FINAL EVALUATION REPORT

California Solar Initiative Multifamily Affordable Solar Housing (MASH) Evaluation

California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102

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EVALUATION OF THE CALIFORNIA SOLAR INITIATIVE MULTIFAMILY AFFORDABLE SOLAR HOUSING (MASH) PROGRAM

DNV

BACKGROUND

DNV evaluated the CSI MASH program for the entire duration of the program, from 2008 through 2021. The program sought to reduce energy costs and make carbon-free solar energy more accessible to low-income residents in Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) service territories.

APPROACH AND OBJECTIVES

DNV performed this evaluation to determine whether MASH achieved its program goals and also to assess program benefits to customers, the environment, and the electrical system. In addition, DNV performed an assessment of program costs, workforce training outcomes, and program metrics.

PROGRAM BENEFITS

- Installed solar generation over the life of the program: over 65 MW
- First-year energy production: 57.4 GWh
- Benefits vary from year to year and depend on customer rates and other characteristics. On average:
  - First year dollars paid: $286 less, a 45% reduction per customer
  - First year electricity use from all sources: 246 kWh more per customer, a 5% increase
  - First year electricity use from the grid: 2,669 kWh less, a 43% reduction per customer
- Combined CO_2 savings from 2011 to 2022: 175,680 MT
- Avoided PM2.5 (fine particulate matter) from 2011 to 2022: 10,373 MT
- Hours of solar sector training provided: 17,799

PROJECTS COMPLETED AND CUSTOMERS SERVED

636
projects completed

1/3
projects installed in DACs

16,356
total households served

14,228
multifamily households served

2,128
mobile home households served

2,177
common areas served

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1 EXECUTIVE SUMMARY

This report presents the evaluation of the California Solar Initiative (CSI) Multifamily Affordable Solar Housing (MASH) program for the duration of the program, from 2008 through 2021.

1.1 Background

In 2005 and 2006, the California Public Utilities Commission (Commission) and the California Energy Commission (CEC) collaborated to establish the California Solar Initiative (CSI) to fund rebates for installation of solar energy systems for PG&E, SCE, and SDG&E customers.[1] In Decision (D.) 06-01-024, the Commission required that a minimum of 10% of program funds be utilized to fund projects installed by low-income residential customers and affordable housing projects.[2] The Multifamily Affordable Solar Housing (MASH) program originated out of Assembly Bill (AB) 2723[3] and was established by the California Public Utilities Commission (CPUC) in D.08-10-036 pursuant to Senate Bill (SB) 1 (Murray, 2006).[4] The objective to of the program was to help make carbon-free solar energy more accessible to low-income residents in California. In addition to utility bill reductions, the program also strived to reduce capital costs for property owners through incentives. AB 217[5] (Bradford, 2013) extended the MASH program through December 31, 2021. This evaluation was done in conformance with D.15-01-027[6], which required the CPUC Energy Division (ED) to perform a close of program evaluation.

The program operated in Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and the San Diego Gas & Electric (SDG&E) service territories. In the SDG&E service territory, the program was implemented by a third-party, the Center for Sustainable Energy (CSE).

As stated in D.08-10-036, the initial goals of the program were to:

- Stimulate the adoption of solar power in the affordable housing sector.
- Improve energy utilization and overall quality of affordable housing through the application of solar and energy efficiency technologies.
- Decrease electricity use and costs without increasing monthly household expenses for affordable housing occupants.
- Increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.

In 2013, AB 217 extended the program, which also set the following additional goals:

- Maximize the overall benefit to ratepayers.
- Require participants who receive monetary incentives to enroll in the Energy Savings Assistance (ESA) program.
- Provide job training and employment opportunities in the solar energy and energy efficiency sectors of the economy.
- Achieve 50 megawatts (MW) of installed capacity for the MASH and Single-Family Affordable Solar Homes (SASH) Programs combined.

The MASH program provided fixed, one-time capacity-based incentives for qualifying solar energy systems, using the Expected Performance Based Buydown (EPBB) methodology. Incentives were calculated utilizing the EPBB methodology and paid after the solar project interconnected. Funding did not extend to battery storage systems, as they were not part of the program scope. The program originally offered two tracks: Track 1 (fixed, up front, capacity-based EPBB incentives) and Track 2 (a competitive application process with variable rebates up to 100% of costs and ongoing maintenance costs,

[1] https://docs.cpuc.ca.gov/published/FINAL_DECISION/92455-01.htm

[2] D0601024 Interim Order Adopting Policies and Funding for the California Solar Initiative

[3] AB 2723 (2006), An act to add Section 2852 of the Public Utilities Code relating to energy (ca.gov)

[4] D0810036 Establishing Multifamily Affordable Solar Housing Program Within the California Solar Initiative[5] AB 217 Implementation − Energy Division staff proposal (ca.gov)

[5] AB 217 Implementation − Energy Division staff proposal (ca.gov)

[6] D.15-01-027, Decision Extending the Multifamily Affordable Solar Housing and Single Family Affordable Solar Homes Programs with the California Solar Initiative (January 29, 2015).

requiring demonstrated tenant benefits.) Track 2 was eventually closed, and all remaining funds were reallocated to Track 1 due to higher demand.[7] Track 1 offered two incentive levels: Track 1A was developed for systems that offset common area load, while Track 1B was used for systems that offset tenant load. To create distinction between the two phases of MASH, the program refers to the initial phase of MASH as “MASH 1.0” and the second phase described below as “MASH 2.0.”

In D.15-01-027, the CPUC established new incentive levels under Track 1C and Track 1D.[8] Track 1C was designed for solar energy systems that offset common area load, non-virtual net metering tenant load or virtual net metering (VNEM) tenant load with less than 50% tenant benefit.[9] Track 1D was designed for solar energy systems that offset VNEM tenant load with at least 50% tenant benefit. Given the higher incentive levels allocated for Track 1D and the established install capacity goal, Track 1D was not offered after 80% of the total incentive funding was reached.

1.2 Objectives

Through this evaluation, DNV seeks to determine whether MASH achieved its program goals and assess program benefits to customers, the environment, and the electrical system. In addition, we performed an assessment of program costs, workforce training outcomes, and program metrics. We provided a geographic breakdown of these benefits, including those located in disadvantaged communities (DACs).

1.3 Approach

Program cost assessment: DNV conducted a cost assessment to determine the financial outcomes of the program. Data sources for this assessment included the MASH Handbook[10], program tracking data, California Distributed Generation Statistics (DGStats) data, and program staff interviews. We performed an analysis to determine planned versus actual spending, as well as an assessment of spending across program components, including administration, marketing, measurement, and incentives. We also performed a total resource cost (TRC) test to determine program cost effectiveness.

Total electrical system benefits: To assess the electrical system benefits, we considered both electric generation and avoided cost estimates. For electric generation, we used solar photovoltaic (PV) system modeling of the net energy metering (NEM) sites and individual system interval data for VNEM sites. Avoided cost estimates were generated using the 2011 and 2021 Distributed Energy Resources Avoided Cost Calculators (ACC).[11]

Total environmental benefits: We performed an assessment of environmental benefits associated with solar installation and resulting generation incentivized under the program. We used marginal carbon dioxide (CO_2) emissions data available for each California’ IOU through the California Self-Generation Incentive Program (SGIP).[12] To estimate avoided carbon emissions by season and by year, we combined hourly marginal emissions with the hourly solar generation profiles. We also used California Air Resource Board (CARB) calculators for solar PV to estimate other pollutants, including nitrogen oxide (NO_x), reactive organic gas, and particulates. We also developed a dollar value for avoided CO_2 emissions.

Total workforce outcomes: The program had specific workforce training requirements, which varied by the size of the system installed. To determine program workforce outcomes, we reviewed a sample of the job training affidavits and summarized the total number of workers trained, hours worked, and types of job tasks.

[7] D1107031 California Solar Initiative Phase One Modifications

[8] CPUC D. 145938475.PDF (ca.gov)

[9] Virtual Net Metering (VNEM) are tariffs available to a combination of a renewable electrical generation facility and a group of benefitting accounts, where the meters for the benefitting accounts are separate from the generation meters.

[10] MASH Handbook

[11] CPUC, willdan.app.com, https://willdan.app.box.com/v/2021CPUCAvoidedCosts/folder/136593940728

[12] http://sgipsignal.com/download-data

Total customers served: To evaluate benefits to program customers, we used program tracking data and customer data to determine the number of multifamily units and properties served, the number of households served, and the location of properties served. We also looked at DAC and California Alternate Rates for Energy (CARE) program status and sorted properties by program phase (MASH 1.0 or MASH 2.0) and by property type and size.

System characteristics by customer type: The evaluation also looked at the system characteristics by customer type. To do this, we looked at the dollar value of award (incentive), program phase, interconnected solar capacity (kW_{AC}), property type, and interconnection meter type (i.e., common area, tenant, VNEM tenant) for each qualifying project. We computed system capacity (i.e., "Size Rating") based on the formula defined in the MASH Handbook:

> *Size Rating (kilowatts) = Quantity of Photovoltaic Modules x CEC Rating of Photovoltaic Modules x CEC Inverter Efficiency Rating/ 1000 (watts/kilowatt)*

We also estimated post-installation electric consumption for benefiter based on their own data meter. Post-installation consumption was calculated as follows:

> *Post-installation electric consumption =*
> *Energy produced by the solar system (directly metered[13] -preferred- or estimated) + Energy taken from the Grid (Energy "delivered" from AMI data) – Energy sold back to the Grid (Energy "received" from AMI data)*

In addition, we compared minimum, maximum, and average incentive level per system capacity ($/kW), and exported allocations by meter type, computed post-installation consumption, compared pre-installation consumption to post-installation consumption by program and by meter type, and quantified the number of participants enrolled in ESA.

Bill reduction outcomes: DNV conducted an analysis to determine customer bill impacts owing to program installations. The assessment quantified changes in energy use and energy expenses in VNEM "benefiters" (tenants and common areas that receive bill credits due to the MASH program.) We analyzed the difference in weather-normalized pre- and first year post-installation energy use for tenants and common areas. We estimated the average amount that energy bills were reduced per common area or tenant (both in dollars and kilowatt hours). We also estimated these bill impacts by CARE vs. Non-CARE customers. It is not possible to estimate these savings for master-metered properties, as these are actual NEM customers, where the energy use recorded is net, not actual, and we do not have visibility to each benefiters' energy use.

Program process metrics: Finally, we summarized the program process by the number of applications received, approved, declined, and withdrawn in total, by Program Administrator (PA), and by year. We reviewed common reasons for denial or withdrawal of applications. Also, we compared program achievements against stated goals.

1.4 Key findings

The table below presents our key findings.

Key findings	Report location	Implication
Data issues, including the disconnect between program tracking ("PowerClerk") data and billing and AMI systems, and incomplete datasets caused delays and issues with completing the evaluation.	Section 5	To better evaluate programs going forward, more comprehensive, clean, and uniform data would be helpful.

[13] Directly metered solar systems include VNEM, which requires a standalone meter, and Performance Monitoring Reporting Service (PMRS) required by MASH.

Key findings	Report location	Implication
The MASH program installed over 65 MW of solar generation over the life of the program.[14]	Section 4.1	The MASH program exceeded the combined 50MW goal set for the SASH and MASH programs.
Incentives to participants accounted for 93.7% of the total program expenditures.	Section 4.1	Program funding was efficiently distributed to promote the goals of the program.
Ninety-three percent of marketing, education, and outreach (ME&O) expenditures occurred prior to 2016 in the MASH 1.0 program.	Section 4.1	The initial marketing initiatives were successful enough to limit future marketing efforts.
Years with highest program expenditures coincided with years of highest number of project installs.	Section 4.1	Supports the implication that the funding was primarily used to pay incentives for complete and operational projects. This also implies increased administration was needed to process applications and incentive payments.
Average administrative costs were lower in MASH 2.0.	Section 4.1	Indicates efficiency gains in the administration of the program.
Average incentives and average project cost per kW installed generally decreased with size of the installations.	Section 4.1	Lower average costs per kW installed indicates the presence of economies of scale in project development and installation. Lower average incentives for larger projects implies effective program design.
Average total project costs decreased by 52% from 2009 to 2022. Comparing the year with the highest avg. cost/kW (2010) against the year with the lowest avg. cost/kW (2020), the average total cost decreased by 65%.	Section 4.1	Lower average costs per kW installed indicates a reduction in hard and soft costs, and a maturing market.
The benefit cost ratio using the TRC over the entire program was 0.43.	Section 4.2	The benefits generated by the program were less than the costs incurred by the program and program participants.
Overall, the first-year production realization rate was 65%.	Section 4.3	Indicates that the solar production of the installed systems was overstated in many of the applications.
The utilities had a combined CO_2 savings of 175,680 metric tons.[15]	Section 4.4	This accounts for avoided cost emissions of $5,829,469 (2022$) from 2011 through 2022.
In nearly all cases, the average number of trainees per project met or exceeded program requirements.	Section 4.5	Indicates the program participants and program met job training requirements. However, most projects simply met the requirements.
Most trainees participated in solar installation or project management/coordination. However, most training hours were dedicated to solar installation training, with 25% more training hours than project management. Project design and engineering trained the fewest workers but provided the greatest number of training hours per trainee.	Section 4.5	On the job training may have struck a balance between more trainees in areas that are easier or less expensive to train and where more hours are required i.e., installation.
Solar job training appears to be successful overall but lacked proper documentation.	Section 4.5	Without primary research, we cannot determine the quality of the workforce training efforts or if they led to successive employment opportunities after the program ended. Also, our analysis can neither confirm nor deny if an individual received training on multiple projects, due to the lack of trainee names in tracking documentation.

[14] Source: MASH and SASH applications for completed projects.

[15] This estimate accounts for the lower realization rate.

Key findings	Report location	Implication
Projects with NEM metering were most frequently used to offset common area load, while VNEM projects mostly served both common area and tenant loads. MASH 2.0 projects were larger and benefited from more common areas and tenant units (per project and kW) than MASH 1.0 projects.	Section 4.6	Indicates that the VNEM provides the opportunity to offset energy costs and load for a larger number of participants.
Based on applications submitted, more than 16,000 households in affordable housing properties or mobile home communities are directly benefitting from MASH projects. Additionally, more than 2,000 common areas are benefitting. Mobile home properties represent 9% of MASH projects.	Section 4.6	Indicates there was more interest from multifamily properties than mobile home communities to participate in the program.
MASH projects were concentrated near major metropolitan areas: San Francisco, Los Angeles, and San Diego. Overall, about 30% of the projects were installed in DACs.	Section 4.6	Indicates developers are more likely to work in major metropolitan areas with larger multifamily housing dwellings.
The majority of MASH projects support medium properties (i.e., properties with 11-99 residential units), followed by large-sized properties, then small properties.	Section 4.6	Supports one PA's observation that contractors typically solicited property owners with larger portfolios.
On average, customers used more energy under the program but paid less on their electricity bills.	Section 4.8	In a low-income situation where some customers were likely previously using less energy than is healthy and safe, this is a desirable outcome.
Customer share of solar energy produced is a function of both system capacity and number of participating tenants, which varies within the same MASH project for a few projects.	Section 4.8	Tenants received a proportional share of the energy produced that was distributed among all tenants according to MASH rules and the physical characteristics of the installation. In some complexes with multiple solar meters, some meters had more tenants allocated than others, which resulted on a lower allocation per tenant compared to other tenants served by the same project.
Across all PAs, 38% of all submitted applications resulted in completed projects.	Section 4.9	The remaining 62% of projects were not completed for a variety of reasons including cancellation, withdrawal, waitlisting, or ineligibility. The large percentage of projects not moving forward may be due to the large number of applications on the MASH 1.0 waitlist. The CPUC decision creating MASH 2.0 stated MASH and SASH projects on the waitlist should be given 30 days from the date requested by the PA to provide documentation of meeting the new program requirements and an additional 10 days to cure from the date the PA notifies them that their documentation was insufficient or incomplete before being removed from the queue. This decision led to many cancelled and withdrawn projects in 2015 and 2016.

Because MASH is now closed, DNV has focused on recommendations that could improve future solar programs. To better evaluate programs going forward, more comprehensive, clean, and uniform data would be helpful. In Section 5, we have provided details of the data issues our team experienced to give greater context on evaluating a solar program with multiple PAs and to improve efforts going forward.

2 INTRODUCTION

This report presents DNV's evaluation of the California Solar Initiative (CSI) Multifamily Affordable Solar Housing (MASH) program for the duration of the program, from 2008 through 2021. The objectives of this assessment were to determine if the program met its goals and to examine its benefits to customers, the environment, and the electrical grid. The evaluation also includes an assessment of program costs, workforce training outcomes, and program process metrics related to the application process and the types of customers and properties served.

2.1 MASH program background

In 2005 and 2006, the California Public Utilities Commission (CPUC or Commission) and the California Energy Commission (CEC) collaborated to establish the California Solar Initiative (CSI) to fund rebates for installation of solar energy systems for PG&E, SCE, and SDG&E customers.[16] In Decision (D.) 06-01-024, the Commission required that a minimum of 10% of program funds be utilized to fund projects installed by low-income residential customers and affordable housing projects.[17] The MASH program was established by the CPUC in D.08-10-036.[18] Under the ratepayer-funded CSI, the MASH program helped make carbon-free solar energy more accessible to many low-income residents in California. In addition to reducing customer utility bills, the program also helped reduce capital costs for property owners through incentives. The program was established in 2008 and operated through the end of 2021, though MASH Program Administrators (PAs) were permitted to complete viable projects through 2022.[19] Although the program closed December 31, 2021, MASH virtual net metering (VNEM) tariffs in Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and the San Diego Gas & Electric (SDG&E) territory remain open for new enrollments, if the projects satisfy the MASH eligibility criteria.[20]

The MASH program was established to provide upfront solar incentives in the form of a one-time rebate paid at the time of project completion to the property owners of qualifying affordable multifamily housing residences. Funding did not extend to battery storage systems, as they were not part of the program scope. The program was overseen by the CPUC and administered by PG&E, SCE, and the Center for Sustainable Energy (CSE) in SDG&E's service area. As stated in D.08-10-036, the goals of the program were to:

- Stimulate the adoption of solar power in the affordable housing sector.
- Improve energy utilization and overall quality of affordable housing through the application of solar and energy efficiency technologies.
- Decrease electricity use and costs without increasing monthly household expenses for affordable housing occupants.
- Increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.

In 2013, the program was extended by AB 217[21], which also added the following goals:

- Maximize the overall benefit to ratepayers.
- Require participants who receive monetary incentives to enroll in the Energy Savings Assistance (ESA) program.
- Provide job training and employment opportunities in the solar energy and energy efficiency sectors of the economy.
- Achieve 50 megawatts (MW) of installed capacity for the MASH and Single-family Affordable Solar Homes (SASH) programs combined.

16 https://docs.cpuc.ca.gov/published/FINAL_DECISION/92455-01.htm

17 D0601024 Interim Order Adopting Policies and Funding for the California Solar Initiative

18 D0810036 Establishing Multifamily Affordable Solar Housing Program Within the California Solar Initiative

19 Multifamily Affordable Solar Housing (ca.gov)

20 Virtual Net Metering (VNEM) are tariffs available to a combination of a renewable electrical generation facility and a group of benefitting accounts, where the meters for the benefitting accounts are separate from the generation meters.

21 AB 217 Implementation − Energy Division staff proposal (ca.gov)

D.15-01-027[22] established a $54 million solar incentive program for MASH, pursuant to AB 217, with the same amount allocated to SASH. The decision also allocated 93% of MASH's budget ($50,220,000) to incentives, while the remaining 6% ($3,240,000) was designated for administration and marketing and 1% for ($540,000) for evaluation activities. The program's budget breakdown by PA is described in Table 2-1.

Table 2-1 MASH total program budget by PA[23]

Program administrator	% of total budget	Budget
PG&E	43.7%	$ 23,598,000
SCE	46.0%	$ 24,840,000
SDG&E	10.3%	$ 5,562,000
Total	**100.0%**	**$ 54,000,000**

The original program design offered two tracks: Track 1 and Track 2. Due to higher demand for Track 1, D.11-07-031 closed Track 2 and all remaining funds were reallocated to Track 1.[24] Track 1 offered two incentive levels: Track 1A was developed for systems that offset common area load, while Track 1B was used for systems that offset tenant load. To create distinction between the two phases of MASH, throughout this report we refer to this initial phase of MASH as "MASH 1.0" and the second phase described below as "MASH 2.0." In 2015 D.15-01-027 established new incentive levels, Track 1C and Track 1D.[25] Track 1C was designed for systems that offset common area load, non-virtual net metering tenant load or VNEM tenant load with less than 50% tenant benefit. Track 1D was designed for systems that offset VNEM tenant load with at least 50% tenant benefit. To reach the installed capacity target, Track 1D could utilize no more than 80% of the incentive budget. We have described additional distinctions between the two tracks below in Table 2-2.

Table 2-2 MASH program descriptions by track

Track	Incentive rate per installed watt (EPBB)	Eligibility requirements
1C: PV system offsetting common area load, non-VNEM tenant load, or VNEM tenant load with less than 50% tenant benefit[26]	$ 1.10	• Provide job training opportunities (JTOs) to more than one trainee, with one additional trainee for each 10 kW up to 50 kW. • Conduct onsite walkthrough energy audit at American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Level I or higher, or enroll in a utility, regional energy network (REN), community choice aggregator (CCA), or federally provided whole-building multifamily energy efficiency program. • Portion of system allocated to offsetting one of the following: o Common area load o Non-VNEM tenant load o VNEM tenant load where tenant receives less than 50% of the economic benefit of allocated generation
1D: PV system offsetting VNEM tenant load with at least 50% tenant benefit.	$1.80	• Provide job training opportunity to more than one trainee, with one additional trainee for each 10 kW up to 50 kW. • Conduct onsite walkthrough energy audit at ASHRAE Level I or higher, or enroll in a utility, REN, CCA, or federally provided whole-building multifamily energy efficiency program. • Portion of PV system allocated to offsetting: o VNEM tenant load where tenant receives at least 50% of economic benefit of allocated generation

22 145938475.PDF (ca.gov)
23 MASH Handbook
24 D1107031 California Solar Initiative Phase One Modifications
25 145938475.PDF (ca.gov)
26 Note, Common Area Load and Non-VNEM Tenant Load may be master metered.

