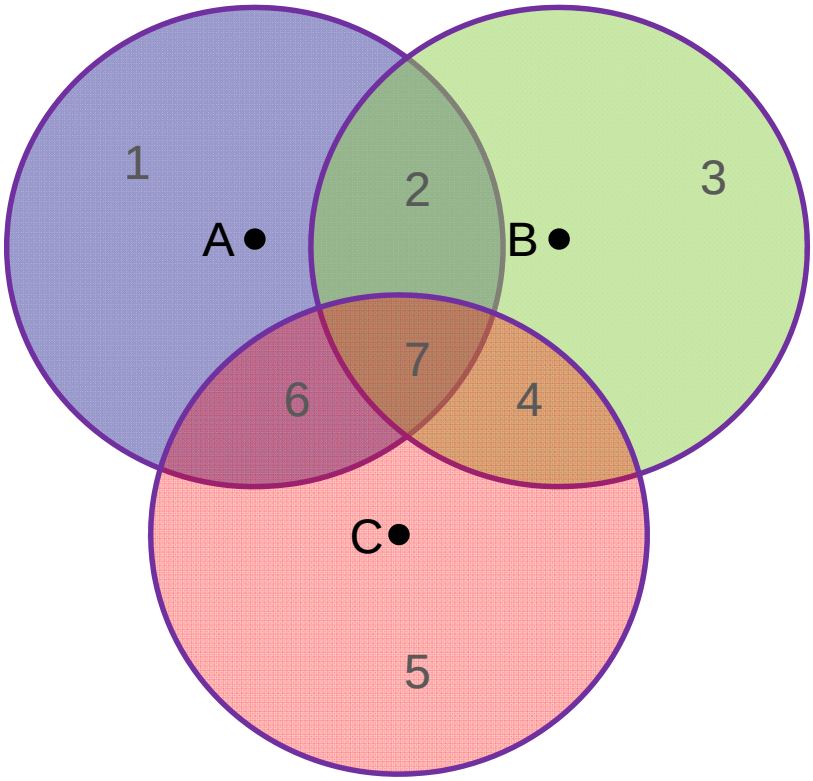
As discussed in the body of the report, we identify suitable ground mount, residential rooftop, and commercial rooftop PV sites through GIS mapping. To assign these sites to available substations, we use a circle with radius 2.5 miles (urban and suburban) or 5 miles (rural) as a proxy for sites that are within range of the substation.

However, in many cases, the rooftop or vacant land is within the radius of more than one substation (see, for example, Figure 6). In such cases, we must select which of the overlapping substations will receive the PV in the overlapping areas.

**Figure 6: Illustration of substations with overlapping "circles of influence"**

To do so, we first map available sites to the various 'faces' defined by the overlap. In Figure 7, the numbers 1-7 define the faces pertaining to substations A, B, and C. Sites in Face 1 are available only to Substation A, while sites in Face 2 are available to Substation A or B, and sites in Face 7 are available to Substation A, B, or C.

**Figure 7: Illustration of mapped 'faces' in overlapping substation circles of influence**




The PV sites are assigned to each substation beginning with the face least shared with other substations. For Substation A, sites would be assigned first from Face 1, then from Faces 4 and 6, and finally from Face 7. The reason for holding off on the commonly held faces is that it is possible that available capacity in Substation A may be filled by any one of the 4 faces available to it; in this case taking sites from Face 1 ensures that the sites in Faces 2, 6, and 7 will be available to other substations, which may have more capacity. Our method thus ensures maximum utilization of potential PV sites.

# Appendix C:  Avoided Cost Calculation

# Table of Contents

# Avoided Cost Appendix

This appendix describes the inputs and methods used to update the avoided costs for E3's evaluation of local distribute PV in Phase 3 of the CSI Evaluation project. This analysis includes method enhancements and data updates since the prior CSI analysis was performed for cost-effectiveness evaluation of the CSI program in Phase 2 of the project. E3's work in the Demand Response (DR) proceedings have produced methodology enhancements in the determination of generation capacity value that have been incorporated into this analysis. Input data for gas and electricity markets have also been updated to reflect historical and forecast markets prices at the end of 2010.

In support of the more granular approach employed in analysis of local distributed PV, this analysis also utilizes distribution avoided cost estimates at the substation level that are based on IOU forecasts of capacity-related work. Those detailed avoided cost estimates are combined with utility substation hourly data from 2010 to provide a more precise determination of the potential cost savings from PV throughout the state.

# Overview of Electricity Avoided Cost Components

The avoided cost used for electricity energy efficiency evaluation is calculated as the sum of six components shown in Table 1.

**Table 1. Components of electricity avoided cost**

| Component | Description |
|---|---|
| Generation Energy | Estimate of hourly wholesale value of energy adjusted for losses between the point of the wholesale transaction and the point of delivery |
| System Capacity | The costs of building new generation capacity to meet system peak loads |
| Ancillary Services | The marginal costs of providing system operations and reserves for electricity grid reliability |
| T&D Capacity | The costs of expanding transmission and distribution capacity to meet peak loads |
| Environment | The cost of carbon dioxide emissions associated with the marginal generating resource |
| Line Losses | The loss in energy from transmission and distribution across distance |

The hourly granularity of the avoided costs is obtained by shaping forecasts of the average value of each component with historical day-ahead and real-time energy prices and actual system loads reported by CAISO's MRTU system for 2010; Table 2 summarizes the methodology applied to each component to develop this level of granularity.

**Table 2. Summary of methodology for electricity avoided cost component forecasts**

| Component | Basis of Annual Forecast | Basis of Hourly Shape |
|---|---|---|
| Generation Energy | Market forwards that transition to the annual average market price needed to cover the fixed and operating costs of a new CCGT, less net revenue from day-ahead energy, ancillary service, and capacity markets. | Historical hourly day-ahead market price shapes from MRTU OASIS |
| System Capacity | Fixed costs of a new simple-cycle combustion turbine, less net revenue from real-time energy and ancillary service markets | Hourly allocation factors calculated as a proxy for rLOLP based on CAISO hourly system loads |
| Ancillary Services | Scales with the value of energy | Directly linked with energy shape |
| T&D Capacity | Survey of utility transmission and distribution deferral values from general rate cases and utility project forecasts. | Hourly allocation factors calculated using substation load data. |
| Environment | Synapse Mid-Level carbon forecast developed for use in electricity sector IRPs | Directly linked with energy shape with bounds on the maximum and minimum hourly value |

Figure 1, below, shows a three-day snapshot of the avoided costs, broken out by component, in Climate Zone 13. To preserve the confidentiality of the utility project and substation data, Figure 1 through Figure 3 show generic climate zone average costs based on rate case filings. This is done for illustrative purposes, as the actual analysis uses avoided costs derived from the confidential project and substation data.

The figure shows that the cost of providing an additional unit of electricity is significantly higher in the summer afternoons than in the very early morning hours. This chart also shows the relative magnitude of different components in this region in the summer for these days. The highest peaks of total cost shown in Figure 1 of over $2,500/MWh are driven by the allocation

of generation and T&D capacity to the peak hours, and by higher energy market prices during the middle of the day.

