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Technical Potential for Local Distributed Photovoltaics in California

Preliminary Assessment

March, 2012



Energy+Environmental Economics

Technical Potential for Local Distributed Photovoltaics in California

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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

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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.

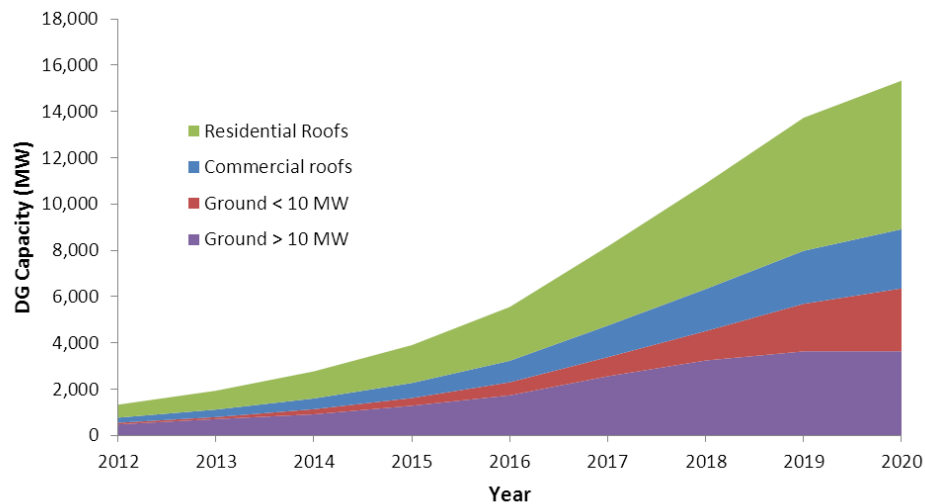
Further, the study does not consider the economic or market potential of LDPV. The public's willingness to pay for LDPV (or lack thereof) and other market factors may constrain the realization of the technical potential identified in this study. Additional study is required to evaluate the economic and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

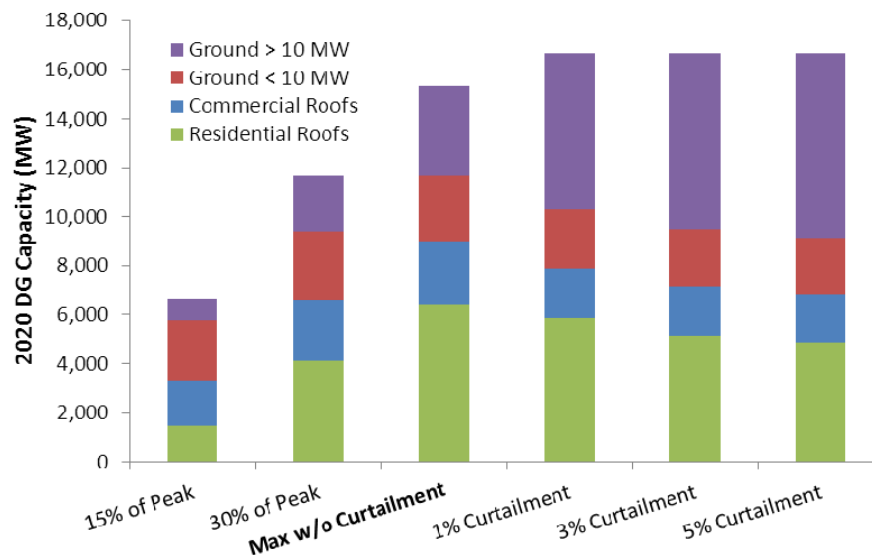
Because our definition of LDPV means generation must be consumed on the feeder or substation at which it is interconnected, PV generation must be distributed throughout the state in rough proportion to load in order to achieve significant penetration. Substations with greater load can accommodate larger 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.

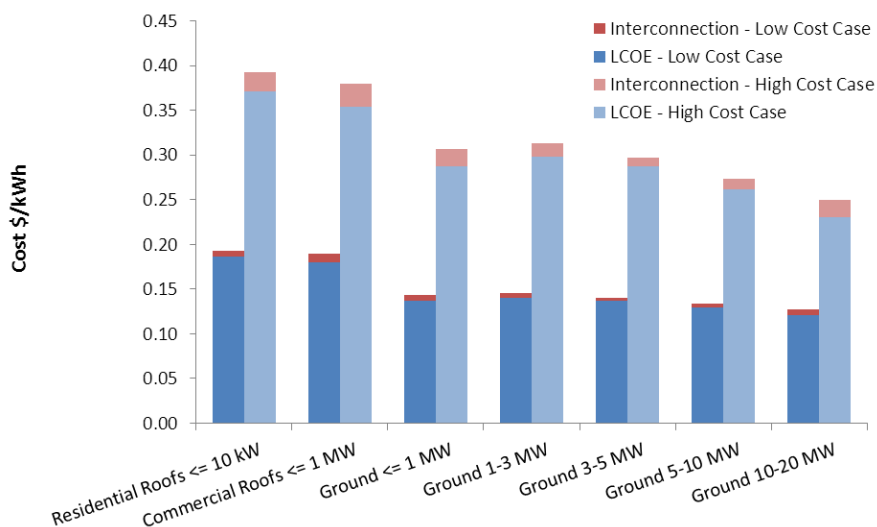
The impact of a small amount of curtailment is significant. Allowing a very small amount of curtailment (no more than 1% of the generated energy associated with any single substation's interconnected PV) further increases the LDPV technical potential by roughly 10%, to more than 16,500 MW. Again, this

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.

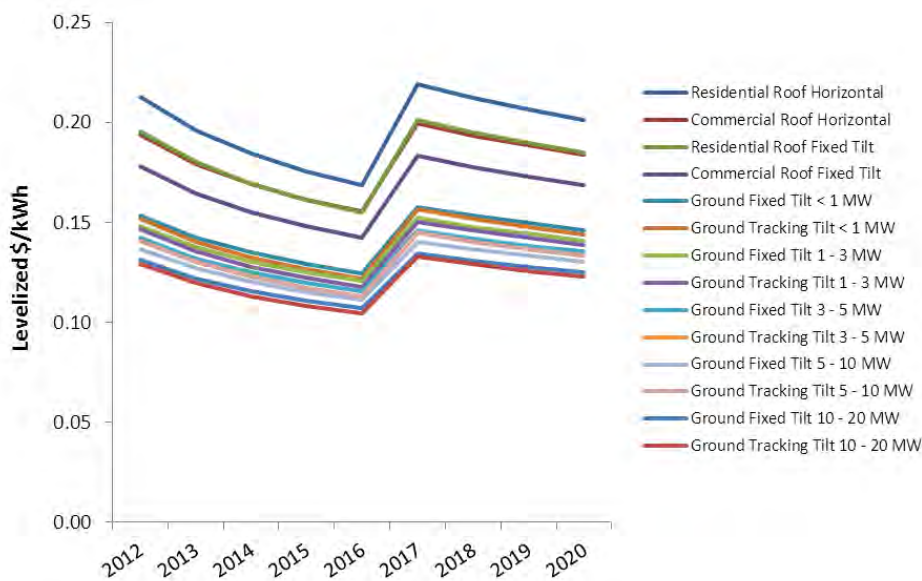
Figure 3: Average Cost of PV systems Installed by 2020 by type (\$2010)



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

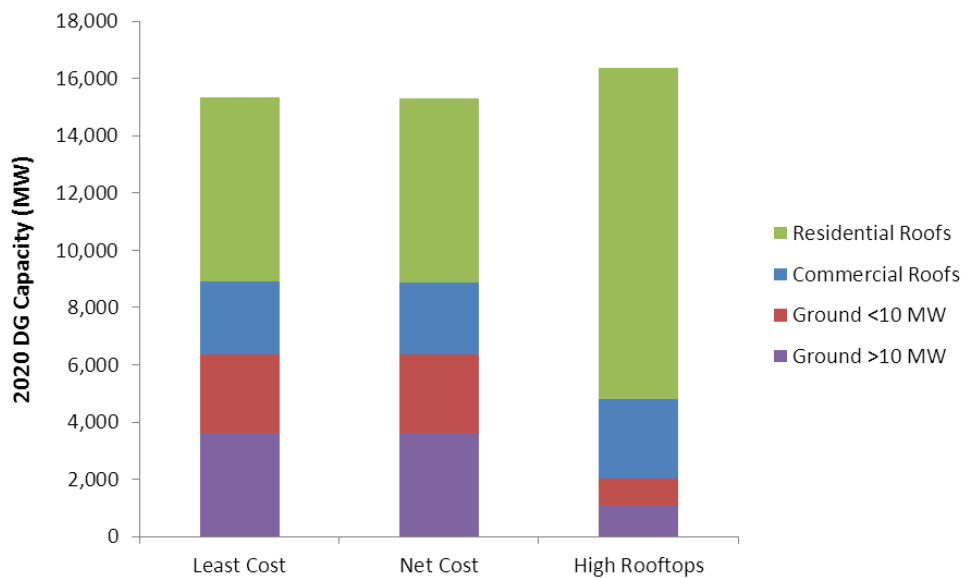


Under our base case installation rate estimate, which reflects a high rate of adoption based on the German experience, roughly 5,500 MW would be installed through 2016 before the ITC expires. This is approximately a third of the identified technical potential, leaving two-thirds to be installed with 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 case 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 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 IOUs⁶. 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 (<i>least cost</i> , <i>least net cost</i> , and <i>high rooftop</i>)
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/ltp_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 constraints 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/aspn/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.

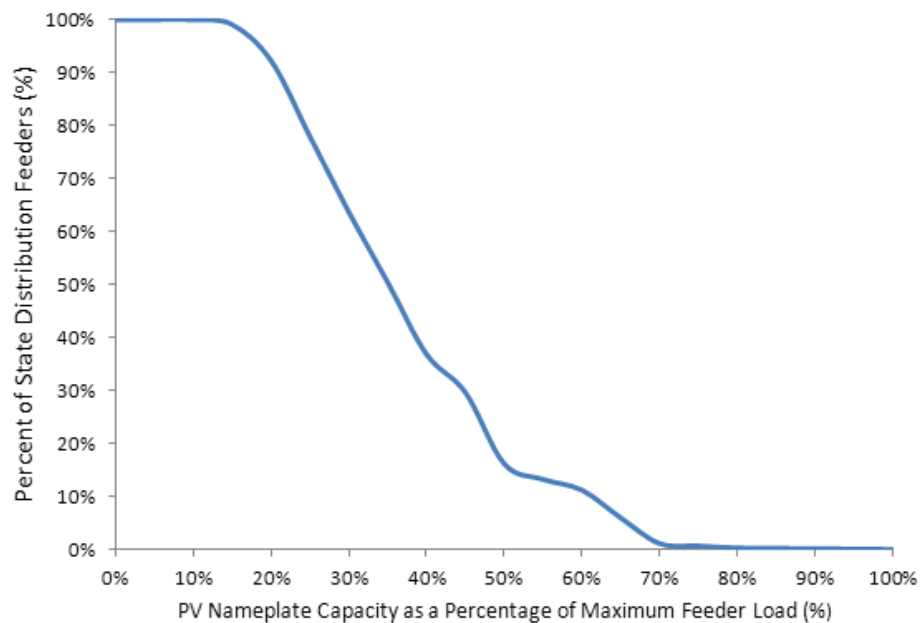
While used for the purposes of this planning level study, the *no backflow* proxy is not perfect. In particular, changes in PV output that are faster than the adjustment time of utility equipment available to control voltage may still cause some voltage problems. Controlling distribution voltage on circuits 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 of 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

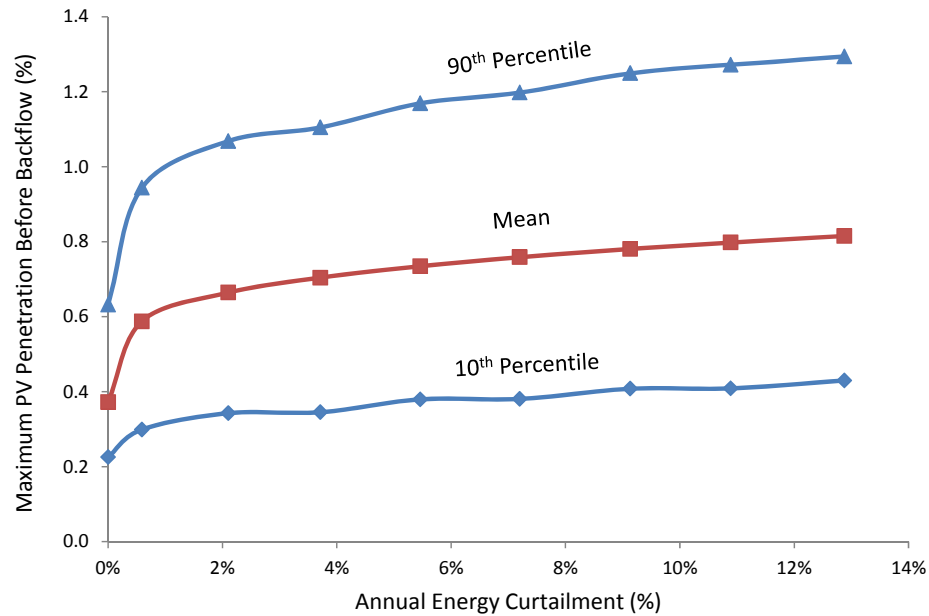


Limited to 15% of peak load, virtually all interconnections do not result in backflow. This may explain the usefulness of a 15% of peak load criterion for Rule 21 tariffs and other interconnection procedures. When the specific feeder line or substation load shapes and the specific DG output shapes are 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 curtailment¹⁶ 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

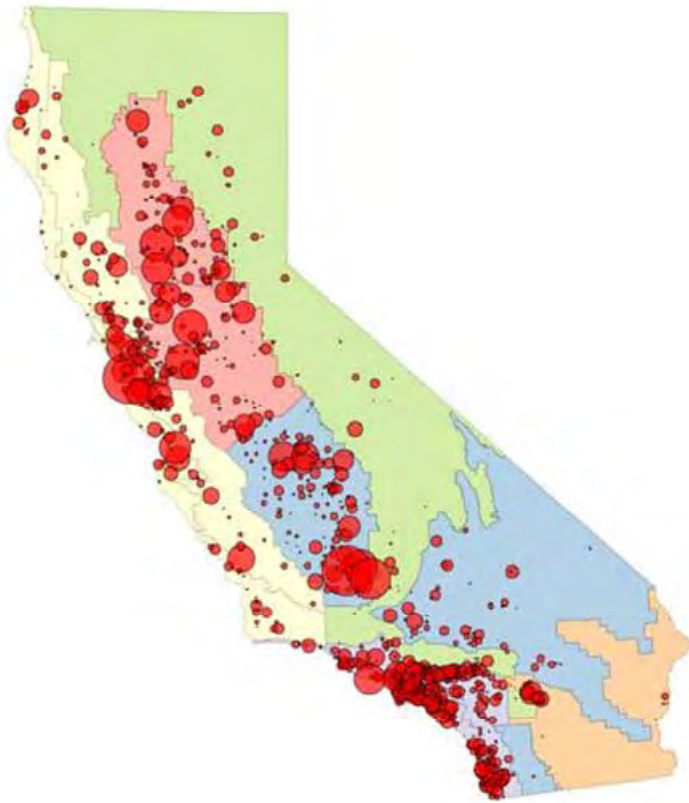


For our base case analysis, we retain the *no backflow* criterion and do not allow for any curtailment. This permits an hour-by-hour comparison of PV output profiles and substation loads. We perform this comparison for each of 1,804 substations in the three IOUs territories. Individual hourly substation 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 load¹⁸ – 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 Rules¹⁹

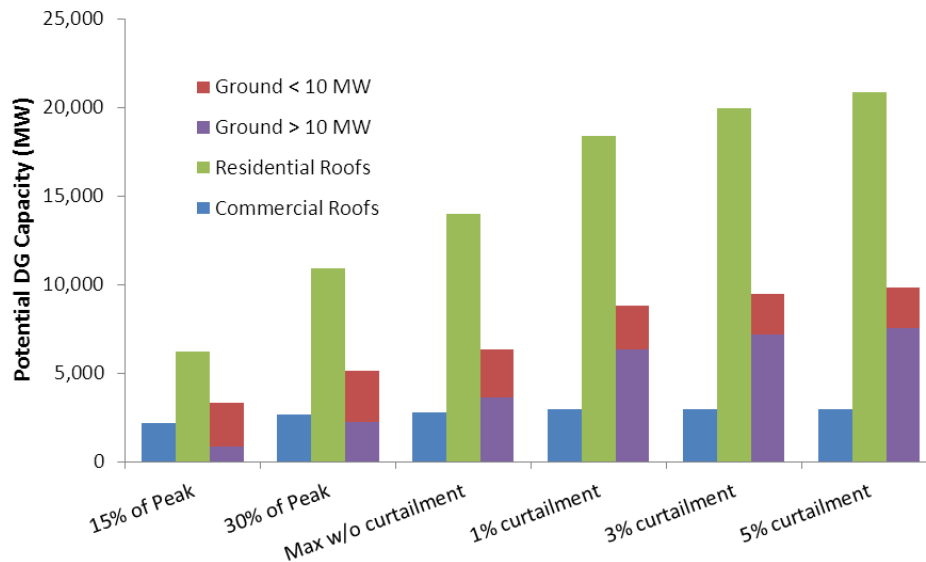


Figure 9 shows that the current 15% of peak rule is the most conservative criterion of those tested for estimating PV interconnection potential. Maximizing PV output while maintaining a no backflow limitation roughly doubles the amount of PV that can be interconnected. Finally, allowing small amounts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

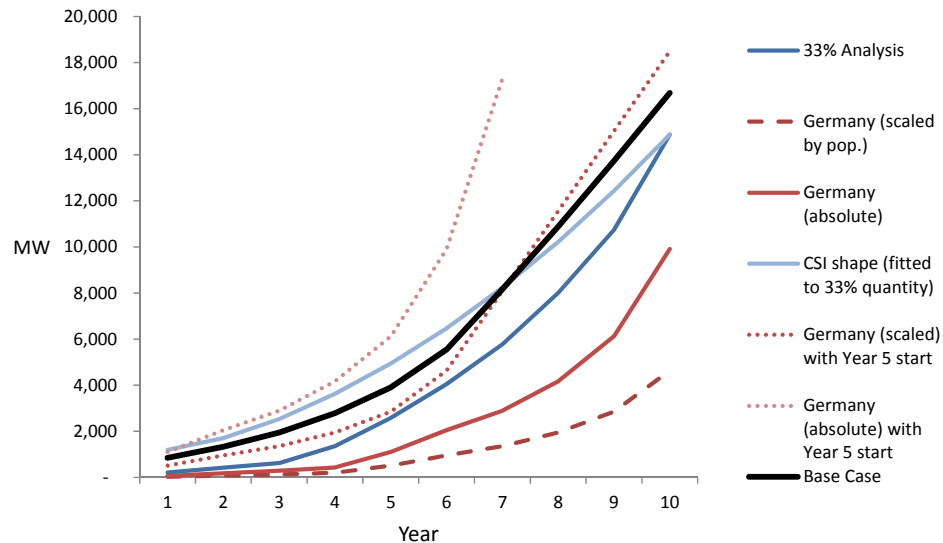
Figure 10 presents our estimated installation rate for distributed PV, as well as several reference points on which our estimate is based. This is an estimate of the *maximum* installation rate that could be achieved given favorable LDPV policy, rather than a forecast of LDPV adoption under current conditions. 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

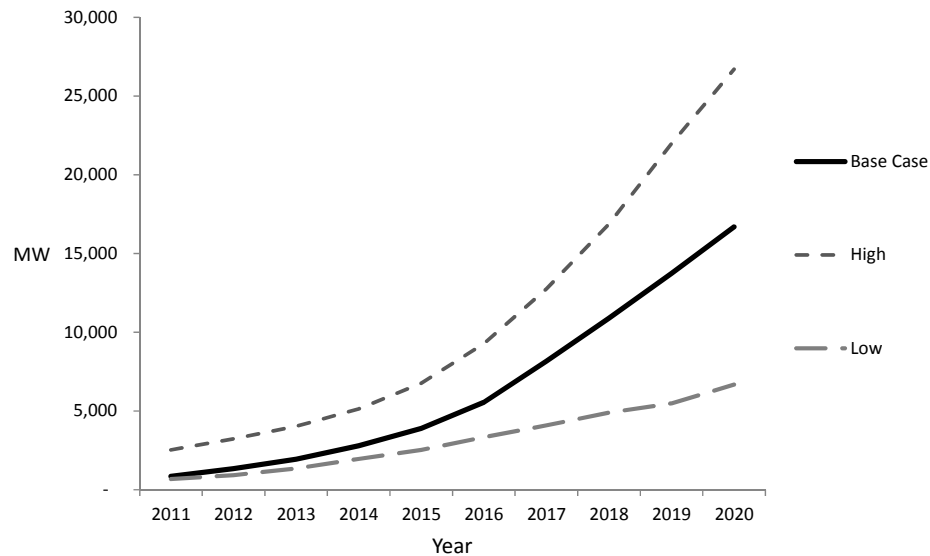
Year 5 starting point. We use Germany's scaled Year 5 since California already has significant experience deploying solar PV.

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 Manual 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

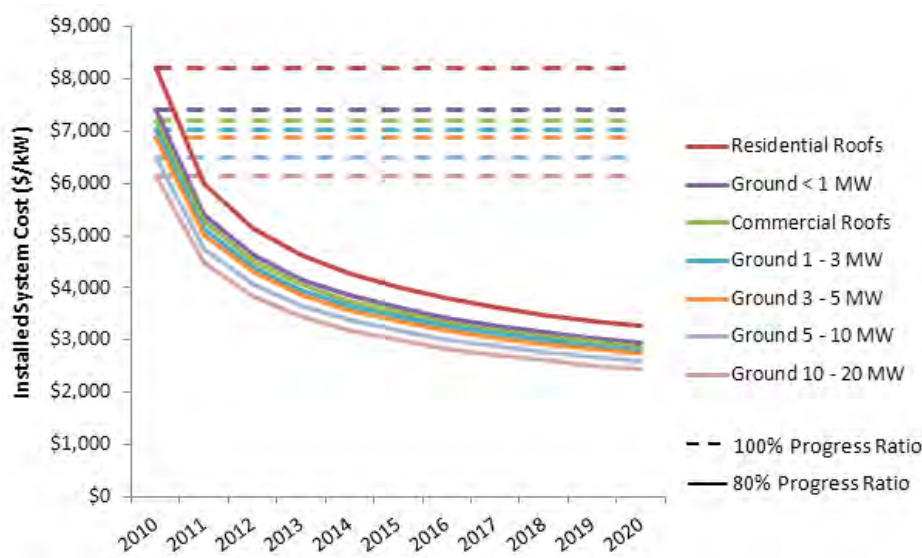
	Data Source	2009 Median Installed Cost (\$2010 \$/kW)
Residential Roof	Installed PV system costs for systems less than 1 MW in size are based on publicly reported costs in the CSI program database through 2009: http://www.californiasolarstatistics.org/current_data_files/ .	\$8,325
Commercial Roof		\$7,317
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 cost²⁸ 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**

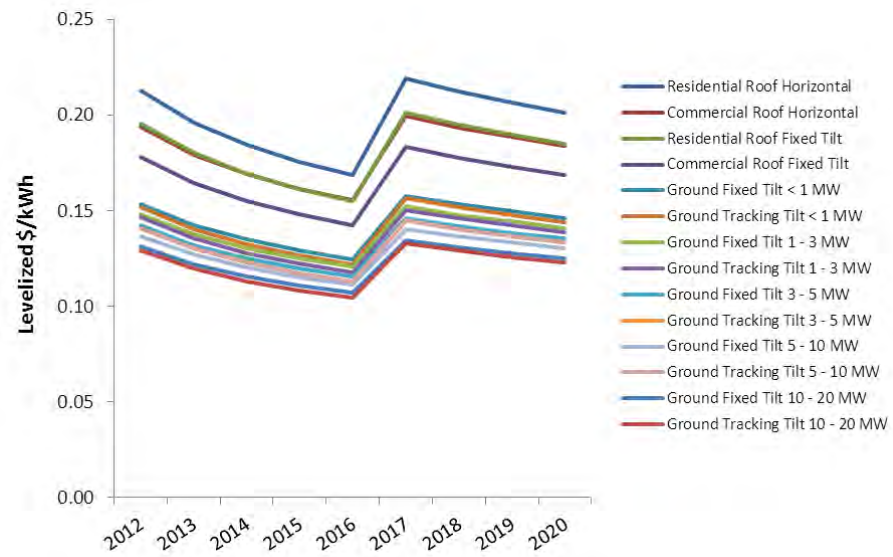
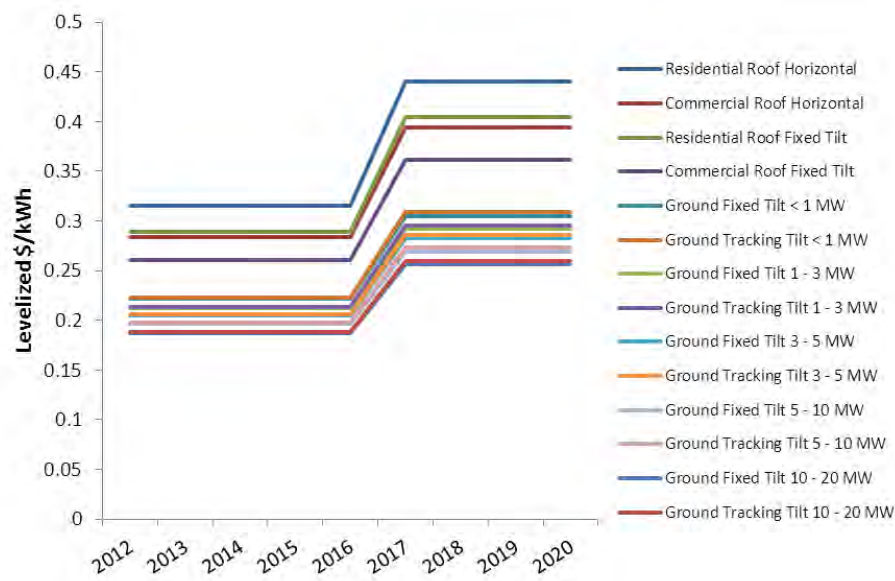


Figure 14: Levelized Cost of PV Generation at a Substation in Fresno (Real \$2010) with a 100% Progress Ratio



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

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.