2.2 Evaluation objectives

We have listed the key goals and objectives of the evaluation below.

1. Assess program costs including program expenditures and uncommitted balances by program component (i.e., administration, marketing, incentives, etc.), and calculate cost effectiveness.
2. Determine the total electrical system benefits due to the program.
3. Determine the total environmental benefits due to the program, using the SGIP/Solar on Multifamily Affordable Housing (SOMAH) and California Air Resource Board (CARB) calculators.
4. Determine the total workforce outcomes due to the program.
5. Summarize program activity by the number of multifamily affordable housing properties and properties that have received a program-subsidized solar system, the number of low-income households served, and the location of the properties, including disadvantaged communities (DACs). Categorize results by size and type of multifamily property.
6. Summarize dollar value of awards, electrical generating capacity of the qualifying renewable energy system, and conduct the following analyses:
    a. Compare common area load, non-VNEM tenant load, and VNEM tenant load (Track 1C projects).[27]
    b. If possible, compare projects by property type (large/small/mobile).
    c. Compute maximum, minimum, and average incentive levels.
    d. Compute maximum, minimum, and average generating capacity by nameplate.
7. Determine bill reduction outcomes for program participants per residence/tenant in dollars and kilowatt hours and summarize results by California Alternate Rates for Energy (CARE)/Family Electric Rate Assistance Program (FERA) vs. Non-CARE/FERA customers.
8. Summarize program metrics including total number of applications received, applications approved, applications declined by PA, and applications withdrawn by customer.
9. Determine progress made toward reaching the stated goals of the program.

[27] Generation data (estimated or metered) will be used when evaluating projects interconnected to master meters or serving master meter accounts. Tenant-level data (billing, savings, etc.) will not be known for these accounts.

3 METHODOLOGY

This section describes DNV's methodology for this evaluation and provides definitions of some terms used in the report.

3.1 Definitions

8760, read "eighty-seven sixty," is an industry term that refers to hourly data for one year. There are 8,760 hours in most years. Leap years have 8,784 hours.

Behind-the-meter refers to the position of a feature (for this study, solar PV) with respect to the electric utility's meter. "Behind-the-meter" is frequently referred to as "the customer side of the meter." The solar PV systems installed with incentives from the MASH program are behind-the-meter. Figure 5-1 illustrates the positioning of the MASH solar PV systems with respect to their meters and the grid. The VNEM system energy produced also flows through a meter, but only in one direction. The multifamily building with onsite solar PV with a net meter may have energy flowing in both directions, to and from the grid, or in one direction, only from the grid if all solar energy is consumed onsite.

Common area is the part or parts of multifamily premises that are not dwellings. Examples include outdoor lighting, hallways and elevators, laundry facilities, pools, etc. These common areas may or may not be individually metered. Some of these individually metered common areas are on non-residential rate schedules.

Master-metered service is supplied to a multifamily accommodation through one meter on a single premise where all the residential dwelling units are not separately metered. This schedule also applies to residential hotels and RV parks if they rent at least 50% of their spaces on a month-to-month basis for at least 9 months of the year to RV units used as permanent residences. This schedule is closed to new properties and to additions to existing meters. Most master-metered service was granted legacy status in 1978-1981.[28]

Net energy metering (NEM) and VNEM are differentiated by:

- The way the customer meters are wired with respect to the grid
- The contractual details that govern the NEM or VNEM interconnections between the investor-owned utilities (IOUs) and the solar customers

VNEM, the concept that solar export credits that are not on site can be credited to customers, was pioneered by the Energy Division (ED) for this program and adopted in D.08-10-036. Some MASH projects include a mix of NEM and VNEM meters. For example, a property that is master-metered may add rooftop solar with a NEM interconnection, and additional solar panels on car ports with a VNEM interconnection. Some participating locations joined more than one MASH project where one of the MASH projects is NEM and another one is VNEM. Please see APPENDIX A for a detailed explanation of NEM and VNEM concepts and their differences.

Submetering or sub-metering is a form of master-metered service. This schedule is applicable to residential service supplied to multifamily accommodations, other than a mobile-home park, through one meter on a single premise and sub-metered to individual tenants.

[28] Source: https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EM%20(Sch).pdf

3.2 Data sources

We used the following data sources to support tasks outlined in the 2022 MASH Workplan to arrive at robust, accurate, and defensible results. Some of these sources were already in the possession of the ED at the onset of this evaluation.

Individual solar PV system data: DNV sourced information from PowerClerk to link each PV system to its physical address and customer characteristics. PowerClerk was the MASH program's online application tool.

Job training affidavits: We used summary data provided by the PAs to assess the workforce outcomes of the program including number trained and hours of training provided by job training category. A sample of job training affidavits provided by the PAs were used to verify a subset of project sites.

Solar generation data (metered): Solar production data was a key input to the system benefits, environmental benefits, and bill reduction outcome analyses. These data were obtained from interval data provided by the IOUs for VNEM systems.

Solar generation data (modeled): For NEM systems, we utilized the DNV Solar Resource Compass (DNV SRC).

Solar radiation data: For the purposes of this evaluation, DNV acquired solar radiation satellite data for 30 areas with a 50-kilometer radius, such that no MASH project fell outside of these radiuses. We obtained all years from 2010 to 2023.

Site-specific information: The program collected tenant addresses during the participants' application process. This information was used to enroll tenants in the ESA program. In addition, for VNEM projects, the VNEM allocation was used to collect data on the allocation of benefits to each tenant and/or common area. Together, this data provided information on the total number of tenant units, size of the properties served, total number of multifamily properties served by the program. DNV used the geographical information to determine whether the customer was in a DAC or non-DAC area.

Billing data: The utilities provide billing data to the ED annually. Post-installation electric usage was obtained from billing data of tenants receiving VNEM allocations. The billing data shows the amount of kWh billed to the customer. The interval data from AMI reflects kWh taken from the grid. The difference between the two is the amount of kWh that was credited to the customer from the VNEM system.

Interval ("AMI") data: The evaluation team requested all interval data available for MASH projects, from AMI or from load research samples, starting in 2008. The California IOUs rolled out AMI meters (universal interval metering) starting in 2007 and clustered mostly between 2015 and 2017. The number of meters per year varied for each IOU.[29] The MASH evaluation period straddles this roll out, which translates into not having interval data for the entire evaluation period. We received interval data for three types of MASH participants:

- Generation data (for VNEM projects)
- Benefiter data (tenants and common areas, for VNEM projects)
- NEM data (for projects with master-meters)

3.3 Program cost assessment

DNV performed a cost assessment to examine project expenditures and measure the financial success of the program. We reviewed spending across program components including administration, marketing, measurement and evaluation, and incentives. To complete this task, we collected relevant data from resources, including:

- MASH Handbook
- Program tracking data
- Program staff interviews

[29] PG&E's roll-out was from 2007-2013. Source https://www.pge.com/includes/docs/pdfs/myhome/customerservice/meter/smartmeter/FINAL_AMI_Report.pdf

Program tracking data were utilized to determine total expenditures annually and by PA. Expenditures were evaluated based on the type of spending (i.e., administration, marketing, and incentives) annually by PA and on average by program phase (MASH 1.0 and MASH 2.0). Total number of projects completed and total capacity interconnected were totaled by PA by year. Annual total system cost, total incentives paid, and total projects completed were used to determine average system cost and average incentive by year, which in turn provided insights on the portion of the total system cost covered by an incentive, on average, each year.

3.4 Total electrical system benefits

For this evaluation, DNV focused on the electrical system benefits at the participants' premises. Both solar generation and avoided costs are highly time dependent. The first step to valuing the total electrical system benefits is to obtain an 8760 profile of energy generated, which can be obtained from utility interval meters, or modeled from PV system capacities (from the tracking data). Accordingly, DNV used two different methods depending on the interconnection type:

Individual System Interval Data for VNEM sites. The IOUs provided interval data from the Advanced Metering Infrastructure (AMI) meters that could be associated to MASH projects. Not all MASH projects have AMI data associated to them. We used these data to generate performance factors — system output expressed as a percent of installed capacity.

PV System Modeling of NEM Sites. DNV utilized this method to estimate the generation output of NEM sites, where the interval data provided by the utilities does not reflect the system's output. We utilized PV system characteristics provided in each MASH application to model energy output using the DNV Solar Resource Compass. For installations where there are several meters involved, and not all meters became interconnected simultaneously, the avoided costs and environmental benefits are based on the earliest date available. For example, if meter 1 became interconnected on February 15, and meter 2 became interconnected on March 15, the system benefits are calculated starting on February 15.

Degradation is a known occurrence with PV systems. For modeled systems, we assumed a degradation of 0.64% per year.[30] The degradation is applied in the calendar year following system installation, regardless of the number of months for which the system was active in the installation year.

Avoided Cost Estimates. The 2021 Distributed Energy Resources Avoided Cost Calculator (ACC) [31] provides 8760 avoided costs by year from 2019 through 2050, including costs ($/MWh) for energy, generation, ancillary services, transmission, distribution, and greenhouse gas (GHG) emissions (the monetized carbon cap and trade allowance cost embedded in energy prices). Additionally, the model provides 8760 estimates of GHG emissions beyond what is embedded in energy prices and of high global warming potential gases, which we count separately as environmental system benefits rather than electricity system benefits.

To estimate avoided costs for 2011 through 2018, we used an earlier version of the ACC from 2011. The earlier tool predates California's Cap-and-Trade Program (which began in 2013), so the breakout of environmental impacts has fewer components than the later tool. The 2011 tool's forecast for 2019 was higher than the 2021 tool's estimate. DNV assumed the 2021 tool contained more accurate values. To reconcile the difference, we interpolated between the 2011 values from the 2011 calculator and the 2019 values from the 2021 calculator.

Generation avoided costs is a straightforward multiplication of the 8760 energy generation array with the 8760 avoided costs array (with appropriate unit conversion). We estimated annual avoided costs as the sum of the hourly avoided costs.

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[30] https://www.osti.gov/biblio/1259256

[31] CPUC, willdan.app.com, https://willdan.app.box.com/v/2021CPUCAvoidedCosts/folder/136593940728

3.5 Total environmental benefits

DNV assessed the environmental benefits associated with solar generation installed under the program. We used marginal CO_2 emissions data available for each California IOU through the California SGIP.[32] These data are provided by WattTime, a nonprofit that uses real-time power generation data to deliver marginal emissions. While the SGIP data has a 5-minute resolution, we aggregated to hourly estimates to match the generation interval data that the IOUs provided for this evaluation. We combined hourly marginal emissions with the hourly solar generation profiles developed in the total electrical system benefits analysis, to estimate avoided carbon emissions by season and by year.

The SGIP data is only available from 2017 onward, so to estimate emissions for earlier years, DNV used the emissions assumptions embedded in the 2011 and 2021 ACCs that were used to estimate environmental avoided costs. As with the avoided cost estimates themselves, we interpolated hourly emissions for 2012 through 2018. To be able to compare the results of this approach to the SGIP values, we used the ACC emissions to estimate emissions for all years, 2011 through 2022.

We used a third approach to estimate emissions of CO_2 and other pollutants. The CARB uses average annual emissions factors in its benefits calculations. While using an average annual emissions factor is less accurate than using hourly emissions data (since it does not account for the timing of generation), the CARB factors allowed us to estimate emissions of NOx, reactive organic gases, and fine particulates. The CO_2 emissions estimated using the CARB factor provide a useful metric for comparing the more accurate SGIP and ACC estimates. For the SGIP and ACC CO_2 emissions estimates, we estimated the corresponding dollar value for avoided CO_2 emissions. The 2021 ACC and 2021 Distributed Energy Resources ACC provided the costs associated with CO_2 emissions.

3.6 Total workforce outcomes

To evaluate total workforce outcomes, DNV reviewed utility summary job training data along with a sample of job training affidavits provided by each utility. Job training data was provided for program activity from 2016 through 2022 for PG&E and SCE. SDG&E provided data for program activity from 2017 through 2020. Data were provided in Excel format and indicated, by project, the number of people trained, hours of training, and job training category (i.e., directly working on solar installation, project design/project engineering, and project management/coordination). In addition to summarized job training data in Excel, a sample of original job affidavits in PDF format was analyzed and compared to the corresponding entries in the Excel data to verify the accuracy of program activity data in Excel.

This evaluation summarizes statistics for workforce development by utility and in total based on the verified Excel data for a sample of job affidavits. The sample of job affidavits included trainee names; however, those data were not captured in the Excel job training data making it impossible to determine if trainees for each project are unique. In other words, our analysis can neither confirm nor deny if an individual received training on multiple projects.

3.7 Total customers served

To assess how the program benefited its customers, we utilized program tracking data and customer billing data from the start of the program until its close in 2021 and conducted interviews with PA program managers to glean additional insights. We analyzed this data to determine the number of multifamily and mobile home properties served, the number of CARE households served, and the location of properties served. We used system location when evaluating and plotting project locations within disadvantaged communities.

[32] SGIP | (selfgenca.com)

We also analyzed the properties served by program (MASH 1.0 or MASH 2.0) and by type and size to provide more depth and context. Property type was not captured in program data; therefore, we used billing data to determine mobile home properties. All non-mobile home properties were categorized as multifamily properties. Properties were also categorized by size based on the number of dwelling units. Small properties are those with 10 or fewer dwelling units, medium properties have 11-99 dwelling units and large properties have 100 or more dwelling units.

Customer feedback was not captured or provided by PAs. This evaluation did not include customer surveys or interviews.

3.8 System characteristics by customer type

For each qualifying project, DNV summarized the dollar value of the incentive amount along with the program (MASH 1.0 or MASH 2.0), interconnected solar generation capacity (kW_{AC}), property type (i.e., multifamily, or mobile home, further categorized as small, medium, or large properties based on number of dwelling units/homes), and interconnection meter type (i.e., NEM, VNEM, or both, and common area and/or tenant). System generation capacity was computed based on the formula defined in the MASH Handbook:

> *Size Rating (kilowatts) = Quantity of Photovoltaic Modules x CEC Rating of Photovoltaic Modules x CEC Inverter Efficiency Rating/ 1000 (watts/kilowatt)*

From this list of all qualifying projects, we summarized the minimum, maximum, and average incentive amounts ($) and capacity ($kW_{AC}$) for all projects, by program. Using site-specific information, similar metrics are provided by property type and by interconnection meter type.

PA-provided data for each project included an indication of the load being offset (e.g., common area and/or tenant load). DNV performed the following analysis and comparisons:

- A comparison of minimum, maximum, and average incentive level/system capacity by meter type (i.e., NEM, VNEM, and both, and common area, NEM tenant, VNEM tenant).
- A computation of post-installation consumption for common area metered accounts, tenant accounts (non-virtual net metering, provided the account is not master metered), and tenant metered accounts participating through VNEM. This is discussed in the following section.

3.9 Bill impacts

Direct program benefits for customers are reductions in energy expenses, and in some cases, increased energy use. DNV analyzed energy use before and after the solar installation to assess these benefits. We estimated the average amount of energy bills changes, both in dollars and kilowatt hours. This analysis required:

- Program tracking data including geographical identifiers and information identifying which billing accounts are associated with the system.
- Pre- and post-installation billing data and interval data for tenant units and common areas benefiting from the program, including electricity (kWh) and dollar amount billed, and CARE participation. While the utilities provide monthly billing data to the ED annually, DNV requested interval data to support this evaluation.

Post-installation electric consumption is calculated for each project based on the type of interconnection meter (NEM or VNEM), as follows:

Post-installation electric consumption =

+ Energy produced by the solar system

+ Energy taken from the Grid

– Energy sold back to the Grid

Where:

Energy produced by the solar system is from the system's AMI interval data for VNEM, and from modeled energy production for NEM (*)

Energy taken from the Grid is electricity delivered by the utility to the customer, from the customer's AMI data

Energy sold back to the Grid is electricity received by the utility from the customer, from the customer's AMI data

(*) Energy production was modeled using the DNV Solar Resource Compass (DNV SRC). The SRC uses physical system characteristics reported by the system owners (installed capacity, tilt, and azimuth) and combines them with geographical location (latitude and longitude supplied by the utilities) and satellite solar irradiance data that is within 50 km of each site[33].

We analyzed the difference in weather-normalized consumption for one-year pre- and one-year post-installation. DNV further analyzed the bill reduction outcomes of the program for participants for CARE vs. non-CARE participants.

3.10 Program process metrics

Using PA applications, program data, and information collected from staff interviews, DNV summarized program processes in terms of the number of MASH applications received, approved, canceled, and withdrawn in total and by year. Our insights are related to the most common reasons for the cancelation or withdrawal of applications result from the minimal data capture by the PAs.

This task entailed summative reporting based on the insights gleaned from the above-described evaluation tasks. Using program data, utility data, information collected from staff interviews, and completed evaluations, DNV measured the overall success of the program as related to the stated MASH program goals.

More specifically, DNV evaluated the following:

- Number of multifamily properties served
- Number of CARE households served
- Programs' impacts on electricity use and costs (e.g., by maintaining or increasing electricity usage without increasing household expenses for occupants)
- Workforce impacts (i.e., training and employment opportunities in the solar sector)
- How to maximize the overall benefit to ratepayers

[33] For information about the SRC, please visit https://src.dnv.com/howitworks

4 RESULTS

4.1 Program cost assessment

A total of $162.34 million was allocated across three utility territories to establish and achieve the goals of the MASH program. MASH 1.0 received $108 million in funding while MASH 2.0 received $54 million.[34] The goals of the MASH program included broad policy objectives to support the growth and development of solar power for residents in affordable housing to reduce electricity costs, improve energy utilization, promote solar technologies, increase overall awareness, and increase job opportunities in the solar sector. Each iteration of the program offered incentives to install solar generation that served limited-income residents in PG&E, SCE, and SDG&E service territories.[35]

The total capacity of installed (completed projects) was 62.7 MW. [36] The total installed capacity increases to 65.535 MW if projects pending payment as of the end of 2022 are included.

The installed capacity was spread across 622 completed projects; including projects with pending payments increases the total to 636 projects. SCE's service territory accounted for 48% of the installed capacity, PG&E accounted for 42%, and SDG&E accounted for 10%.

Incentives accounted for 93.7% of the total program expenditures.

Table 4-1 shows the program totals for installed capacity, number of completed projects, incentives, and expenditures for each of the PAs.

Table 4-1 MASH completed projects by PA (through December 2022)

	PG&E	SCE	SDG&E	Totals
Installed capacity (MW)	26.349	30.192	6.161	62.702
Number of completed projects	309	251	62	622
Total incentives paid (Millions)	$50.33	$61.15	$14.22	$125.71
Total program expenditures (Millions)	$57.64	$68.56	$16.40	$142.60

As of June 2022, two PAs (PG&E and SCE) had 14 projects that were pending with projected capacity of 2.83 MW and projected incentives of $4.42 million. These MASH applications were started prior to the program close deadline and were delayed. These applications are presented in Table 4-2 but are not included in the other findings.

Table 4-2 MASH reserved applications for pending projects by PA

	PG&E	SCE	SDG&E	Totals
Installed capacity (MW)	2.47	0.36	0	2.83
Number of pending projects	12	2	0	14
Total incentives (Millions)	$3.83	$0.59	$0	$4.42

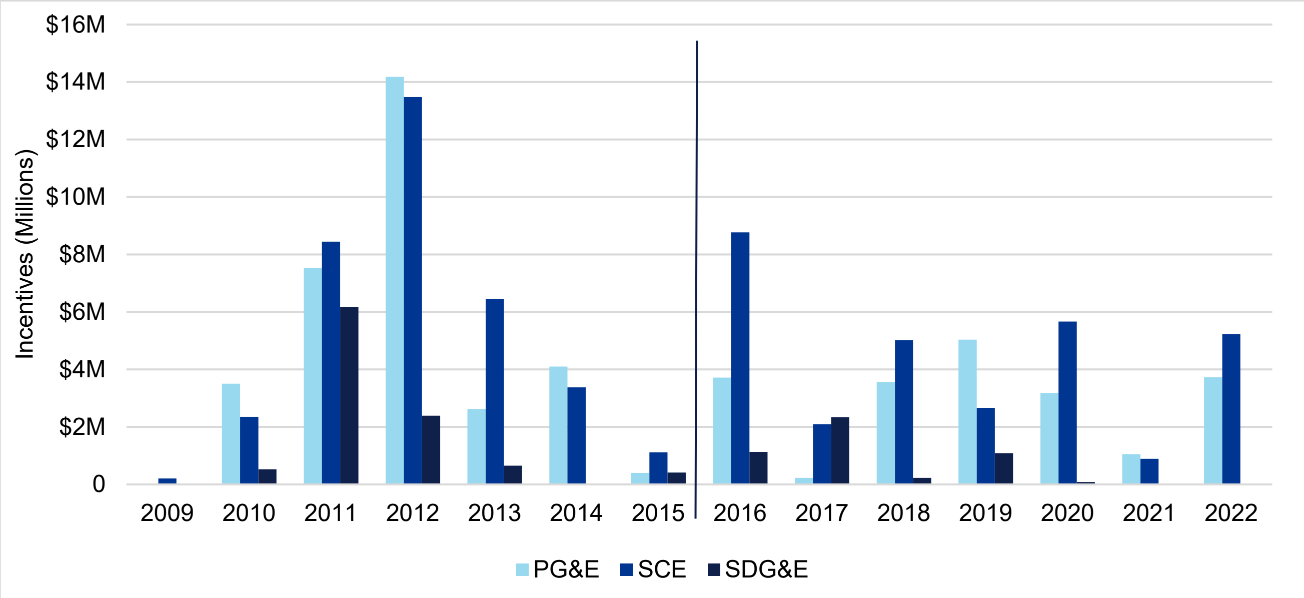
Final incentive payments were made upon project completion. Figure 4-1 shows the total incentives paid, by each PA, for projects completed during each calendar year.