**Figure 1. Three-day snapshot of energy values in CZ13 in 2017**

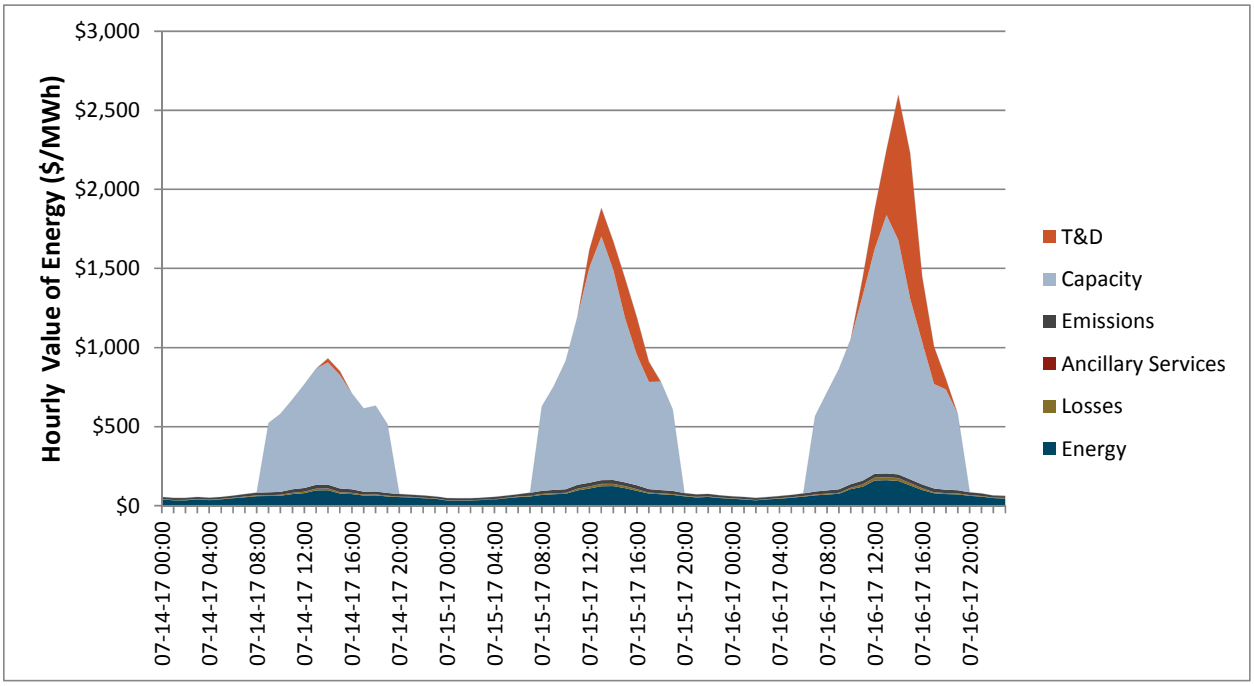



Figure 2 shows average monthly value of electricity reductions, revealing the seasonal characteristics of the avoided costs. The energy component dips in the spring, reflecting increased hydro supplies and imports from the Northwest; and peaks in the summer months when demand for electricity is highest. The value of capacity—both generation and T&D—is concentrated in the summer months and results in significantly more value on average in these months.

**Figure 2. Average monthly avoided cost in CZ13 in 2017**

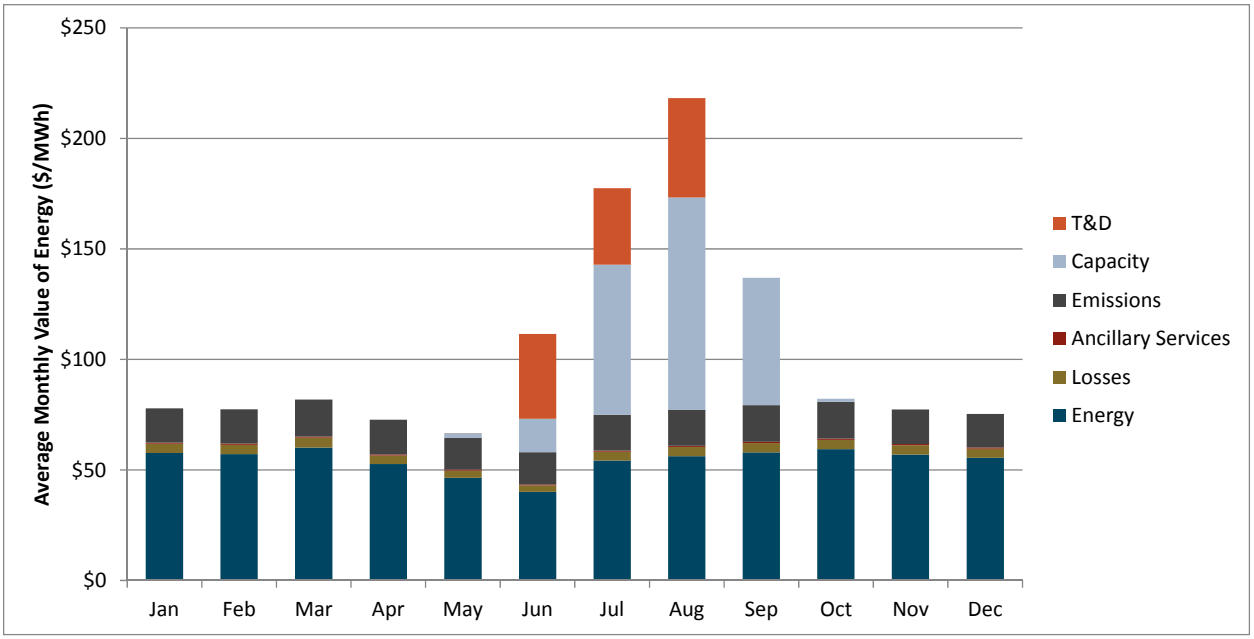
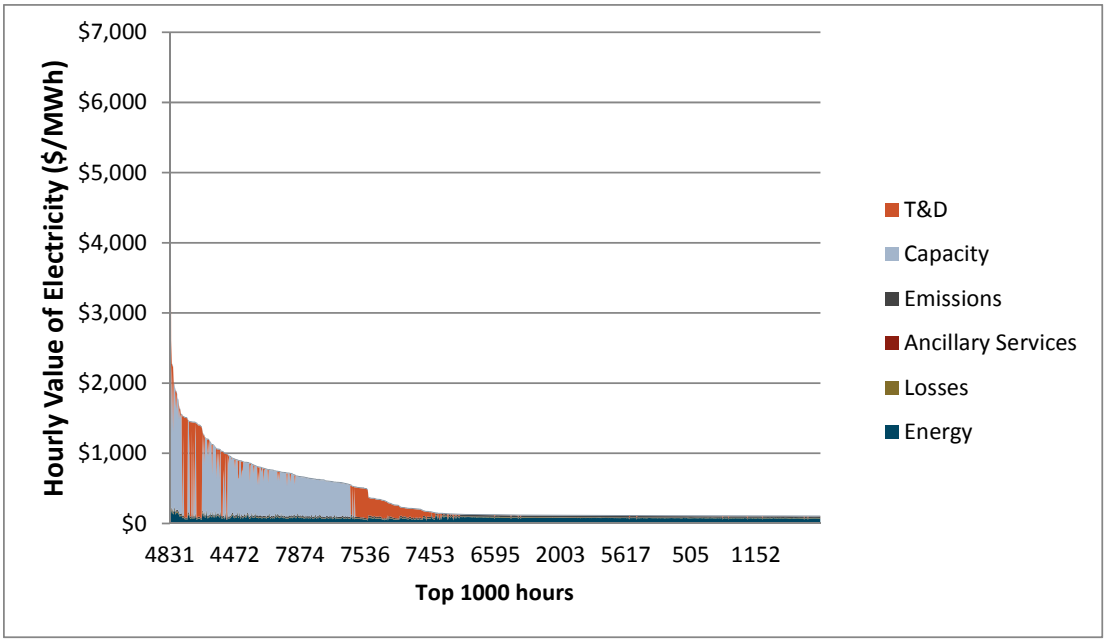



Figure 3 shows the components of value for the highest value hours in sorted order of cost. This chart shows the relative contribution to the highest hours of the year by component. Note that most of the high cost hours occur in approximately the top 200 to 400 hours—this is because most of the value associated with capacity is concentrated in a limited number of hours. While the timing and magnitude of these high costs differ by climate zone, the concentration of value in the high load hours is a characteristic of the avoided costs in all of California.

**Figure 3. Price duration curve showing top 1,000 hours for CZ13 in 2017**




# Generation Avoided Cost Methodology

## *Determination of Value of Generation Capacity*

Generation capacity is calculated using the DR method, updated with 2010 input data. The method assumes that in the resource balance year (2017) and beyond, the value of capacity will equal the fixed cost of a new CT less the net revenues that the CT would attain from the selling to the real-time energy and ancillary service markets. In the years prior to resource balance, the capacity value is interpolated from the resource adequacy value of $28.07/kW-yr in 2008. The capacity value is allocated over the top 250 hours of system load.

To determine the long-run value of capacity, the avoided cost model performs an hourly dispatch of a new CT to determine energy market net revenues. The CT's net margin is

calculated assuming that the unit dispatches at full capacity in each hour that the real-time price exceeds its operating cost (the sum of fuel costs and variable O&M) plus a bid adder of 10%. In each hour that it operates, the unit earns the difference between the market price and its operating costs. In each hour where the market prices are below the operating cost, the unit is assumed to shut down. The dispatch uses the 2010 MRTU real-time market shape[1], and adjusts for temperature performance degradation using average monthly 9am – 10pm temperatures.