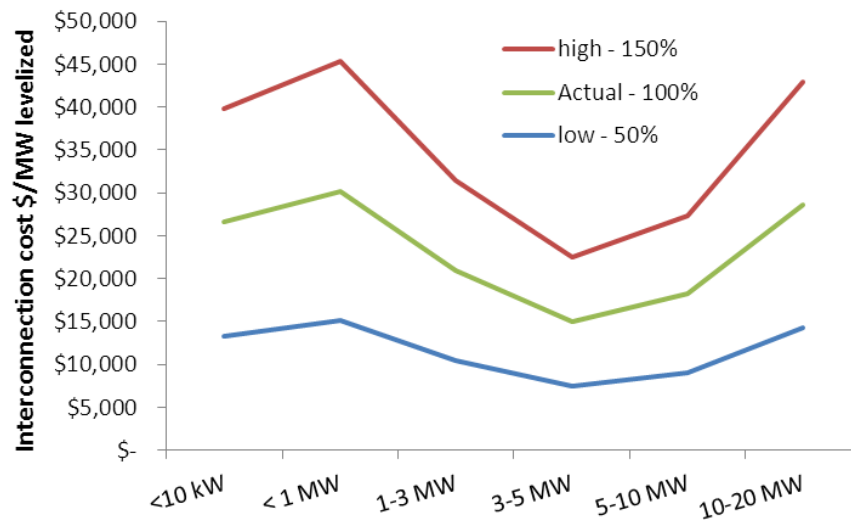
Table 14 provides median interconnection costs across the state in dollars per MW, as well as the median cost by utility. There is significant uncertainty regarding interconnection cost data. For the most part, PG&E's costs (which were based on far fewer data points) are much higher than SCE's, though 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

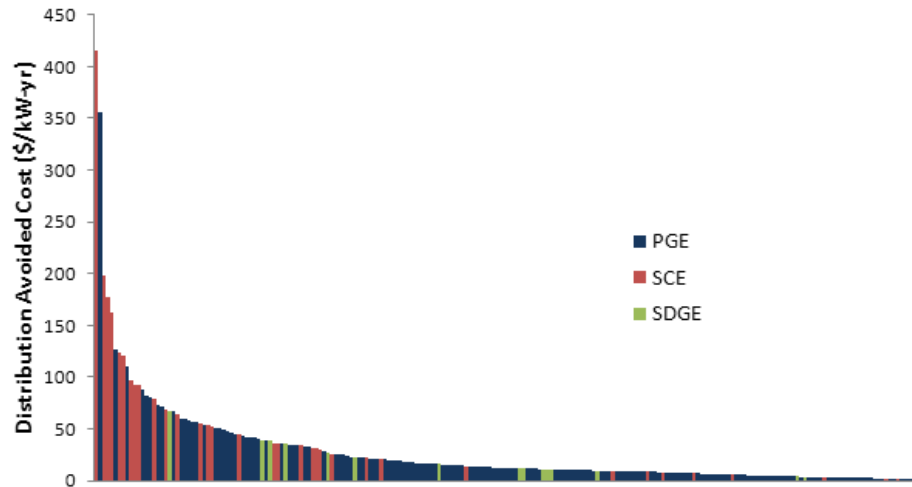
³² Previous CSI evaluation reports are available on the CPUC website: <http://www.cpuc.ca.gov/PUC/energy/Solar/evaluation.htm>.

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.

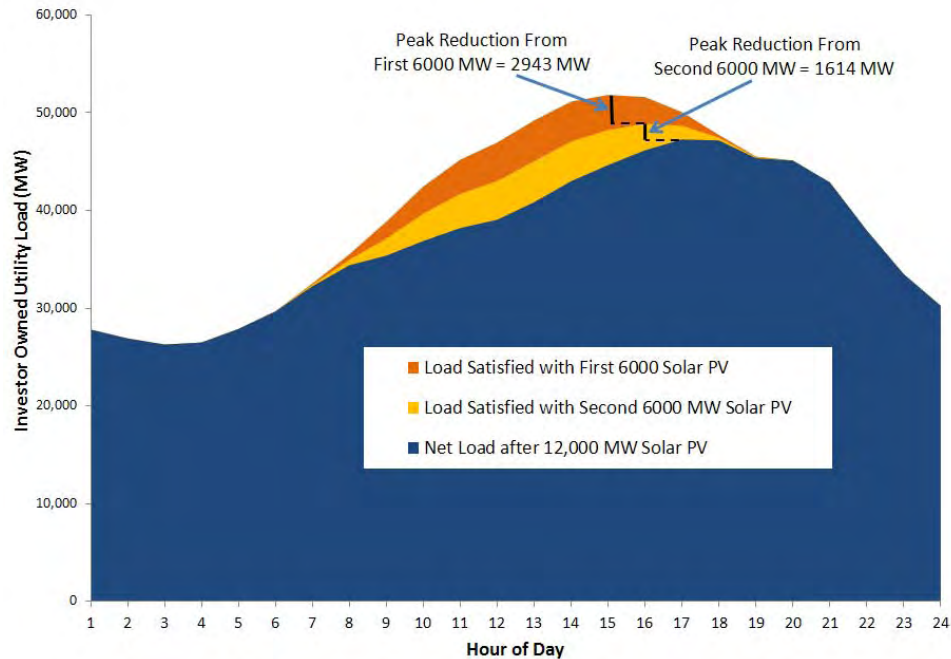
3.3.2.2 Adjustment for High Penetration

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 15,000th 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,

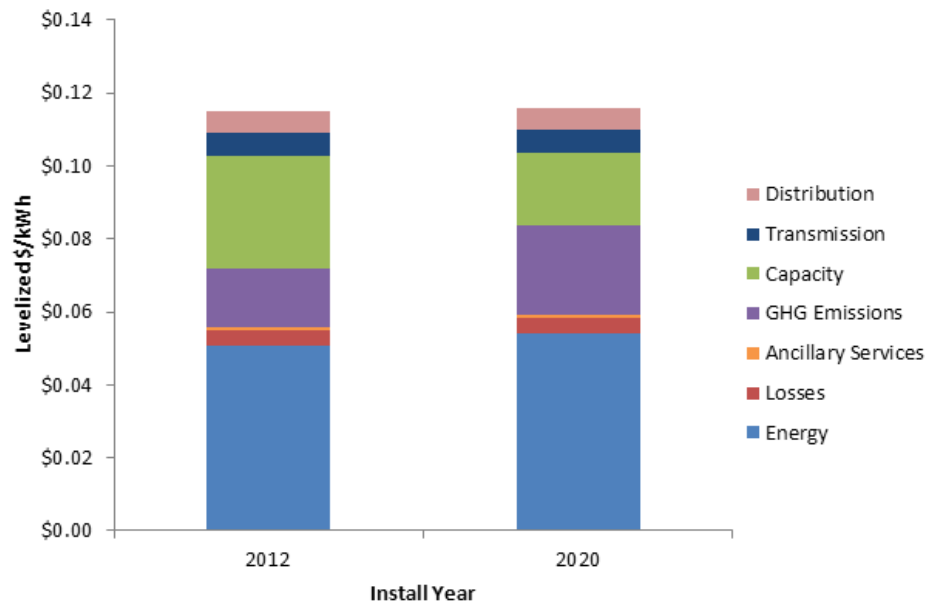
marginal energy value of a PV output load shape in the LTPP production simulation runs developed for the All Gas and Environmentally Constrained cases in the LTPP proceeding. Over the decade, this results in a 15% reduction in energy value.

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.

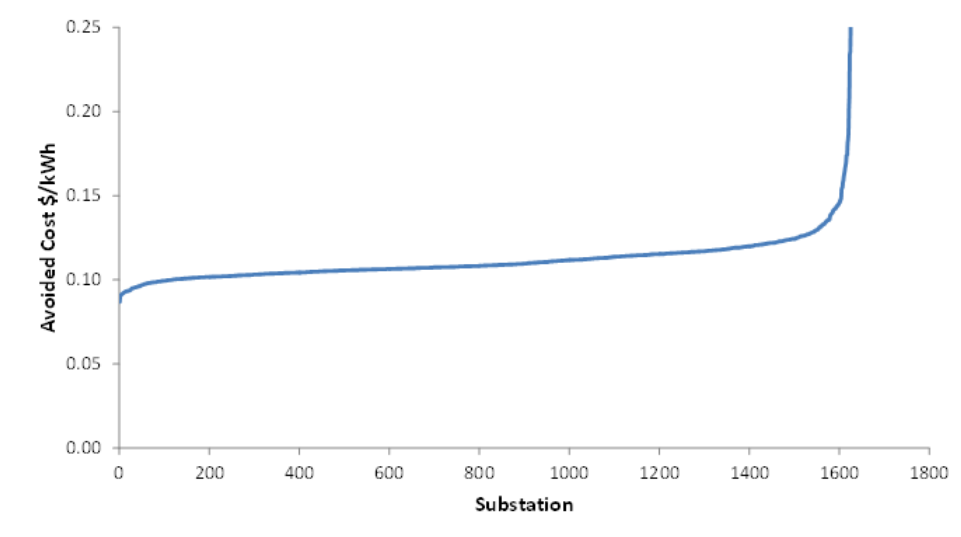
Figure 19: Lifecycle avoided cost in 2012 and 2020 for a PG&E substation in Fresno



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.

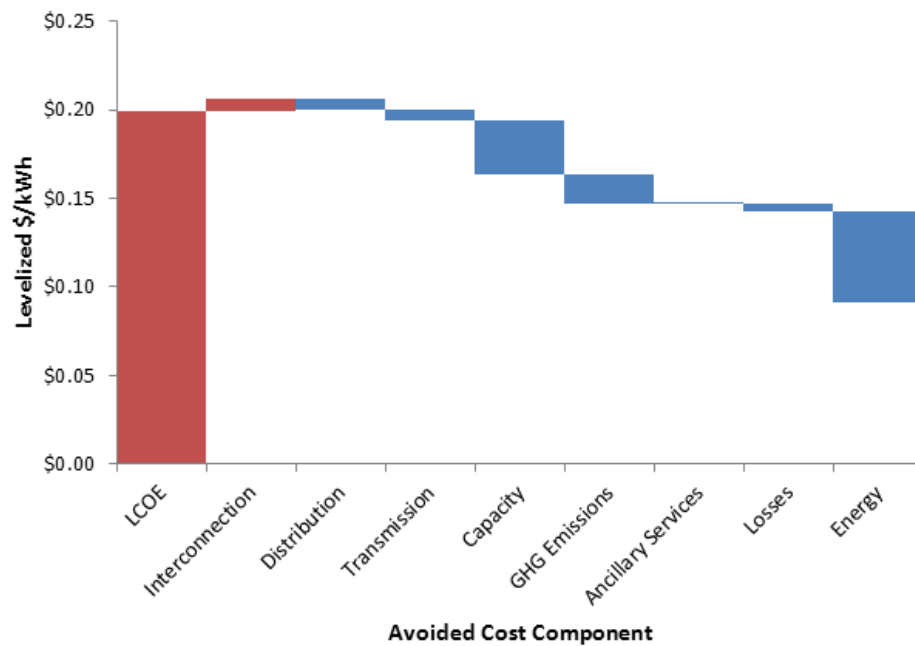
Figure 20: Avoided Costs by Substation (2010 \$)



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

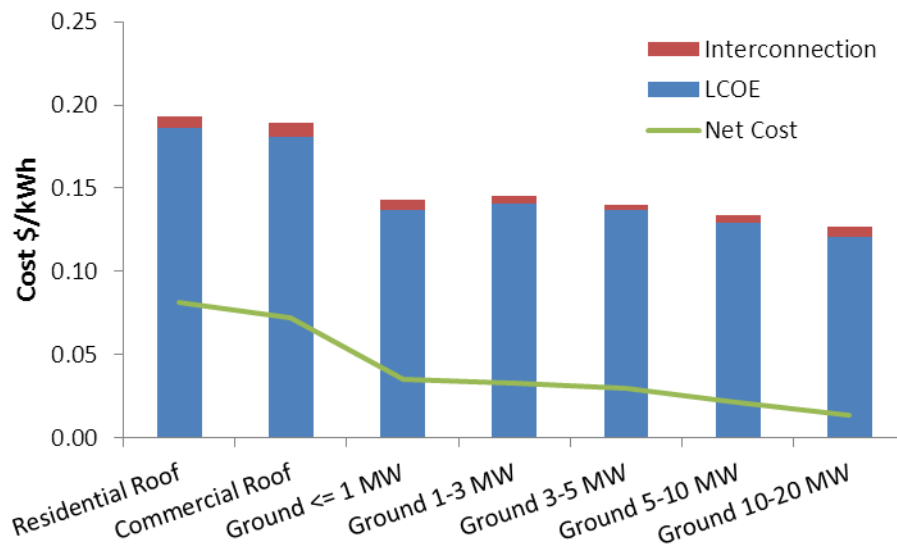
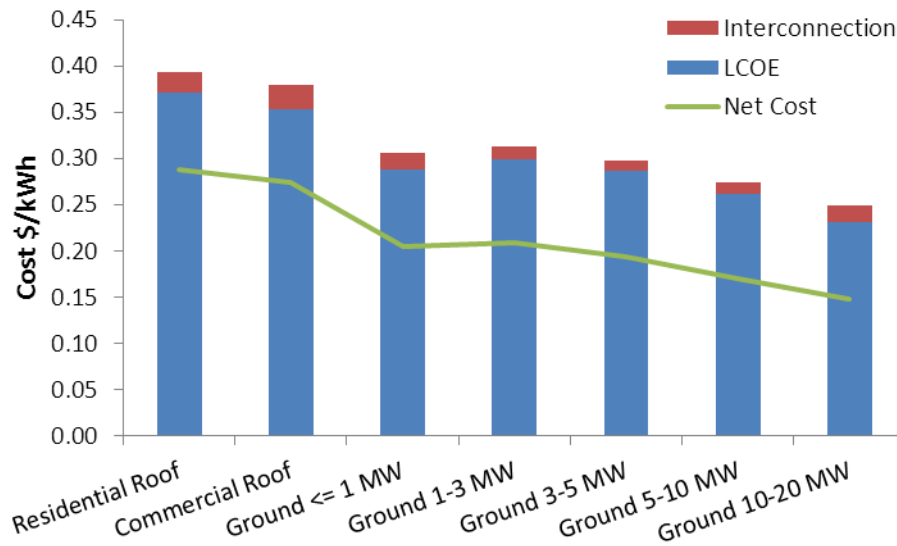


Figure 23: Average Cost of PV Systems Installed by 2020 by type (\$2010), 100% Progress Ratio

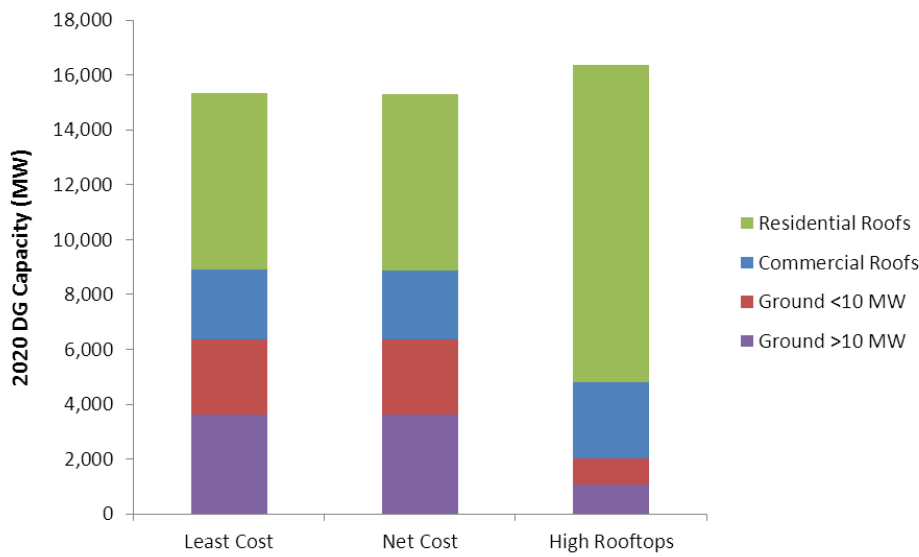


4 Results

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.

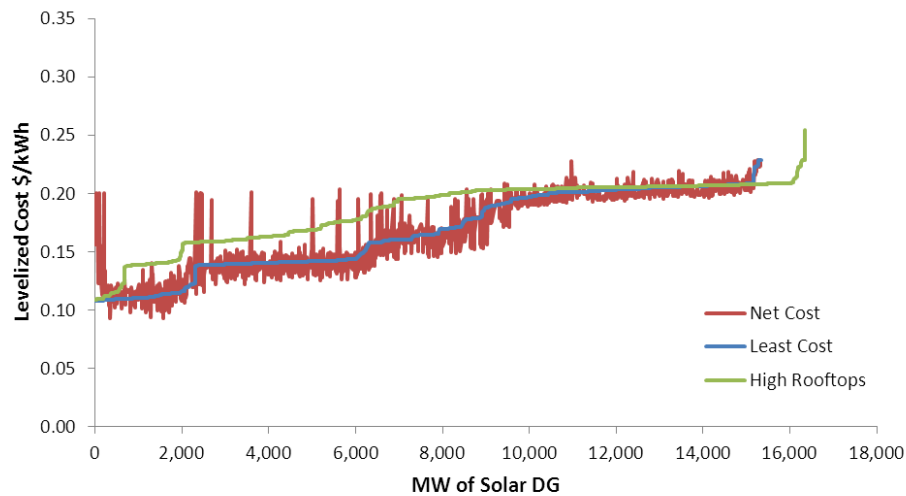
The *high rooftop* scenario installs PV on a much larger proportion of roofs. The total estimated technical potential in this scenario is slightly higher as a result of our method for assigning capacity to substations. As discussed in Section 3.2, we perform an hour-by-hour comparison of available substation 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.

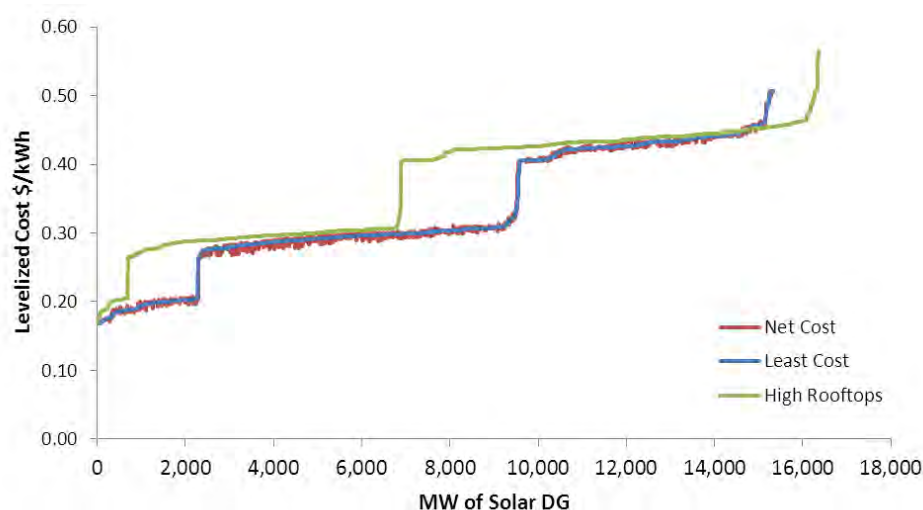
Figure 25: Levelized Cost PV Supply Curves for Three Scenarios Under a “Max Without Curtailment” Interconnection Policy; Low Cost Case



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

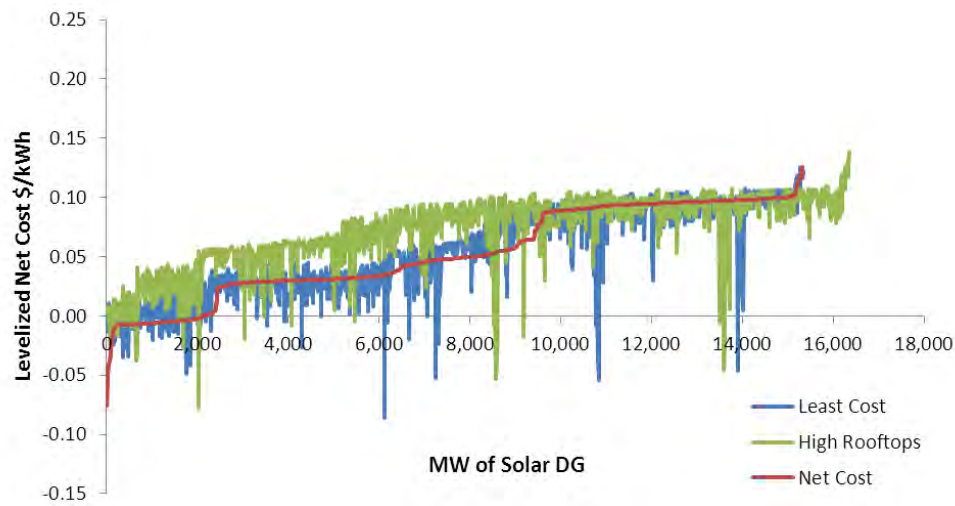
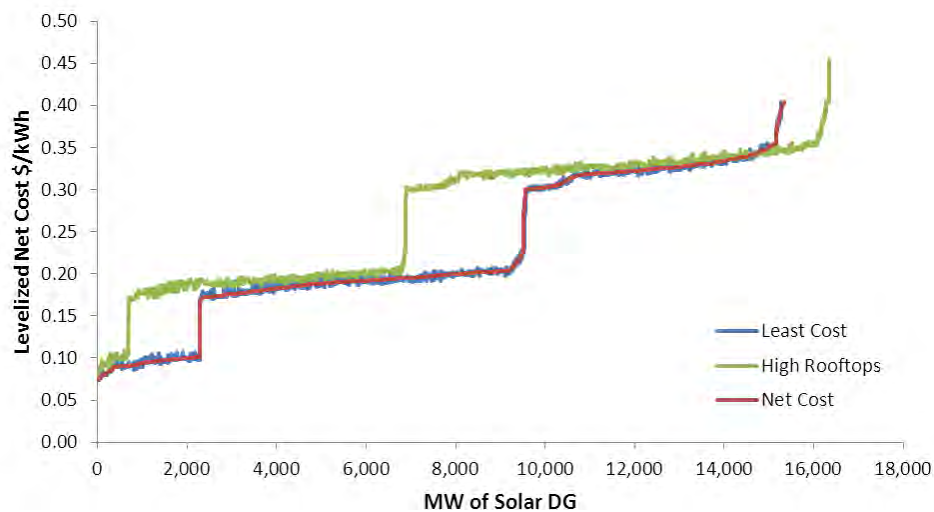