34 Microsoft Word - June 2022 MASH Semi Annual Report.docx (ca.gov)

35 The SDG&E program was administered by a third-party (CCSE/CSE)

36 Source: MASH and SASH applications for completed projects.

Figure 4-1 MASH annual incentives for completed projects by PA



(1) Line denotes end of MASH 1.0 and start of MASH 2.0

Table 4-3 MASH annual incentive for completed projects by PA[37]

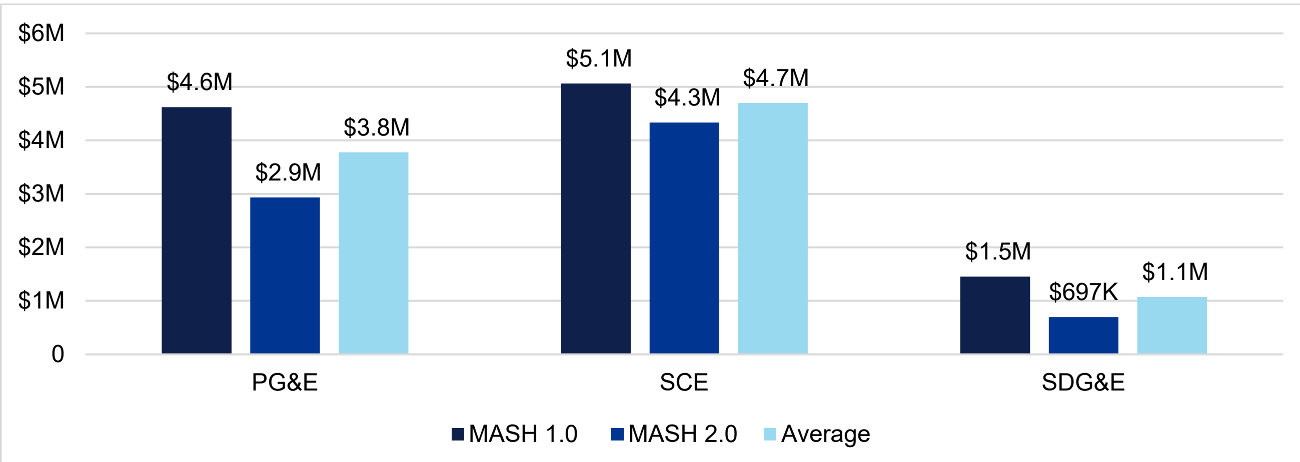
Year	PG&E	SCE	SDG&E	Total
2009		$112,061		$112,061
2010	$3,354,664	$2,449,733	$460,412	$6,264,809
2011	$6,862,348	$6,601,675	$5,411,481	$18,875,504
2012	$10,958,741	$11,392,179	$2,401,816	$24,752,736
2013	$4,129,839	$5,770,604	$653,638	$10,554,081
2014	$4,100,084	$3,377,642		$7,477,726
2015	$349,058	$1,114,057		$1,463,115
2016	$3,059,020	$8,768,301	$1,549,437	$13,376,758
2017	$946,911	$2,093,872	$2,341,066	$5,381,849
2018	$3,452,329	$4,691,507	$229,983	$8,373,819
2019	$5,151,655	$2,844,174	$1,085,701	$9,081,530
2020	$2,110,746	$4,237,946	$87,241	$6,435,933
2021	$2,129,570	$2,470,850		$4,600,420
2022	$3,728,920	$5,229,977		$8,958,897
Grand Total	**$50,333,885**	**$61,154,578**	**$14,220,775**	**$125,709,238**

MASH 1.0 provided fixed, capacity-based rebates at $1.90 per watt for solar PV generating systems that offset common area electrical load (MASH 1A) or at $2.80 per watt for offsetting tenant area electrical load (MASH 1B). Track 1 applications were reviewed on a first-come, first-served basis. Track 2 was a competitive application process and provided variable rebates up to 100% of system costs and ongoing maintenance costs. To receive Track 2 funds, an applicant had to demonstrate direct tenant benefit. Track 2 consisted of two application cycles per year.

[37] The incentives in Table 4-3 were provided by the PA in data requests and include payments for completed projects only.

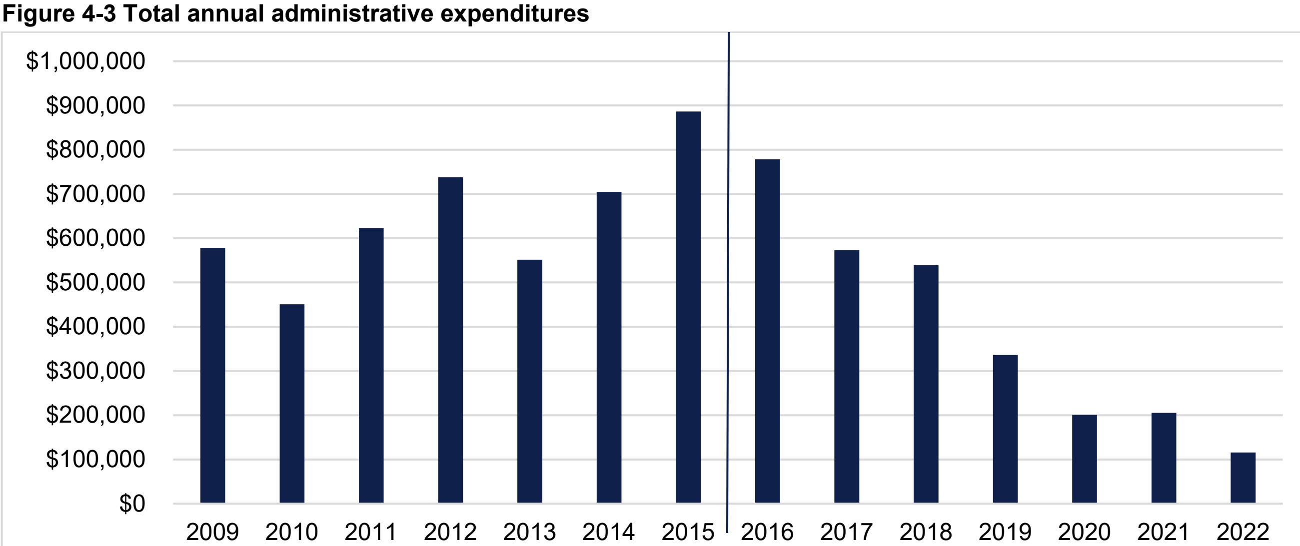
The expenditures comprised of spending on incentives, administration, marketing, education, and outreach (ME&O), and measurement and verification (M&V). Incentives accounted for more than 93% of the total expenditures over the program. Figure 4-2 shows the reported average annual incentives for MASH 1.0, MASH 2.0, and the program average for each PA. MASH 1.0 provided higher average annual incentives than MASH 2.0 in each service territory. SCE paid the highest average annual incentives of the three programs — approximately $4.7 million per year. MASH 1.0 averaged over $5 million each year, and MASH 2.0 averaged $4.3 million per year.

Figure 4-2 MASH average incentives by PA



Administrative expenses accounted for 5.1% of the reported expenditures. Annual administrative costs average more than $520,000 each year with the highest levels of expenditure in 2016 and 2015. PG&E reported administrative expenses of over $498,000 per year between 2014 and 2016. Figure 4-3 shows the annual administrative expenditures for the program. During interviews, most PAs reported the administrative budgets to be sufficient. However, one PA noted that in 2020, they had to request some funds be reallocated to administrative to continue the program. Also, SDG&E was able to use residual funds toward the end of the program to host a tenant education event.

Figure 4-3 Total annual administrative expenditures



(1) Line denotes end of MASH 1.0 and start of MASH 2.0

Table 4-4 presents the annual administrative expenditures by PA along with the total for each program year.

Table 4-4 Annual administrative costs by PA

Year	PG&E	SCE	SDG&E	Annual Total
2009	$209,940	$259,093	$109,100	$578,133
2010	$220,976	$87,948	$141,702	$450,626
2011	$178,740	$277,489	$166,579	$622,808
2012	$316,180	$274,960	$146,571	$737,711
2013	$277,326	$231,279	$42,804	$551,409
2014	$438,359	$176,214	$90,089	$704,662
2015	$551,732	$137,142	$197,451	$886,325
2016	$504,308	$145,134	$128,914	$778,356
2017	$351,305	$120,450	$101,293	$573,048
2018	$321,884	$190,767	$26,386	$539,037
2019	$153,688	$174,149	$8,377	$336,214
2020	$43,312	$151,914	$5,484	$200,710
2021	$118,238	$85,682	$1,329	$205,249
2022	$80,698	$34,976	$149	$115,823
Total	**$3,766,686**	**$2,347,197**	**$1,166,228**	**$7,280,111**

Figure 4-4 shows the average annual administrative costs by MASH program. PG&E consistently reported the highest annual administrative costs; followed by SCE and SDG&E. The administrative costs per MW installed varied by program administrator and generally decreased between MASH 1.0 and MASH 2.0 as shown in Figure 4-5. SDG&E had the highest administrative costs per MW installed for MASH 1.0 at $358,795 followed by PG&E at $203,650, and SCE incurred the lowest administrative costs per MW installed of $112,544 per MW installed for MASH 1.0. The administrative costs per MW for MASH 2.0 were lower for all PAs at $100,993, $52,016, and $74,125 for PG&E, SCE, and SDG&E, respectively. Figure 4-5 also shows “Cost per MW Completed” which reflects the total admin costs (MASH 1.0 and MASH 2.0 combined) divided by all the total MWs installed.

Figure 4-4 Average administrative expenditures for MASH 1.0 and MASH 2.0 by PA

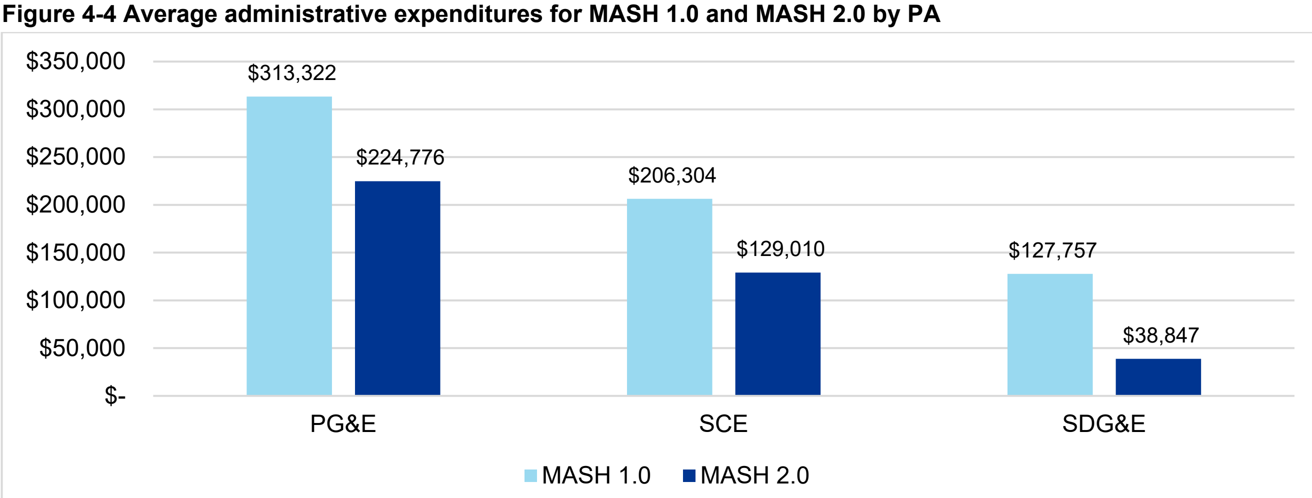
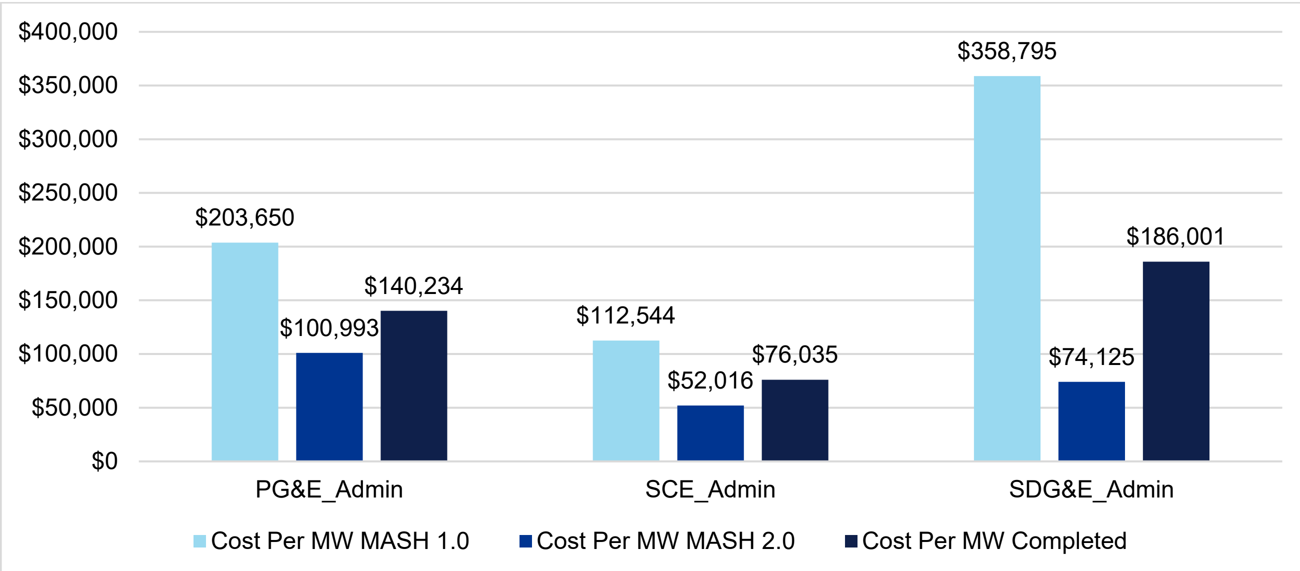


Figure 4-5 Administrative expenditures per MW by program



ME&O and M&V accounted for the remaining 1.2% of the program expenditures. As shown in Figure 4-6, total ME&O costs (total for all PAs) varied annually. Ninety-three percent of the ME&O expenditures occurred prior to 2016 in the MASH 1.0 program. PA interviews revealed that most of the marketing occurred during MASH 1.0.

Figure 4-6 Total ME&O annual costs

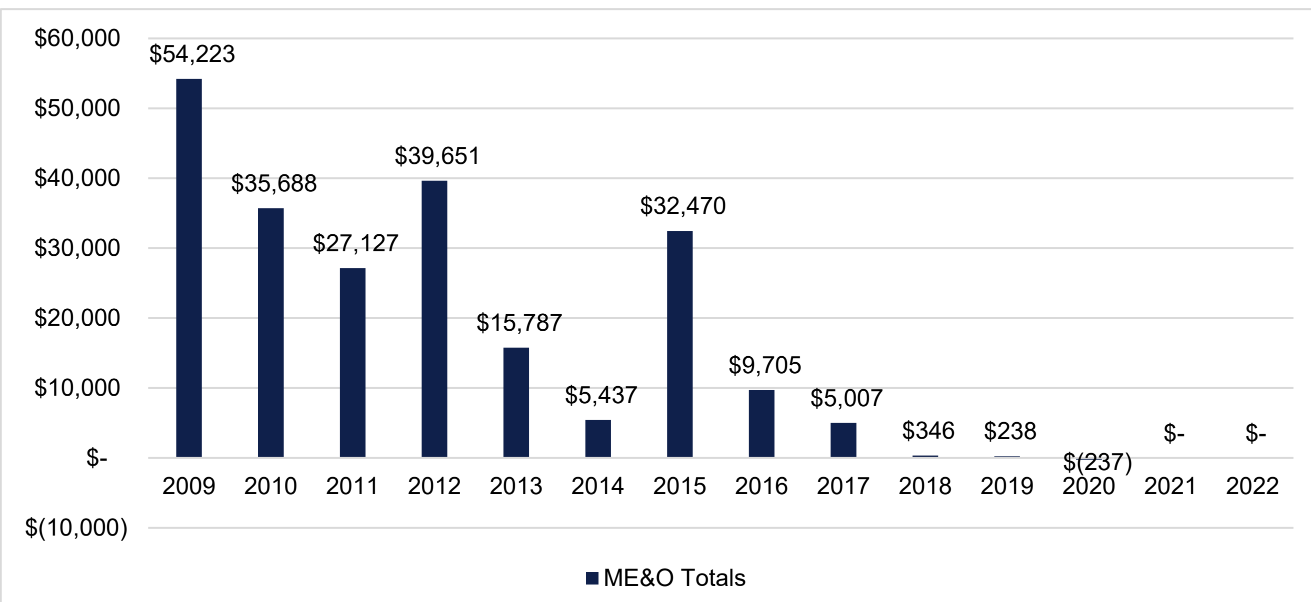


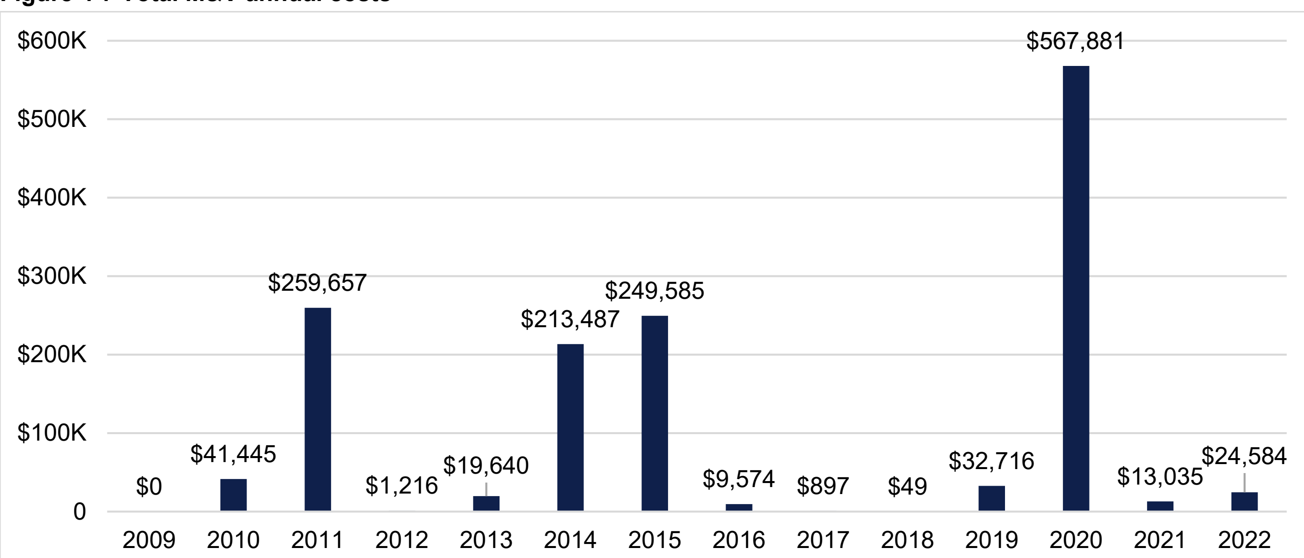
Table 4-5 presents the annual marketing, education, and outreach expenditures by PA. There were no marketing expenditures in 2021 and 2022 because the program was closing.

Table 4-5 ME&O annual costs by PA[38]

Year	PG&E	SCE	SDG&E	ME&O Totals
2009	$19,638	$17,039	$17,546	$54,223
2010	$13,636	$4,191	$17,861	$35,688
2011	$6,020	$90	$21,017	$27,127
2012	$4,220	$24,755	$10,676	$39,651
2013	$7,463	$0	$8,324	$15,787
2014	-$13,745[39]	$4,405	$14,777	$5,437
2015	$4,691	$7,931	$19,848	$32,470
2016	$0	$3,807	$5,898	$9,705
2017	$0	$2,318	$2,689	$5,007
2018	-$237	$0	$583	$346
2019	$237	$0	$1	$238
2020	-$237	$0	$0	-$237
Total	**$41,686**	**$64,536**	**$119,220**	**$225,442**

Periodic M&V was performed throughout the program with approximately 90% of the reported M&V expenditures occurring in 2011, 2014, 2015, and 2020. Figure 4-7 shows total M&V costs by year.