The method also re-expresses the capacity value as $ per kW of degraded capacity, rather than $ per kW of nameplate capacity. This re-expression increases the $/kW capacity value by about 8%. The use of the degraded capacity is part of a series of methodology enhancements introduced in the DR proceeding to more precisely model to operation of a combustion turbine at different ambient temperature conditions throughout the year.

The capacity value calculations are performed using both Northern California and Southern California market prices and weather information. Consistent with the DR methodology, the final capacity value for each year is the average of the results for Northern and Southern California (50% Northern and 50% Southern).

## Temperature effect on unit performance

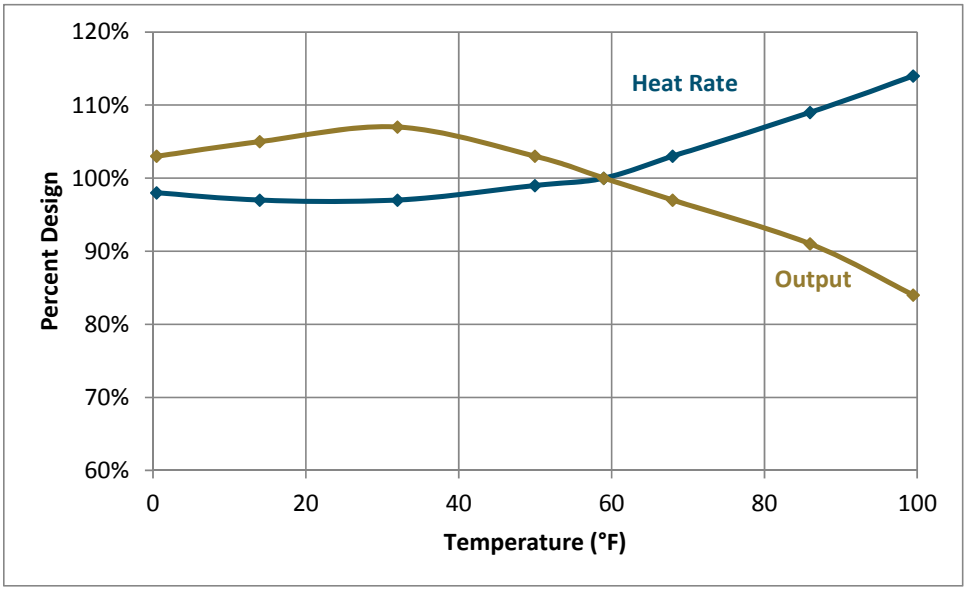
The CT's rated heat rate and nameplate capacity characterize the unit's performance at ISO conditions,[2] but the unit's actual performance deviates substantially from these ratings

[1] The real-time market shape annual level is adjusted annually by 1) the percentage change in natural gas burner tip prices and 2) the energy market calibration factor. The energy market calibration factor is used to adjust the energy market prices to a level such that a new CCGT would not over or under collect in the resource balance and all subsequent years, and is described in more detail in the energy market section.

[2] ISO conditions assume 59ºF, 60% relative humidity, and elevation at sea level.

throughout the year. In California, deviations from rated performance are due primarily to hourly variations in temperature. Figure 4 shows the relationship between temperature and performance for a GE LM6000 SPRINT gas turbine, a reasonable proxy for current CT technology.

**Figure 4. Temperature-performance curve for a GE LM6000 SPRINT combustion turbine.**




The effect of temperature on performance is incorporated into the calculation of the CT residual; several performance corrections are considered:

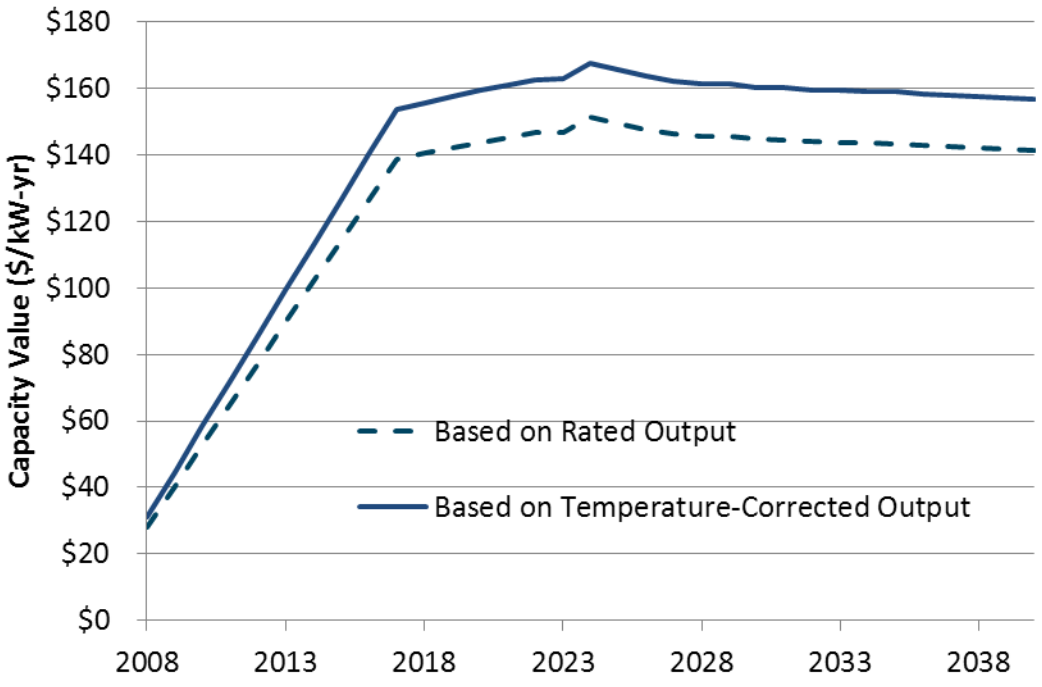
- In the calculation of the CT's dispatch, the heat rate is assumed to vary on a monthly basis. In each month, E3 calculates an average day-time temperature based on hourly temperature data throughout the state and uses this value to adjust the heat rate—and thereby the operating cost—within that month.
- Plant output is also assumed to vary on a monthly basis; the same average day-time temperature is used to determine the correct adjustment. This adjustment affects the revenue collected by the plant in the real-time market. For instance, if the plant's

output is 90% of nameplate capacity in a given month, its net revenues will equal 90% of what it would have received had it been able to operate at nameplate capacity.

- The resulting capacity residual is originally calculated as the value per nameplate kilowatt—however, during the peak periods during which a CT is necessary for resource adequacy, high temperatures will result in a significant capacity derate. Consequently, the value of capacity is increased by approximately 10% to reflect the plant's reduced output during the top 250 load hours of the year as shown in Figure 5.

The forecast annual generation capacity values are shown below.

**Figure 5. Adjustment of capacity value to account for temperature derating during periods of peak load**



## Determination of energy market values.

The updated avoided energy costs are developed using a method similar to what was used for the prior CSI analysis. In years prior to resource balance, the average energy cost is based on the NYMEX market price forecast if available. If not available, the method interpolates between the last available NYMEX market price and the long-run energy market price. The long-run energy market price is used for the resource balance and all subsequent years.

The annual long-run energy market price is set so that the CCGT's energy market revenues plus the capacity market payment equal the fixed and variable costs of the CCGT (i.e.: the CCGT is made whole). The long-run energy market price begins with the 2010 MRTU day-ahead market price escalated by the natural gas burner tip forecast. The energy market price is then increased or decreased with an energy market calibration factor so that the CCGT is made whole. The energy market calibration factor is applied to both 1) the real-time market prices used to determine CT energy revenues and the value of capacity, and 2) the day-ahead energy market used to determine CCGT energy revenues. This creates a feedback effect between the energy and capacity avoided costs. The feedback effect is illustrated with the following example.