Figure 28: Levelized Net Cost PV Supply Curves for Three Scenarios Under a “Max Without Curtailment” Interconnection Rule; High Cost Case



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	3	6	\$0.9	\$0.140	\$0.3	\$0.042	
		Commercial Roof							
		Ground < 10 MW							
		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	2	4	\$0.5	\$0.120	\$0.1	\$0.026
			Ground < 10 MW						
			Ground 10-20 MW						
		Desert	Residential Roof	2	5	\$0.5	\$0.109	\$0.1	\$0.014
			Commercial Roof						
			Ground < 10 MW						
			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

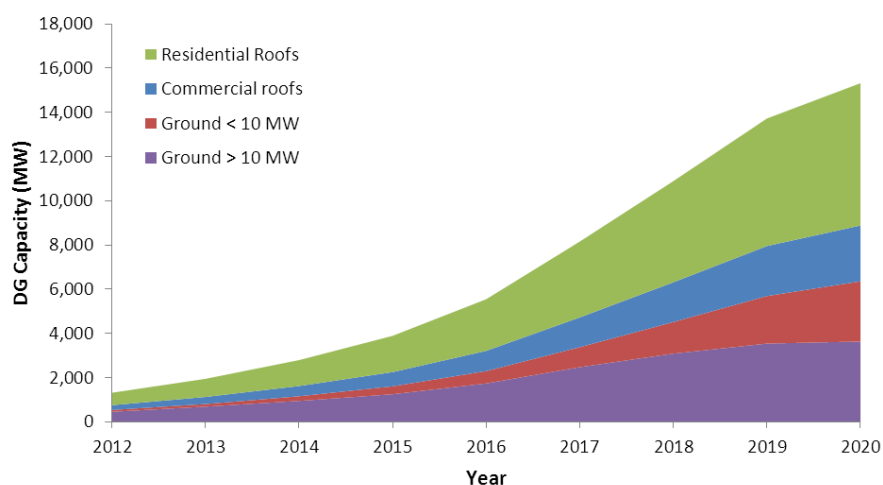
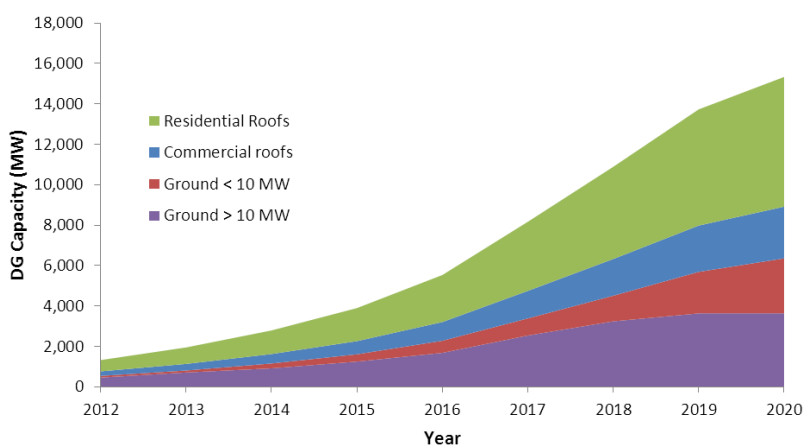


Figure 30: Installed PV by Type Under The *Least Cost* Scenario, “Maximum Without Curtailment” Interconnection Policy; High Cost Case



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

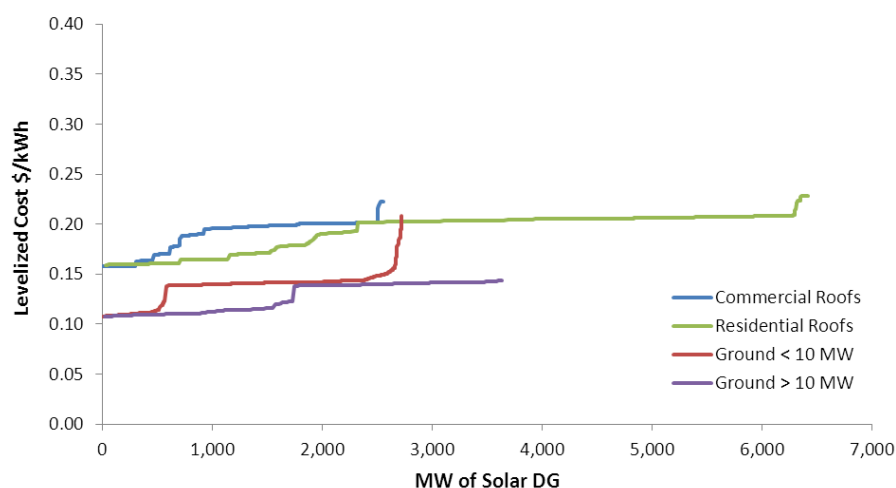
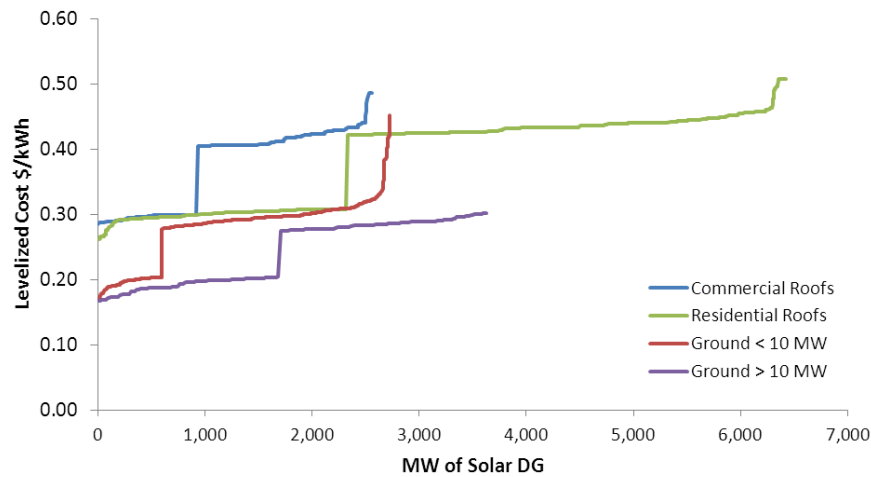


Figure 32: Supply Curves by PV Type Under the *Least Cost* Scenario; High Cost Case



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

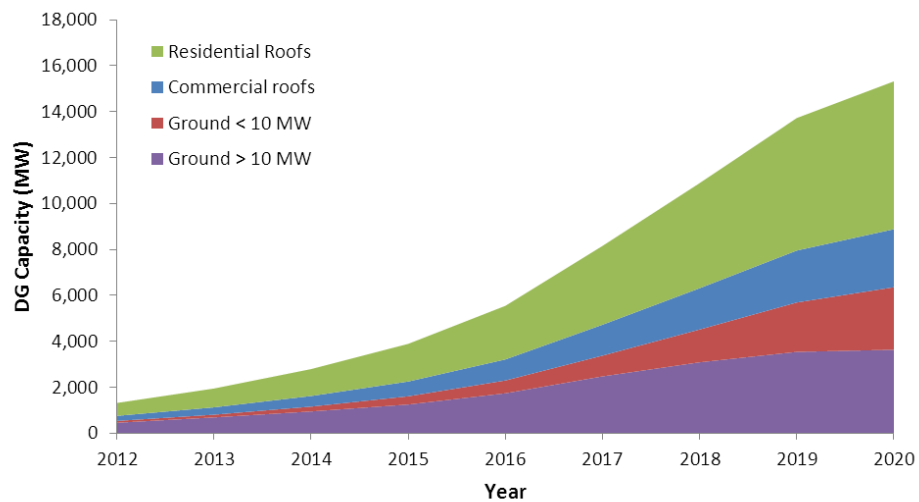


Figure 34 and Figure 35 show supply curves under the *least net cost* scenario in the low and high cost cases respectively. These figures differ from Figure 31 in that the vertical axis is net cost rather than cost. The curves are similar, however, with ground-mounted systems less expensive than rooftop.

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

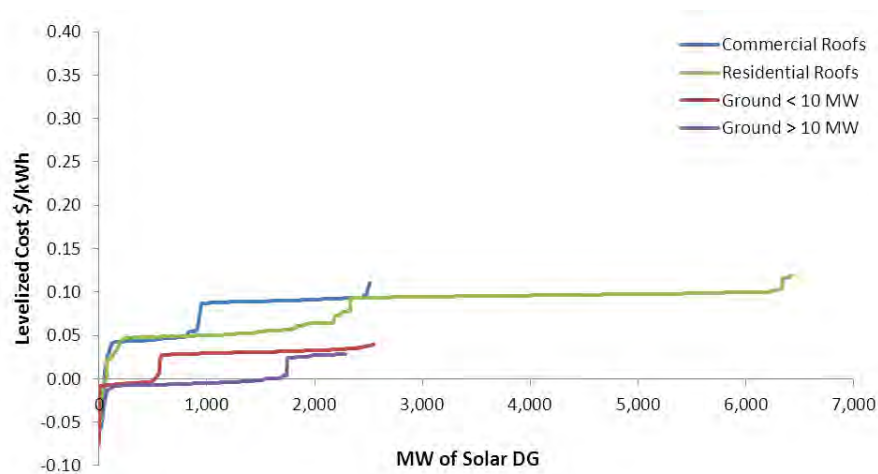
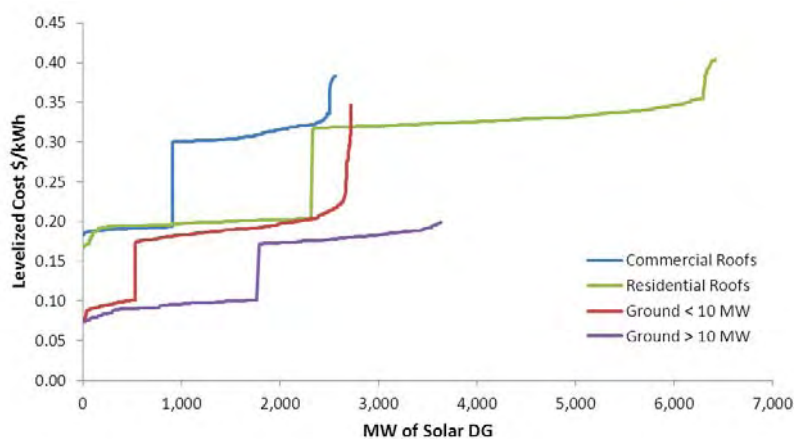


Figure 35: Supply Curves by PV Type under the *Least Net Cost Scenario*; High Cost Case



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

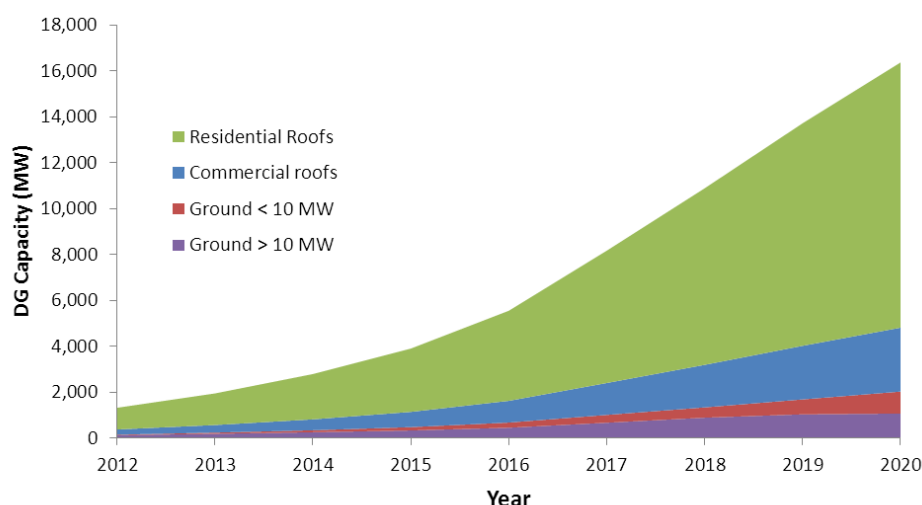


Figure 37 and Figure 38 show the supply curves for resources selected under the *high rooftop* scenario. Because rooftop PV is selected first under this scenario, many of the ground-mounted sites can no longer be interconnected under the interconnection limit as the capacity for DG at a particular substation 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

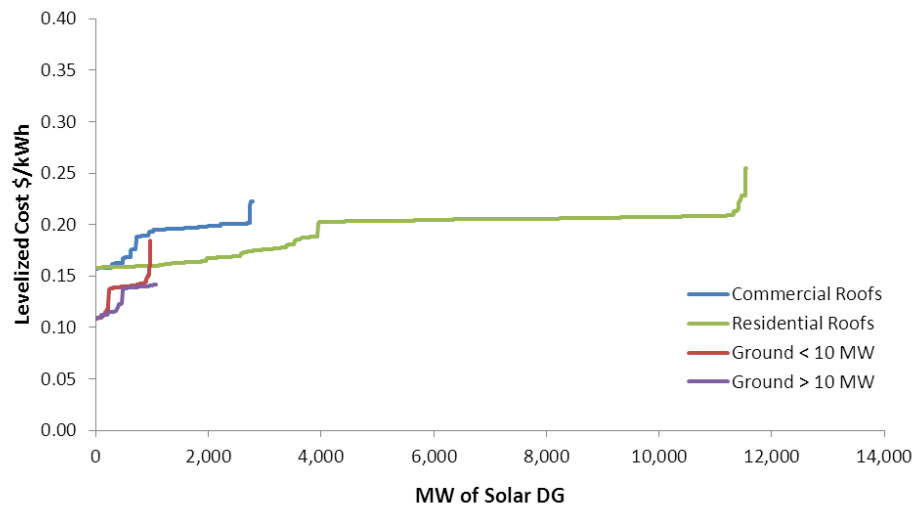
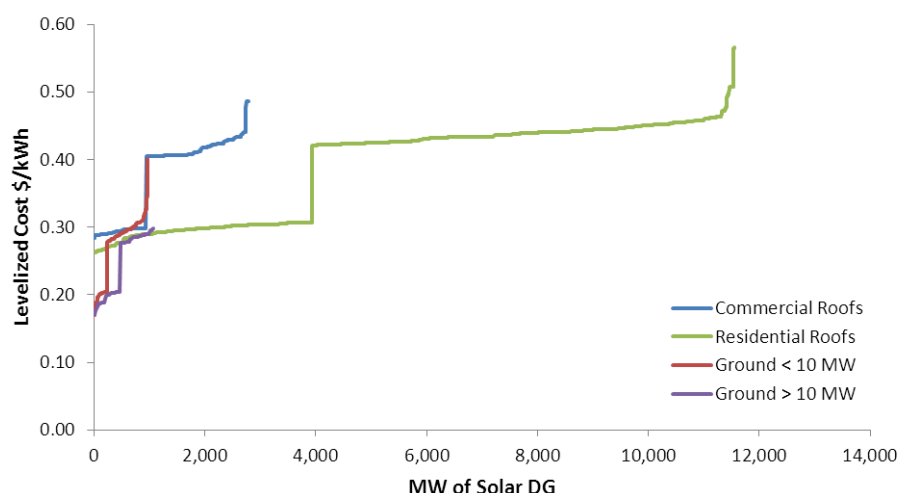


Figure 38: Supply curves by PV type under the *high rooftop* scenario; High Cost Case



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

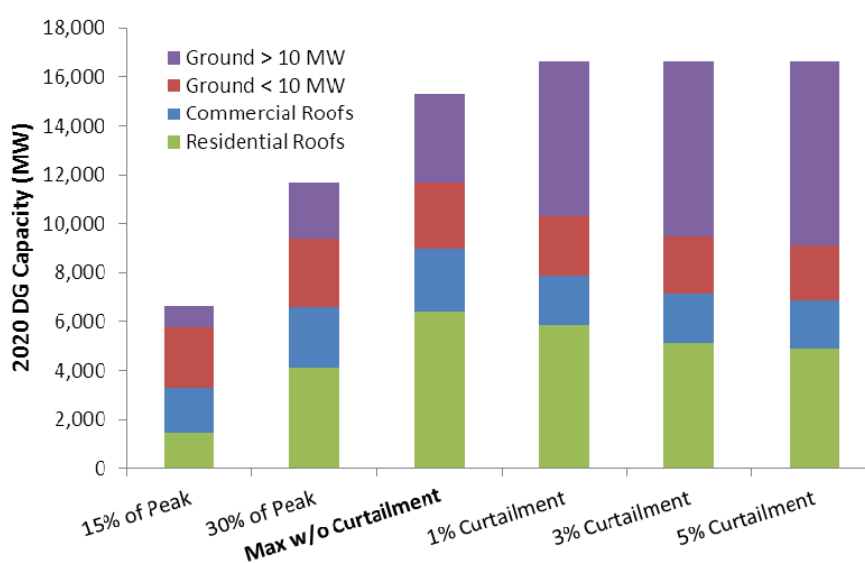
Sensitivity	Scenario	Installed MW by 2020	Cost (\$2010, millions)	Net Cost (\$2010, millions)
3% Curtailment	Cost	16,680	\$10,450	\$6,970
	Net Cost	16,660	\$10,430	\$6,960
	Roofs First	16,680	\$11,690	\$8,580
5% Curtailment	Cost	16,670	\$10,390	\$6,900
	Net Cost	16,640	\$10,370	\$6,880
	Roofs First	16,660	\$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

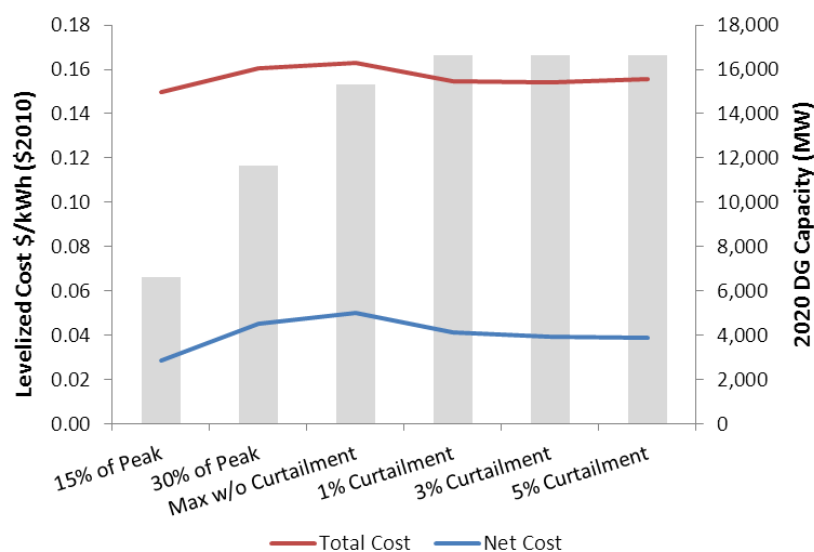
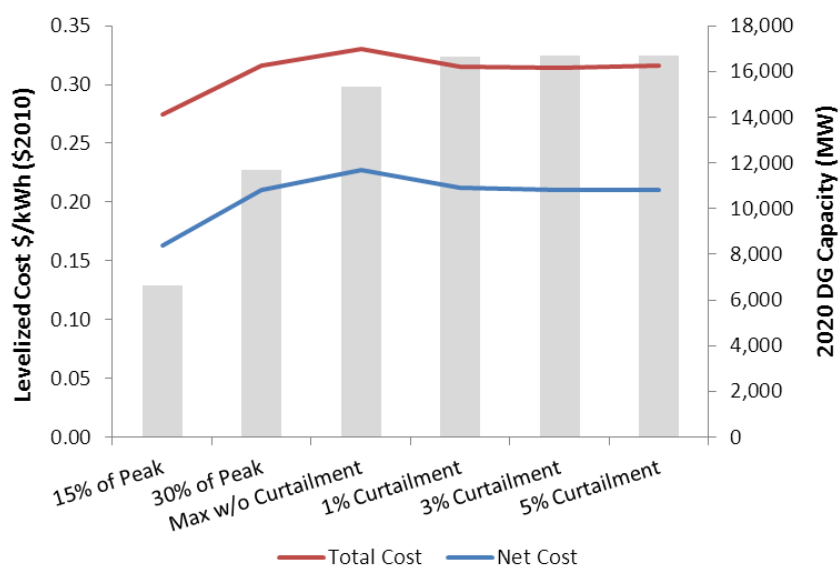


Figure 41: 2020 Cost under Various Interconnection Potential Criteria and *Least Cost* Scenario; High Cost Case



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

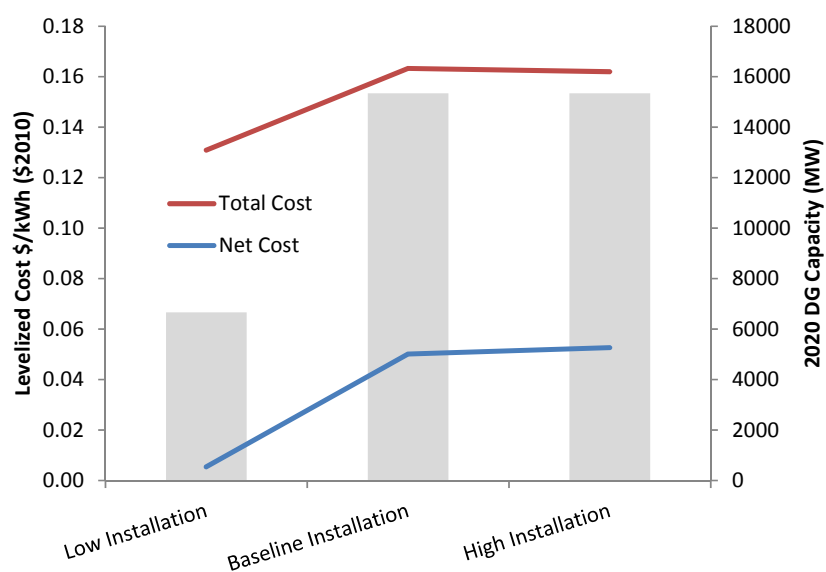
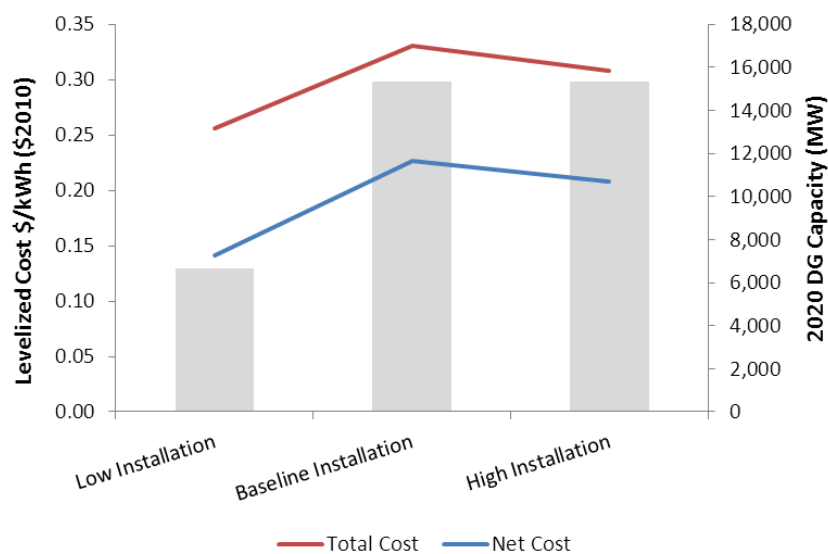


Figure 43: Levelized Cost and Net Cost in 2020 under High and Low Installation Rate, *Least Cost Scenario*; High Cost Case



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

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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						