Figure 4-7 Total M&V annual costs

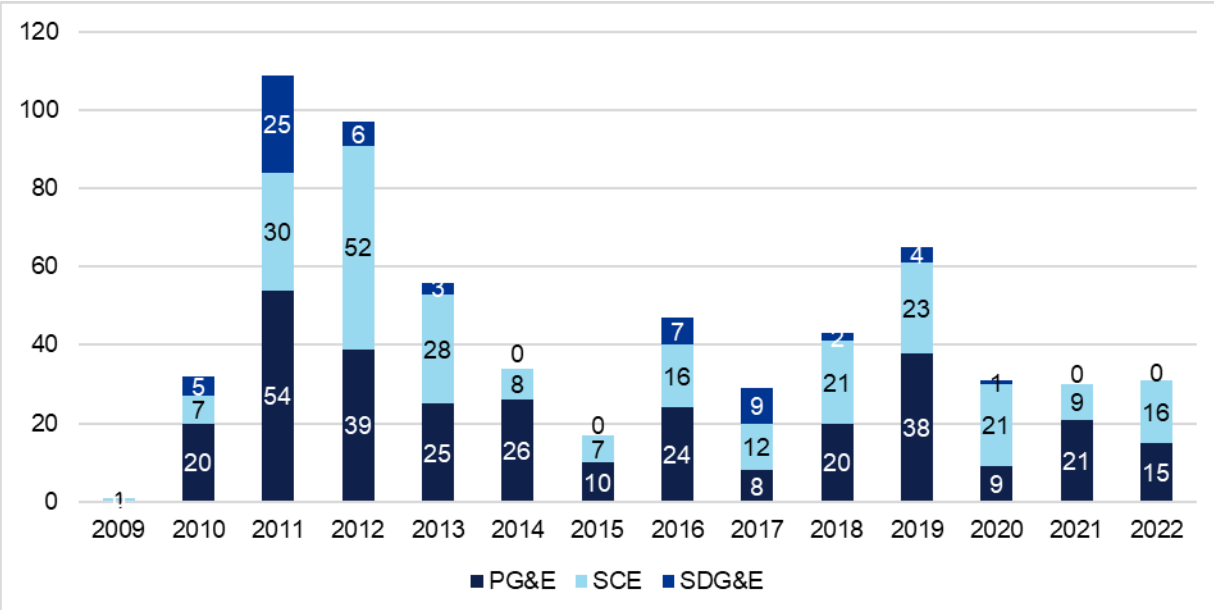


[38] Table 4-5 was created from the MASH Semi-Annual reports from 2009-2020. CSI Progress Reports (ca.gov)

[39] PG&E conducted some reclassifying between early program marketing and administrative dollars since the last Semi-Annual Progress Report. Microsoft Word - Dec 2014 MASH Semi-Annual Progress Report_FINAL.doc (ca.gov)

Large program expenditures coincide with the years having the highest incentive payments and completed projects. In 2011 and 2012, 109 and 97 projects were completed, respectively. In each year, more than half of the projects were completed in the PG&E and SCE service territories. Figure 4-8 shows the number of projects incentivized annually by PA.

Figure 4-8 Number of projects incentivized annually by PA



As shown in Figure 4-9 and detailed by PA in Table 4-6, the average incentive per project for MASH 1.0 ranged between $2,905/kW and $3,582/kW. The incentives covered approximately 45%-57% of the average cost/kW for MASH 1.0. The average cost/kW of MASH 1.0 projects was between $5,963/kW and $6,439/kW.[40] The average incentive per project for MASH 2.0 ranged between $1,223/kW and $1,443/kW. The incentives covered approximately 30%-35% of the average cost/kW for MASH 2.0. The average cost/kW of MASH 2.0 projects was between $3,678/kW and $4,383/kW. The average project cost came down over the program timeframe by 52% (compare 2009:2022). Comparing the year with the highest cost/kW (2010) against the year with the lowest cost/kW (2020), average costs decreased by 65%. In 2022, the average system cost per kW was $3,634 and the average incentive per kW was $1,334.

Figure 4-9 Average cost per kW and average incentive per kW

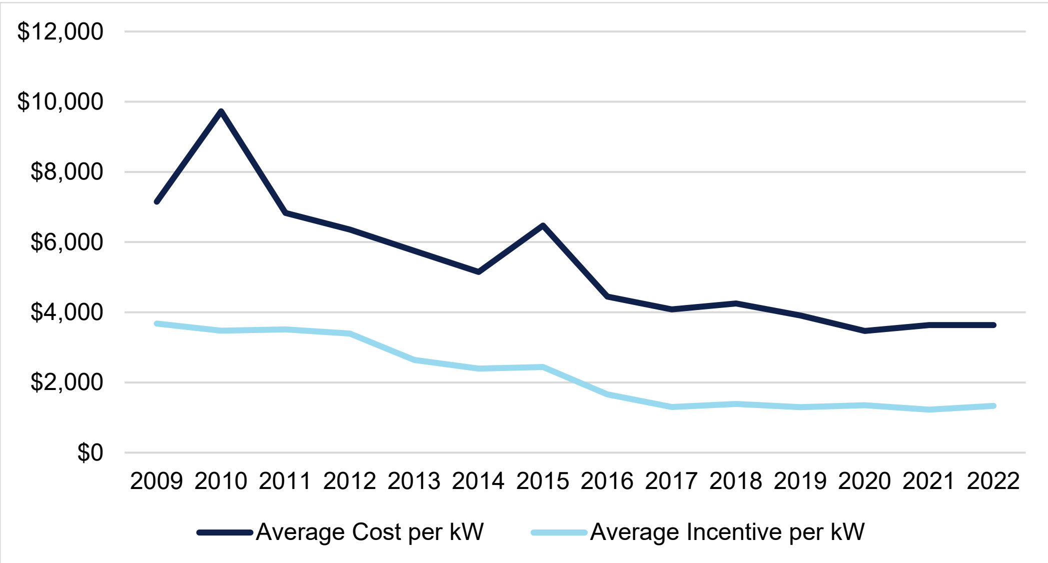


Table 4-6 Capacity, average project cost/kW*, and average incentive by PA and MASH program

	PA	Total CEC PTC Rating (kW)	Average Cost/kW	Average Incentive/kW
MASH 1.0	PG&E	10,770	$6,439	$2,905
	SCE	12,832	$5,963	$3,011
	SDG&E	2,492	$6,293	$3,582
MASH 2.0	PG&E	15,580	$4,023	$1,223
	SCE	17,362	$3,678	$1,297
	SDG&E	3,669	$4,383	$1,443

*The totals in the graph are based on the data provided by the PAs through data requests. These totals are less than the totals reported in the MASH report.

The average total project costs for multifamily properties were $78,613 for small (up to 10 units), $317,126 for medium (11-99 units), and $933,639 for large (100 units or more) in MASH 1.0 and $153,291 for small, $320,541 for medium, and $915,692 for large in MASH 2.0. For all property sizes, the average system capacity increased and the average cost per kW decreased in MASH 2.0. The average total cost increased during MASH 2.0 for small property but this can be explained by the tripling of the system capacity for these properties in MASH 2.0. Medium and large properties saw about a 30% increase in system capacity and decreased cost/kW. Refer to Table 4-7 for specific values.

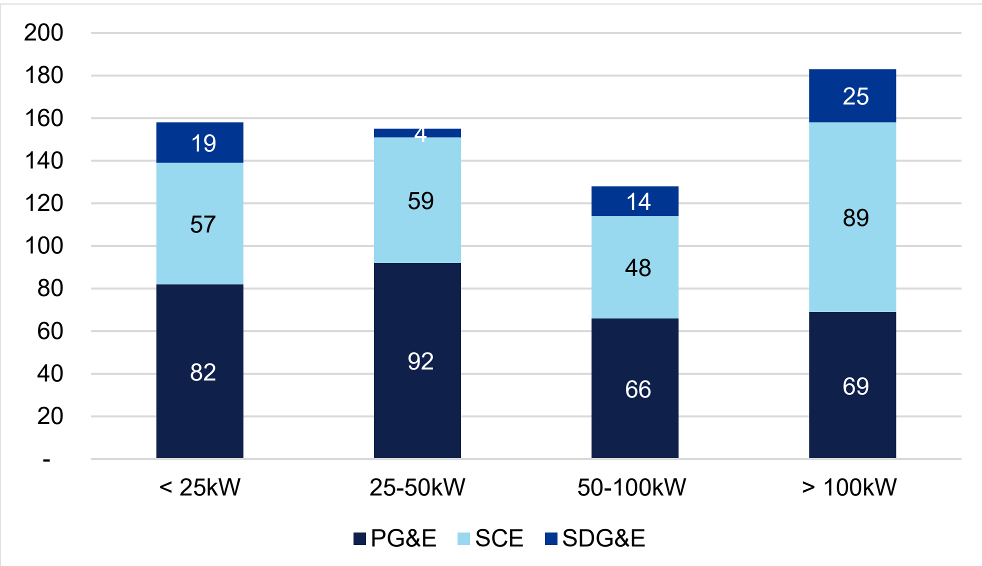
40 Contractors reported project costs. Costs were not verified by DNV.

Table 4-7 Average system cost, average CEC PTC rating, and average cost/kW by program phase and by tenant units on property (small, medium, large)

	Average System Cost	Average CEC PTC Rating (kW)	Average Cost/kW
MASH 1.0 Small	$78,613	13.02	$6,036
MASH 2.0 Small	$153,291	40.96	$3,742
MASH 1.0 Medium	$317,126	48.03	$6,602
MASH 2.0 Medium	$320,541	78.46	$4,085
MASH 1.0 Large	$933,639	160.13	$5,831
MASH 2.0 Large	$915,692	240.23	$3,812

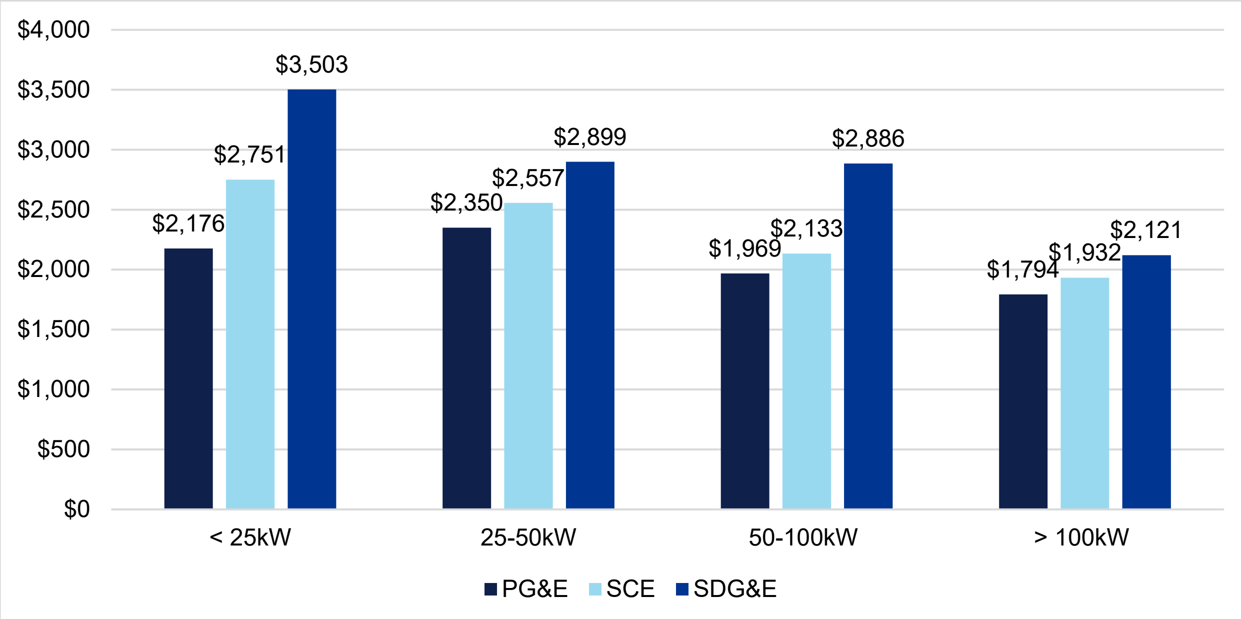
In Figure 4-10, projects are categorized by the total CEC PTC rating into one of four size categories — 25kW or less, 25-50kW, 50kW-100kW, or greater than 100kW. PG&E had the most projects (56%) in the 25kW or less and 25-50kW categories with 82 and 92 projects, respectively. SCE accounts for 89 (49%) of the 183 projects in the largest size category.

Figure 4-10 Number of completed projects by size



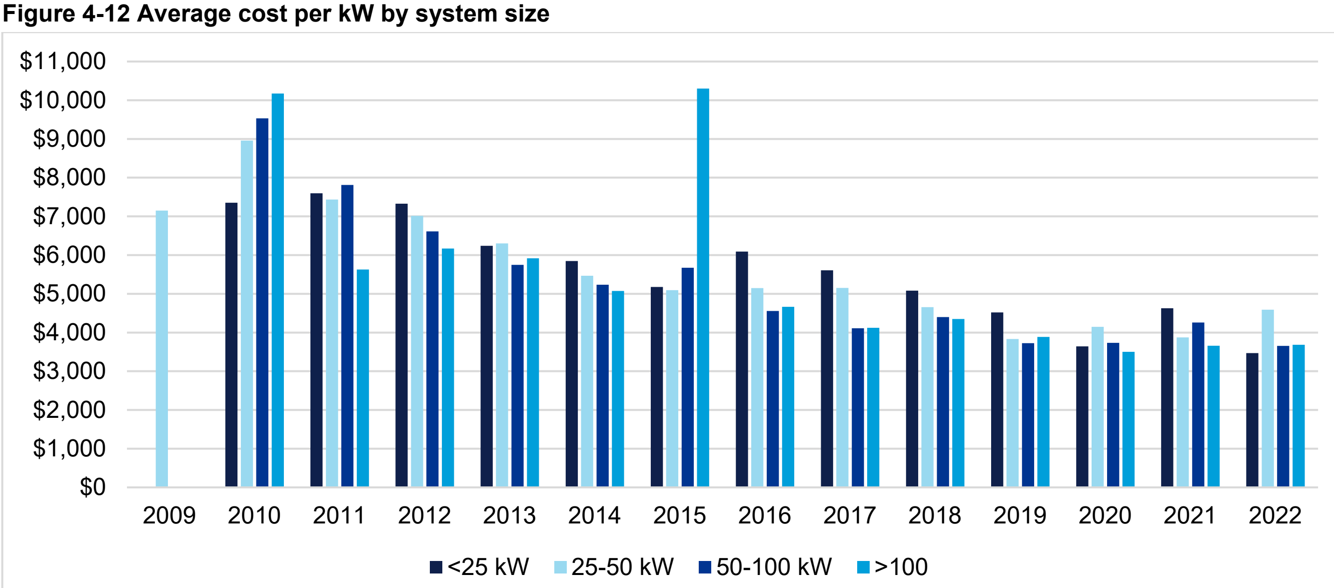
In Figure 4-11, the average incentive per kW had the lowest range in the largest system size (capacity) category (i.e., $1,794/kW - $2,121/kW) and the highest average incentives/kW were paid to the smallest system size category. The average incentives paid ranged from $2,176/kW to $3,503/kW for the smallest size category (<25kW), $2,350/kW to $2,899/kW in the 25kW-50kW category, $1,969/kW to $2,886/kW in the 50kW-100kW category, and $1,794/kW to $2,121/kW in the largest size category. SDG&E consistently paid the highest average per kW incentive, followed by SCE, then PG&E with the lowest average per kW incentive.

Figure 4-11 Average program incentive per kW by system size and PA



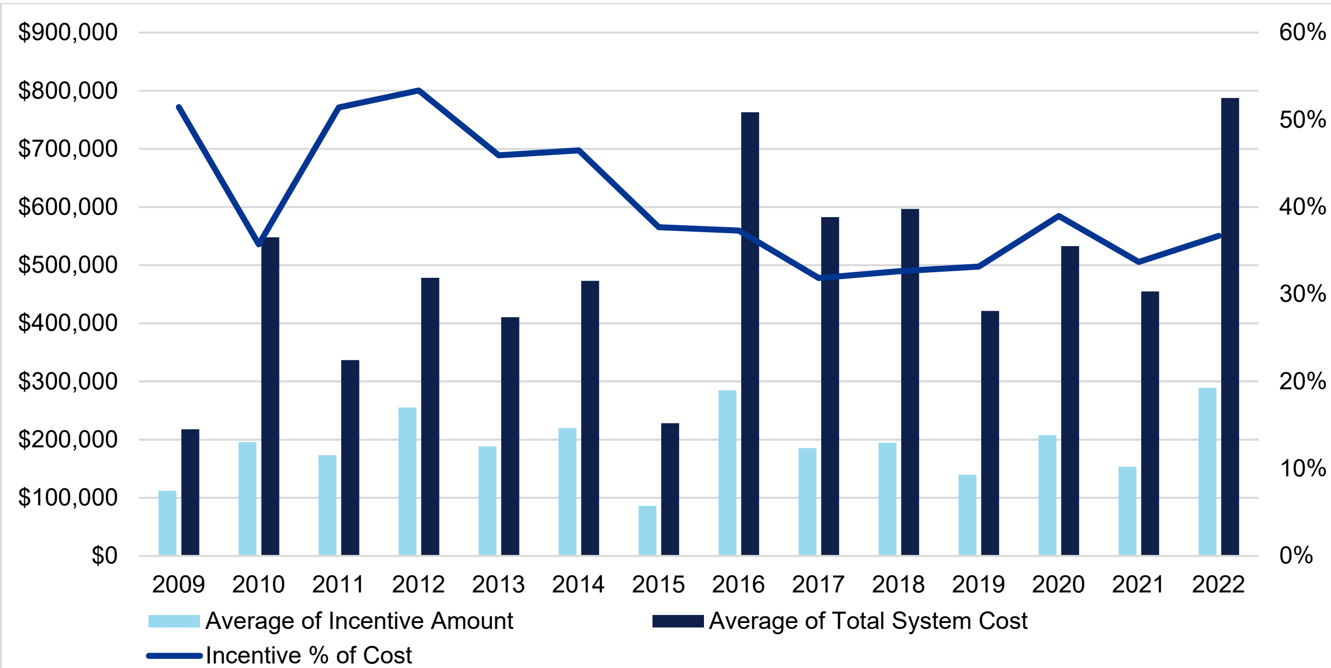
Average system costs per kW were highest in 2010. The maximum costs per kW were in 2010 and 2011, depending on system size, and ranged from $8,101/kW to $12,794/kW. The average cost, depending on system size ranged between $7,351 and $9,860. Systems over 100 kW, on average, cost the most per kW. The lowest costs per kW were in 2020 and 2021, again depending on system size. The lowest costs ranged between $2,351/kW and $3,376/kW depending on size. Systems greater than 100kW had the lowest cost per kW. The average cost during this timeframe ranged between $3,470 and $5,331. Figure 4-12 shows average cost per kW for each system size range by year. In 2022, the average system cost based on the size of the installations $3,470 for systems < 25 kW, $4,591 for systems 25-50 kW, $3,656 for systems 50-100 kW, and $3,682 for systems over 100 kW.

Figure 4-12 Average cost per kW by system size



Between 2009 and 2022 the average incentive to a property was 41% of total system cost. The percentage of total cost incentivized ranged from a high of 53% down to 33%. The percentage generally trended down as seen in Figure 4-13. The downward trend is the result of many factors including changes to incentive levels over the life of the program, decreases in overall system costs, advantageous tax credits, and changes to financing arrangements over the years, as financing companies gained experience with the program and solar installations in general.

Figure 4-13 Average project cost versus average project incentive by year



4.2 Benefit cost assessment (BCA)

The goals outlined in AB 217 for the MASH program included maximizing the overall benefits to ratepayers. To that end, the TRC test is used to evaluate the impact of the program on all ratepayers — both participants and non-participants. The TRC test "measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs."[41] The TRC is one of the five cost-effectiveness tests outlined in CPUC D.09-08-026 to evaluate distributed generation. Appendix A of the decision outlines the benefits and costs categories, input variables, and sources to be used in the TRC analysis. The benefits and costs in the analysis are shown in Table 4-8.

4.2.1 Cost-effectiveness

To measure the cost-effectiveness of the program, DNV assessed program expenditures relative to the benefits generated by the projects installed. The cost assessment reviewed spending across program components, including administration, marketing, and incentives. We collected cost data from program reports, program staff interviews, California Distributed Generation Statistics, and through data requests from PAs. We calculated operating expense based on the average cost of maintaining and operating a solar system, including the cost of removal at the end of the system life.

Program benefits including electrical system benefits, environmental benefits, and the federal tax incentives were calculated using information gathered from the PAs through data requests and PA interviews during the evaluation. The total benefits

41 SPM at 18.

of the installed systems are the sum of the avoided electricity costs, avoided environmental costs, and bill savings. The total benefits include the benefit that accrued during the program years (2008-2022) and expended benefits for the remaining life of the system. Like the cost assessment, the benefits analysis assumes a 30-year life of the installed systems.

Table 4-8 Inputs for TRC test for the MASH program

TRC Inputs	Description	Modelling assumptions
Administrative costs	Program administration costs from CSI data, as reported by IOUs.	Costs reported in MASH semi-annual reports as of June 2022 report.
Avoided costs of electricity – energy	Values computed as described in Task 4.	
Avoided costs of electricity – GHG	Values computed as described in Tasks 4 and 5.	
Federal Tax Incentives	Estimated credit available for solar PV investments.	Assumed to be 30% of the total system costs.
Participant costs – equipment/ installation (measure costs)	Costs (including financing costs and taxes) were self-reported by applicants/developers and may not be accurate.	Total system costs report in utility data files.
Operating and maintenance (O&M) costs	Estimated based on the cost of the system.	Estimated to be 1% of the total reported system costs for each year.
Utility interconnection costs	Cost of interconnecting the solar system to the utility distribution system.	Assumed to be included in the total system costs reported by the participants.

DNV developed a benefit-cost model to assess the effectiveness of the MASH program using the cost and benefit assessments developed during the evaluation. An assessment of the entire program — which spanned two decades — required the valuation of costs and benefits be converted to constant dollar based on the project completion year. That is, costs were assumed to be incurred in the year the project was completed and then discounted back to the beginning of the program to capture changes in general price level and to account for the time value of money. Below we outline the assumptions for each of the costs categories considered in the BCA.

4.2.1.1 BCA model details

The evaluation spans 2009-2022, the years in which costs or benefits were incurred in the program. Costs are the sum of total system costs, program administration costs, and estimated operation expenses[42]. The analysis assumed a 30-year life of the installed system.[43] Operating expenses were estimated annually at 1% of the total system costs for 30 years starting in the completion year. The costs were converted to 2022 dollars[44] by using the GDP Price Deflator. The GDP Price Deflator is a "measure of inflation in the prices of goods and services produced in the United States, including exports. The GDP Price Deflator closely mirrors the GDP price index, although they are calculated differently."[45] Federal tax incentives are included in the model as a benefit to the system owner. The federal tax incentives assumed to be 30% of the total system costs. Any state tax credits received were treated as transfers and not explicitly accounted for in the calculation.