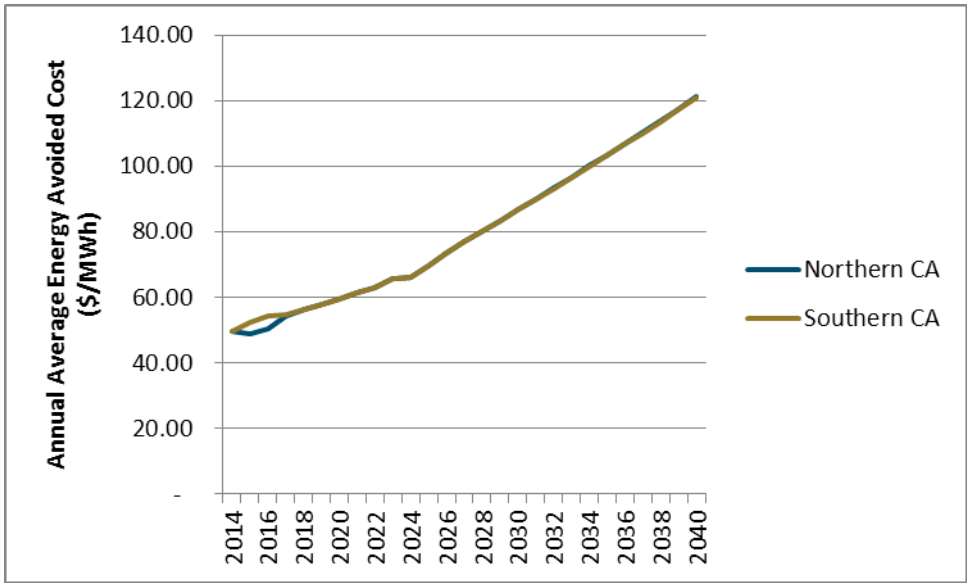
> *Assume that the CCGT would collect more revenue through the capacity and energy markets than is needed to cover its costs. The methodology decreases the calibration factor to decrease the day-ahead energy market prices and market revenues to make the CCGT whole. To keep the real-time and day-ahead markets in sync, the methodology also would decrease the real-time energy market prices by the calibration factor. The decrease in real-time energy market prices would result in lower net revenues for a CT, and therefore raise the value of capacity (as higher capacity payment revenue is needed to incent a new CT to build). When we re-examine the CCGT, the raised value of capacity*

*results in the CCGT collecting excess revenues, so the calibration factor needs to be decreased more, and the process repeats*[3].

[3] The actual process steps for determining the calibration factor for each year (and therefore the real-time and day-ahead market prices) are listed below.

1. Set the annual day-ahead energy price at the 2010 level increased by the percentage change in the forecast annual gas burner tip price.
2. Set the energy market calibration factor to 100%
3. Multiply (1) by (2) to yield the adjusted annual day-ahead price
4. Calculate capacity cost
    a. Multiply the real-time 2010 hourly price shape by the adjusted annual day ahead price
    b. Dispatch a new CT against the hourly prices in Northern and Southern CA from 4a to determine real time dispatch revenue in Northern and Southern CA
    c. Calculate ancillary service revenues as 7.6% of the real-time dispatch revenue
    d. Capacity value is the net capacity cost. Net capacity cost = the levelized cost of the new CT plus fuel and O&M costs less 4.b and 4.c
    e. Adjust capacity value ($/kW-yr) to reflect degraded output at system peak weather conditions
    f. Set the capacity value at the average of Northern and Southern CA capacity values
5. Calculate energy cost
    a. Multiply the day-ahead 2010 hourly price shape by the adjusted annual day ahead price
    b. Dispatch a new CCGT against the hourly prices from 5.a to determine the day-ahead dispatch revenue
    c. Calculate the excess (deficient) margin of a CCGT unit as the levelized cost of a new CCGT plus fuel and O&M costs less 5.b and less 4.e (adjusted for CCGT output degradation)
6. If there is excess or deficient margin for the CCGT unit, decrease or increase the energy market calibration factor, and repeat from step 2.

**Figure 6: Annual Average Energy Avoided Costs**

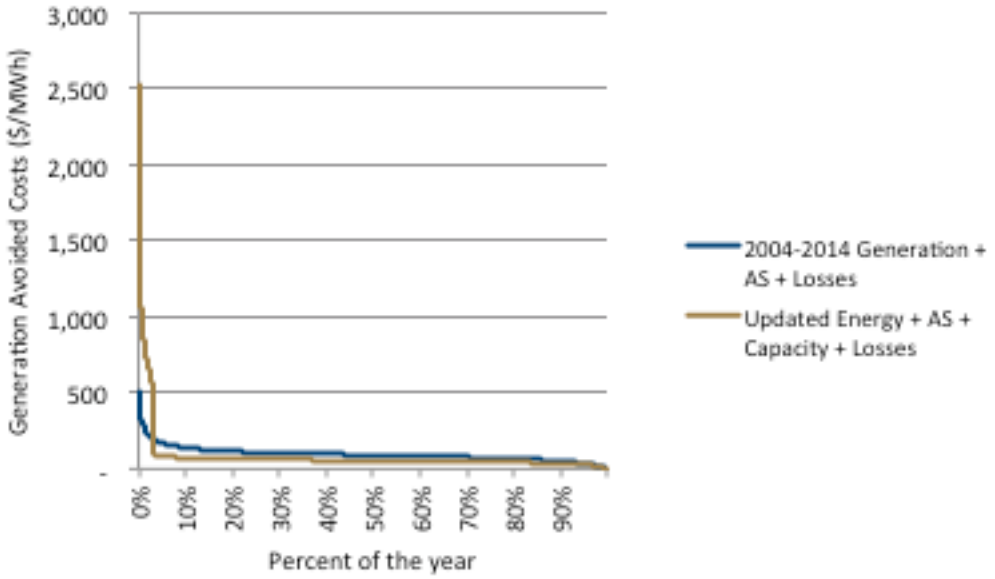



## Hourly Shaping of Energy Costs

The annual energy avoided costs are converted to hourly values by multiplying the annual value by 8760 hourly market shapes. The hourly shape is derived from day-ahead LMPs at load-aggregation points in northern and southern California obtained from the California ISO's MRTU OASIS. In order to account for the effects of historical volatility in the spot market for natural gas, the hourly market prices are adjusted by the average daily gas price in California. The resulting hourly market heat rate curve is integrated into the avoided cost calculator, where, in combination with a monthly natural gas price forecast, it yields an hourly shape for wholesale market energy prices in California.

Total energy and capacity avoided costs are shown in Figure 7 below. The avoided costs are shown in descending order. The cost shape reflects 1) the allocation of capacity costs to the top 250 system load level hours in the year and 2) the shaping of the energy costs based on 2010 MRTU California wholesale market information.

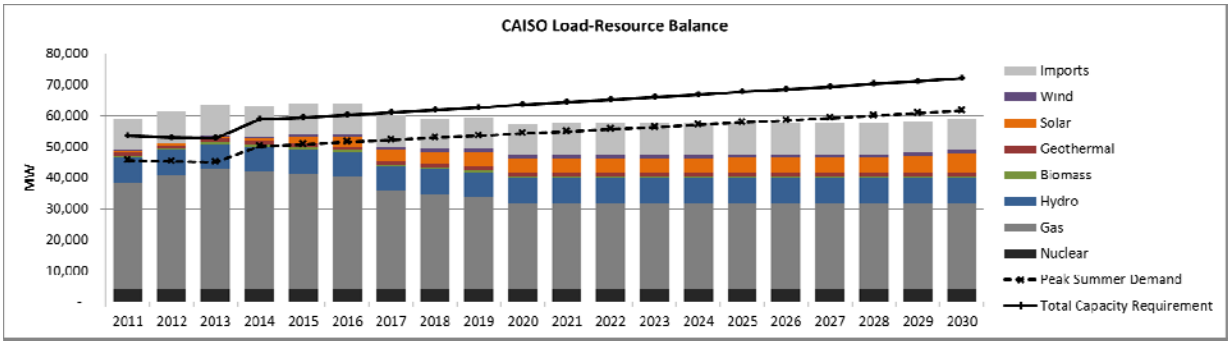
**Figure 7: Hourly Generation Avoided Costs for 2017**




## Generation Resource Balance Year

The resource balance year determines when the capacity and energy markets will reflect the full cost of new plants. The prior CSI and DR proceedings used a resource balance year of 2015. Based on the Joint IOU July 1, 2011 filing in the LTPP proceeding (R.10-05-006 track 1), we use a resource balance year of 2017. 2017 reflects the middle load trajectory with 10,000 MW of imports, no demand response, and no incremental EE or combined heat and power after 2013. The 10,000 MW import assumption is lower than the CPUC's recommended value of 17,000 MW. However, E3 believes that 10,000 MW is a more appropriate value to use for this analysis as it is more consistent with actual import amounts at the time of the California system peak conditions.