	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						

	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						

	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						

	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						

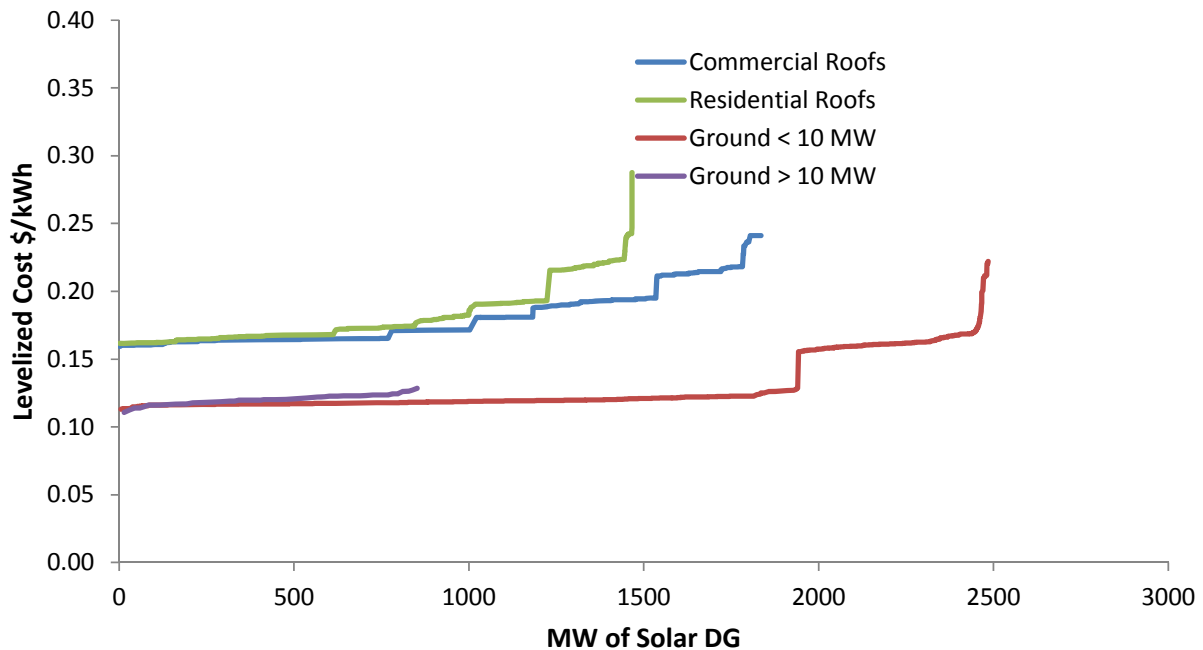
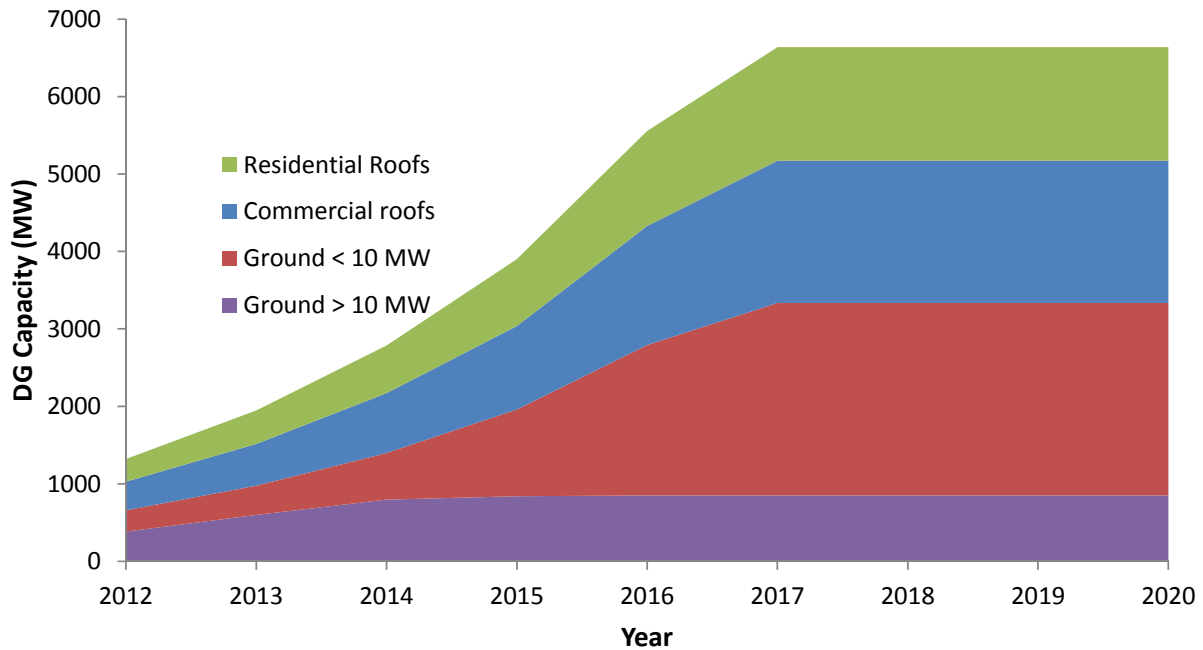
	Ground 10-20 MW	37	79	\$11.0	\$0.139	\$2.2	\$0.028
Sonoma	Residential Roof	251	429	\$89.1	\$0.208	\$41.0	\$0.096
	Commercial Roof						
	Ground <= 1 MW	1	1	\$0.2	\$0.166	\$0.1	\$0.055
	Ground 1-3 MW						
	Ground 3-5 MW	4	8	\$1.1	\$0.145	\$0.2	\$0.027
	Ground 5-10 MW	16	34	\$4.8	\$0.141	\$0.8	\$0.025
	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						

	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
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

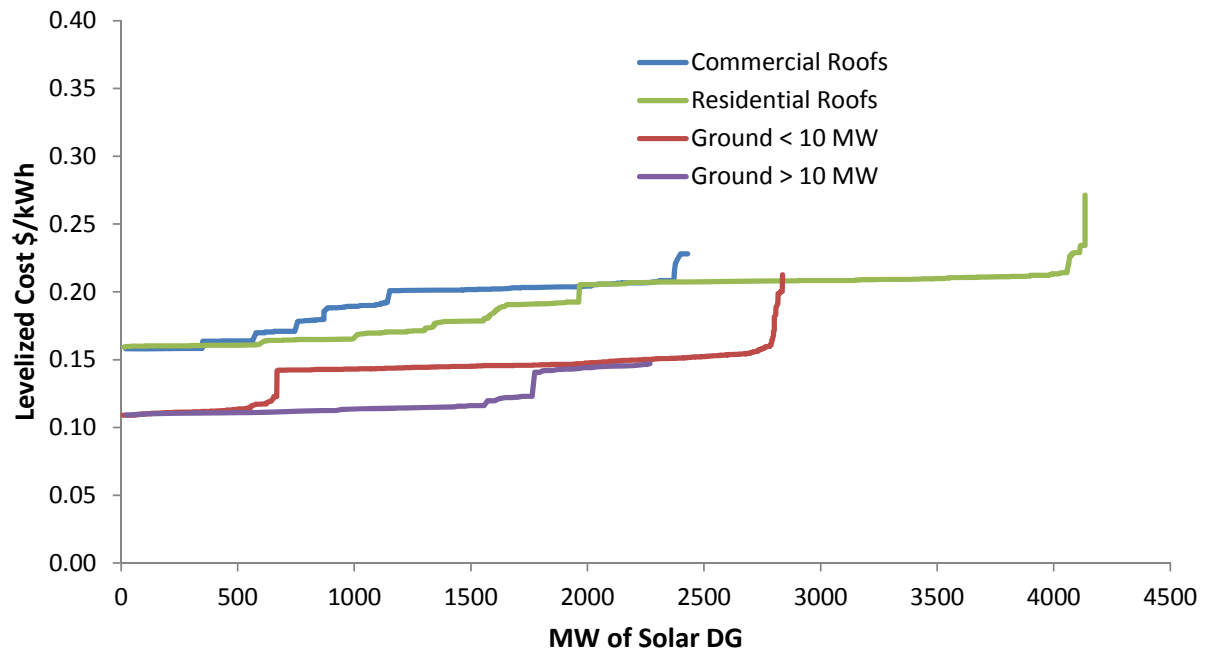
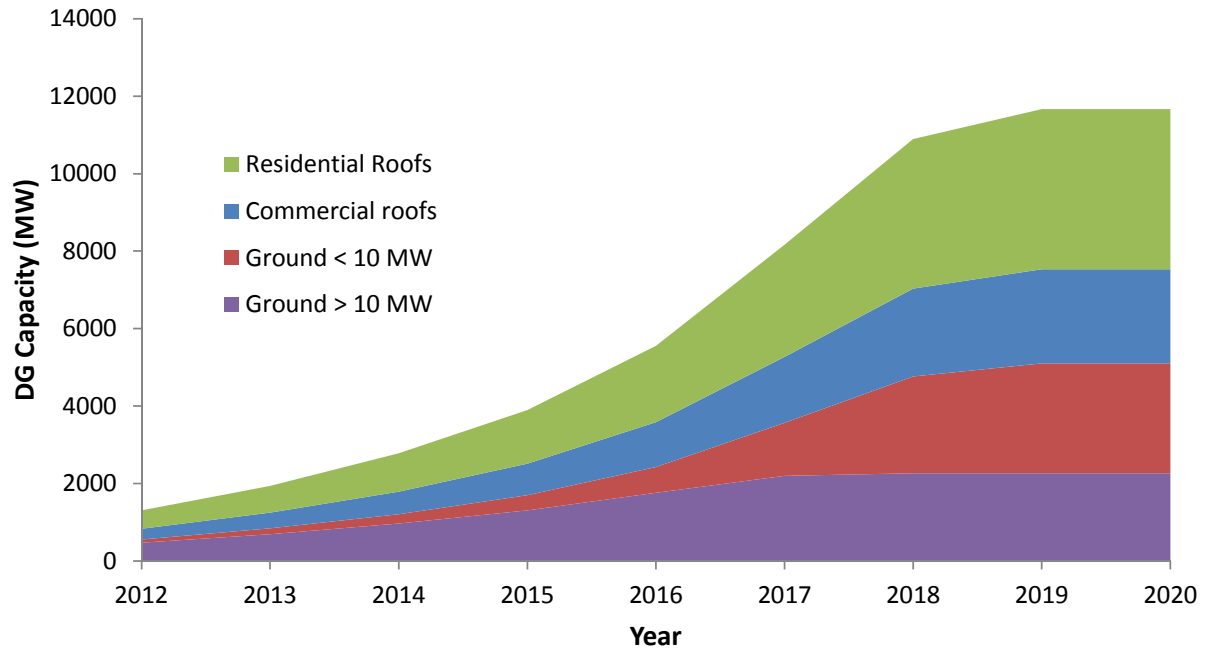
Least Net Cost Summary Table, 15% Interconnection Constraint

Utility	Climate Zone	Type	MW	GWh	Cost (\$2010)			
					Cost in 2020		Net Cost in 2020	
						\$M	\$/kWh	\$M
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

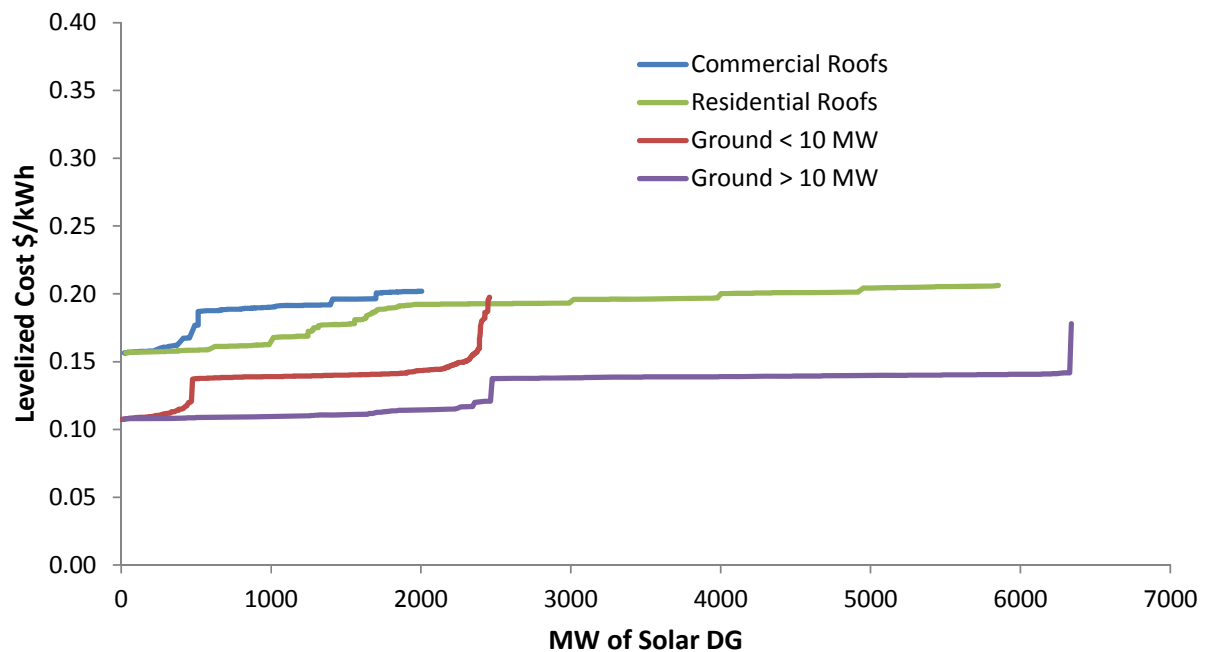
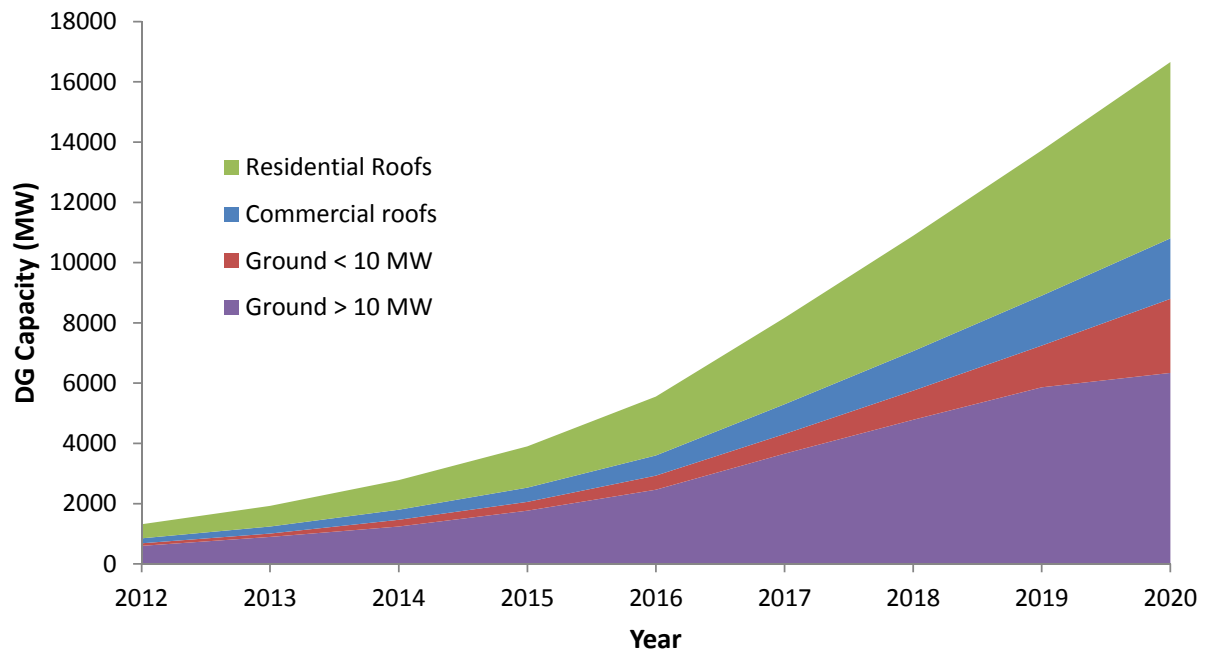
Least Net Cost Summary Table, 30% Interconnection Constraint

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

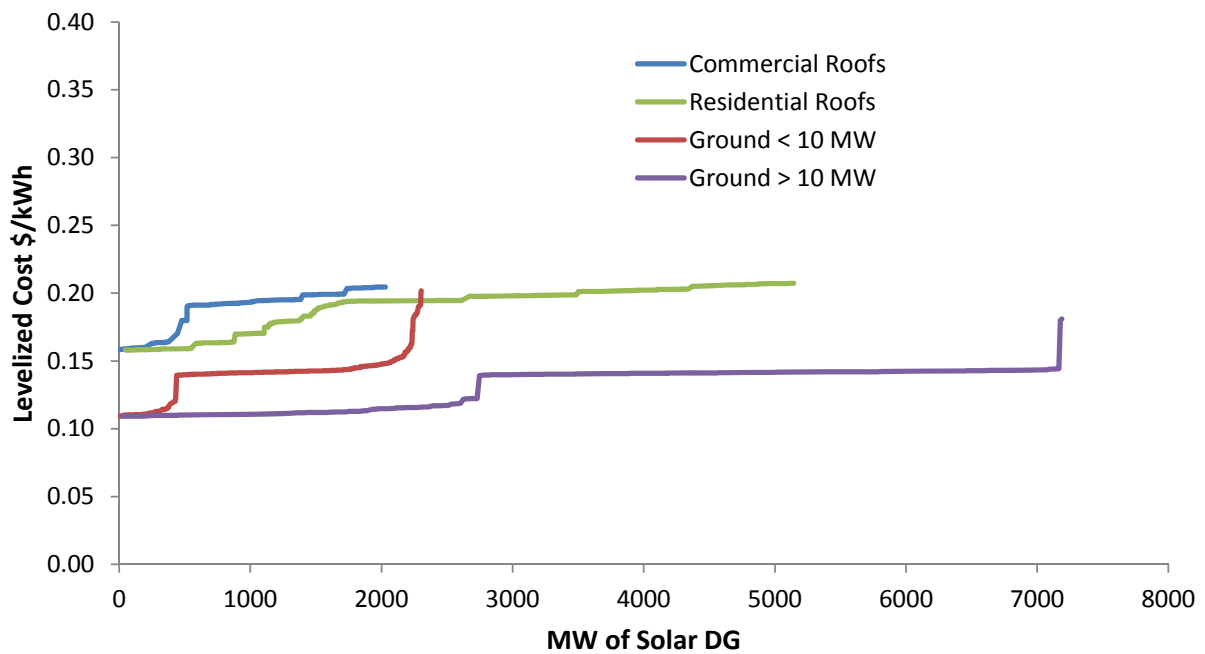
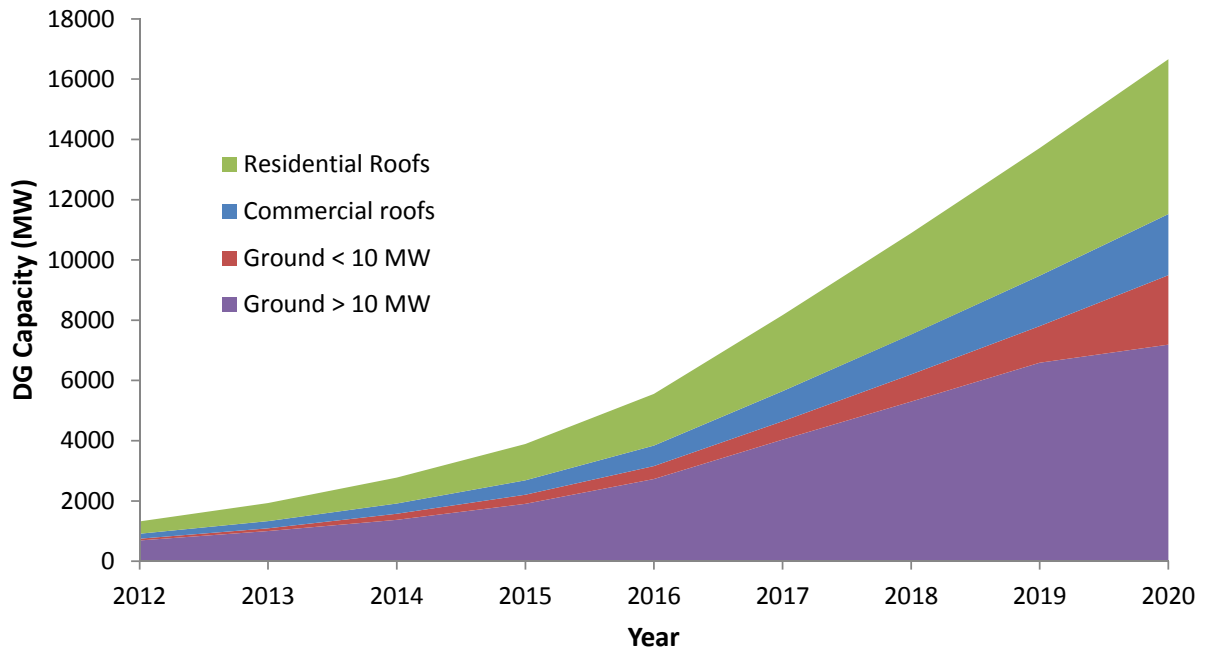
Least Net Cost Summary Table, 1% Curtailment Interconnection Constraint

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	4	10	\$1.3	\$0.127	\$0.3	\$0.030
		Commercial Roof						
		Ground < 10 MW						
		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	4	10	\$1.3	\$0.126	\$0.3	\$0.031
		Ground < 10 MW						
		Ground 10-20 MW						
	Desert	Residential Roof	4	10	\$1.2	\$0.124	\$0.3	\$0.029
		Commercial Roof						
		Ground < 10 MW						
		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	801	1,691	\$240.2	\$0.142	\$52.0	\$0.031
		Ground < 10 MW	1,261	2,649	\$366.6	\$0.138	\$76.1	\$0.029
		Ground 10-20 MW						
	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	427	907	\$128.9	\$0.142	\$24.5	\$0.027
		Ground < 10 MW	629	1,331	\$178.0	\$0.134	\$24.8	\$0.019
		Ground 10-20 MW						
	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

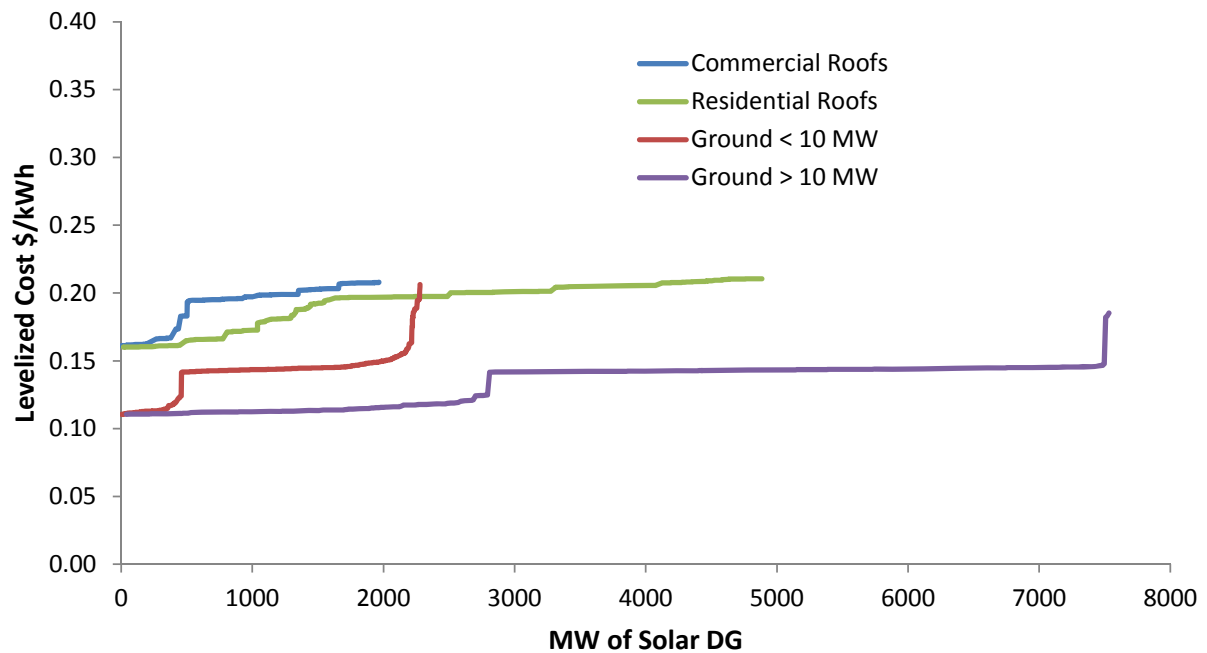
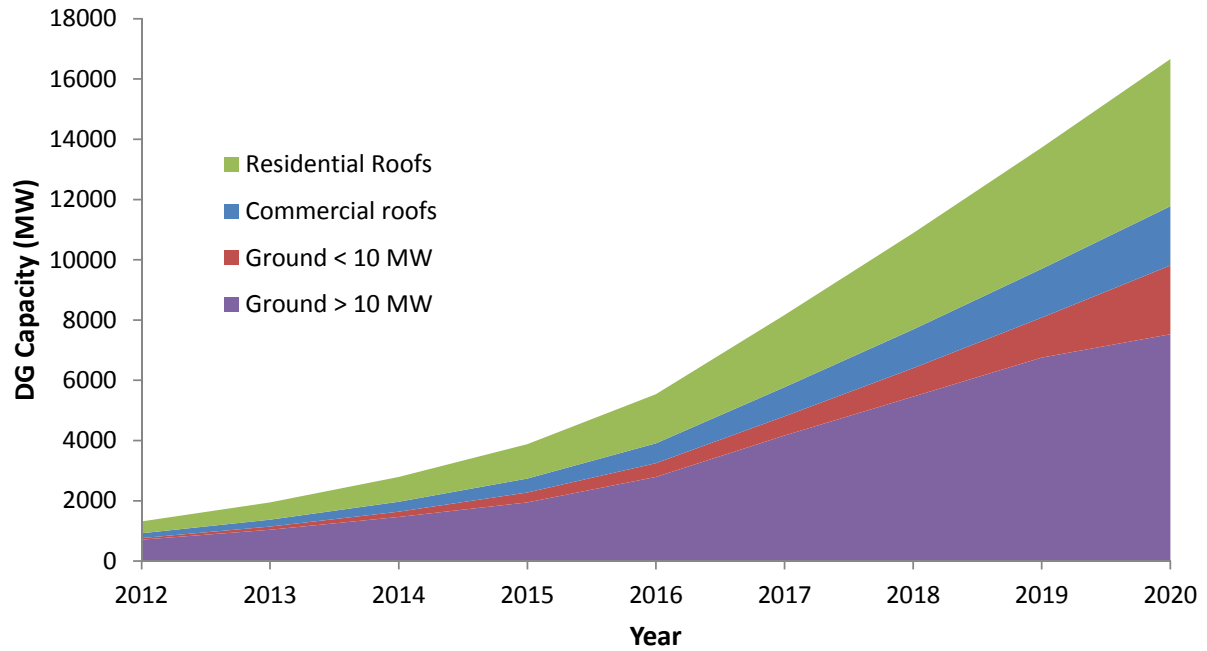
Least Net Cost Summary Table, 3% Curtailment Interconnection Constraint