To assess the cost-effectiveness of the program, the present value was obtained by discounting the benefits and costs — for each PA — to the first year of the program. Discounting the benefits and costs back to the first year allows for comparison of the value generated by the program (benefits) relative to the costs incurred by the utility and program

[42] The operation expenses are estimated at 1% of system initial cost. National Renewable Energy Laboratory: New Best Practice Guide for Photovoltaic System Operations and Maintenance. 2017.

[43] Appendix C includes BCA calculations using a 25-year life of the installed system.

[44] Annual program costs are adjusted to constant 2022 dollars using the GDP deflator from the BEA.

[45] GDP Price Deflator | U.S. Bureau of Economic Analysis (BEA)

participants. The analysis uses two discount rates: the utility weighted average cost of capital (WACC) as prescribed in CPUC D.09-08-026 The annual program benefits and costs are discounted to generate streams of annual benefits and costs for the life of the systems installed. The present value of the benefits and costs are presented below for each PA.

In Table 4-9, the present value of benefits and cost were compared to develop the benefit-cost ratio. The total present value of the benefits across the life of the program was $106M. Approximately, 48% ($51.3M) of the total benefits were attributed to SCE service territory, 42% ($45.3M) to PG&E service, and the 10% ($10.5M) to SDG&E. The total present value of the costs across the life of the program was $247.5M. Approximately, 46% ($112.9M) of the total costs are in the SCE service territory, 42% ($105M) in the PG&E service, and the 12% ($29.6M) to SDG&E. The WACC for each utility PG&E (7.44%), SCE (7.68%), and SDG&E (7.55%) were used to discount the benefits and costs[46].

The present values were used to calculate the benefit cost ratio (BCR) — present value of benefits divided by present value of costs) for each utility. Table 4-9 shows the BCR for each utility. The present value of costs exceeds the net present value of benefits for each utility resulting in a BCR of less than 1. SCE had the highest BCR of 0.45; followed by PG&E with 0.43, and SDG&E with 0.36. The total net present value (present value of benefits minus present value of costs) is negative for the program with a value of -$140.3M or a BCR of 0.43.

Table 4-9 Net present value, net present cost, and cost benefit ratio by PA (WACC)

Rate	NPV	PG&E	SCE	SDG&E	Description
WACC	Benefits	$45,325,821	$51,331,987	$10,537,484	NPV of total avoided costs and environmental benefits, Federal tax credit
WACC	Costs	$104,922,122	$112,965,024	$29,629,898	NPV of total administrative cost, reported project costs, and estimated O&M costs
WACC	Benefit cost ratio	0.43	0.45	0.36	Ratio of net present value of benefits relative to costs

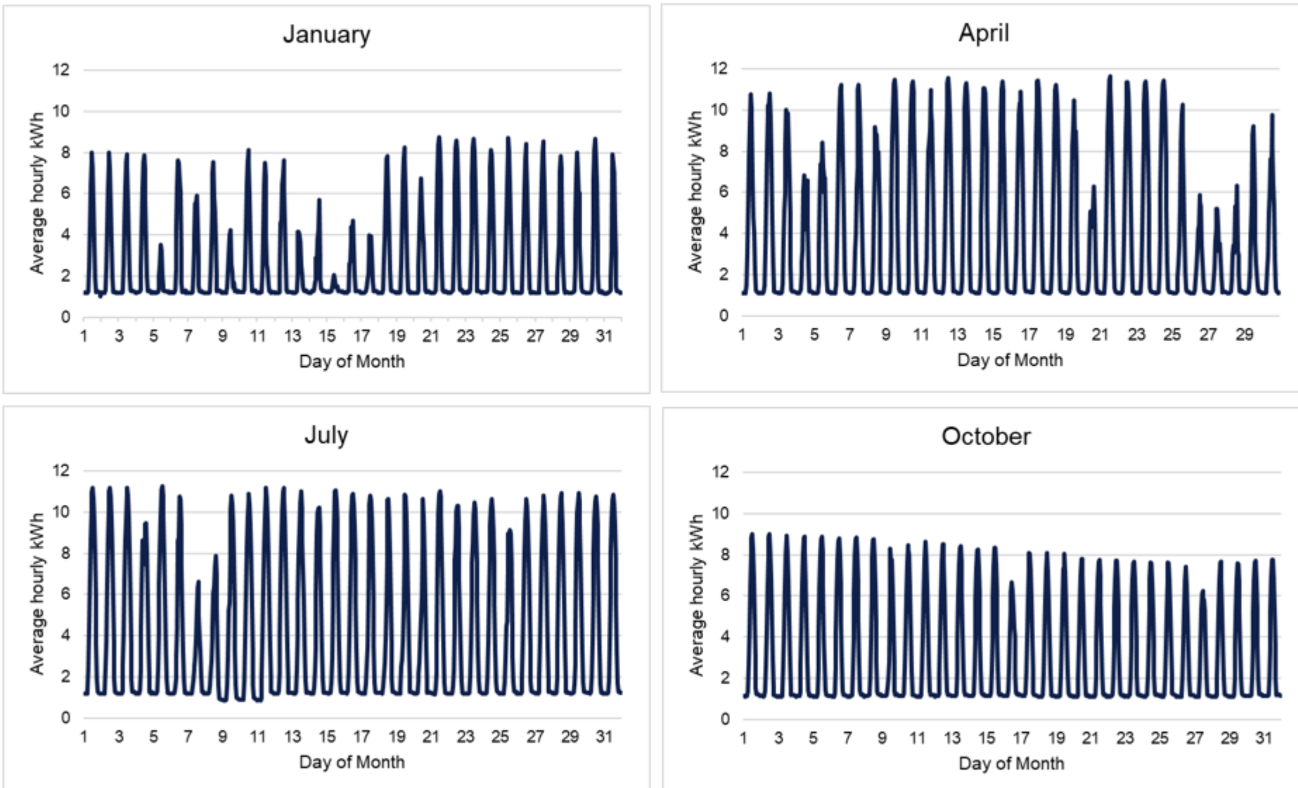
4.3 Total electrical system benefits

Developing hourly generation profiles was a key first step to estimating electrical system benefits (reported in this section), as well as environmental benefits (Section 4.4), and bill impacts (Section 4.8).The calculation of total electrical system benefits began with site-level generation profiles for each system installed under the MASH program. The DNV team developed generation profiles for VNEM systems directly from AMI data and for NEM systems modeled the hourly solar production profile using DNV's Solar Resource Compass (SRC) with the provided PV system characteristics as inputs.

Figure 4-14 provides an illustration of these hourly generation data, showing generation averaged over VNEM sites in SCE's Climate Zone 6. The figure highlights profiles for January, April, July, and October. Averaging over multiple sites dampens variation, but one can see higher variation in January and April due to weather factors. Generation is highest in the summer when days are longer and the sun is higher, and there is typically a higher share of sunny days. The profile shows some generation even at night, probably due to light from artificial sources like area lighting.

46 Rate of Return (ROR) (Actual and Authorized) (ca.gov). As of 4/10/2023.

Figure 4-14 Example of hourly generation profiles (SCE Climate Zone 6 VNEM average hourly generation)



DNV estimated annual production from NEM MASH installations using the DNV SRC and compared these values to the expected production submitted in the MASH applications. For VNEM MASH installations, we used AMI interval data, as described in Section 3.3. Overall, VNEM MASH installations achieved approximately two-thirds (67%) of expected production. As a sensitivity analysis, we applied the more accurate meter-based ratio of 0.66 to PG&E NEM installations and 0.62 to SCE NEM installations. Across all IOUs and all metering types, MASH installations achieved 65% of their estimated production. These results are summarized in Table 4-10 below. Analyzing these results by size of installation, segmented into small-medium-large categories, provides directional insight that production for larger systems fell short of expectations to a greater degree than that for small and medium systems. This result could be confounded with other factors such as location, soiling, etc.

Table 4-10 Estimated vs actual first year production

IOU	Interconnection type	System size	Number of projects	Expected production (per application) (kWh)	First year kWh	Realization rate
PG&E	VNEM[1]	Small (≤100kW)	48	2,658,657	2,095,335	0.79
		Medium (100kW-500kW)	31	5,992,432	4,216,499	0.70
		Large (>500kW)	6	5,756,526	3,194,190	0.55
		Total	85	14,407,615	9,506,023	0.66
	NEM[2]	Small (≤100kW)	123	5,766,335	3,804,579	0.66
		Medium (100kW-500kW)	36	6,937,522	4,577,319	0.66
		Large (>500kW)	7	5,417,629	3,574,506	0.66

IOU	Interconnection type	System size	Number of projects	Expected production (per application) (kWh)	First year kWh	Realization rate
		Total	166	18,121,486	11,956,404	0.66
	PG&E Total	Total	251	32,529,101	21,462,428	0.66
SCE	**VNEM**	Small (≤100kW)	31	1,565,909	1,092,403	0.70
		Medium (100kW-500kW)	38	8,931,660	6,135,999	0.69
		Large (>500kW)	11	9,794,617	5,365,482	0.55
		Total	80	20,292,186	12,593,884	0.62
	NEM	Small (≤100kW)	89	4,158,497	2,580,877	0.62
		Medium (100kW-500kW)	51	10,883,457	6,754,570	0.62
		Large (>500kW)	15	13,467,637	8,358,383	0.62
		Total	155	28,509,591	17,693,830	0.62
	SCE Total	Total	235	48,801,777	30,287,714	0.62
SDG&E	**VNEM**	Small (≤100kW)	23	883,465	735,065	0.83
		Medium (100kW-500kW)	17	3,862,593	3,032,602	0.79
		Large (>500kW)	3	2,044,077	1,873,627	0.92
	SDG&E Total	Total	43	6,790,135	5,641,294	0.83
Overall	**All**	**Total**	**529**	**88,121,013**	**57,391,436**	**0.65**

(1) VNEM solar production was obtained from the interval data provided by the IOUs
(2) NEM solar production was estimated using the DNV Solar Resource Compass

An analysis by climate zone categories, coastal-inland-desert, shows no notable differences by climate zone, as demonstrated in Table 4-11.

Table 4-11 Production by climate zone categories

IOU	Type	Climate zone group[47]	Number of MASH projects	Realization rate
PG&E	VNEM	Coastal or mild	55	0.68
		Inland	30	0.64
SCE	VNEM	Coastal or mild	13	0.82
		Desert	18	0.69
		Inland	49	0.59
SDG&E	VNEM	Coastal or mild	23	0.85
		Inland	20	0.79

There are multiple reports that detail the loss in solar energy production due to California wildfire smoke.[48] This evaluation did not analyze the effect of smoke on the energy production of MASH projects. However, this could be a contributing factor to solar production that is lower than expected. Table 4-12 shows the number of projects that are installed in years where wildfires were more likely to cause energy production losses.

[47] Climate zones 1-7 and 16 are coastal or mild, zones 8-13 are inland, and zones 14 and 15 are desert.

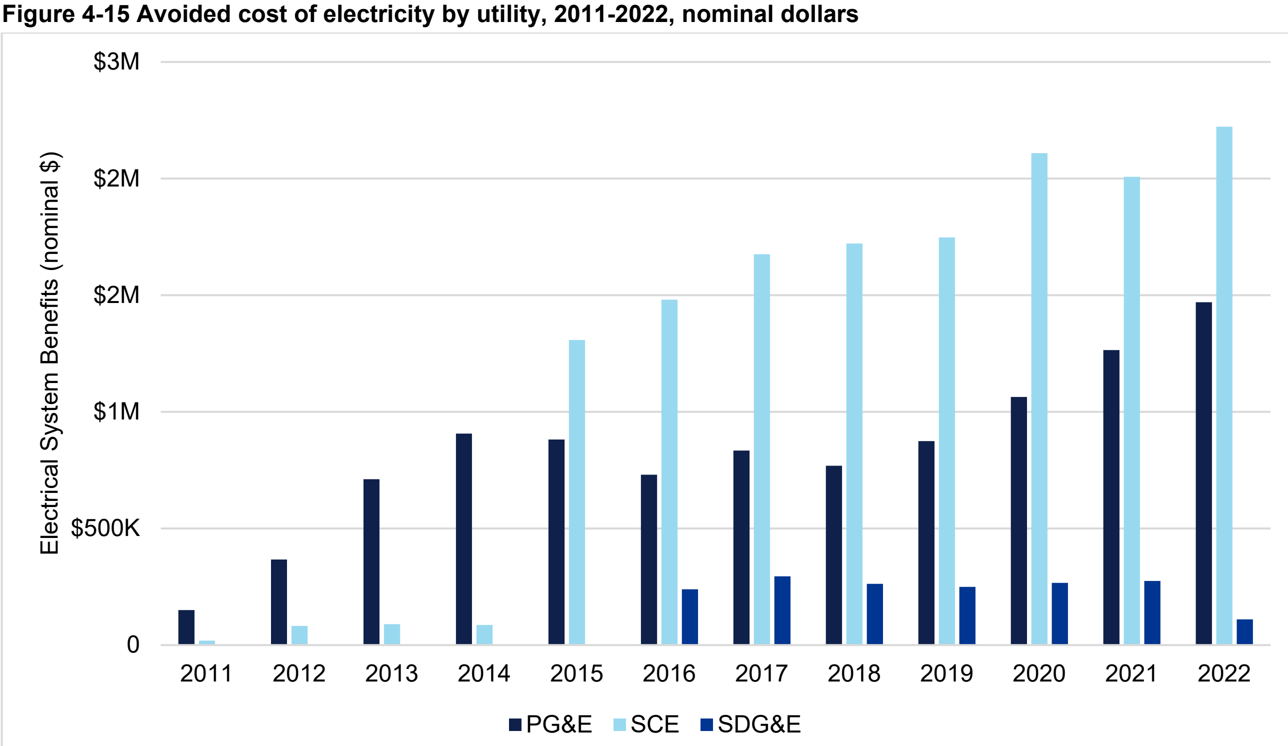
[48] Examples include
Energy Information Administration. Smoke from California wildfires decreases solar generation in CAISO. September 30, 2022, accessed on April 3, 2023, https://www.eia.gov/todayinenergy/detail.php?id=45336.
Bloomberg News. Wildfire Smoke Can Slash California Solar Power Output by Nearly a Third. December 7, 2022. Accessed April 3, 2022. https://www.bloomberg.com/news/articles/2022-12-07/wildfire-smoke-can-slash-california-solar-power-output

Table 4-12 First year production: MASH projects in high wildfire vs. low wildfire impact years

IOU	Interconnection type	Wildfire level	Total number of projects	Realization rate
PG&E	VNEM	Less high[49]	68	0.68
		Very high[50]	17	0.61
	NEM	Less high	139	0.66
		Very high	17	0.66
SCE	VNEM	Less high	50	0.63
		Very high	30	0.61
	NEM	Less high	127	0.62
		Very high	28	0.62
SDG&E	VNEM	Less high	34	0.77
		Very high	9	0.94

The 2011 and 2021 ACCs[51] provided hourly levelized values of electricity by utility and climate zone spanning energy, generation capacity, transmission capacity, distribution capacity, ancillary services, losses, methane leakage, cap-and-trade, GHG adder, and GHG gas rebalancing. We aggregated the site-level results by utility and climate zone and multiplied the resulting aggregate profile by the hourly avoided costs by year to produce annual avoided costs. Figure 4-15 shows the results aggregated to the utility level. Between 2011 and 2022, PG&E accrued cumulative electricity system benefits (in 2022 dollars) of $11.5M, SCE accrued $16.4M, and SDG&E accrued $2M.

Figure 4-15 Avoided cost of electricity by utility, 2011-2022, nominal dollars



[49] Less high years are 2009-2016, 2019, and 2022. Acres burned during these years ranged from 134,462 to 829,224 per year. Data is from Statistics | CAL FIRE.
[50] Very high years are 2017, 2018, 2020 and 2021, where acres burned ranged from 1.5M to 4.3M per year. Data is from Statistics | CAL FIRE.
[51] 2021 ACC Electric model v1b, CPUC, willdan.app.com, https://willdan.app.box.com/v/2021CPUCAvoidedCosts/folder/136593940728

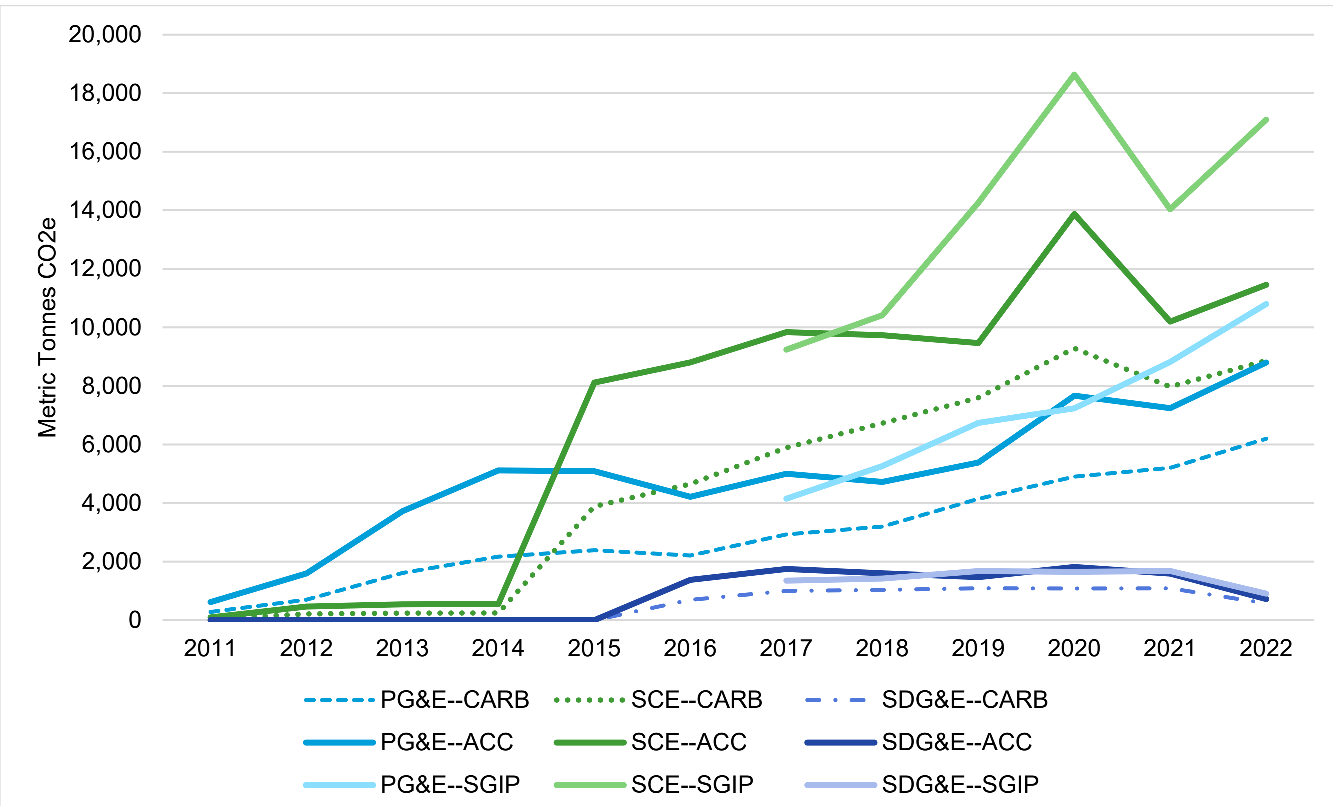
4.4 Total environmental benefits

The DNV team calculated total environmental benefits for the program three ways. The California SGIP provides marginal CO_2 emissions data, but only from 2017 onward. To develop estimates of emissions prior to 2017, we used the emissions assumptions embedded in the 2011 and 2021 ACCs. We used the ACC values to estimate emissions from 2017 to 2022 as well, for comparison to the SGIP estimate. Lastly, we used average annual emissions factors from the CARB to estimate CO_2 equivalent emission as well as other pollutants of interest.

Figure 4-16 shows the results of the three analyses by utility. For PG&E and SDG&E, the SGIP and ACC estimates from 2017 to 2022 are similar in magnitude but differ in shape, with the SGIP values being higher in some years and lower in others. Except for 2017, SCE's SGIP estimates are higher than the ACC estimates, by up to 51% in 2019. The CARB estimates (dotted/dashed) are lower than the SGIP and ACC estimates for all three utilities. CARB's average annual factors do not consider when these solar PV systems generate electricity and the variation in avoided emissions across hours.

Based on the combined ACC (2011 to 2016) and SGIP (2017 to 2022) estimates, PG&E avoided more than 63,000 metric tons of CO_2 equivalent, SCE avoided more than 102,000 metric tons, and SDG&E avoided more than 10,000 metric tons.

Figure 4-16 Metric tons of CO_2 equivalent emissions



To estimate the value of avoided emissions, we applied the hourly levelized value of avoided emissions from the 2011 and 2021 ACCs to both the ACC emissions estimate and the SGIP emissions estimates. Figure 4-17 shows both sets of results for each of the three utilities. From 2011 to 2022, PG&E avoided emissions values of about $1.9 million in 2022 dollars, SCE avoided emissions valued at almost $3.6 million, and SDG&E avoided emissions valued at almost $340,000.