**Figure 8. Evaluation of resource balance year**



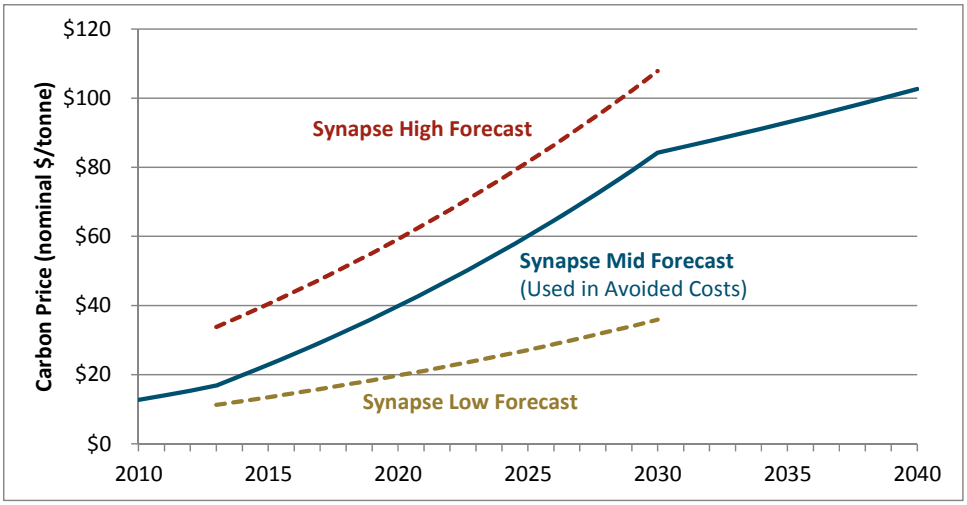

## *Environment*

The environmental component is an estimate of the value of the avoided CO2 emissions. While there is not yet a CO2 market established in the US, it is included in the forecast of the future. While there is some probability that there will not be any cost of CO2, that the likelihood of federal legislation establishing a cost of CO2 is high. Since a forecast should be based on expected value, the avoided costs forecast includes the value of CO2.

More challenging for CO2 is estimating what the market price is likely to be, given a market for CO2 allowances is established. The price of CO2 will be affected by many factors including market rules, the stringency of the cap set on CO2 allowances, and other elements.

The extant E3 Calculators use $30 per short ton as the value of CO2 reductions from EE. This update uses a forecast developed by Synapse Consulting through a meta-analysis of various studies of proposed climate legislation. The Synapse mid-level forecast used for the update was developed explicitly for use in electricity sector integrated resource planning and so serves as an appropriate applied value for the cost of carbon dioxide emissions in the future. This is the same forecast used for CSI and DR. Figure 9 shows the Synapse price forecasts.

**Figure 9. The CO2 price series embedded in the avoided cost values**

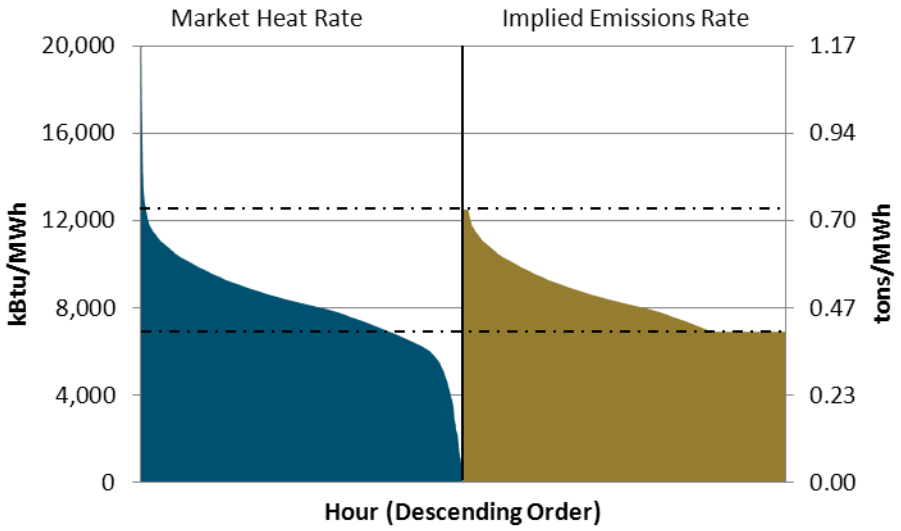



Assuming that natural gas is the marginal fuel in all hours, the hourly emissions rate of the marginal generator is calculated based on the day-ahead market price curve. The link between higher market prices and higher emissions rates is intuitive: higher market prices enable lower-efficiency generators to operate, resulting in increased rates of emissions at the margin. Of course, this relationship holds for a reasonable range of prices but breaks down when prices are extremely high or low. For this reason, the avoided cost methodology bounds the maximum and minimum emissions rates based on the range of heat rates of gas turbine technologies. The maximum and minimum emissions rates are bounded by a range of heat rates for proxy natural gas plants shown in Table 3; the hourly emissions rates derived from this process are shown in Figure 10.

**Table 3. Bounds on electric sector carbon emissions.**

| | Proxy Low Efficiency Plant | Proxy High Efficiency Plant |
|---|---|---|
| Heat Rate (Btu/kWh) | 12,500 | 6,900 |
| Emissions Rate (tons/MWh) | 0.731 | 0.404 |

**Figure 10. Hourly emissions rates derived from market prices (hourly values shown in descending order).**




## Hourly Allocation of Generation Capacity Value

The generation capacity value is allocated to hours using the methodology from the DR proceeding. Capacity value is allocated to 250 hours based upon hourly system load data collected from 2007 through 2010. In each full calendar year, hourly allocators are calculated for that year's top 250 load hours; the allocators, which sum to 100% within each year, are inversely proportional to the difference between the annual peak plus operating reserves and the loads in each hour. This allocation methodology, which serves as a simplified and transparent proxy for models of relative loss-of-load probability (rLOLP), results in allocators that increase with the load level.

The annual series of allocators for each of the full calendar years are used to develop reasonable estimates of the relative fraction of capacity value that is captured within each month as shown in Figure 11. By considering loads within the four-year period from 2007-2010, the Avoided Cost Calculator captures the potential diversity of peak loads across different years.

**Figure 11. Calculation of monthly capacity allocation based on historical data from 2007-2010.**

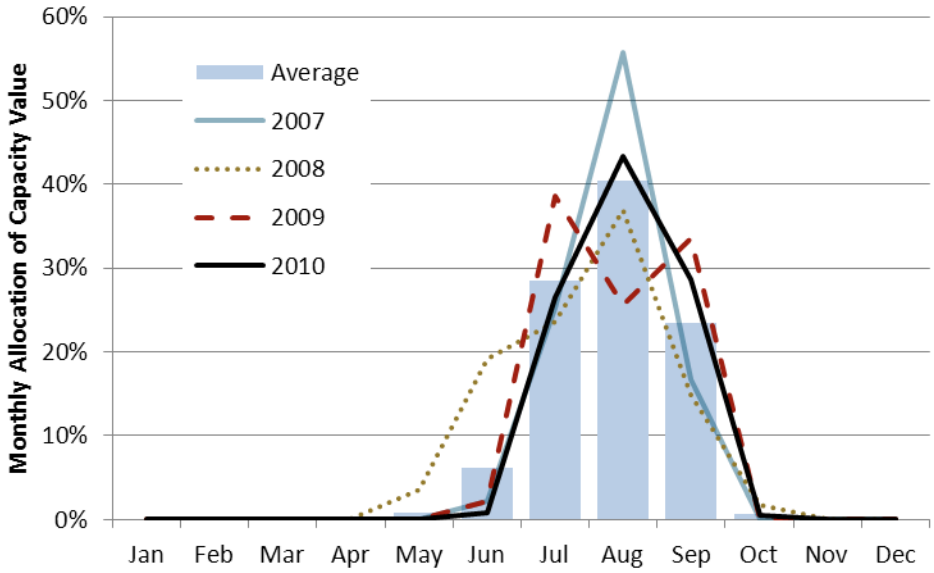
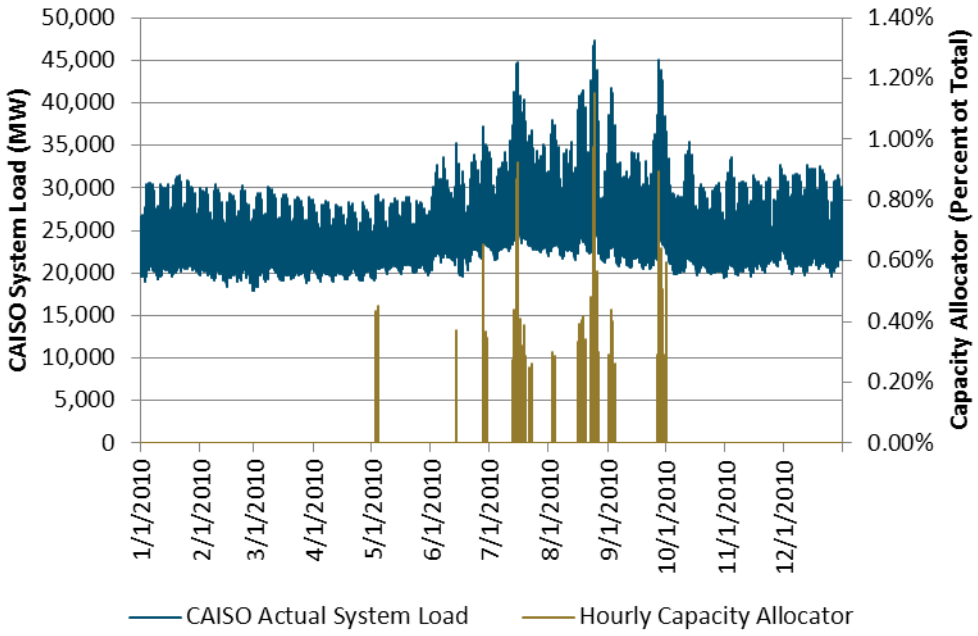