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

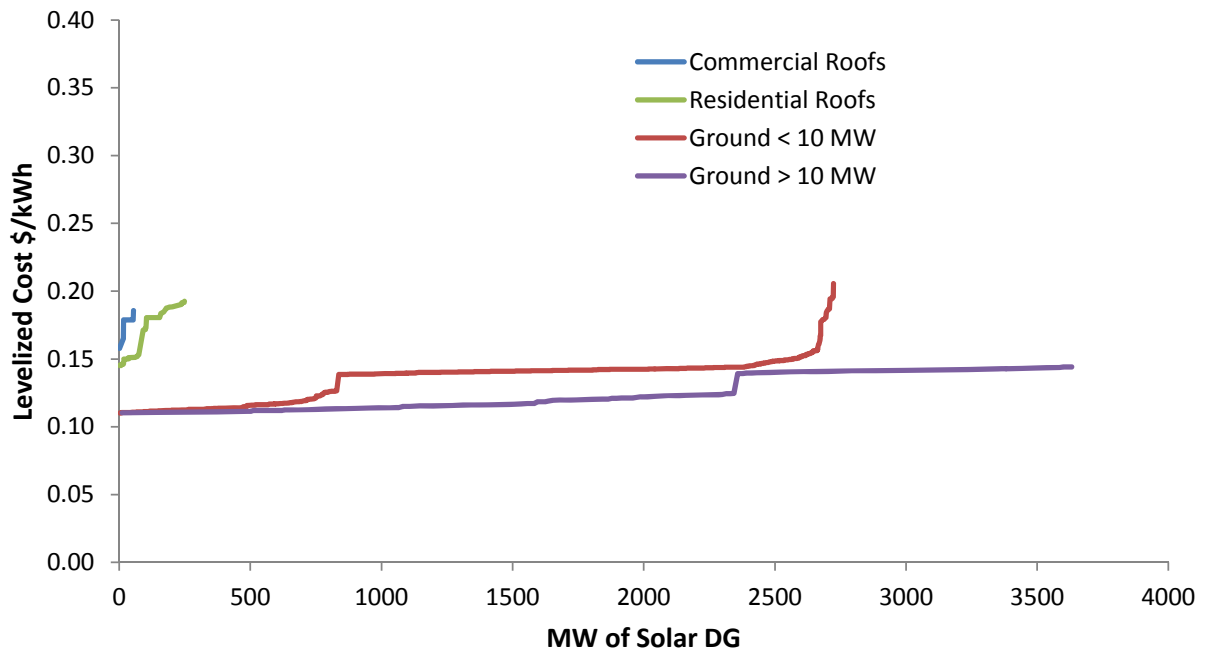
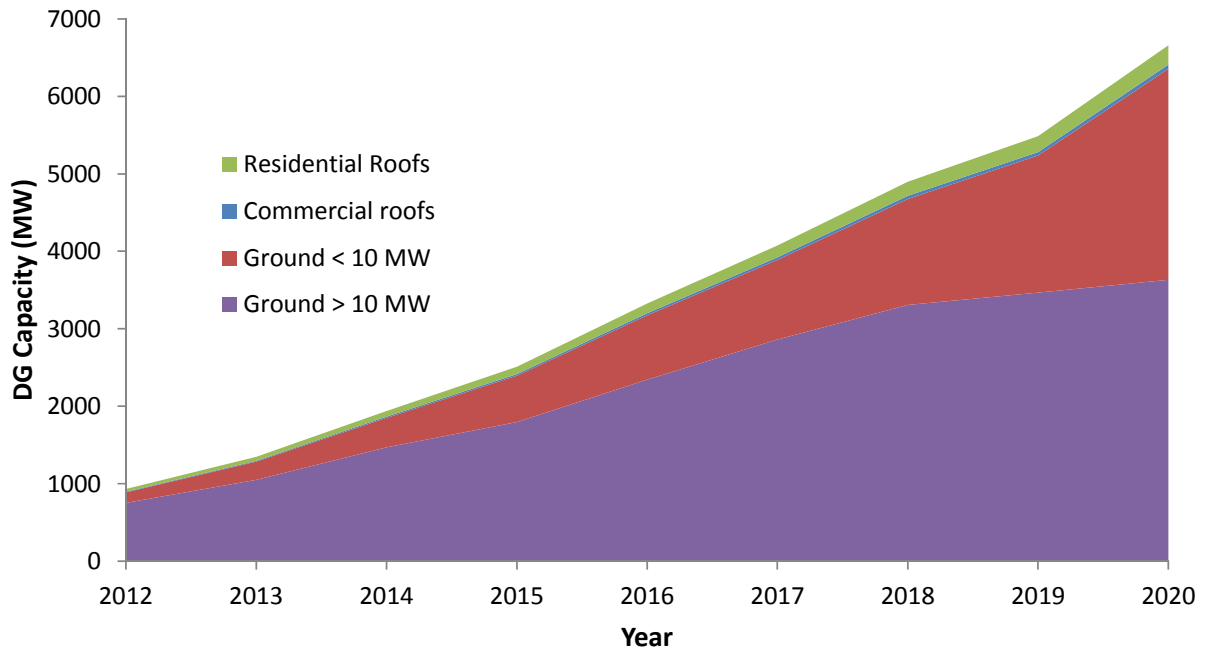
Least Net Cost Summary Table, 5% Curtailment Interconnection Constraint

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

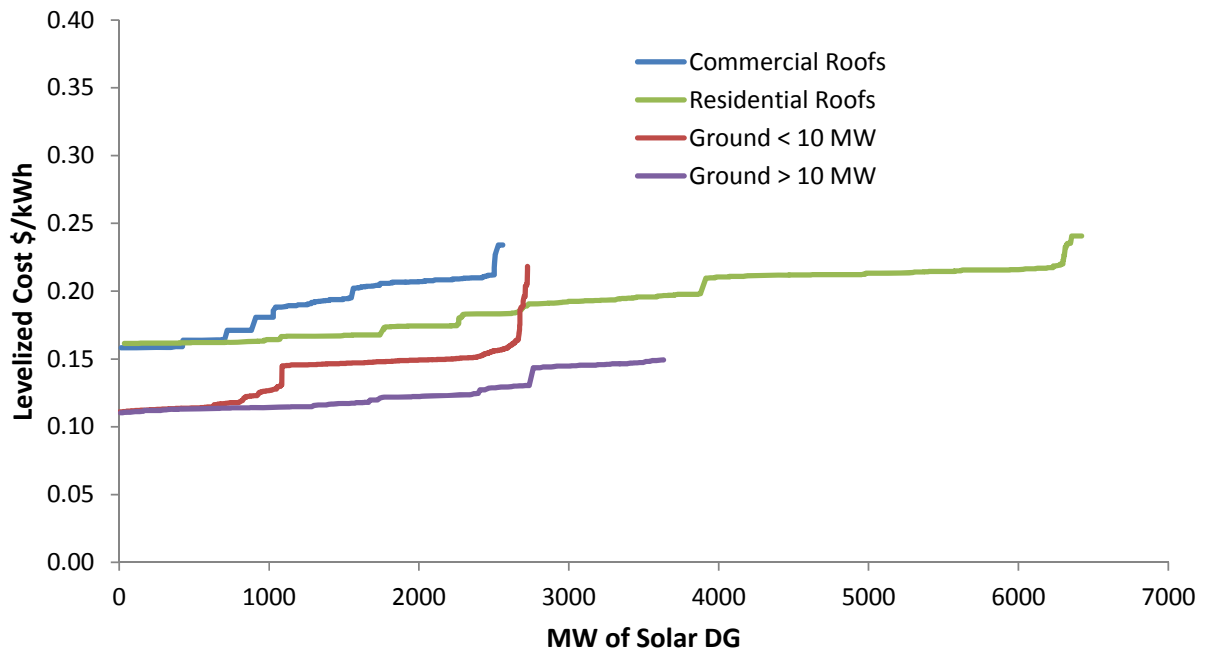
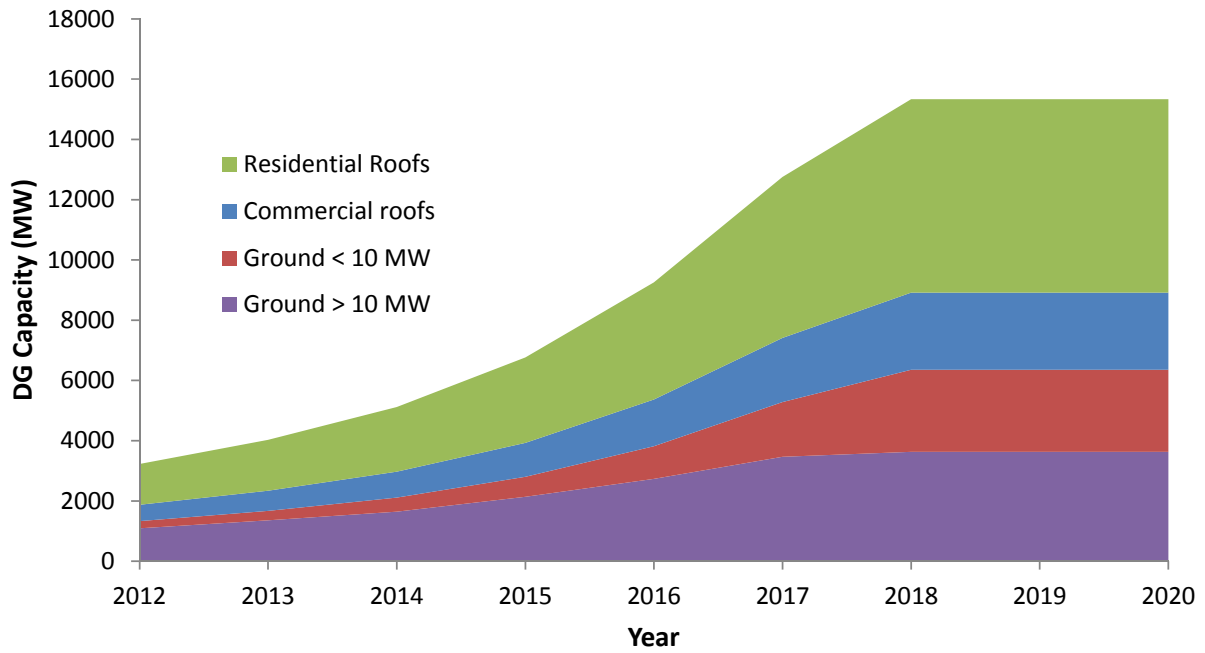
Least Net Cost Summary Table, Low Adoption Rate

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	103	191	\$36.0	\$0.188	\$12.8	\$0.067
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
	North Central Valley	Residential Roof	265	490	\$92.7	\$0.189	\$31.3	\$0.064
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
	South Central Valley	Residential Roof	119	220	\$40.4	\$0.184	\$11.7	\$0.053
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
	Mountain	Residential Roof	4	8	\$1.4	\$0.179	\$0.4	\$0.052
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
SCE	North Coast	Residential Roof	3	6	\$1.0	\$0.174	\$0.4	\$0.067
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
	South Coast	Residential Roof	2,651	4,938	\$892.8	\$0.181	\$259.9	\$0.053
		Commercial Roof	1,452	2,481	\$451.3	\$0.182	\$129.5	\$0.052
		Ground < 10 MW						
		Ground 10-20 MW						
	South Central Valley	Residential Roof	515	971	\$177.0	\$0.182	\$55.7	\$0.057
		Commercial Roof	183	313	\$58.7	\$0.187	\$8.3	\$0.026
		Ground < 10 MW						
		Ground 10-20 MW						
	Desert	Residential Roof	185	345	\$61.5	\$0.178	\$18.6	\$0.054
		Commercial Roof	32	54	\$10.1	\$0.187	\$3.3	\$0.062
		Ground < 10 MW						
		Ground 10-20 MW						
	Mountain	Residential Roof	116	218	\$38.7	\$0.177	\$13.3	\$0.061
		Commercial Roof	107	180	\$32.0	\$0.178	\$10.5	\$0.058
		Ground < 10 MW						
		Ground 10-20 MW						
SDGE	South Coast	Residential Roof	764	1,411	\$254.1	\$0.180	\$92.3	\$0.065
		Commercial Roof	152	260	\$47.0	\$0.181	\$17.0	\$0.065
		Ground < 10 MW						
		Ground 10-20 MW						
	South Central Valley	Residential Roof	6	11	\$2.0	\$0.180	\$0.9	\$0.081
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
	Desert	Residential Roof	2	5	\$0.9	\$0.181	\$0.4	\$0.080
		Commercial Roof						
		Ground < 10 MW						
		Ground 10-20 MW						
		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						

	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

	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
Mendocino	Ground 10-20 MW						
	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
Merced	Ground 5-10 MW	15	30	\$9.5	\$0.312	\$6.2	\$0.204
	Ground 10-20 MW						
	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
Mono	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
	Ground 1-3 MW						
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						

	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						

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						

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

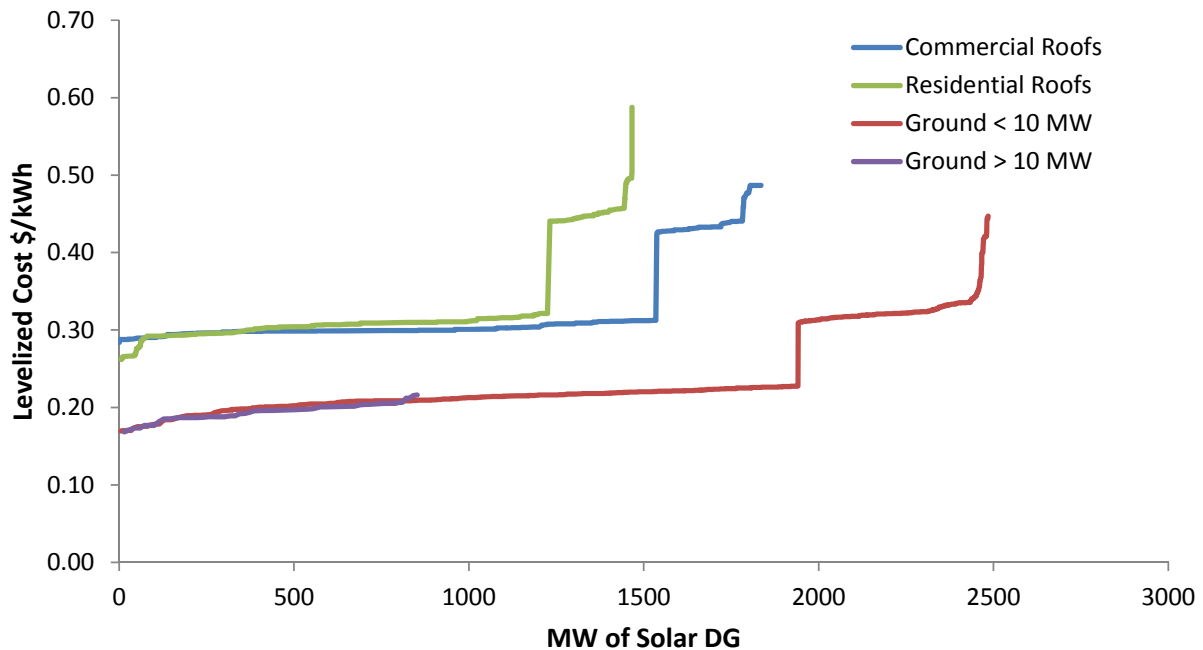
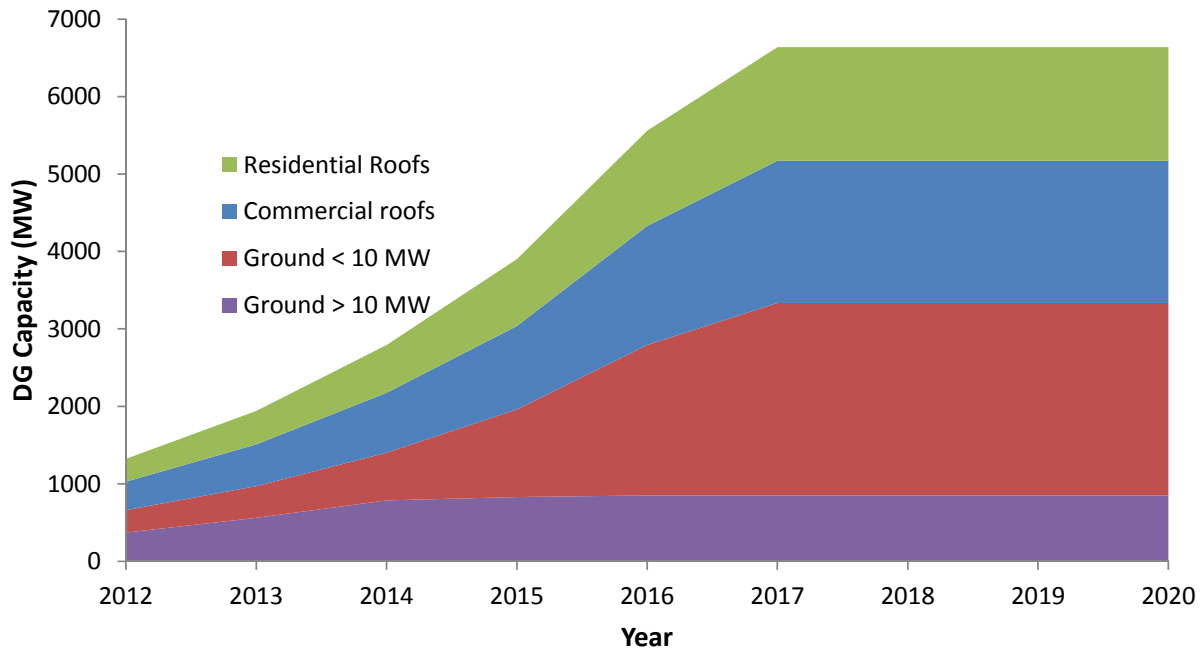
	Ground 3-5 MW	4	9	\$2.9	\$0.310	\$1.9	\$0.204
	Ground 5-10 MW	21	45	\$13.6	\$0.299	\$8.8	\$0.194
	Ground 10-20 MW	37	79	\$23.2	\$0.293	\$14.9	\$0.188
Sonoma	Residential Roof	251	429	\$201.0	\$0.469	\$154.6	\$0.361
	Commercial Roof						
	Ground <= 1 MW	1	1	\$0.5	\$0.369	\$0.3	\$0.262
	Ground 1-3 MW						
	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

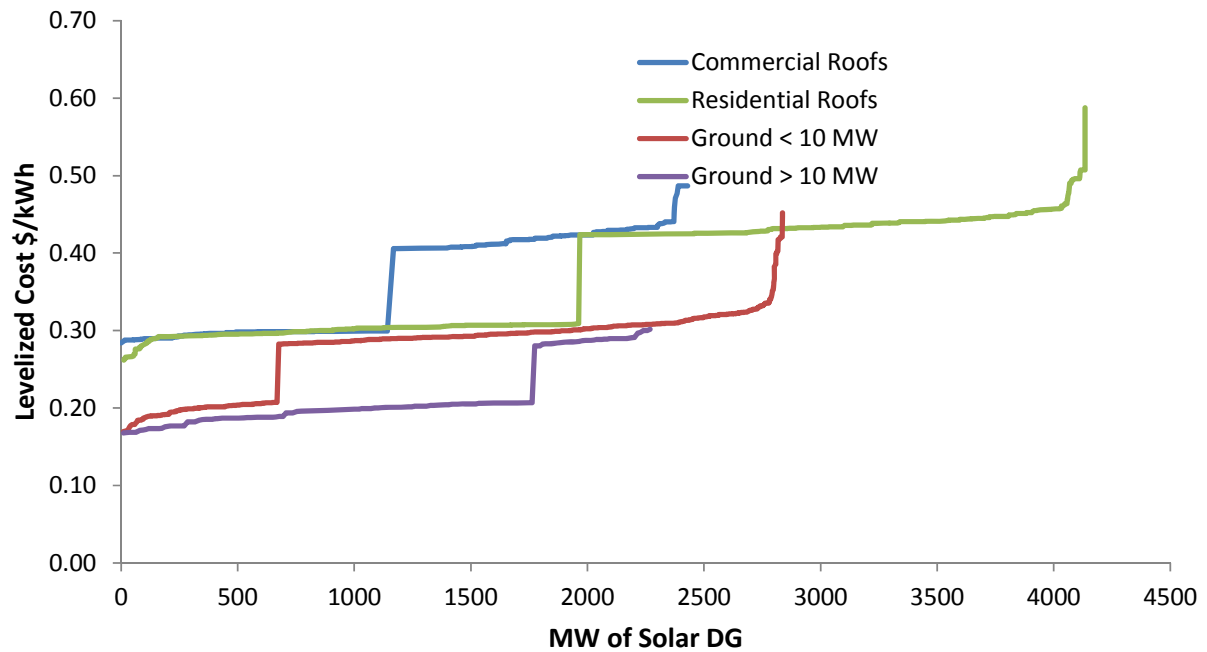
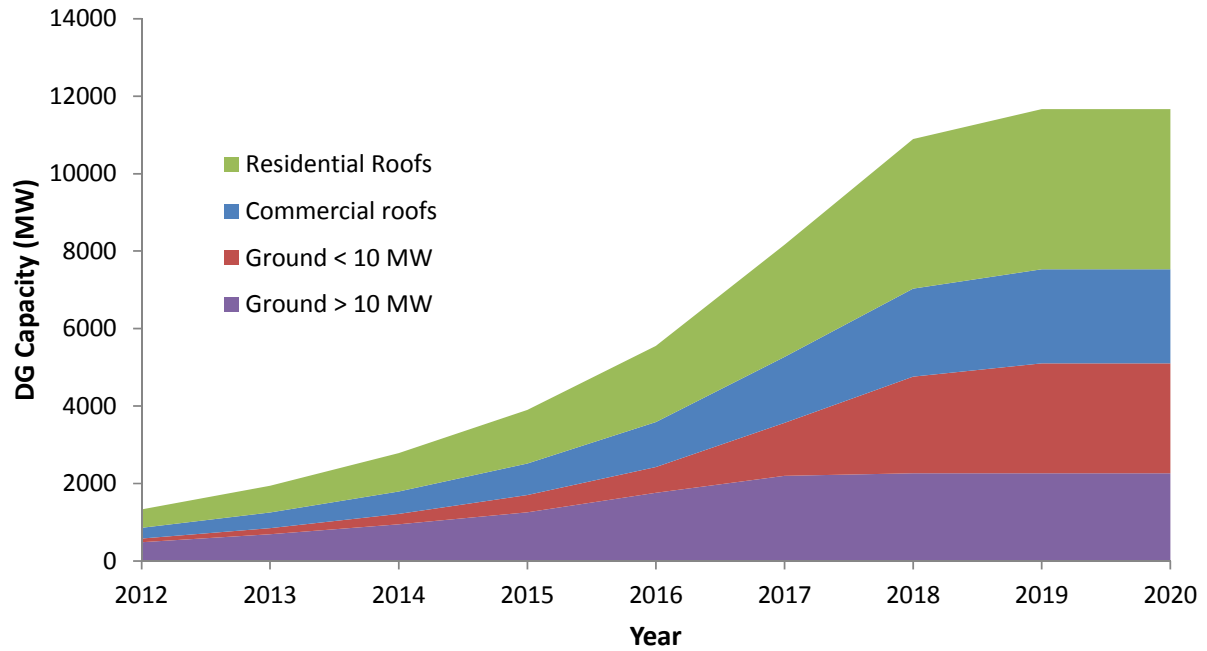
Least Net Cost Summary Table, 15% Interconnection Constraint