Figure 4-17 Value of avoided emissions

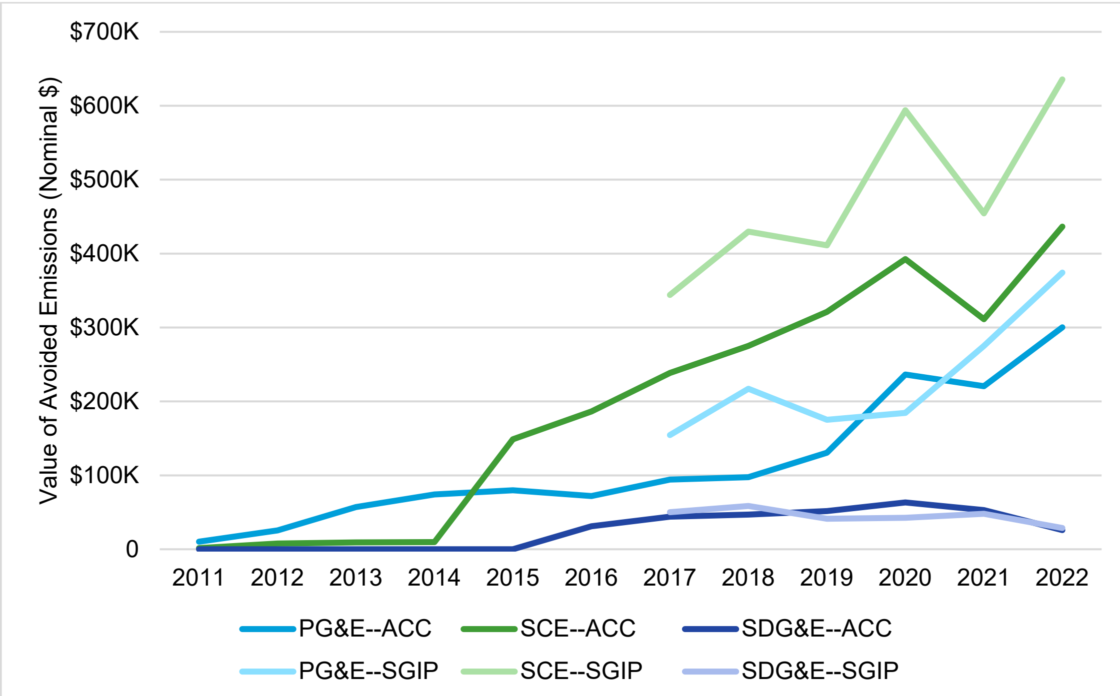
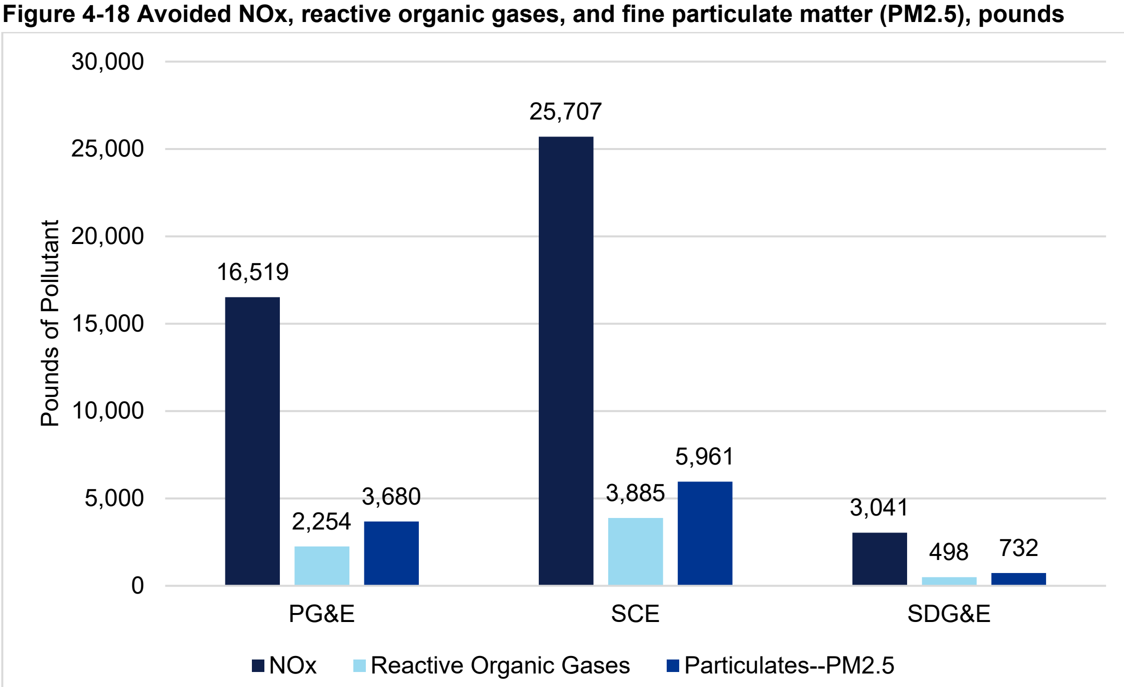


Figure 4-18 shows how much other pollutants of interest were reduced from 2011 to 2022 (cumulative) because of the program. Shown are reduction in nitrogen oxides (NOx), reactive organic gases, and fine particulate matter (particles less than 2.5 micrometers in diameter, or PM 2.5). We calculated these values using average annual emissions factors from CARB.

Figure 4-18 Avoided NOx, reactive organic gases, and fine particulate matter (PM2.5), pounds



4.5 Total workforce outcomes

To be eligible for a MASH incentive, contractors were required to follow all the MASH job training requirements. For each MASH project, contractors were required to provide at least one student or graduate of a job training program with at least one full paid day (8-hour day) of work for each 10kW (CEC-AC) of system size, up to 50kW. Training requirements increased as the system size increased. Table 4-13 outlines the required number of JTOs (trainees) and minimum hours per project based on system size.

Table 4-13 Job training opportunities requirement matrix

System size (CEC-AC)	JTOs
0 – 10kW	1 JTO and no less than 8 hours
10kW – 20kW	2 JTOs and no less than 16 hours
20kW – 30kW	3 JTOs and no less than 24 hours
30kW – 40kW	4 JTOs and no less than 32 hours
40kW and greater	5 JTOs and no less than 40 hours

Job training is further classified into one of three categories:

1. Directly working on solar installation
    a. Installing electrical components
    b. Installing mechanical components
    c. Completing system installation
    d. Conducting maintenance and troubleshooting activities
2. Project design/project engineering
    a. Designing systems
3. Project management/coordination
    a. Managing the project

As noted in Section 3.6, the PAs provided job training data for program activity in the later years of the program ranging from 2016 to 2022 across the three PAs. Training activity generally declined for all PAs in 2020 most likely due to the pandemic. PG&E showed the highest percentage of solar installation trainees whereas SCE and SDG&E had more project management/coordination trainees. Figure 4-19, Figure 4-20, and Figure 4-21 summarize the annual number of job trainees by job category for each year. Results for each PA are shown separately.

Figure 4-19 PG&E number of trainees per job category by year

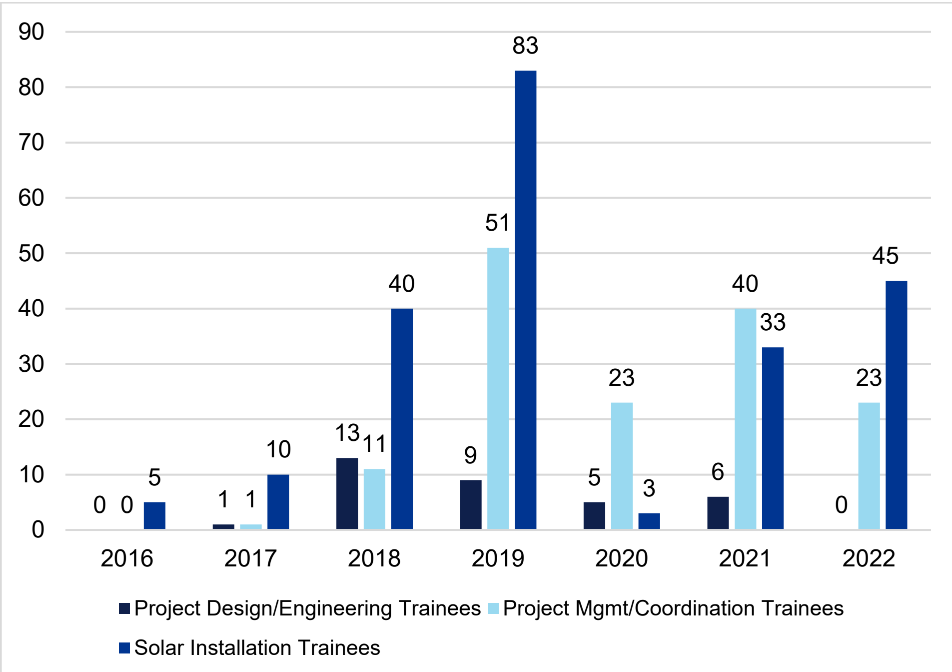


Figure 4-20 SCE number of trainees per job category by year

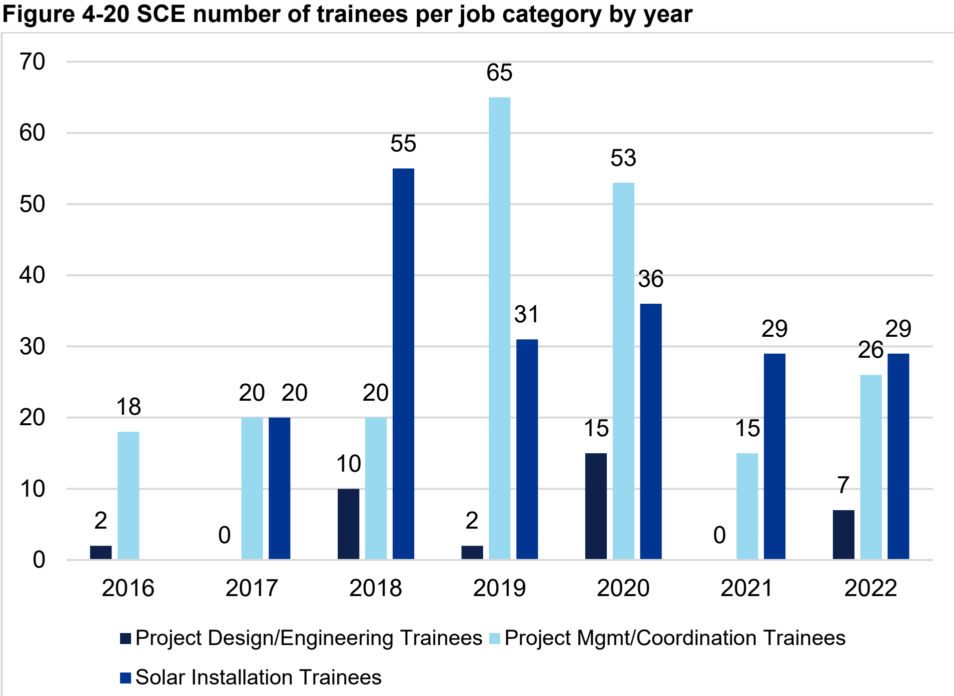
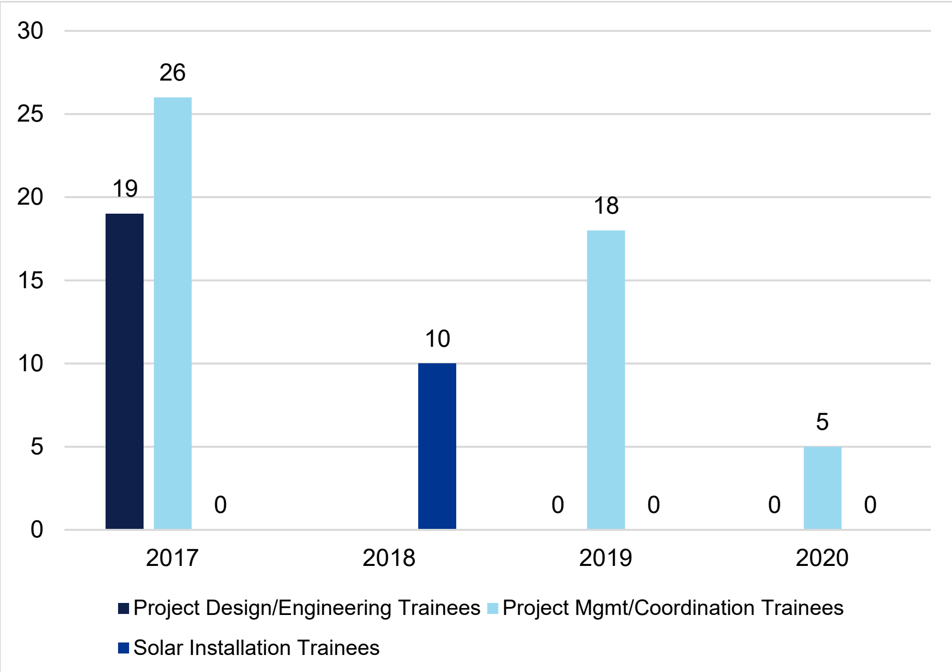


Figure 4-21 SDG&E number of trainees per job category by year



For Figures 4-19 to 4-21, totals include:

- Solar installation
  - 439 trainees
  - 9,163 training hours
  - Average of 20.87 hours/trainee
- Project design/engineering
  - 89 trainees
  - 2,437 training hours
  - Average of 27.38 hours/trainee
- Project management/coordination
  - 425 trainees
  - 6,359 training hours
  - Average of 14.96 hours/trainee

The majority of trainees participated in solar installation or project management/coordination training; however, most of training hours were dedicated to solar installation training. On average, solar installation training received approximately 25% more training hours than project management trainees. Project design and engineering trained the fewest workers but provided the greatest number of training hours per trainee. This could indicate the complexity of system design.

DNV evaluated each utility's workforce training data for all completed projects between 2016 and 2022. In Figure 4-22, Figure 4-23, and Figure 4-24, the average JTO per project (considering all completed projects) was compared against the required JTO for each system size. In most cases, the average number of trainees per project exceeded program requirements. There were two exceptions to PAs meeting JTO requirements: PG&E projects requiring four trainees results in an average of 3.8 trainees, and SCE projects requiring five trainees resulted in an average of 4.9 trainees.

Figure 4-22 PG&E JTO required vs. average reported for projects

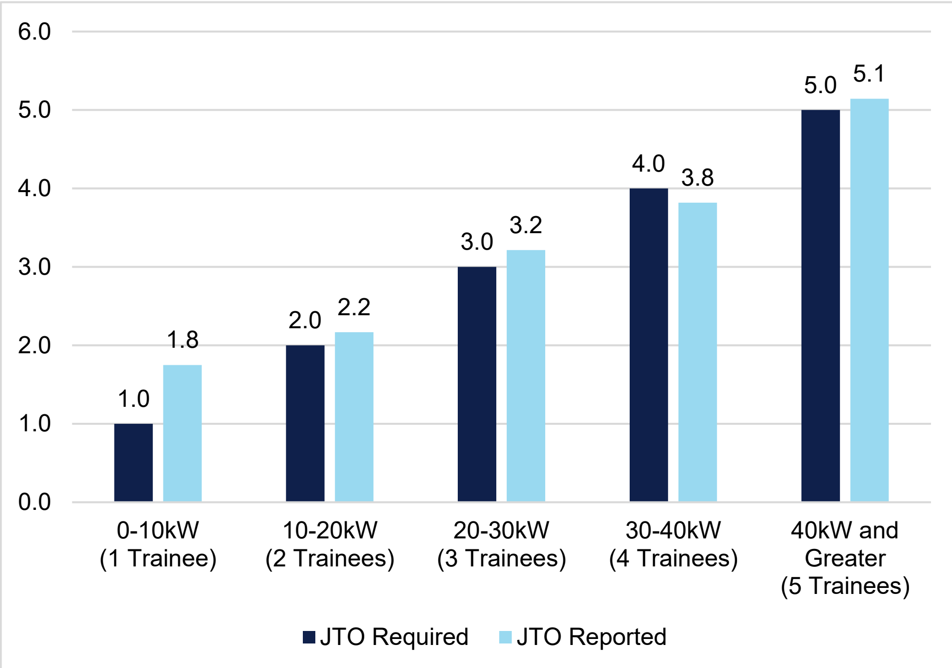


Figure 4-23 SCE JTO required vs. average reported for projects

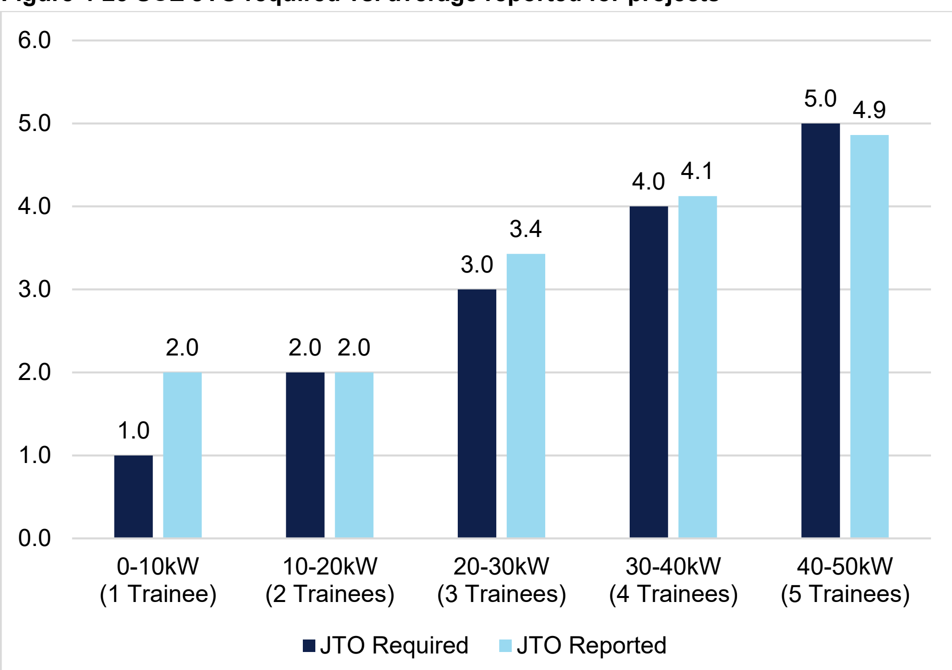
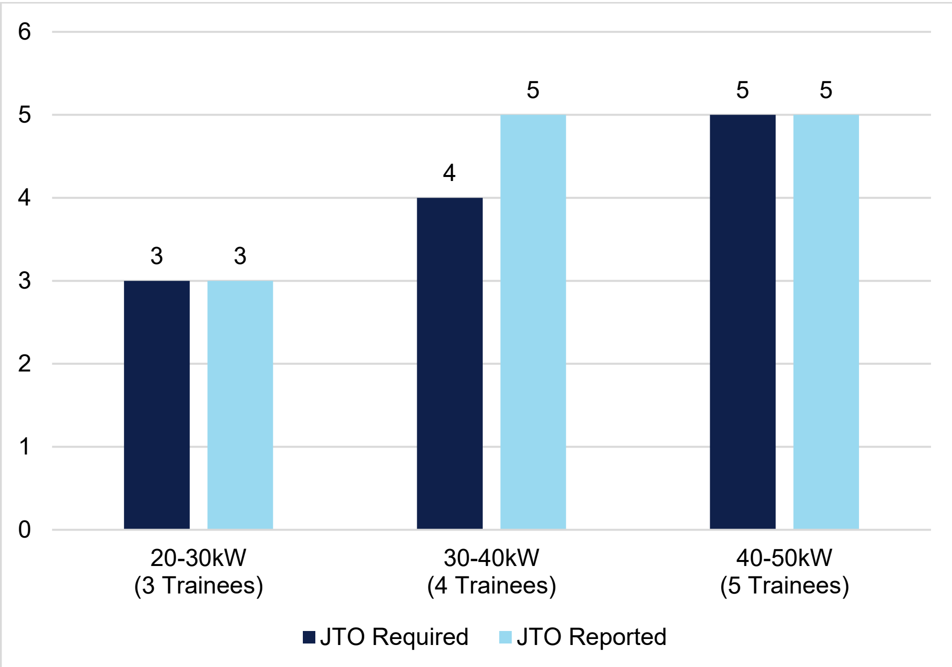


Figure 4-24 SDG&E JTO required vs. average reported for projects



In most cases, JTO requirements were met or exceeded. When evaluating all projects and considering the overall average number of trainees by project size, all PAs met or exceeded the job training requirements for projects less than 30 kW in size. For projects 30-40 kW, SCE and SDG&E exceeded the requirements while PG&E's average was slightly under the requirement. For projects 40-50 kW, PG&E's and SDG&E met or exceeded the requirements while SCE's average was slightly under the requirement.

Table 4-14 presents the annual job training data for eligible projects for each PA. Annual data including number of trainees and number of hours trained by PA. The average number of trainees per project was computed. The number of eligible projects along with the number of trainees and training hours reached a peak 2019 with 259 trainees working 6,021 hours on 60 eligible projects.

Table 4-14 Job training statistics by PA

Year	PA	Number of eligible projects	Number of trainees	Number of hours	Average trainees/project
2016	PG&E	2	5	40	2.5
	SCE	16	20	160	1.3
	SDG&E	-	-	-	-
2017	PG&E	2	12	309	6
	SCE	12	40	320	3.3
	SDG&E	9	45	360	5
2018	PG&E	15	64	1,167	4.3
	SCE	21	85	2,233	4
	SDG&E	2	10	80	5
2019	PG&E	33	143	3,403	4.3
	SCE	23	98	2,474	4.3
	SDG&E	4	18	144	4.5

Year	PA	Number of eligible projects	Number of trainees	Number of hours	Average trainees/project
2020	PG&E	7	31	408	4.4
	SCE	21	104	2,784	5
	SDG&E	1	5	40	5
2021	PG&E	21	79	1,713	3.8
	SCE	9	44	816	4.9
	SDG&E	-	-	-	-
2022	PG&E	15	68	544	4.5
	SCE	16	62	804	3.9
	SDG&E	-	-	-	-
Total		**229**	**933**	**17,799**	**4.1**

Table 4-15 summarizes the annual data presented above by PA. Overall 229 eligible projects provided 17,799 training hours to 933 trainees.

Table 4-15 Job training totals by PA

PA	Total projects	Total trainees	Total hours
PG&E	95	402	7,584
SCE	118	453	9,591
SDG&E	16	78	624
Total	**229**	**933**	**17,799**

In interviews, the PAs noted that although workforce training was an important area and where MASH was a pioneer as one of the first solar programs with this requirement, it is indeterminate what the trainees learned or if it resulted in employment opportunities. To assess training outcomes, primary research with the job trainees would be required, which was outside the scope of this evaluation. Refer to 1.11 for a complete list by project.