**Table 4. Summary of monthly capacity allocation based on historical load data from 2007-2010.**

| Month | Capacity Allocation (%) | Rounded Number of Peak Hours |
|---|---|---|
| January | 0.0% | - |
| February | 0.0% | - |
| March | 0.0% | - |
| April | 0.0% | - |
| May | 0.9% | 2 |
| June | 6.1% | 14 |
| July | 28.5% | 75 |
| August | 40.4% | 98 |
| September | 23.5% | 60 |
| October | 0.6% | 1 |
| November | 0.0% | - |
| December | 0.0% | - |
| Total | 100.0% | 250 |

The hourly allocation uses the rounded number of peak hours from above to determine the number of peak hours that are deemed to occur in each month. The algorithm used to allocate the value of capacity to hours parallels the process used for the historical analysis but shifts the time scale from allocation across an entire year to allocation within single months. Thus, for each month in 2010, the value of capacity is allocated to the number of peak hours in that month so that the allocators sum to the total monthly allocation shown in Table 4. As with the historical analysis, the allocators are inversely proportional to the difference between the month's peak load plus operating reserves and the load in the relevant hour.

**Figure 12. Hourly allocation of generation capacity based on loads for 2010.**




## Loss Factors

**Table 5: Generation capacity loss factors**

| | PG&E | SCE | SDG&E |
|---|---|---|---|
| Generation Peak | 1.109 | 1.084 | 1.081 |

**Table 6. Marginal energy loss factors by time-of-use period and utility.**

| Time Period | PG&E | SCE | SDG&E |
|---|---|---|---|
| Summer Peak | 1.109 | 1.084 | 1.081 |
| Summer Shoulder | 1.073 | 1.080 | 1.077 |
| Summer Off-Peak | 1.057 | 1.073 | 1.068 |
| Winter Peak | - | - | 1.083 |
| Winter Shoulder | 1.090 | 1.077 | 1.076 |
| Winter Off-Peak | 1.061 | 1.070 | 1.068 |

## *Ancillary Services (A/S)*

Besides reducing the cost of wholesale purchases, reductions in demand at the meter result in additional value from the associated reduction in required procurement of ancillary services. The CAISO MRTU markets include four types of ancillary services: regulation up and down, spinning reserves, and non-spinning reserves. The procurement of regulation services is generally independent of load; consequently, behind-the-meter load reductions and distributed generation exports will not affect their procurement. However, both spinning and non-spinning reserves are directly linked to load—in accordance with WECC reliability standards, the California ISO must maintain an operating reserve equal to 5% of load served by hydro generators and 7% of load served by thermal generators.

As a result, load reductions do result in a reduction in the procurement of reserves; the value of this reduced procurement is included as a value stream in the Avoided Cost Calculator. It is assumed that the value of avoided reserves procurement scales with the value of energy in each hour throughout the year. According to the CAISO's April 2011 Annual Report on Market Issues and Performance[4], CT A/S revenues from 2008 through 2010 averaged 7.6% of the CT

[4] Table 2.10 Financial analysis of a new combustion turbine (2006-2010)

energy market revenue. E3 uses this figure to assess the value of avoided A/S procurement in each hour.

# T&D Capacity

## *Distribution Avoided Costs*

Distribution avoided costs are estimated based on capacity-related project lists provided by the IOUs. Using the project costs and forecast load growth and deficiencies for the project areas, E3 calculated the cost savings that could result from deferral of those projects. This method is referred to as the "Present Worth" method in the literature and is well suited to the evaluation of the value of reducing loads in specific project areas. The deferral value is the present value of the extant project less the present value cost of the deferred project. Dividing by the amount of load reduction needed to attain the deferral yields the $/kW avoided cost, and applying a capital recovery factor that is constant in real dollars provides the $/kW-yr avoided cost.

DCost[p] = PV(Invest[p][y] * (1-((1+i)/(1+r))^deltaT)/deltaL * CRFR

Where

DCost[p] = distribution avoided cost for project p
PV indicates a present value calculation over the utility planning horizon
Invest[p][y] = distribution capacity-related project cost in year y
i = equipment inflation rate
r = utility discount rate
deltaT = deferral length in years
deltaL = load reduction needed to attain deltaT deferral
CRFR = capital recovery factor that is constant in real dollars

This method is identical to that used in prior E3 avoided cost estimations, but for this analysis, the planned investments were aggregated at a more granular level.

The project cost lists provided by utilities reflect investments five to ten years into the future. However, as the PV installations have substantially longer useful lives, it is likely that using such truncated project forecasts would underestimate the distribution value that could be provided by distributed PV. To correct for this underestimation, we assume that the project costs would recur after 15 years of normal load growth.

Figure 13 shows PG&E's project-related distribution avoided costs. The PG&E avoided costs are based on individual projects and their identified load deficiencies in the year of service. If no deficiency was provided, then the average load growth in the corresponding distribution planning area is used. The data was developed by PG&E in support of their General Rate Case proceeding, and contains forecasts for the years 2009 through 2013. While the information is dated, we believe that it is representative of the spread of PG&E distribution costs and sufficient for the purposes of this CSI study.

**Figure 13: PG&E Distribution Avoided Costs**

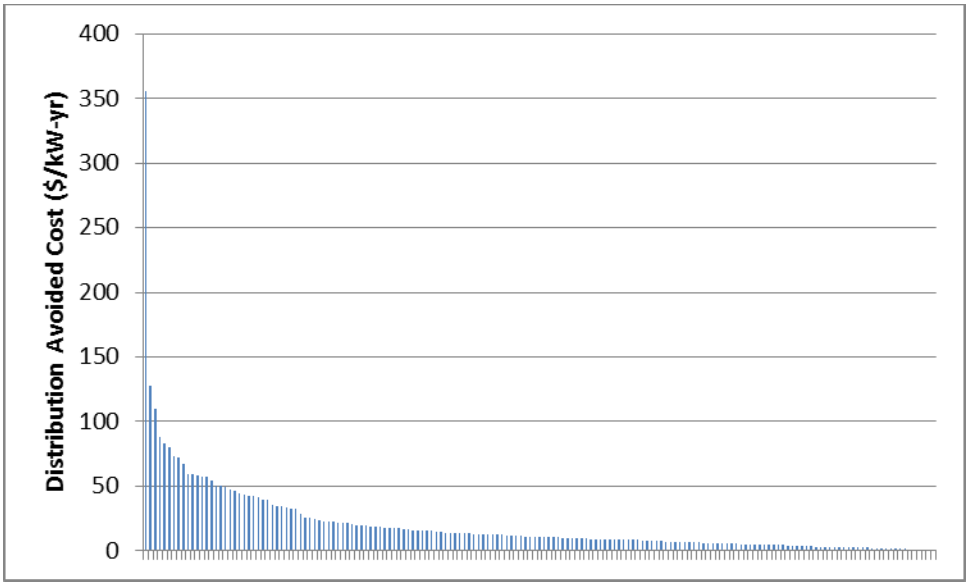



Figure 14 shows SCE's distribution avoided costs. SCE's distribution system is more flexible and interconnected than a typical radial system. Because of the flexibility in system reconfiguration,

the need for distribution system capacity is drive by load growth over wide geographic areas. Accordingly, the SCE distribution avoided cost values are based on aggregate investments from 2011 through 2019 and forecast growth within SCE SYS ID areas.