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	\$0.133
		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

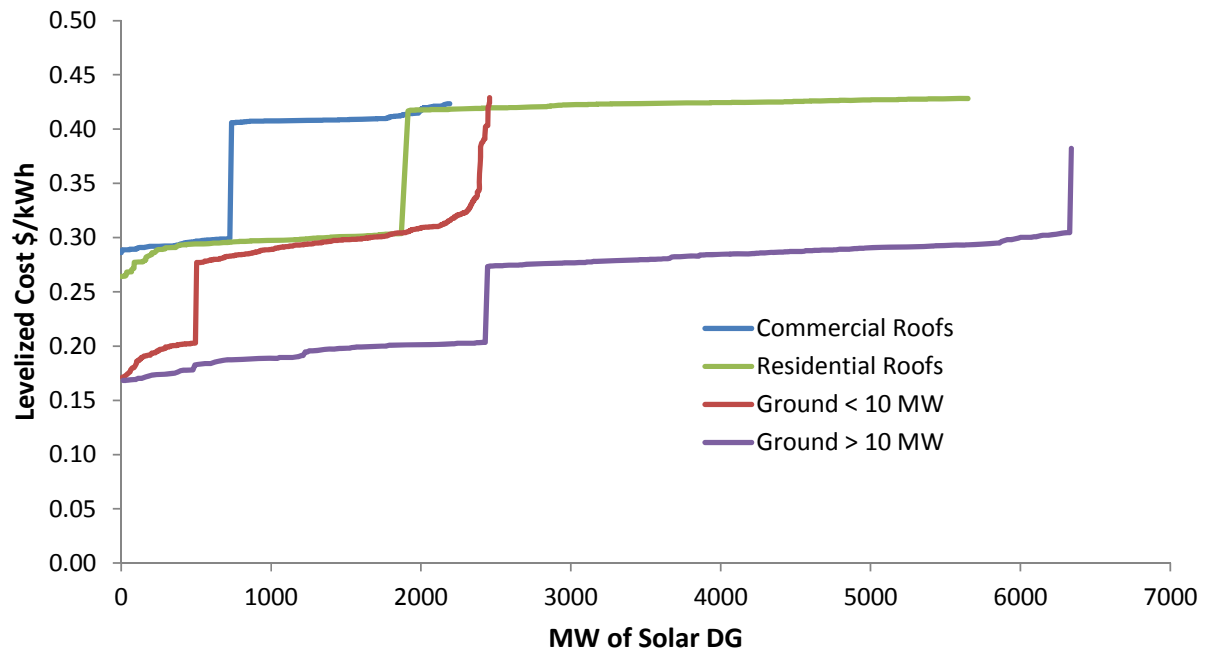
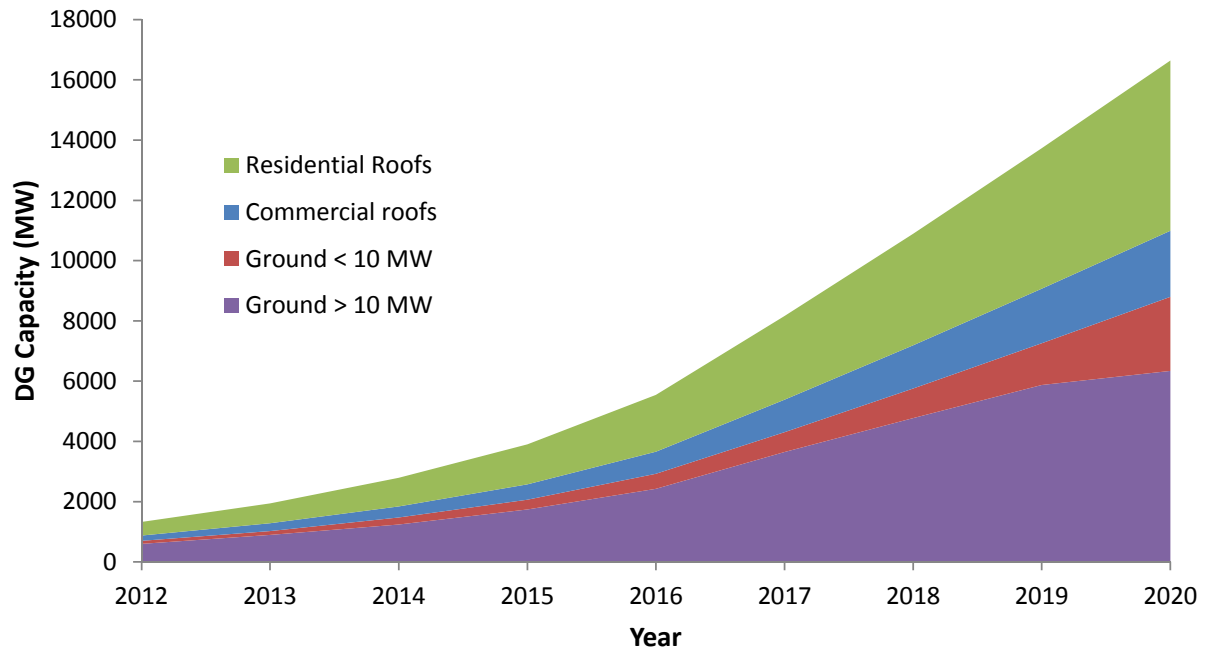
Least Net Cost Summary Table, 30% Interconnection Constraint

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	2	5	\$1.4	\$0.286	\$0.9	\$0.188
		Commercial Roof						
		Ground < 10 MW						
		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	2	4	\$1.1	\$0.283	\$0.8	\$0.187
		Ground < 10 MW						
		Ground 10-20 MW						
	Desert	Residential Roof	2	5	\$1.0	\$0.203	\$0.5	\$0.106
		Commercial Roof						
		Ground < 10 MW						
		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

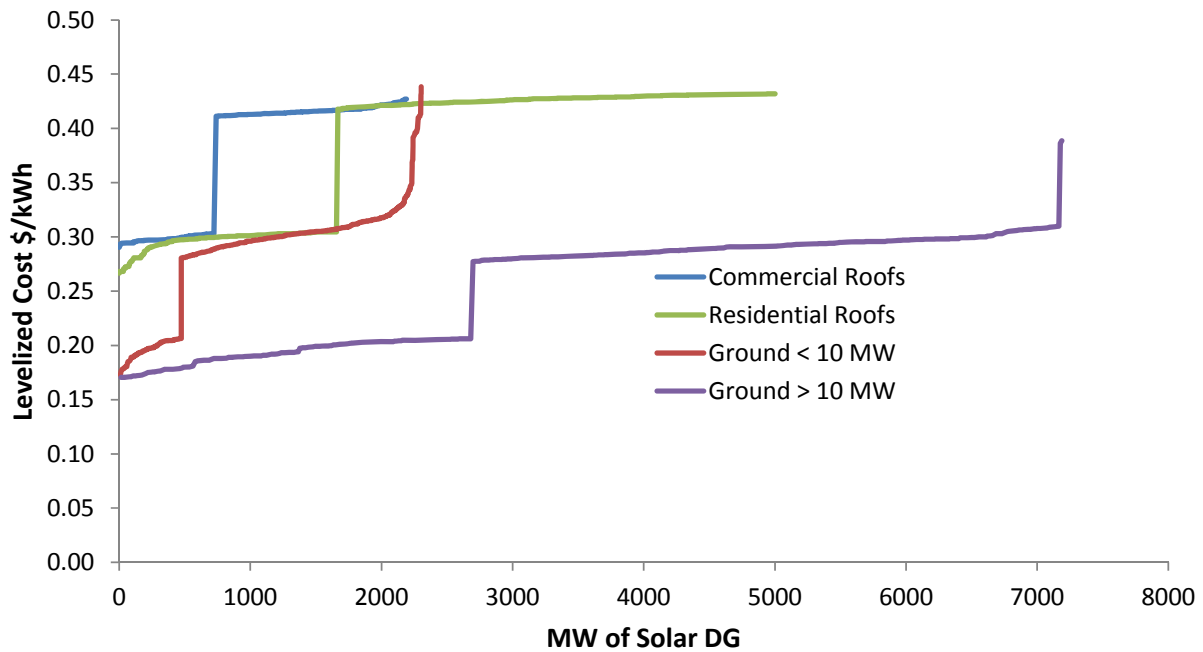
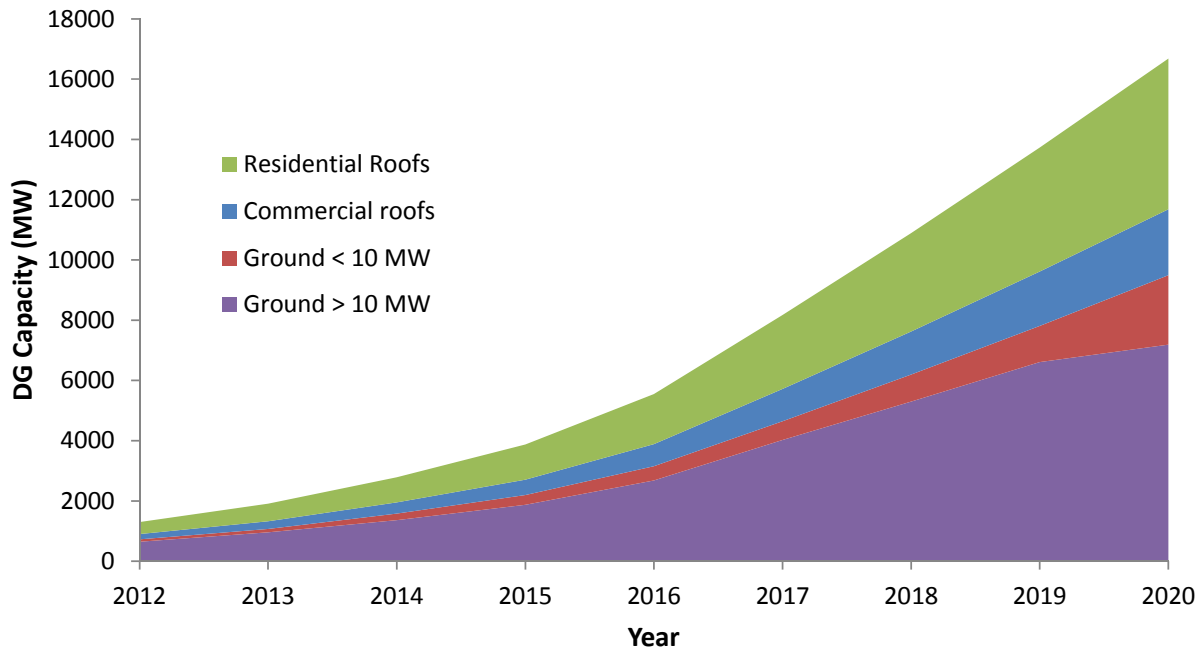
Least Net Cost Summary Table, 1% Curtailment Interconnection Constraint

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

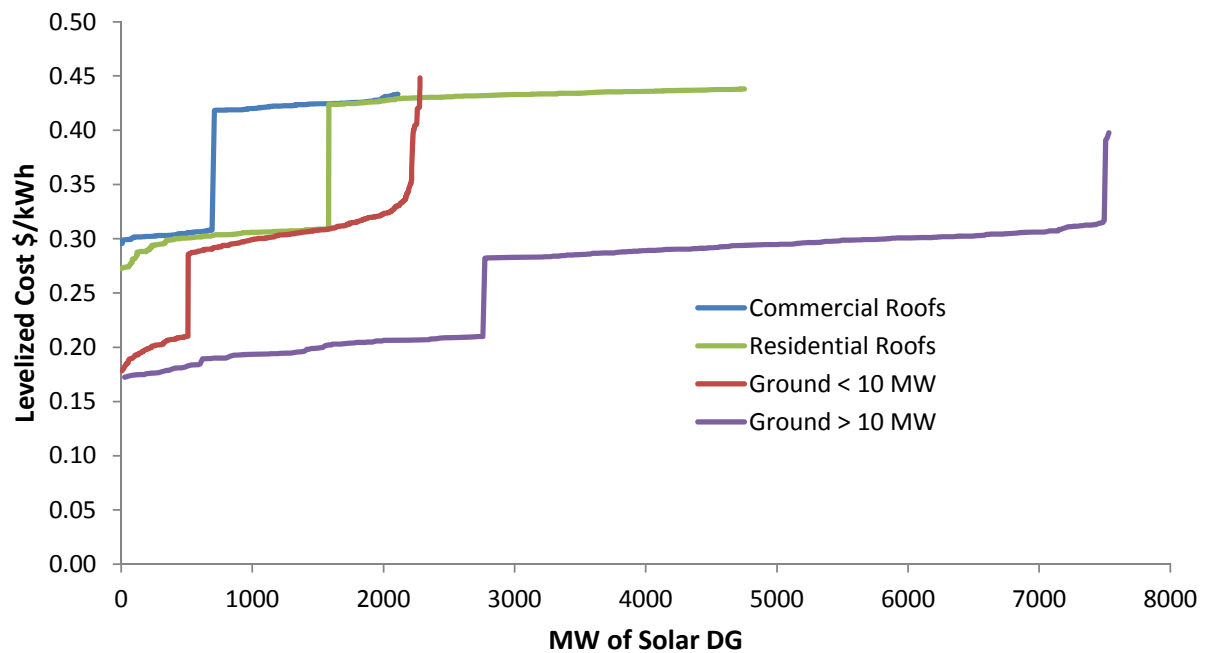
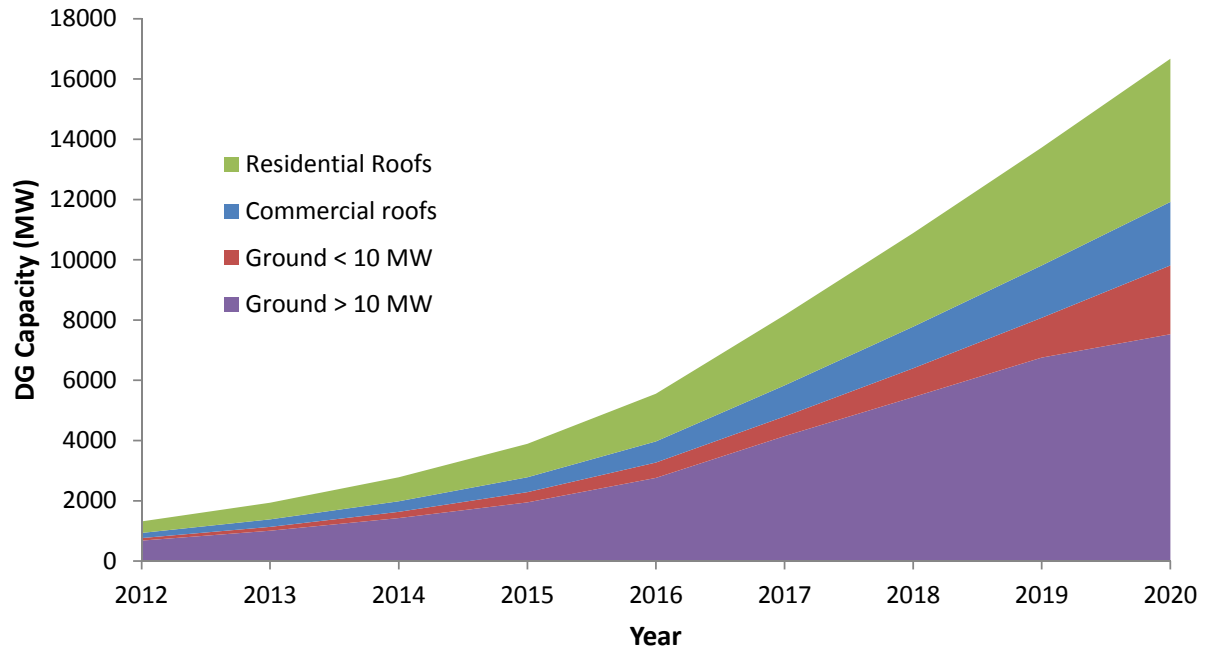
Least Net Cost Summary Table, 3% Curtailment Interconnection Constraint

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	

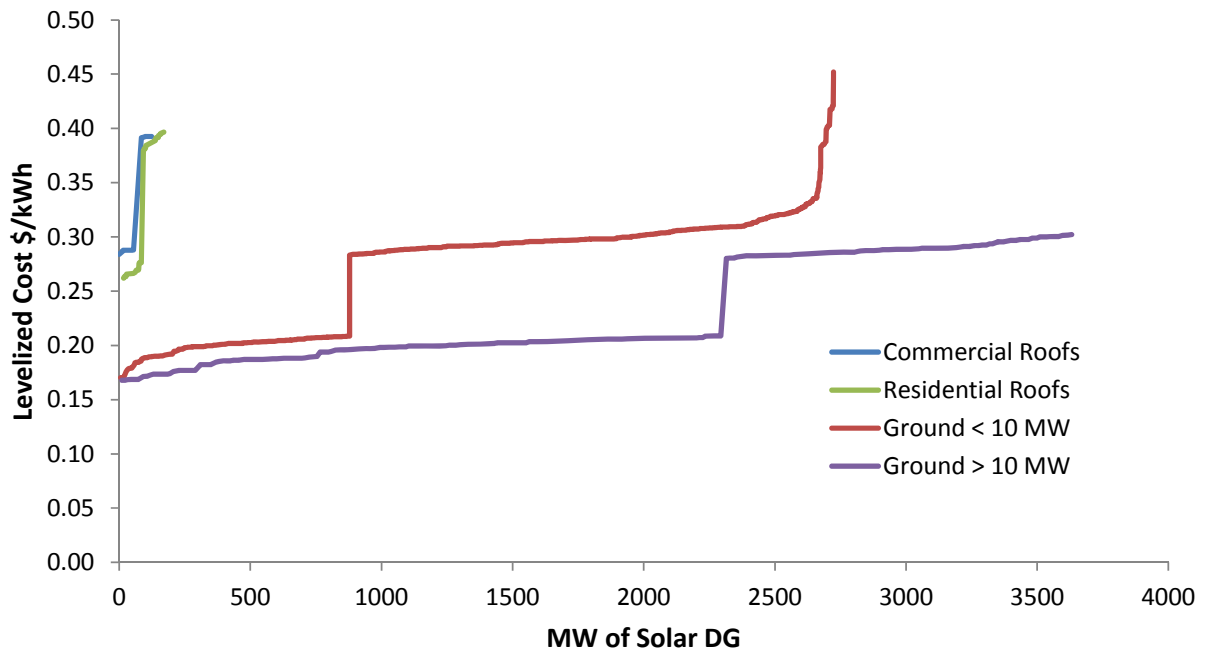
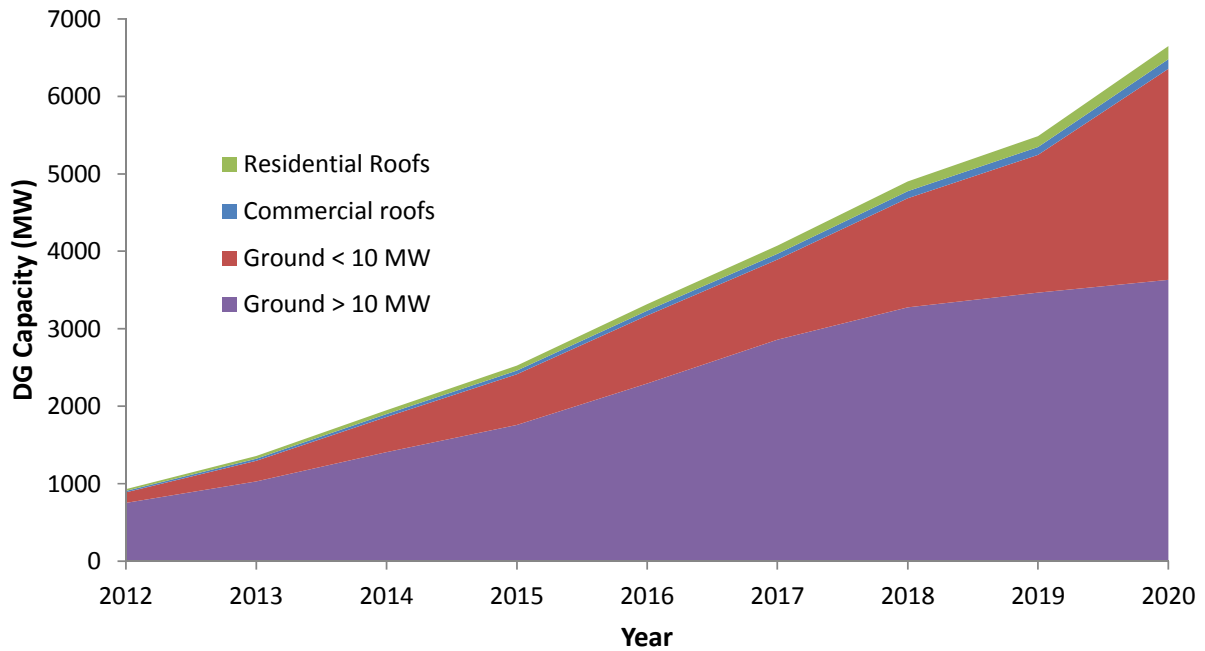
Least Net Cost Summary Table, 5% Curtailment Interconnection Constraint

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

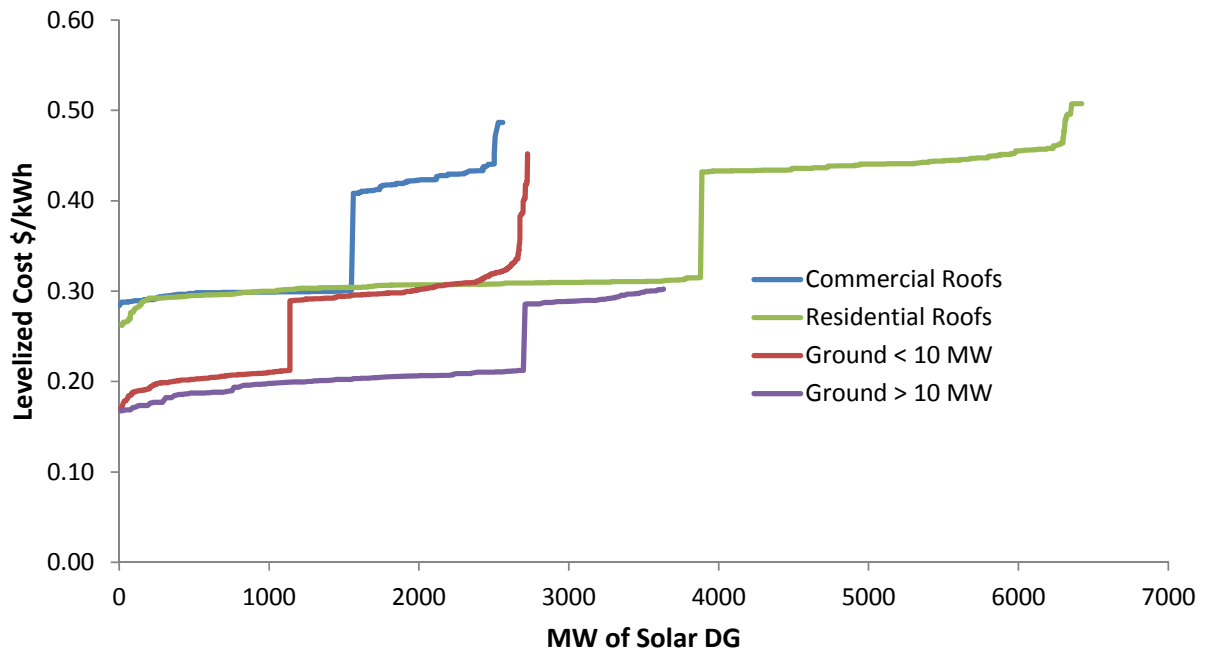
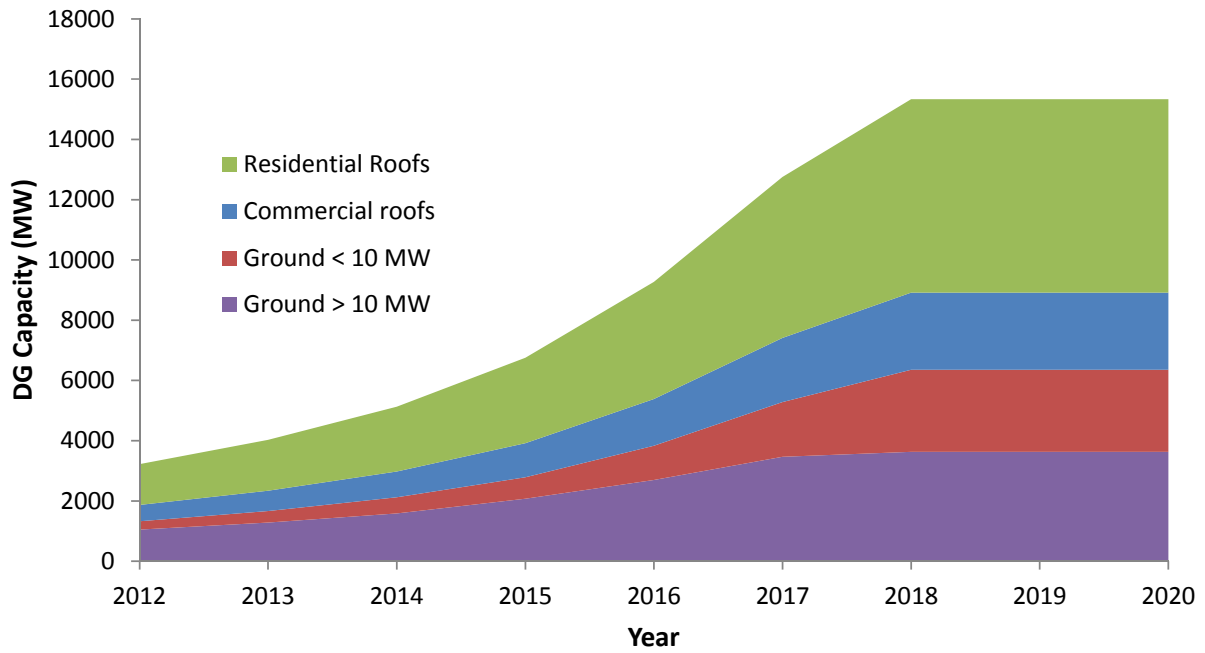
Least Net Cost Summary Table, Low Adoption Rate

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.