4.6 Total customers served

All MASH 1.0 and MASH 2.0 program installations serve common areas and/or households residing in multifamily properties (i.e., multifamily and mobile home properties). Table 4-16 provides a summary of the number of program installations, the total capacity of program solar project installations, and the prevalence of these installations in DACs. SCE had almost half of its projects installed in DACs. Whereas SDG&E had <15% of its projects located in DACs.

Table 4-16 MASH project locations

	Number of projects[52]	Calculated CEC PTC rating (kW)	# Projects located in DACs	% Projects located in DACs
PG&E	321	26,349.40	**79**	24.6%
SCE	253	30,192.10	**116**	45.8%
SDG&E	62	6,161.19	**8**	12.9%
Total	**636**	**62,702.68**	**203**	**31.9%**

Figure 4-25 and Figure 4-26 map MASH program installations located in DACs and all project locations, respectively. The utility services areas are defined as follows: PG&E in red, SCE in yellow, and SDG&E in green. DAC areas within each service territory area are shaded. Each dot represents a single project's location, and the size of the dot denotes the system capacity. In general, projects were concentrated near major metropolitan areas: San Francisco, Los Angeles, and San

[52] Includes 14 projects with pending payments (PG&E and SCE).

Diego. However, there were also several projects in the Central Valley region of California, near Fresno and San Joaquin Valley. Overall, about 30% of the projects were installed in DACs. However, looking at the maps, projects not located in DACs were located near DACs. Several projects were also installed in the Oakland area. Larger capacity projects were more likely to be installed outside of major metropolitan areas.

Figure 4-25 MASH projects located in DACs

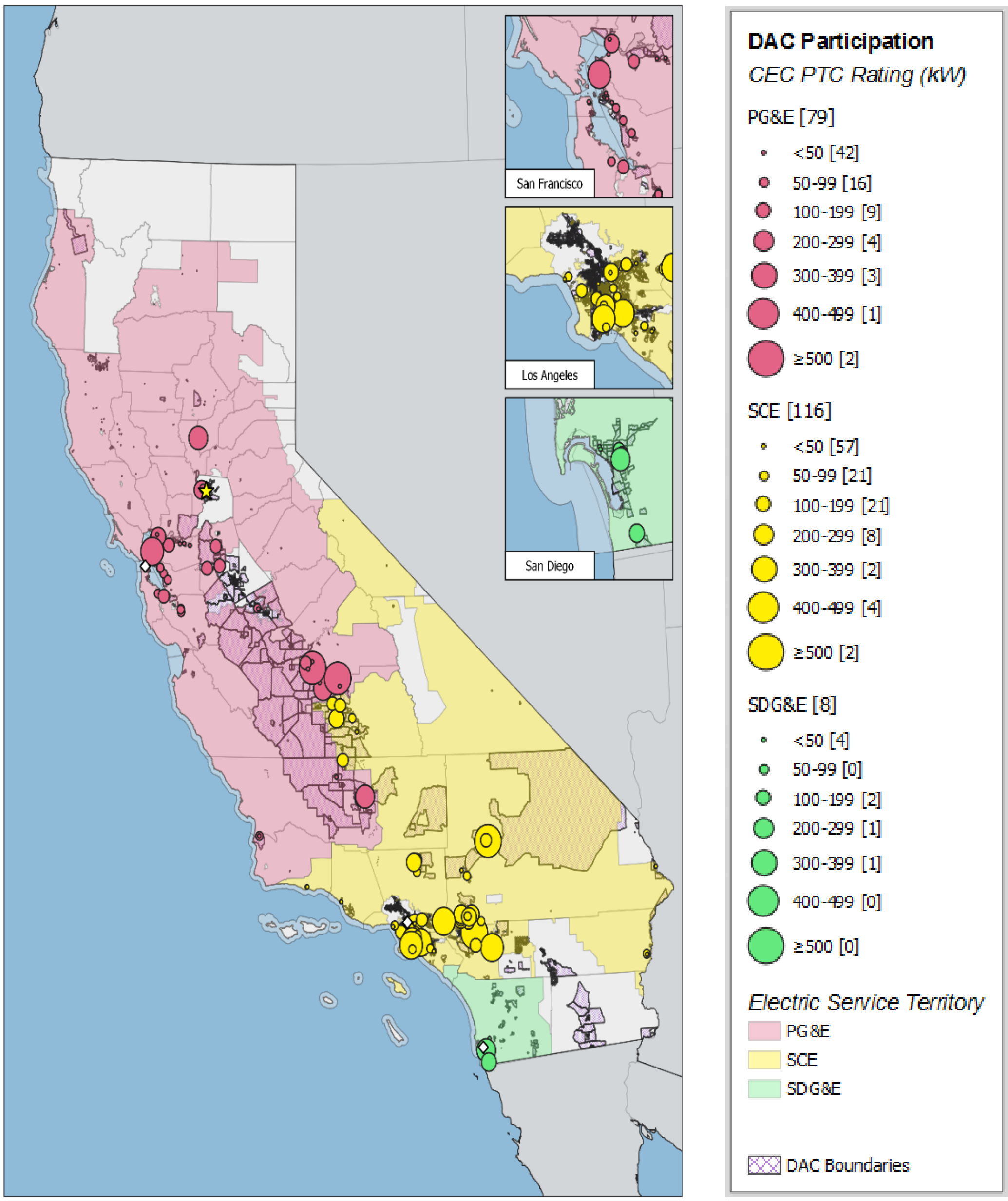
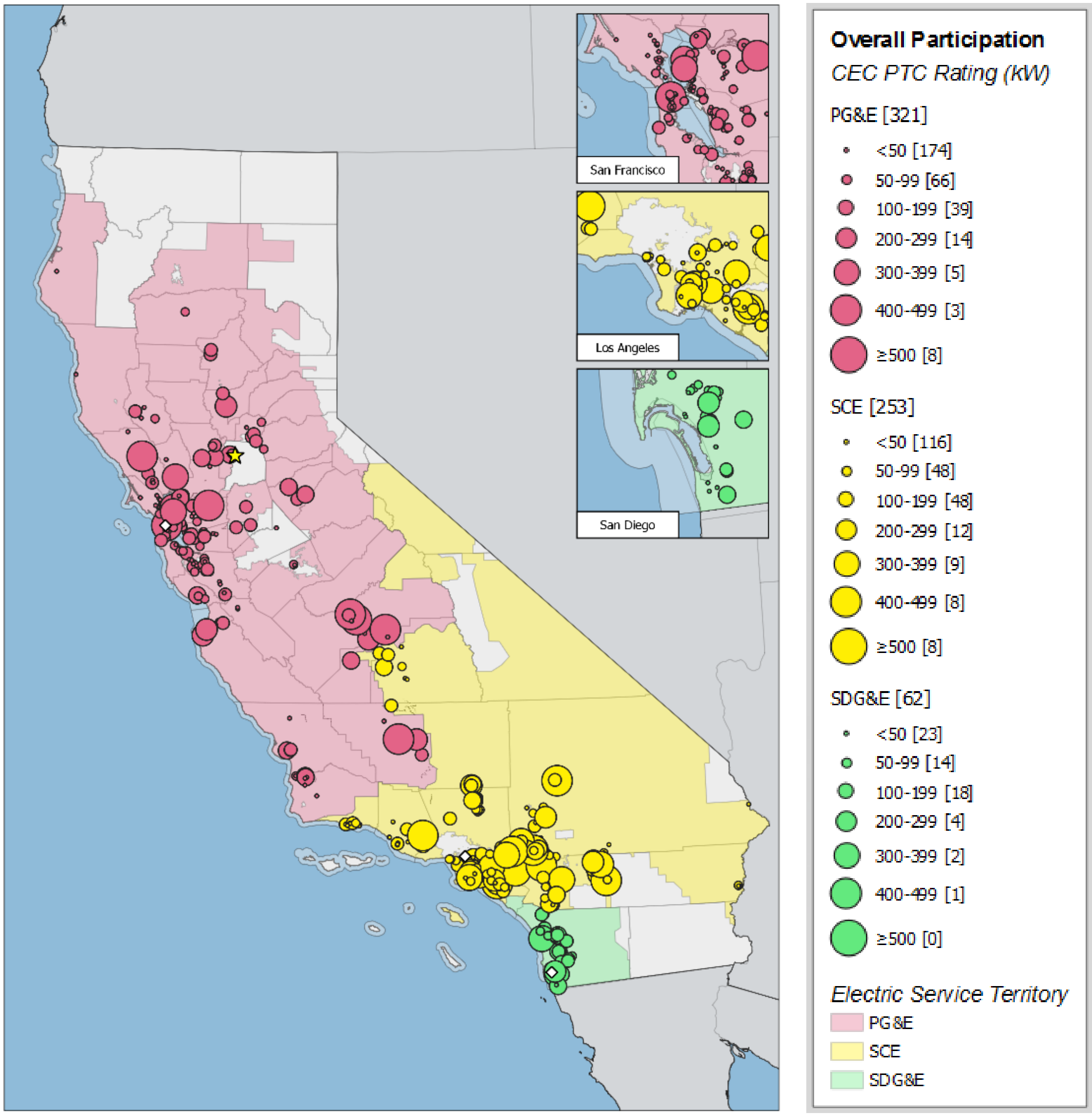


Figure 4-26 All MASH project locations



We analyzed this data further to determine the number of multifamily and mobile home properties served, the number of households served, and the number of common areas served. In total, only 9% of the projects served mobile home properties. We have summarized the total properties by property type and PA in Table 4-17.

Table 4-17 Number of multifamily and mobile home properties (completed projects)

	Multifamily projects	Mobile home projects	Total projects	% Multifamily	% Mobile home
PG&E	282	27	309	91%	9%
SCE	242	9	251	96%	4%
SDG&E	42	20	62	68%	32%
Total	566	56	622	91%	9%

Based on submitted applications, more than 16,000 households are directly benefitting from MASH projects. Additionally, property residents are benefitting from the more than 2,000 common areas participating in MASH projects. Mobile home properties represent 9% of MASH projects but those projects represent 13% of the households served and 6% of the common areas served. We also looked at the number of CARE and non-CARE participants in the billing data. Not all MASH participants could be identified in the billing data. Of those that could be identified, 55% of PG&E's participants and 79% of SDG&E participants are CARE customers as of Q1 of 2022. We were not able to identify CARE customers in SCE MASH projects.[53]

The number of households and common areas served by property type are summarized in Table 4-18.

Table 4-18 Number of tenant and common areas served (source: applications for MASH completed projects)

	Multifamily		Mobile homes		Total	
	Households served	Common areas	Households served	Common areas	Households served	Common areas
PG&E	5,772	898	711	64	6,483	962
SCE	6,086	931	1,289	50	7,375	981
SDG&E	2,370	215	128	19	2,498	234
Total	14,228	2,044	2,128	133	16,356	2,177

MASH projects are interconnected employing one of two metering types: NEM and VNEM. NEM interconnections directly offset behind-the-meter load. PG&E, SCE, and SDG&E began to offer a VNEM utility tariff option in June 2009. These tariffs allow multifamily affordable property owners that participate in the MASH Program to install a single solar PV system that covers the electrical load of the owner's common areas as well as the tenants' individual meters that are located within the residential complex. Based on a prearranged allocation determined by the property owner, the participating utility allocates the kilowatt-hours resulting from the energy produced by the solar PV generating system to both the property owner's and tenants' individual utility accounts. PAs captured the type of load being offset (i.e., common area and/or tenant) in the program tracking database. Table 4-19 summarizes the number of projects by metering type: NEM, VNEM or both. Most projects (55%) are NEM metering, and very few (1%) projects use both metering types. SDG&E had no projects with NEM metering; all projects within their service territory utilized VNEM metering.

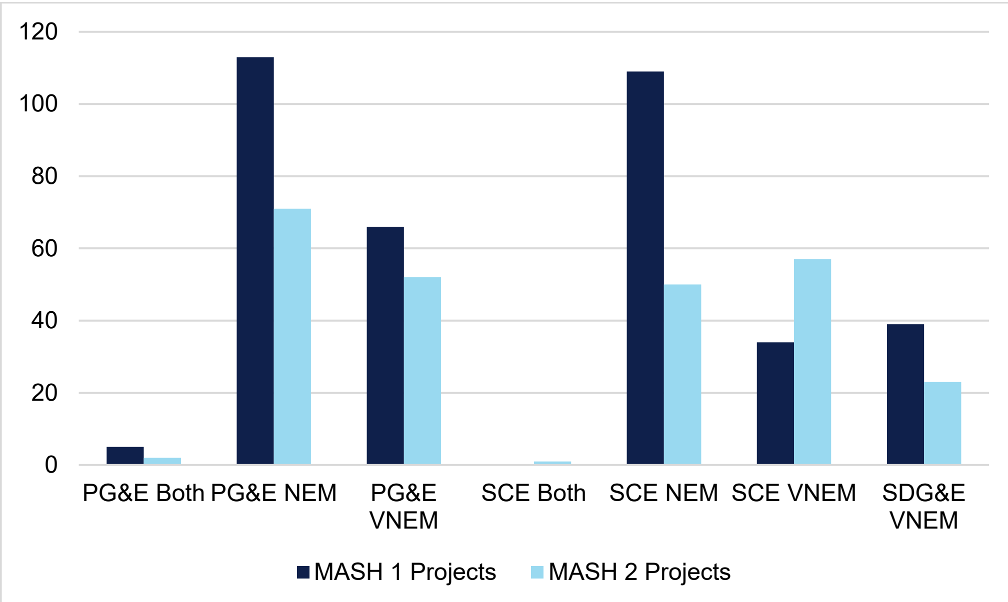
Table 4-19 Metering types by PA

Row Labels	NEM	VNEM	Both	Total
PG&E	184	118	7	309
SCE	159	91	1	251
SDG&E	0	62	0	62
Total	**343**	**271**	**8**	**622**

Overall, during MASH 1.0, 61% (222 projects) of completed projects interconnected with a NEM metering type, this percentage decreased to 47% (121 projects) during MASH 2.0. VNEM metering types saw a reverse trend with 38% (139 projects) selecting VNEM metering type in MASH 10, and 52% (132 projects) choosing VNEM under MASH 2.0. Because almost half of the projects were completed in PG&E's service territory, their results influenced the overall results, which are summarized in Figure 4-27 Project count by metering type, program, and PA.

[53] SCE transitioned to a new billing system in 2021. The CARE information that SCE last provided to the Energy Division is still on the prior system, and the MASH data is on the new system.

Figure 4-27 Project count by metering type, program, and PA



NEM interconnections were most frequently used for common area load. For example, PG&E program participants installed 137 projects employing VNEM and 183 projects with NEM. Of those 183 NEM projects, 156 projects off-set only common area load. VNEM interconnections more commonly provided bill credits to participating accounts including both common area and tenant accounts. For example, PG&E's 137 VNEM projects provide benefits to common areas and tenants for 83 of those 137 projects.

For additional insight, Figure 4-28 and Figure 4-29 summarize common area and tenant accounts benefitting by meter type for each program (MASH 1.0 and MASH 2.0) for all PAs combined.

Figure 4-28 MASH 1.0 projects supporting common area and tenant accounts by metering type

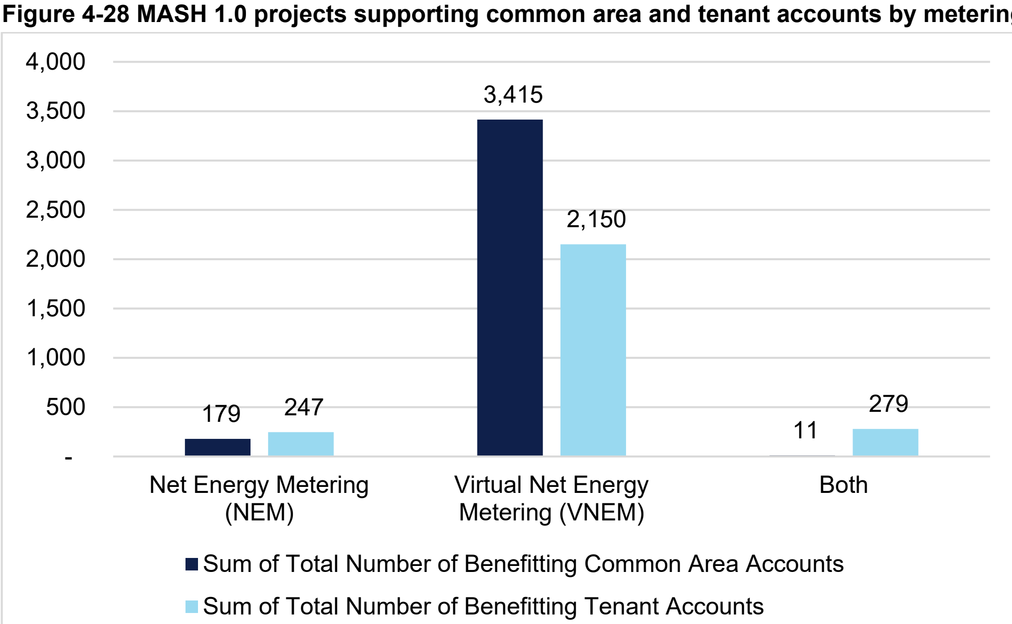
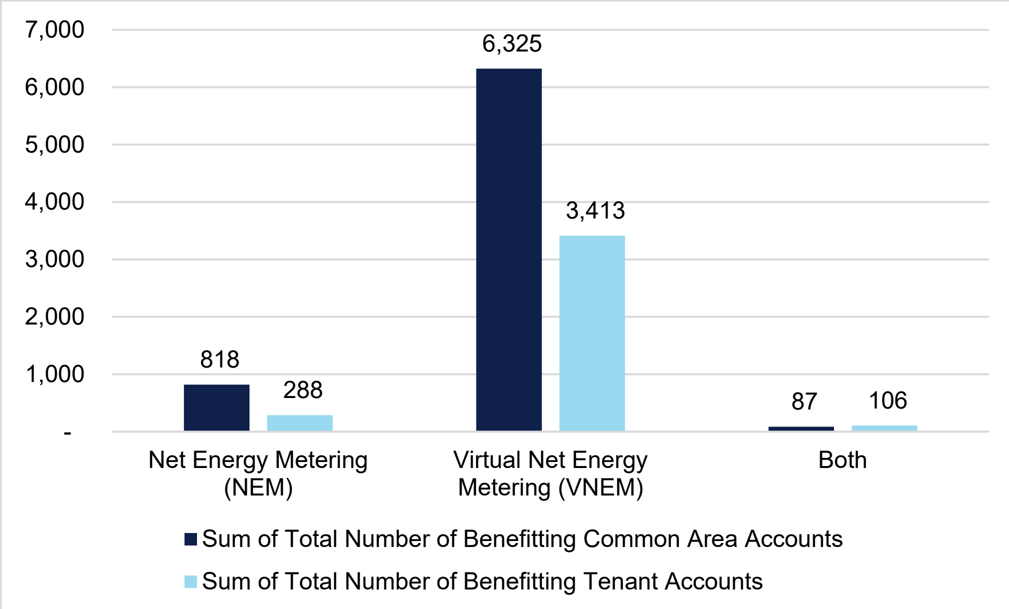
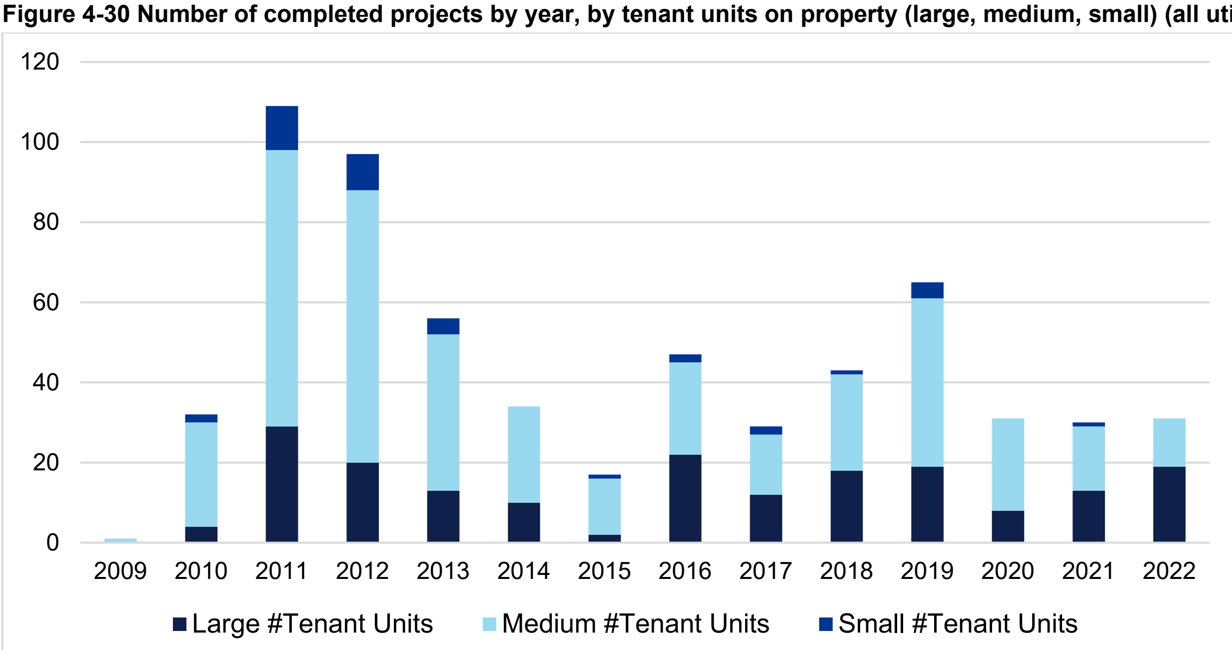


Figure 4-29 MASH 2.0 projects supporting common area and tenant accounts by metering type



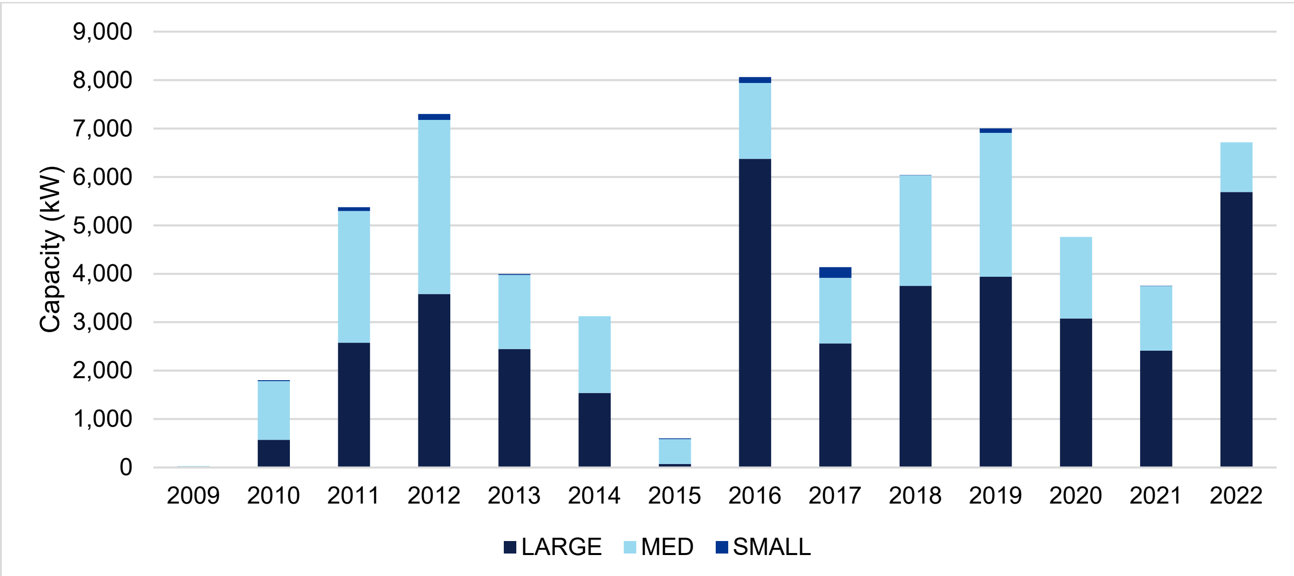
In Figure 4-30, DNV categorized completed projects as small, medium, or large based on the number of tenant units in the properties the project served. Small properties are those with 10 or fewer units, medium properties have 11 to 99 units, and large properties have more than 100 units. The majority (396 projects) of projects support medium properties, followed by large-sized properties, then small properties with 189 and 37 completed projects, respectively. During an interview, one PA observed that contractors typically solicited property owners with larger portfolios.