**Figure 14: SCE Distribution Avoided Costs**

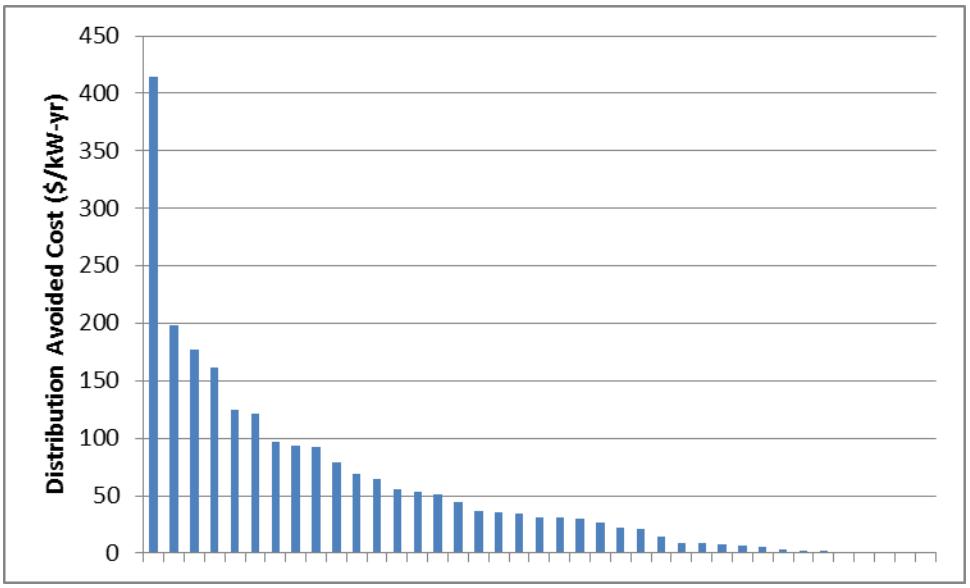
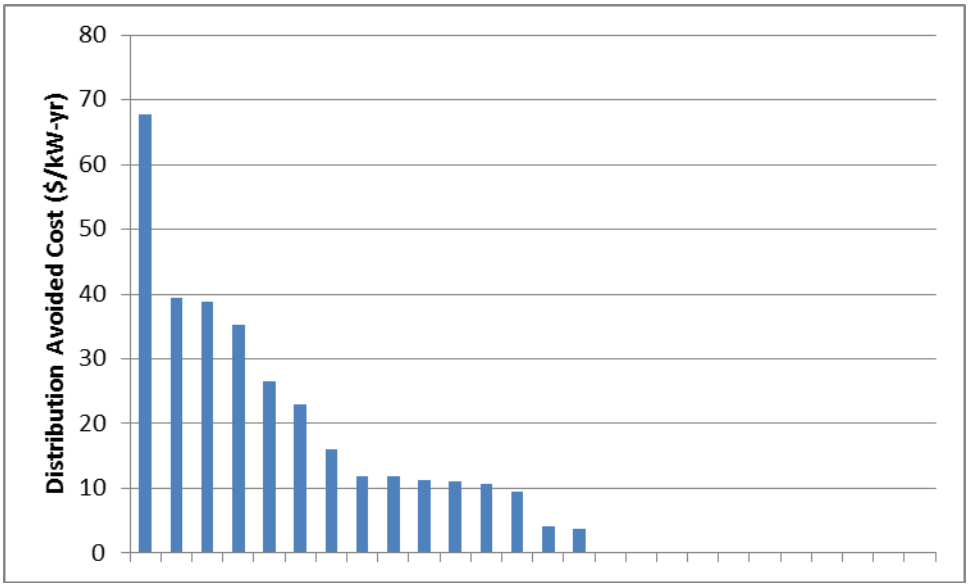



Figure 15 shows SDG&E's distribution avoided costs. SDG&E's avoided costs are developed at the substation level. Forecast investment costs for 2011 through 2014 are combined with average forecast substation growth over the same period.

**Figure 15: SDG&E Distribution Avoided Costs**




In addition to the project-related distribution costs, we also include the distribution capacity-related costs associated with projects under $1 million which PG&E does not explicitly forecast in its General Rate Case proceedings. We directly use PG&E's GRC forecast avoided cost for that class of projects and apply it to all areas in PG&E's service territory. The cost is additive with the distribution avoided cost developed from the PG&E's project list Neither SCE nor SDG&E have a similar class of costs in their GRC proceedings, so no adjustment is needed for those utility service territories.

**Table 7: PG&E Avoided Costs for Small Distribution Projects**

| Line No. | DIVISION | PROJECTS UNDER $1 MILLION ($/PCAF-kW-yr) |
|---|---|---|
| 1 | CENTRAL COAST | $ 37.08 |
| 2 | DE ANZA | $ 11.63 |
| 3 | DIABLO | $ 40.50 |
| 4 | EAST BAY | $ 26.74 |

| | | | |
|---|---|---|---|
| 5 | FRESNO | $ | 26.43 |
| 6 | KERN | $ | 19.49 |
| 7 | LOS PADRES | $ | 28.98 |
| 8 | MISSION | $ | 23.99 |
| 9 | NORTH BAY | $ | 25.54 |
| 10 | NORTH COAST | $ | 22.57 |
| 11 | NORTH VALLEY | $ | 38.44 |
| 12 | PENINSULA | $ | 28.54 |
| 13 | SACRAMENTO | $ | 25.30 |
| 14 | SAN FRANCISCO | $ | 12.95 |
| 15 | SAN JOSE | $ | 23.74 |
| 16 | SIERRA | $ | 47.25 |
| 17 | STOCKTON | $ | 25.83 |
| 18 | YOSEMITE | $ | 38.97 |

The avoided distribution costs are allocated to hours of the year based on substation load shapes provided by the IOUs. The peak allocation capacity factor (PCAF) assigns higher value to those hours when the substation loads are highest. All loads within one standard deviation of the station peak load are allocated distribution capacity values, with the peak hour receiving the highest allocation, and the loads near the one standard deviation threshold receiving near zero allocation.

PCAF[s][h] = (Load[s][h] – Threshold[s])/Sum[h](Load[s][h] – Threshold[s])

Where

PCAF[s][h] = peak capacity allocation factor for substation s, hour h.
Load[s][h] = the hourly substation load
Threshold[s] = substation peak load – one standard deviation of substation loads over the year
Sum[h] indicates the summation of all hourly load increments above the threshold
All hours where Load[s][h] are below Threshold[s] are excluded from the calculation.

## *Transmission Avoided Costs*

Transmission avoided costs are for subtransmission system "downstream" of the California ISO. The costs were originally developed for the California Energy Commission's *2013 Time Dependent Valuation of Energy for Development of Building Efficiency Standards* and for the CPUC's valuation of Demand Response (DR) in 2010.

The 2011 Subtransmission Avoided Costs in 2011 dollars are shown below.

**Table 8: Subtransmission Avoided Costs ($/kW-yr)**

| Year | 2011 |
|---|---|
| PG&E | 19.29 |
| SCE | 23.39 |
| SDG&E | 21.08 |

## Sources

PG&E's avoided cost is from PG&E's 2011 GRC Phase II Proceeding, A.10-03-014, Exhibit (PG&E-2), p. 4-3.

SCE's avoided cost is from the spreadsheet SCE provided to E3 for the DER proceeding. That spreadsheet is *TD Avoided Costs (march 2008)_v2.xls*. Note that SCE's recommended value in that spreadsheet was adjusted to reflect SCE's position on the benefits provided by DR. To be consistent with avoided costs used for ratemaking and energy efficiency evaluation, E3 restored the General Plant Loaders and O&M costs removed from SCE's DR-specific values. E3 used SCE's General Plant Loading Factor of 5.9% (on capital) and a fixed O&M cost of $16.52/kW-yr. To adjust for inflation, E3 used SCE's escalation factors to convert the values to 2011 dollars. The escalation factors are shown in the figure below.

At the time the avoided costs were developed, SDG&E did not have readily available estimates of subtransmission avoided costs. Given that the SCE and PG&E avoided costs were close in magnitude, and given that subtransmission avoided costs have consistently been near these values, E3 used the average of the PG&E and SCE values to represent SDG&E avoided costs.