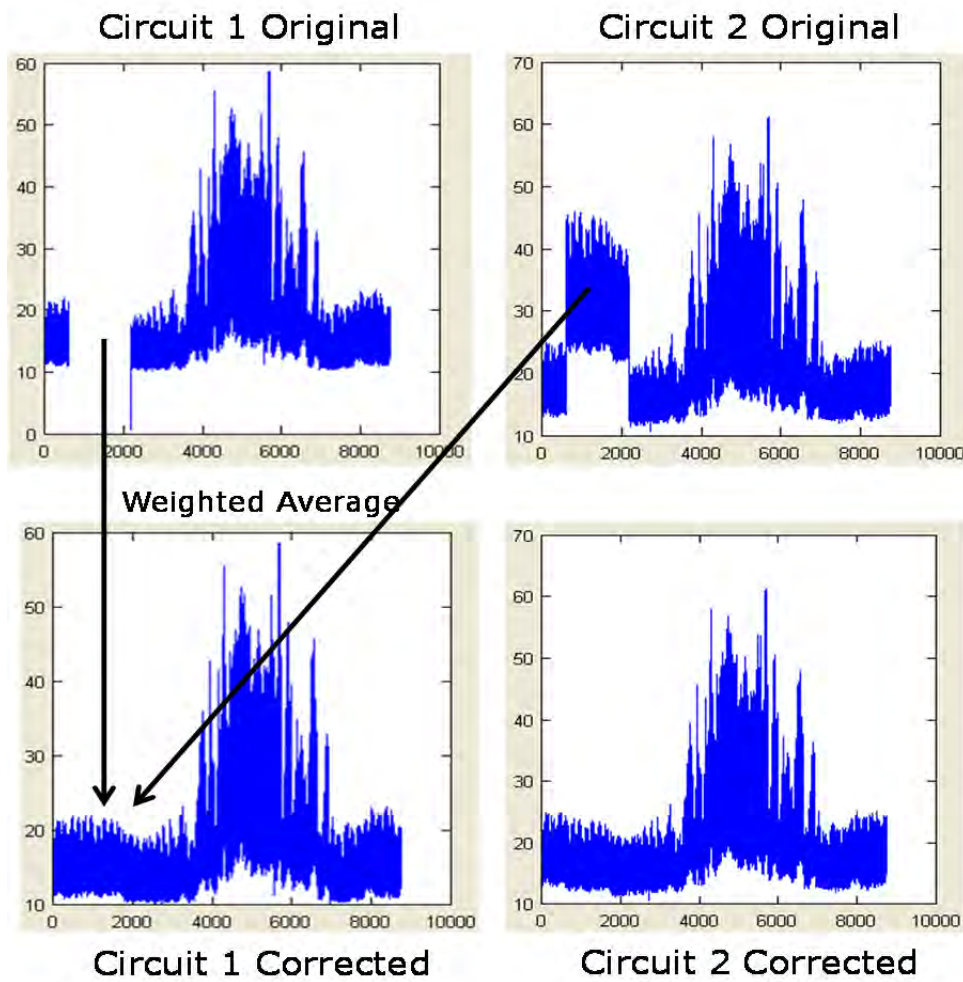
Utility	# of Substations	# with Peak Load Values	# with 8760 Load Curves
PGE	1,019	1,019	24
SCE	680	677	400
SDGE	105	101	20
<i>Total</i>	<i>1,804</i>	<i>1,797</i>	<i>444</i>

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

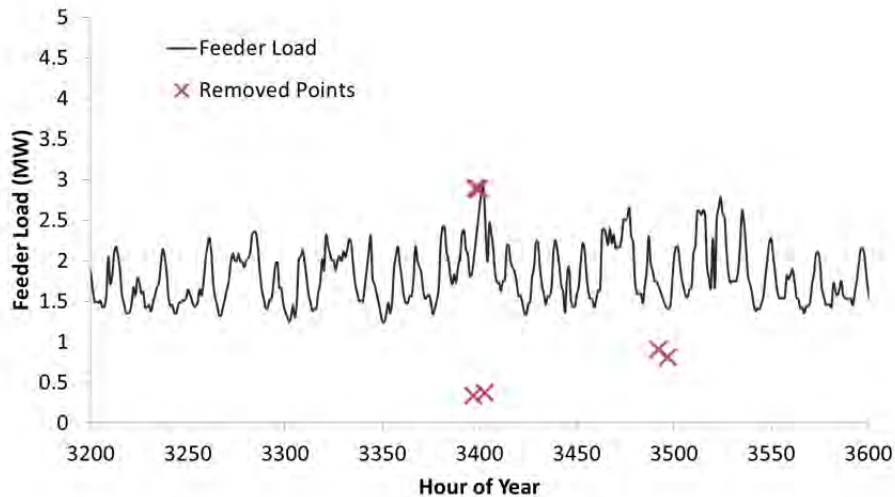
Not all of the provided hourly substation load profiles were suitable for determining available DG capacity; in some cases data were missing or required cleaning. In cases where load from one feeder was obviously shifted to another, we move the load back to the original feeder (see Figure 1).

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

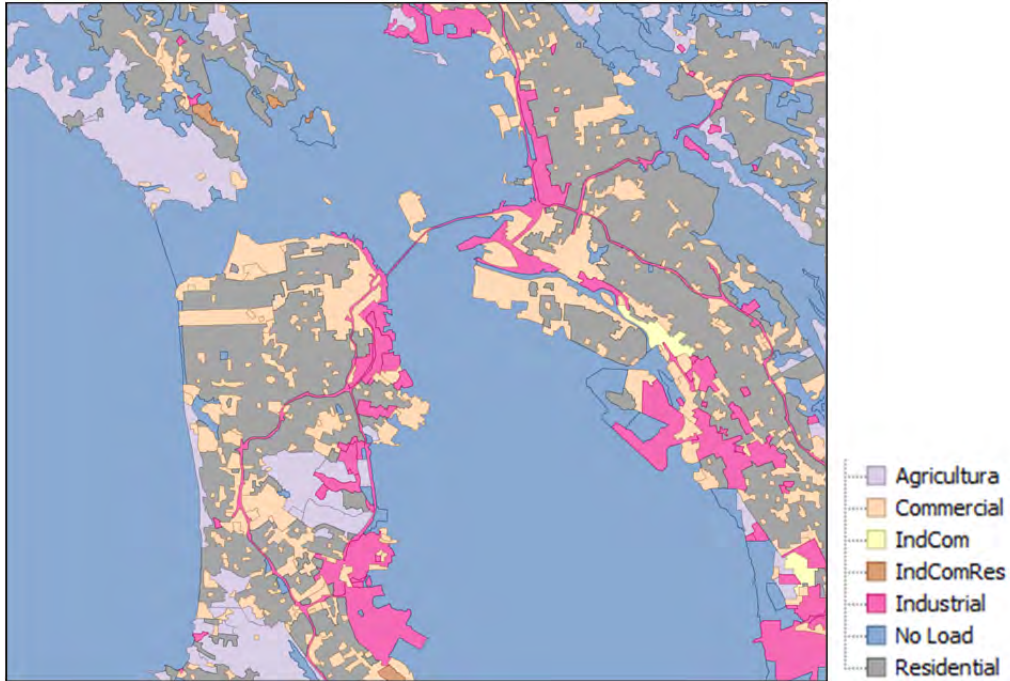
Finally, we estimated minimum hourly load based on the average load provided in the clean shapes. Only PG&E provided minimum (and maximum and mean) load for each hour of the year for each of their readings. We used the PG&E data to develop an hourly distribution of the difference between average and 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:

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

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:

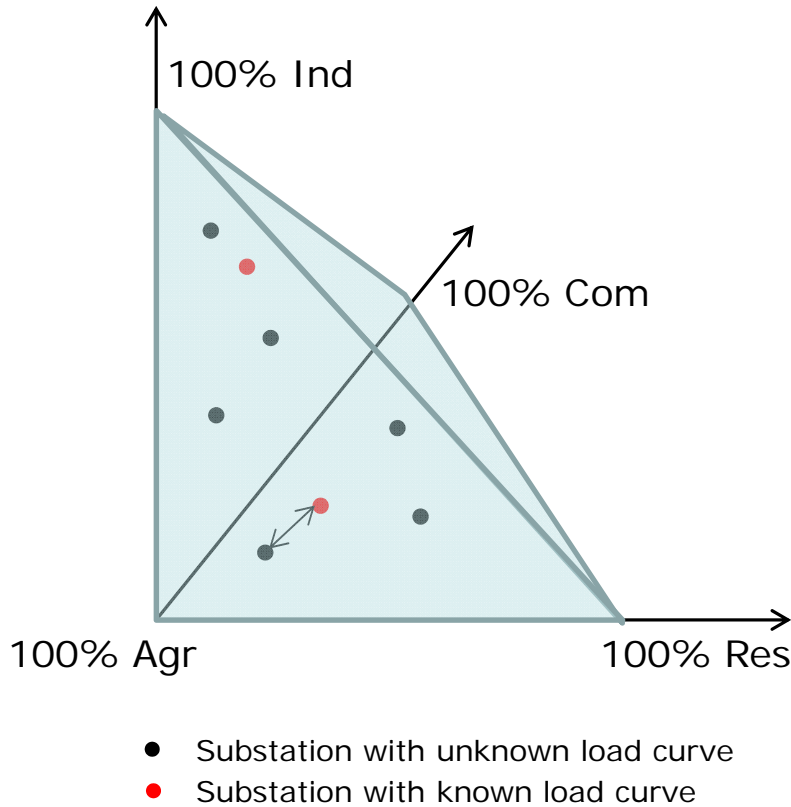
$$Res\ Contribution = \frac{Area \times \beta_{res}}{\sum_i Area_i \beta_i}$$

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

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

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.

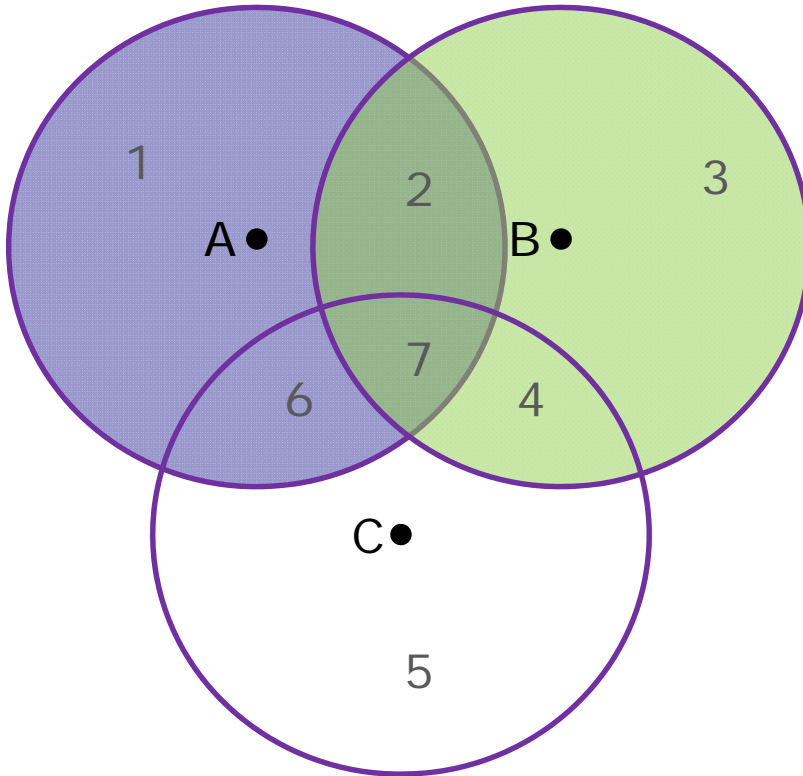
However, in many cases, the rooftop or vacant land is within the radius of more than one substation (see, for example, Figure 6). In such cases, we must select which of the overlapping substations will receive the PV in the overlapping areas.

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

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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

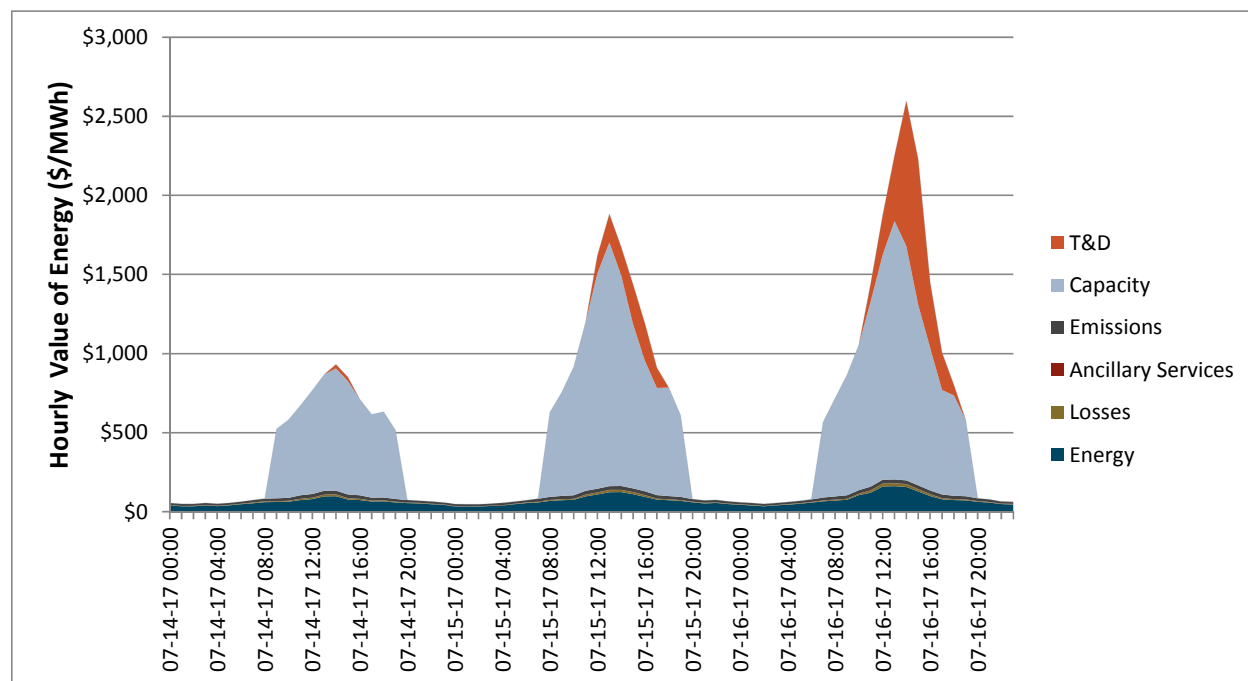


Figure 2 shows average monthly value of electricity reductions, revealing the seasonal characteristics of the avoided costs. The energy component dips in the spring, reflecting increased hydro supplies and imports from the Northwest; and peaks in the summer months when demand for electricity is highest. 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

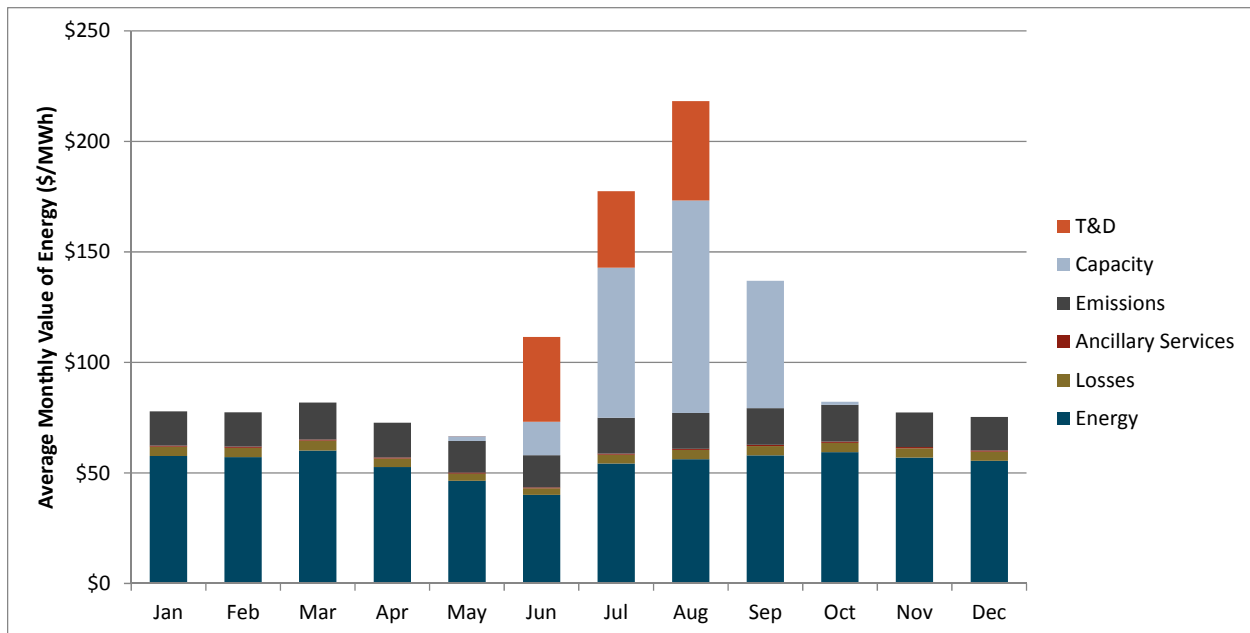
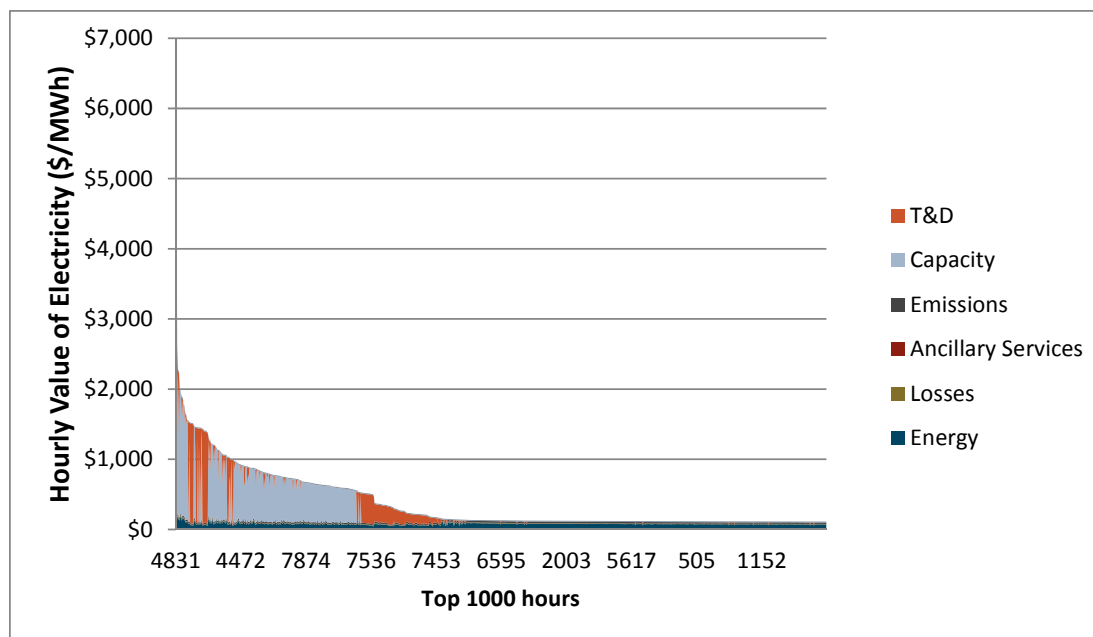


Figure 3 shows the components of value for the highest value hours in sorted order of cost. This chart shows the relative contribution to the highest hours of the year by component. Note that most of the high cost hours occur in approximately the top 200 to 400 hours—this is because most of the value 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 shape¹, 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

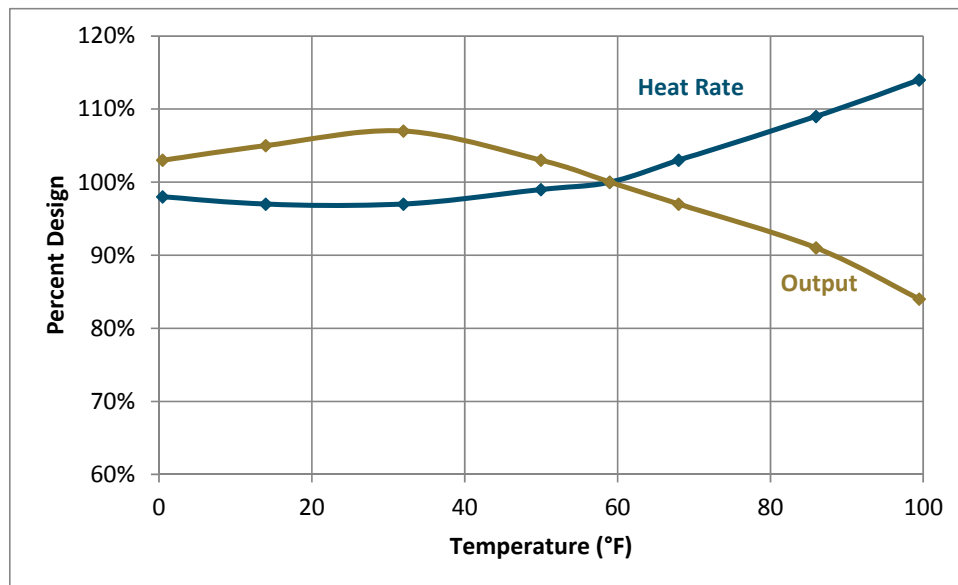
The CT's rated heat rate and nameplate capacity characterize the unit's performance at ISO conditions,² but the unit's actual performance deviates substantially from these ratings

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 59°F, 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:

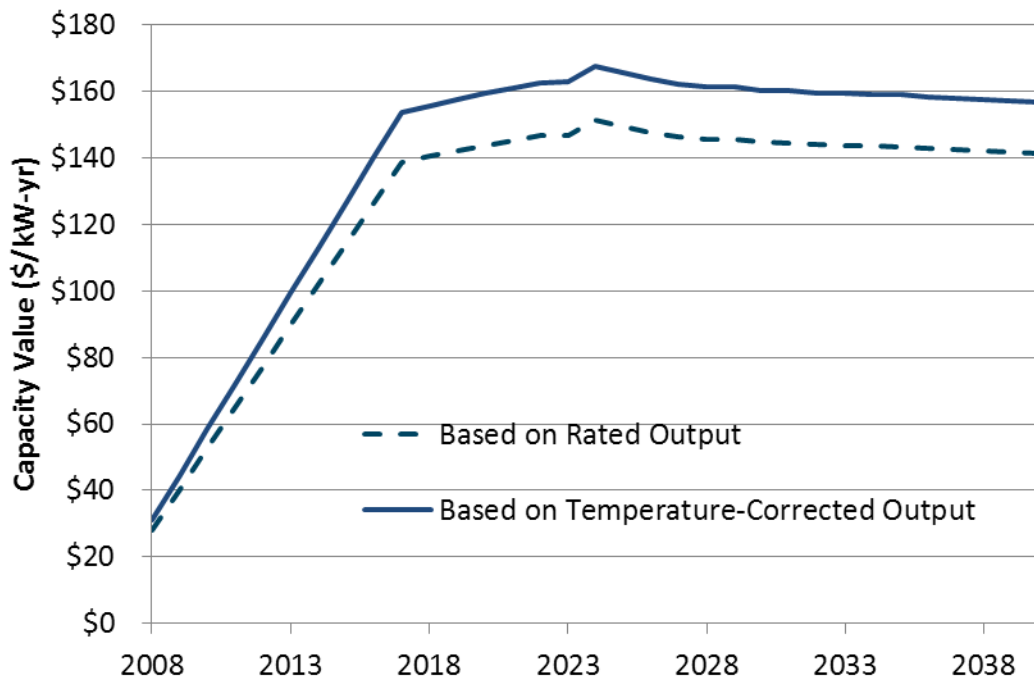
- In the calculation of the CT's dispatch, the heat rate is assumed to vary on a monthly basis. In each month, E3 calculates an average day-time temperature based on hourly temperature data throughout the state and uses this value to adjust the heat rate—and thereby the operating cost—within that month.
- 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.

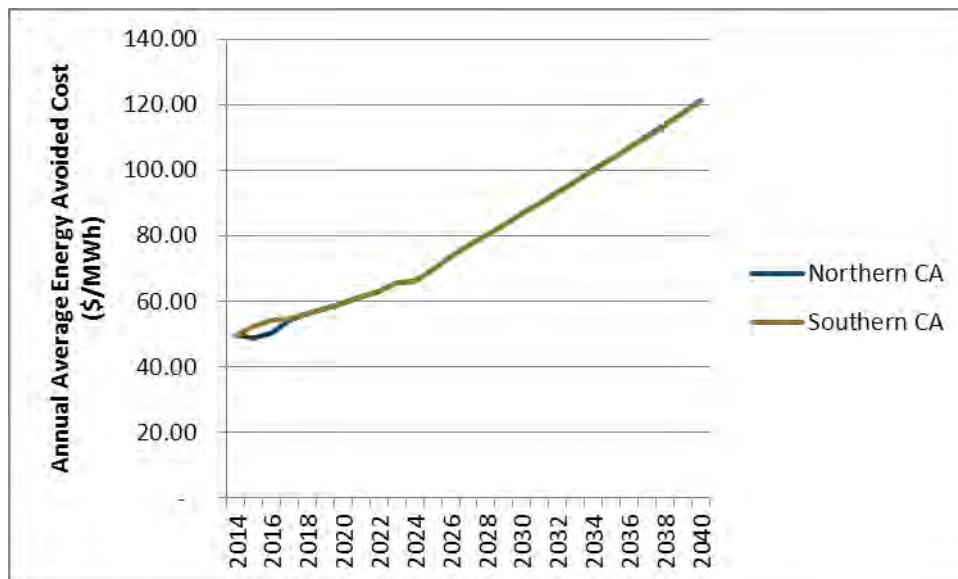
Assume that the CCGT would collect more revenue through the capacity and energy markets than is needed to cover its costs. The methodology decreases the calibration factor to decrease the day-ahead energy market prices and market revenues to make the CCGT whole. To keep the real-time and day-ahead markets 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 repeats³.

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

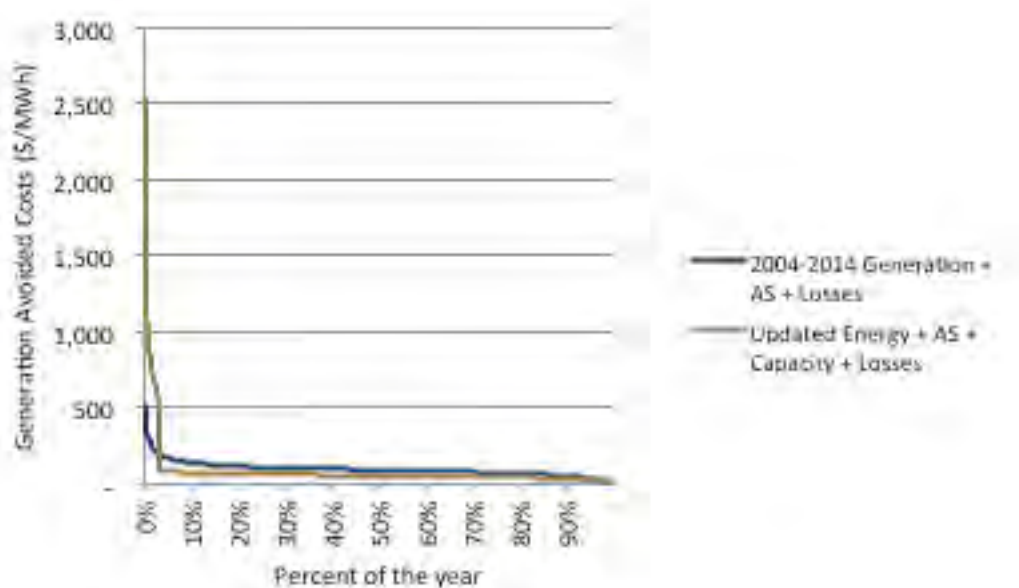


Hourly Shaping of Energy Costs

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.

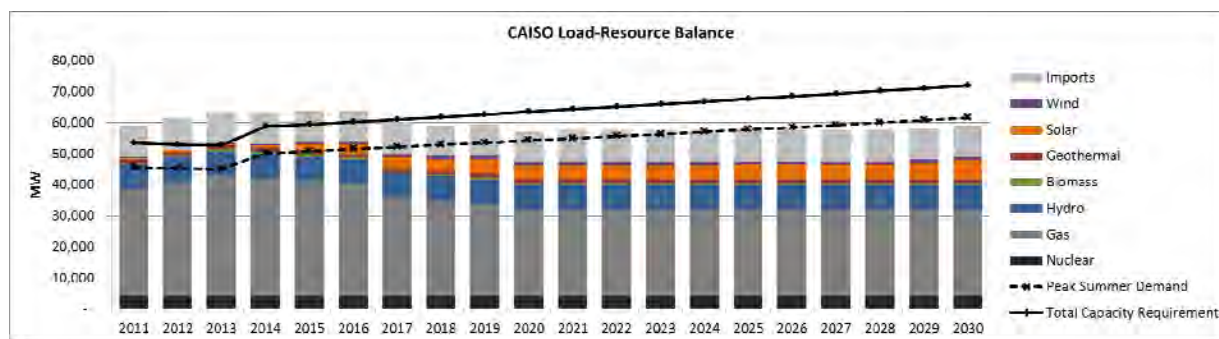
Figure 7: Hourly Generation Avoided Costs for 2017



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



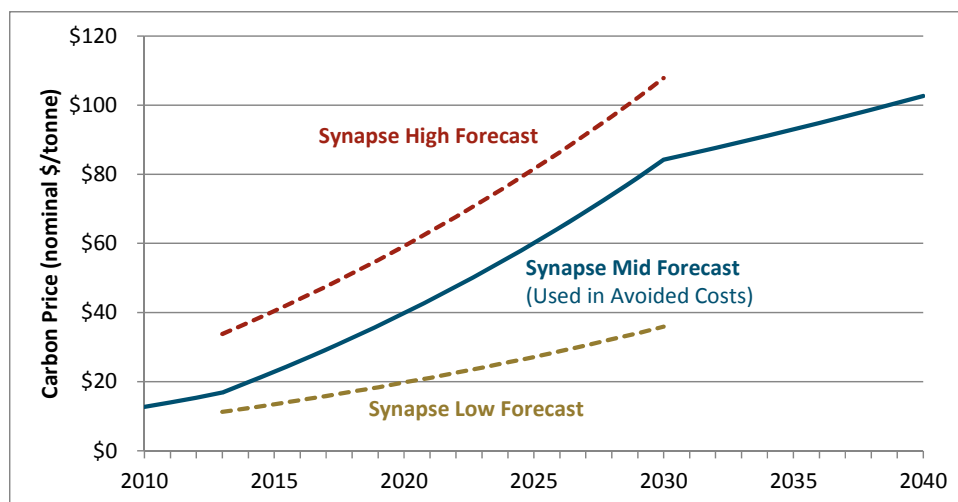
Environment

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

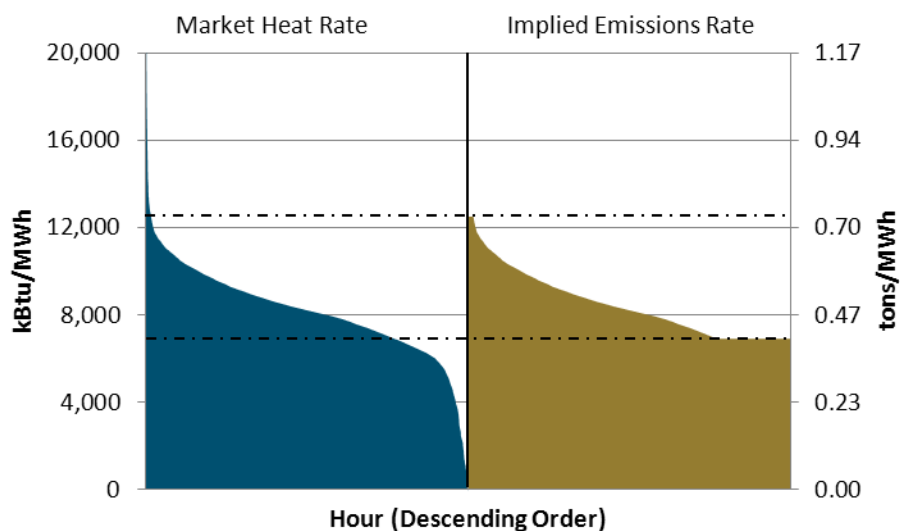


Assuming that natural gas is the marginal fuel in all hours, the hourly emissions rate of the marginal generator is calculated based on the day-ahead market price curve. The link between higher market prices and higher emissions rates is intuitive: higher market prices enable lower-efficiency generators 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.

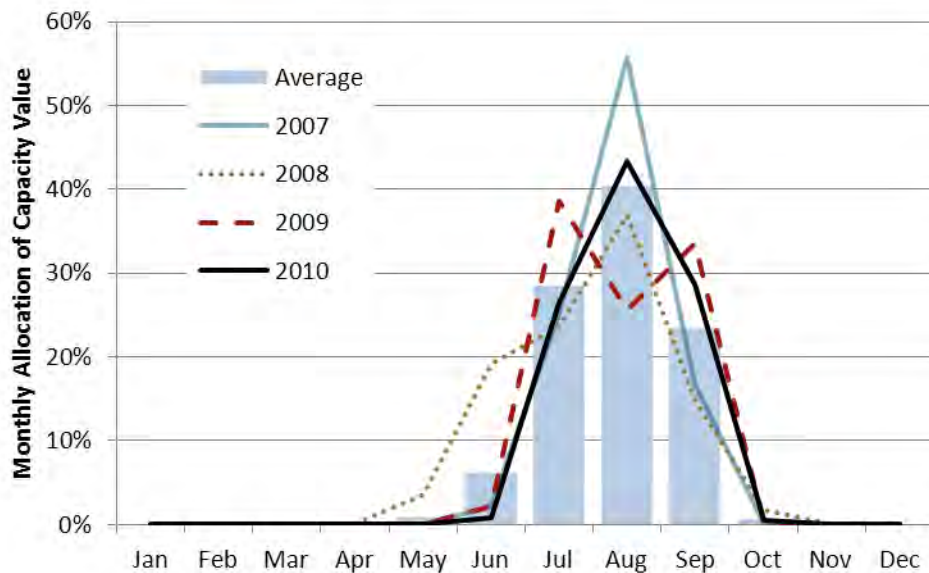
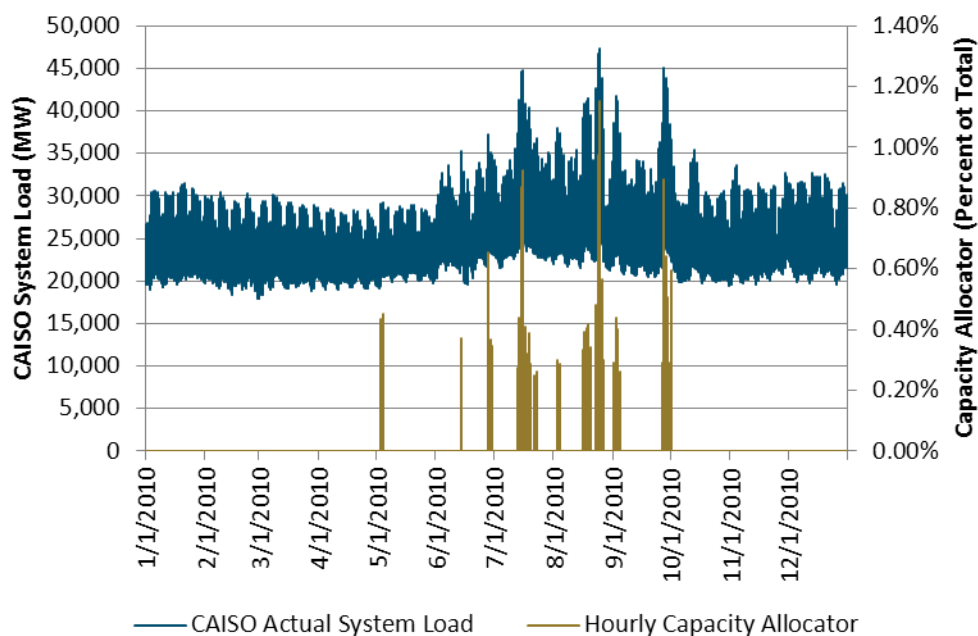


Table 4. Summary of monthly capacity allocation based on historical load data from 2007-2010.

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 Performance⁴, 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.

$$D\text{Cost}[p] = PV(\text{Invest}[p][y] * (1 - ((1+i)/(1+r))^{\text{delta}T}) / \text{delta}L * \text{CRFR}$$

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

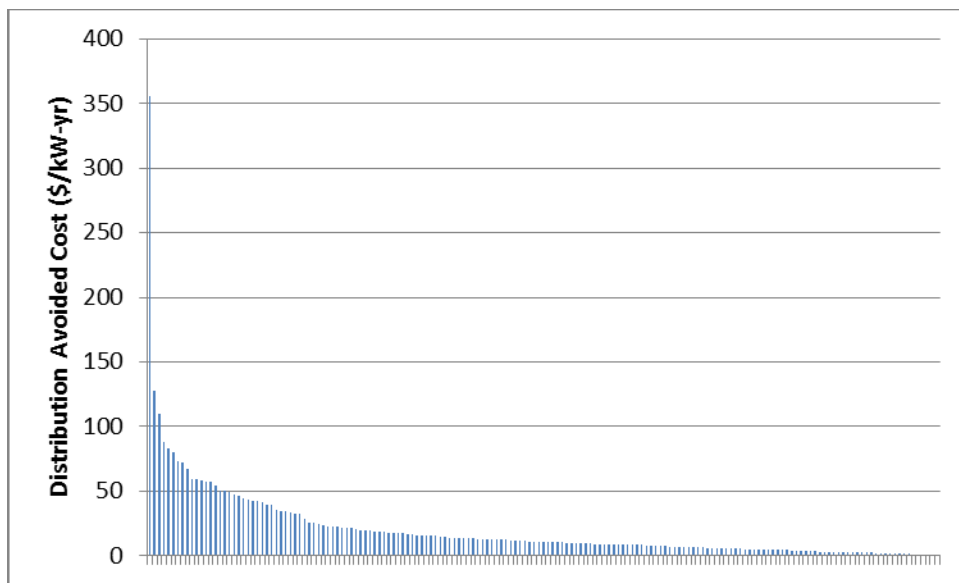


Figure 14 shows SCE's distribution avoided costs. SCE's distribution system is more flexible and interconnected than a typical radial system. Because of the flexibility in system reconfiguration,

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

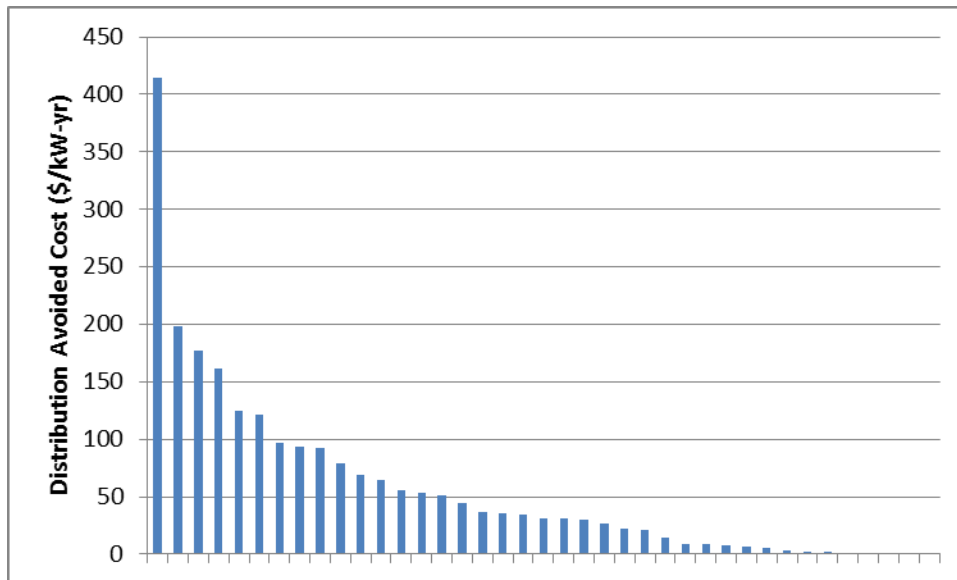
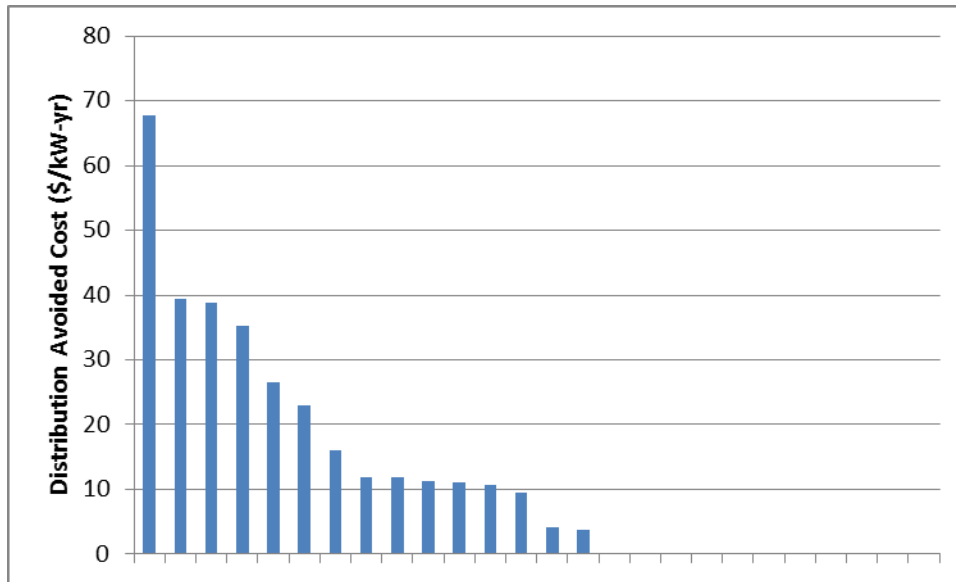


Figure 15 shows SDG&E’s distribution avoided costs. SDG&E’s avoided costs are developed at the substation level. Forecast investment costs for 2011 through 2014 are combined with average forecast substation growth over the same period.

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

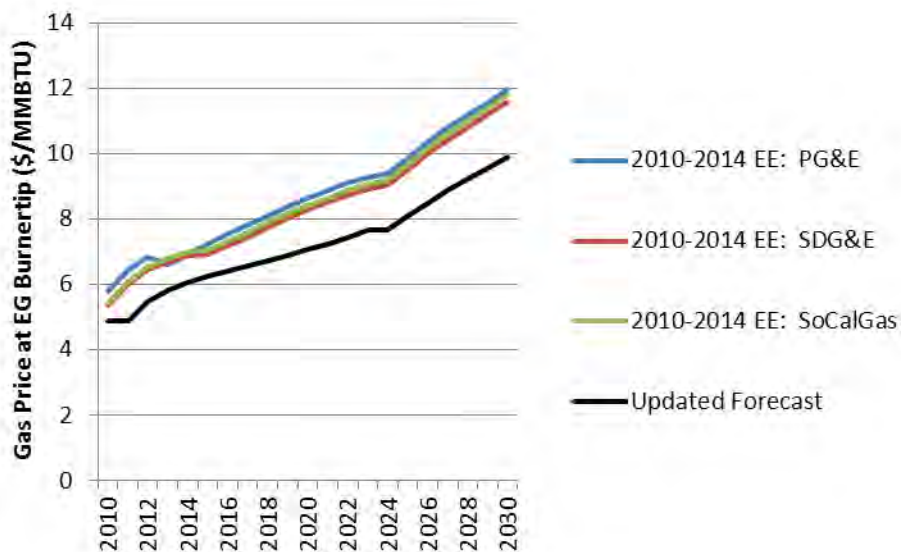
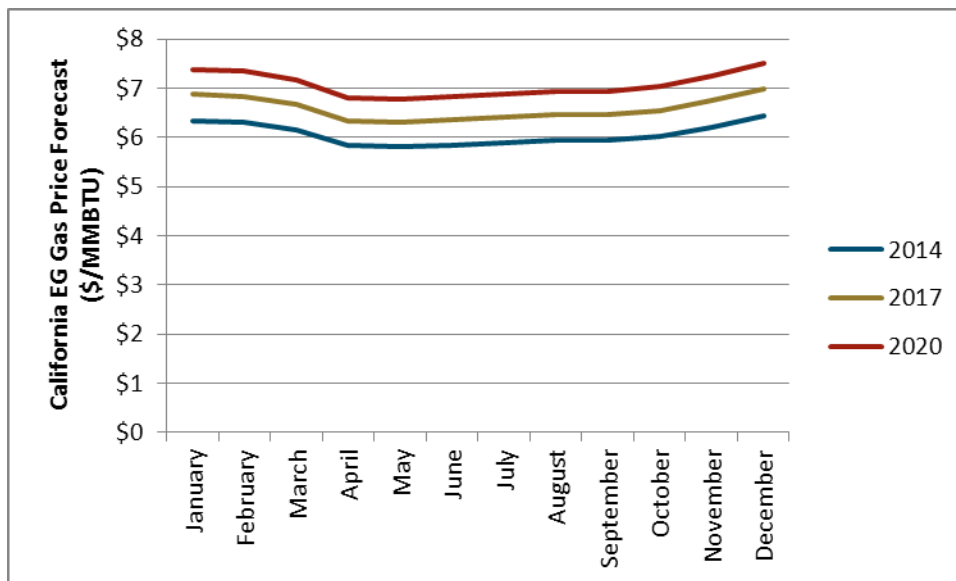


Figure 17. Snapshot of monthly gas price forecast shapes for 2014, 2017, and 2020.



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%