The SDG&E staff working on providing avoided costs for the DER proceeding concurred with this averaging approach.

### Allocation of transmission avoided costs to hours

Like the cost of generation capacity, the avoided cost of transmission capacity is allocated over a limited number of hours in the year in which the transmission system would be likely to experience constraints. For the CSI analysis, the transmission avoided costs are allocated 50% based on system peak demands and 50% based on distribution substation demands.

## Line Losses

The value of both energy and capacity are increased to account for losses. Table 9 shows the loss factor assumptions used in the energy cost value. In the case of energy, the loss factors are differentiated by time of use period broken down into two seasonal categories (May-September and October-March) and three hourly periods (peak, shoulder, and off-peak). The losses for energy are measured from the customer to the wholesale market hub. For capacity costs, the loss factors are estimates of the losses during the highest load hours, and are measured from the customer to the relevant point on the grid—the distribution and transmission levels and the generator busbar (Table 10).

**Table 9: Energy Loss Factors by Utility and Time Period**

| Time Period | PG&E | SCE | SDG&E |
|---|---|---|---|
| Summer Peak | 1.109 | 1.084 | 1.081 |
| Summer Shoulder | 1.073 | 1.080 | 1.077 |
| Summer Off-Peak | 1.057 | 1.073 | 1.068 |
| Winter Peak | - | - | 1.083 |
| Winter Shoulder | 1.090 | 1.077 | 1.076 |
| Winter Off-Peak | 1.061 | 1.070 | 1.068 |

**Table 10: Capacity Loss Factors**

| | PG&E | SCE | SDG&E |
|---|---|---|---|
| Distribution | See below | 1.022 | 1.043 |
| Transmission | See below | 1.054 | 1.071 |
| Generation | 1.109 | 1.084 | 1.081 |

PG&E's loss factors are from their 2011 GRC Application, and vary by Division. Those loss factors are shown below.

**Table 11: PG&E T&D Loss Factors**

| DIVISION | Mtr to Trans | Mtr to Primary | Mtr to Secondary |
|---|---|---|---|
| CENTRAL COAST | 1.053 | 1.019 | 1.000 |
| DE ANZA | 1.050 | 1.019 | 1.000 |
| DIABLO | 1.045 | 1.020 | 1.000 |
| EAST BAY | 1.042 | 1.020 | 1.000 |
| FRESNO | 1.076 | 1.020 | 1.000 |
| KERN | 1.065 | 1.023 | 1.000 |
| LOS PADRES | 1.060 | 1.019 | 1.000 |
| MISSION | 1.047 | 1.019 | 1.000 |
| NORTH BAY | 1.053 | 1.019 | 1.000 |
| NORTH COAST | 1.060 | 1.019 | 1.000 |
| NORTH VALLEY | 1.073 | 1.021 | 1.000 |
| PENINSULA | 1.050 | 1.019 | 1.000 |
| SACRAMENTO | 1.052 | 1.019 | 1.000 |
| SAN FRANCISCO | 1.045 | 1.020 | 1.000 |
| SAN JOSE | 1.052 | 1.018 | 1.000 |
| SIERRA | 1.054 | 1.020 | 1.000 |
| STOCKTON | 1.066 | 1.019 | 1.000 |
| YOSEMITE | 1.067 | 1.019 | 1.000 |

# Other Data Sources and Inputs

This section provides further discussion of data sources and methods used in the calculation of the hourly avoided costs.

## *Natural gas forecast*

The natural gas price forecast, which is the basis for the calculation of forecast electricity prices, is based upon the methodology from the CPUC MPR 2009 Update. This forecast is based upon NYMEX Henry Hub futures updated in December 2010, average basis differentials, and delivery charges to utilities. The forecast is shown in Figure 16. The MPR's forecast methodology has been expanded to incorporate expected monthly trends in gas prices—commodity prices tend to rise in the winter when demand for gas as a heating fuel increases. Figure 17 shows three snapshots of the monthly shape of the natural gas price forecast.

**Figure 16. Natural gas price forecast**

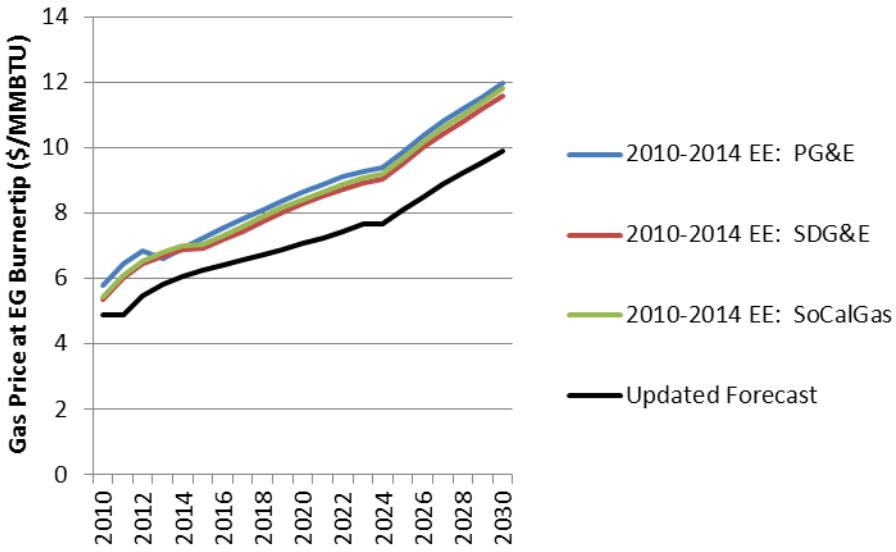
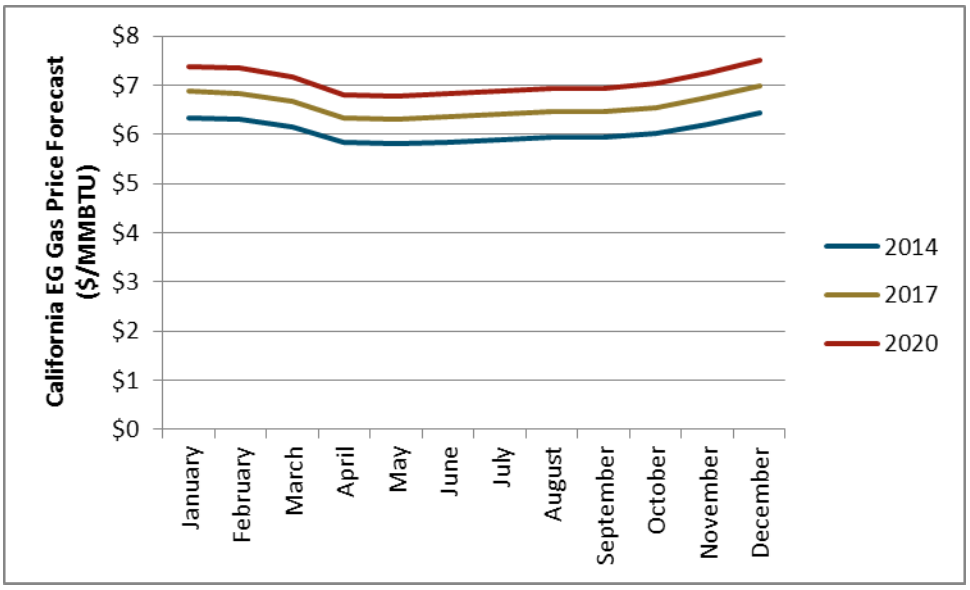


**Figure 17. Snapshot of monthly gas price forecast shapes for 2014, 2017, and 2020.**




## *Power plant cost assumptions*

The cost and performance assumptions for the new simple cycle plants are based on the 100 MW simple cycle turbine included in the California Energy Commission's Cost of Generation report.

**Table 12. Power plant cost and performance assumptions (all costs in 2009 $)**

| | Simple Cycle Gas Turbine |
|---|---|
| Heat Rate (Btu/kWh) | 9,300 |
| Plant Lifetime (yrs) | 20 |
| Instant Cost ($/kW) | $1,230 |
| Fixed O&M ($/kW-yr) | $17.40 |
| Variable O&M ($/kW-yr) | $4.17 |
| Debt-Equity Ratio | 60% |
| Debt Cost | 7.70% |
| Equity Cost | 11.96% |