Figure 4-30 Number of completed projects by year, by tenant units on property (large, medium, small) (all utilities)



In Figure 4-31, DNV computed the annual total CEC PTC Rating (kW) for completed projects for each property size (i.e., small, medium, and large) based on the number of tenant units in the properties the project served. The total capacity (kW) completed during the entire program totalled 38,594 kW for large properties, 23,402 kW for medium sized properties and 705 kW for small properties, based on number of tenant units in properties served.

Figure 4-31 CEC PTC capacity by year, by tenant units on property (large, medium, small)



In the data provided by the PAs, customer feedback data was not included. During our evaluation, DNV did not see a mechanism for collecting customer feedback. To better evaluate programs going forward more comprehensive data would be helpful. This should include primary data collection from customers on an ongoing or periodic basis.

4.7 System characteristics by customer type

Using data collected by PAs for each MASH project incentivized, DNV determined the minimum, maximum, and average incentive for the entire program and for each program phase (MASH 1.0 and MASH 2.0). As shown in Table 4-20, the minimum incentives were close in value. MASH 2.0 projects on average received lower incentives.

Table 4-20 Minimum, maximum, and average incentive levels by program

Incentives	Entire program	MASH 1.0	MASH 2.0
Minimum	$4,207	$4.207	$4,706
Maximum	$2,301,501	$2,301,501	$1,480,446
Average	$204,604	$215,429	$189,930

Table 4-21 presents the minimum, maximum, and average capacity for the entire program and for each program phase (MASH 1.0 and MASH 2.0). In all statistics MASH 2.0 figures were larger than MASH 1.0 values which supports our finding that MASH 2.0 projects were on average larger than MASH 1.0 projects.

Table 4-21 Minimum, maximum, and average capacity (kW) by program

Capacity	Entire program	MASH 1.0	MASH 2.0
Minimum	2.498 kW	2.498 kW	5.14 kW
Maximum	990.96 kW	951.23 kW	990.96 kW
Average	103.04 kW	71.29 kW	146.08 kW

Table 4-22 presents the minimum, maximum, and average incentive and capacity for each property size (i.e., large, medium, and small based on number of tenant units) for the entire program (i.e., MASH 1.0 and MASH 2.0). The average incentive decreases as property size category decreased. Average system capacity followed a similar trend.

Table 4-22 Minimum, maximum, and average incentive and capacity (kW) by number of tenant units (property size)

Property Size	Incentive	Capacity
Large	AVG: $387,124	AVG: 204.20 kW
	Range: $15,121 - $2,301,501	Range: 12.146 kW - 990.961 kW
Medium	AVG: $128,988	AVG: 59.10 kW
	Range: $5,595 - $867,379	Range: 2.622 kW - 372.787 kW
Small	AVG: $39,559	AVG: 19.06 kW
	Range: $4,207 - $177,092	Range: 2.498 kW - 165.157 kW

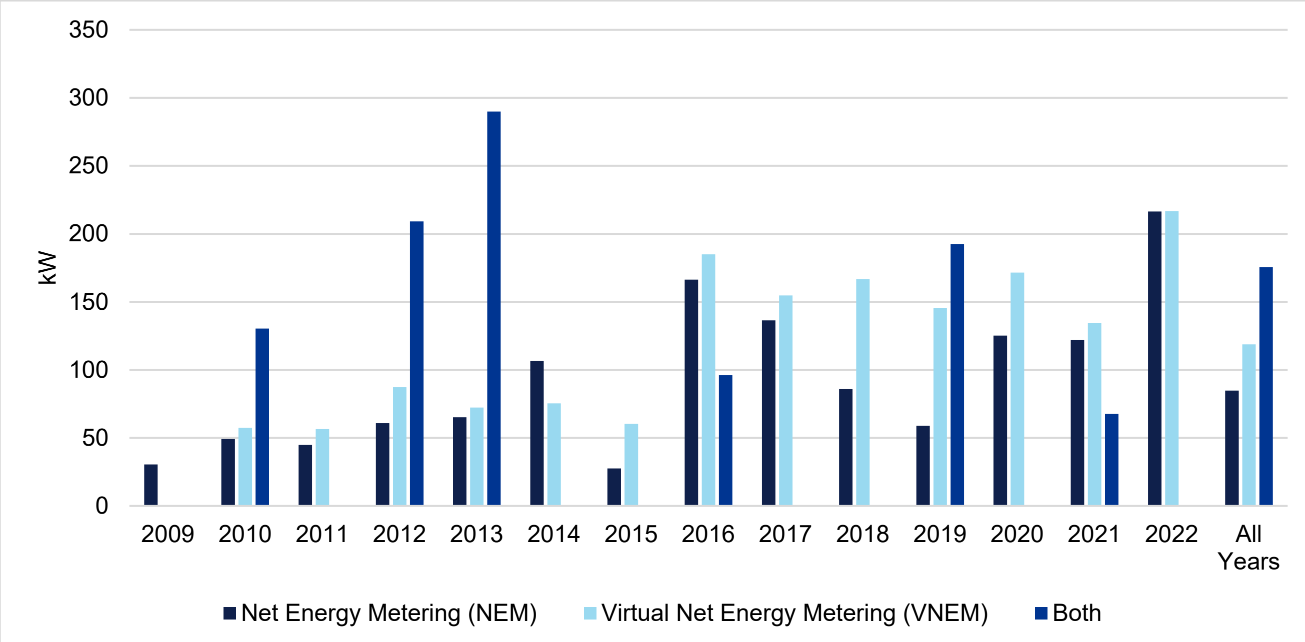
As stated previously, project capacity increased as the years progressed. When considering metering type, 55% of the completed projects were interconnected under NEM, 44% interconnected with VNEM, and 1% of the projects employed both metering types. Projects interconnecting with NEM were on average the smallest in size with an average system size across all years of 84.86 kW. VNEM systems were approximately 50% larger with an average system size of 118.79 kW. Eight projects interconnected with both NEM and VNEM. Their average system size was 175.53 kW. See Table 4-23 below.

Table 4-23 Minimum, maximum, and average capacity by metering type (completed project)

	NEM	VNEM	Both
Count	343	271	8
Sum	29,107.08 kW	32,191.37 kW	1,404.23 kW
Minimum	2.49 kW	2.77 kW	67.63 kW
Maximum	990.96 kW	925.93 kW	355.42 kW
Average	84.86 kW	118.79 kW	175.53 kW

Figure 4-32 shows the average system capacity by year for each metering type. Yearly averages follow as similar trends seen when looking at metering type by program. On average, NEM projects are smaller than VNEM projects. Projects using both meter types vary in average size because two or less projects were completed in any given year.

Figure 4-32 Average system capacity by year by metering type

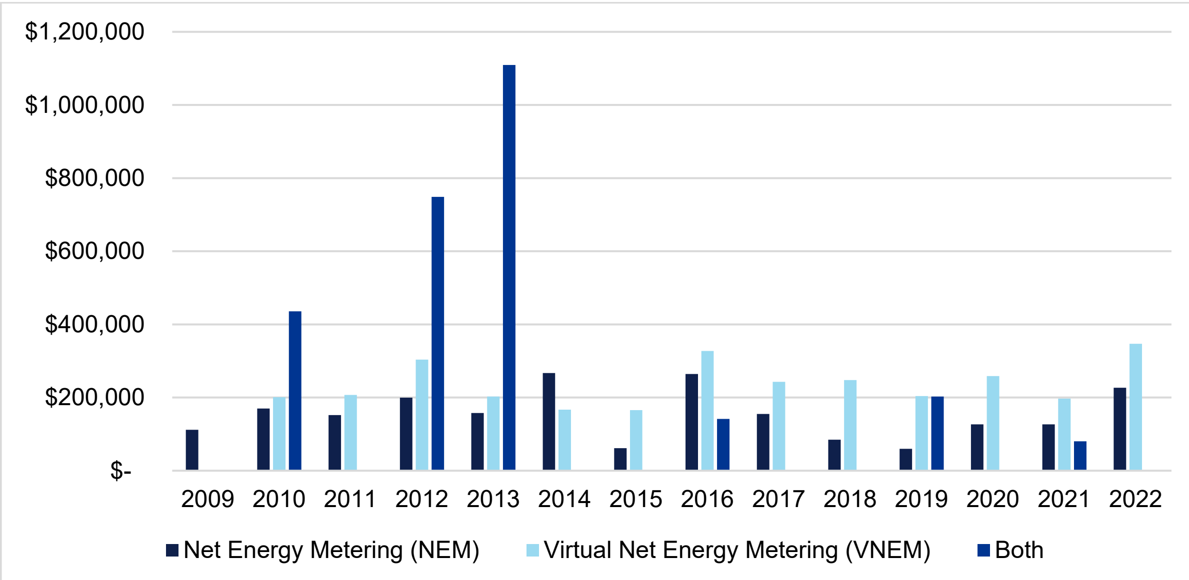


DNV also compared incentives provided to projects for the various metering types. Table 4-24 and Figure 4-33 summarize the average, minimum and maximum incentive levels by metering type. Projects with both NEM and VNEM meters on average received the highest incentives.

Table 4-24 Incentives by metering types

	NEM	VNEM	Both
Average of incentive amount	$164,193	$240,498	$526,977
Minimum	$4,207	$9,522	$80,600
Maximum	$2,301,501	$2,099,164	$1,245,363

Figure 4-33 Average incentive by year by meter type (count)



4.7.1 ESA cross-program participation

In interviews, the PAs reported that MASH was not a successful tool of referral for ESA. SCE noted that most tenants who participated in the program were previously enrolled. While PG&E and SDG&E reported that the information provided was not helpful for the ESA teams they coordinated with.

4.8 Bill impacts

This report considers two types of bill impacts: changes in energy use, and changes in dollars paid by customers. There are several reasons why these do not correspond perfectly: access to solar energy is likely to put customers at a lower pricing tier if on tiered rates, or to have reduced energy use in higher-priced time-of-use (TOU) periods (before the advent of the more recent, solar-driven TOU rates). Medical need discounts, differences in taxes from one county to the next, and other factors contribute to these differences. Last, we report bill impacts for projects that became interconnected on different years without adjusting for periodic rate increases: on average, 100 kWh cost $14.96 in California in 2010, and $24.46 in 2022.[54]

Bill impacts are reported separately for cases where the pre-interconnection and the post-interconnection ("pre-" and "post-") occurred entirely before COVID, or if COVID[55] straddled the pre- and post- periods at any time. This is because the effect of COVID on electricity consumption is difficult to model in this situation, where there are two major changes (solar energy and COVID) both of which have the effect of potentially increasing residential energy use.

The weather-normalized bill impacts analysis indicates that, on average, tenants that had access to MASH system energy before COVID used 138 kWh more per year, about a 3.2% increase, whereas during COVID, tenants used 377 kWh more, an 8.6% increase. Table 4-27 shows that tenant bills were reduced over 40% on average on the year after installation.

Weather normalization and comparisons of pre- and post-program participation years require complete, well-defined data. Due to data quality and data availability issues, this section presents results that are based on PG&E only. APPENDIX B includes a detailed description of these issues.

[54] Source: Form EIA-816M. https://www.eia.gov/electricity/data/eia861m/ DNV calculations for California historic sales, December-2010 final and December-2022 preliminary.

[55] COVID is defined as starting on March 15, 2020.

Table 4-25 PG&E customer impacts: overall change in electricity use from both sources (grid and solar)

Time period	Benefiter	Number of premises	Mean first year electricity use change, weather-normalized (kWh per year)	% change	Standard error of mean	95% confidence level	
						Lower	Upper
Before COVID	Common Area	107	-98 (1)	-2% (1)	120	-333	137
	Tenant	1,373	138	3%	32	75	202
During COVID-	Common Area	83	61 (1)	1% (1)	111	-156	278
	Tenant	1,130	377	9%	41	297	458
Both	Common Area	190	-29 (1)	-1% (1)	83	-192	134
	Tenant	2,503	246	6%	26	196	297

(1) kWh for common areas is not statistically significant

Table 4-26 PG&E customer impacts: reduction in electric use from grid

Time period	Benefiter	Number of premises	Mean first year electricity use change, weather-normalized (kWh per year)	% change	Standard error of mean	95% confidence level	
						Lower	Upper
Before COVID	Common Area	107	4,040	8%	437	3,184	4,897
	Tenant	1,373	2,622	44%	43	2,538	2,705
During COVID-	Common Area	83	5,478	1%	921	3,671	7,284
	Tenant	1,130	2,727	41%	46	2,638	2,817
Both	Common Area	190	4,668	4%	466	3,755	5,582
	Tenant	2,503	2,669	43%	31	2,608	2,731

Table 4-27 PG&E customer impacts: electric bill

Time period	Benefiter	Number of premises	Mean first year bill reduction (dollars per year)	% change	Standard error of mean	95% confidence level	
						Lower	Upper
Before COVID	Common Area	33	-$309	-58%	62	-$430	-$188
	Tenant	680	-$228	-42%	11	-$250	-$206
During COVID	Common Area	83	-$869	-76%	182	-$1,227	-$511
	Tenant	1,130	-$320	-46%	16	-$352	-$229
Both	Common Area	116	-$710	-73%	134	-$972	-$447
	Tenant	1,810	-$286	-45%	11	-$307	-$264

While on average, tenants in both periods experienced higher energy use, these impacts varied widely from tenant to tenant. Figure 4-34 and Figure 4-35 show this dispersion. Each dot represents a tenant premises, with the level of use before MASH on the X axis and the level of use after MASH on the Y axis. In the period with no COVID, the number of customers that use more energy is similar to the number that used the same or less (702 Vs 671). In the period with COVID, there are more customers that use more energy than the same or less (716 Vs 414).

Figure 4-36 and Figure 4-37 present a different view of the same finding. The Y axis presents the annual change in electricity use, and the X axis presents the customers, ranked in ascending order. The first graph shows that the change in energy use goes from negative to zero at about half of the distribution, while the second graph shows that this happens approximately in the first third. In both cases, most customers have increases of 5,000 kWh or less, but the cases before COVID have some outliers that increased their energy use by almost 15,000 kWh per year.

Figure 4-34 Tenant daily kWh, before and after, before COVID

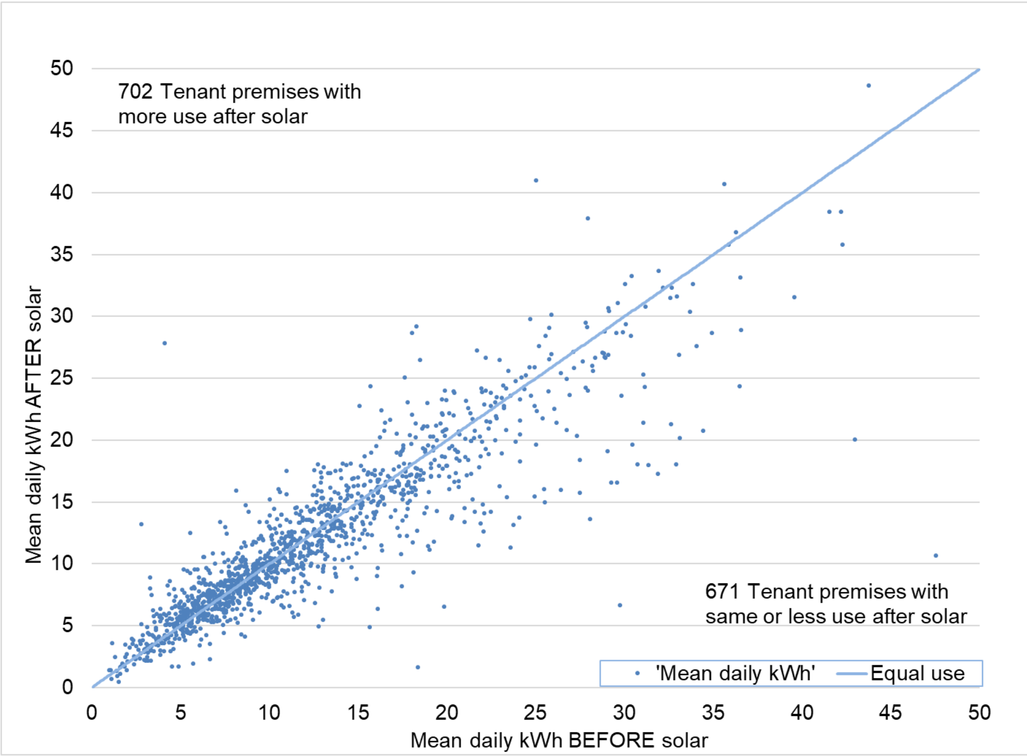


Figure 4-35 Tenant daily kWh, before and after, during COVID

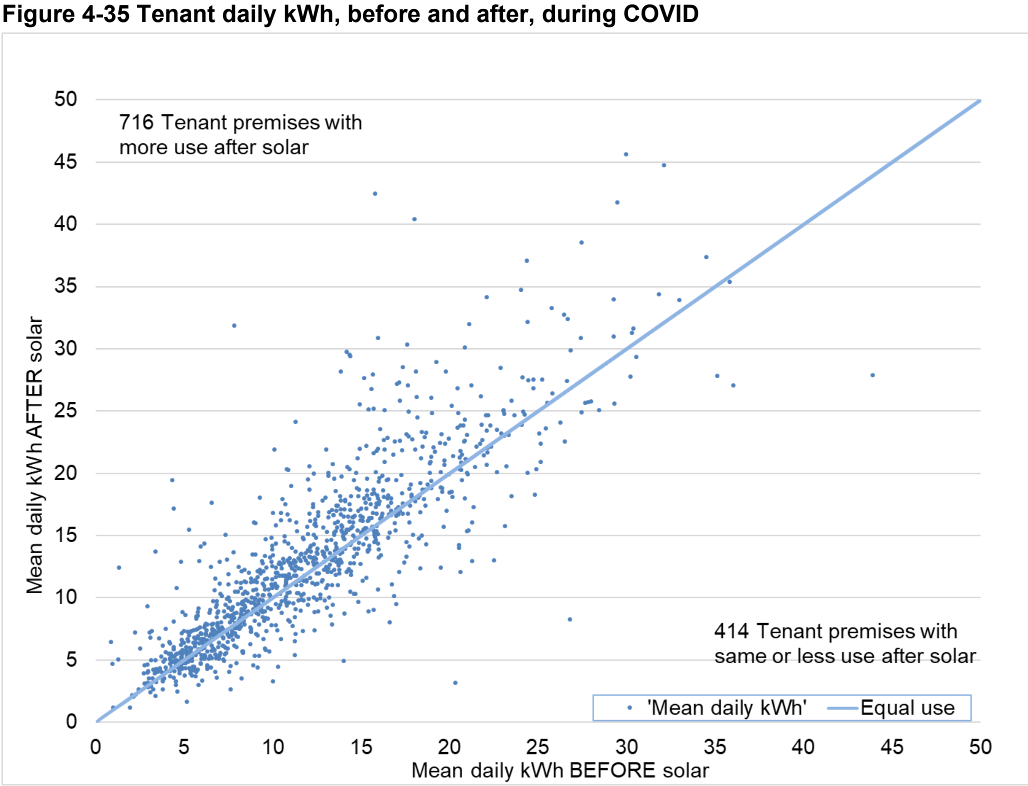


Figure 4-36 Tenant change in annual kWh used, before COVID

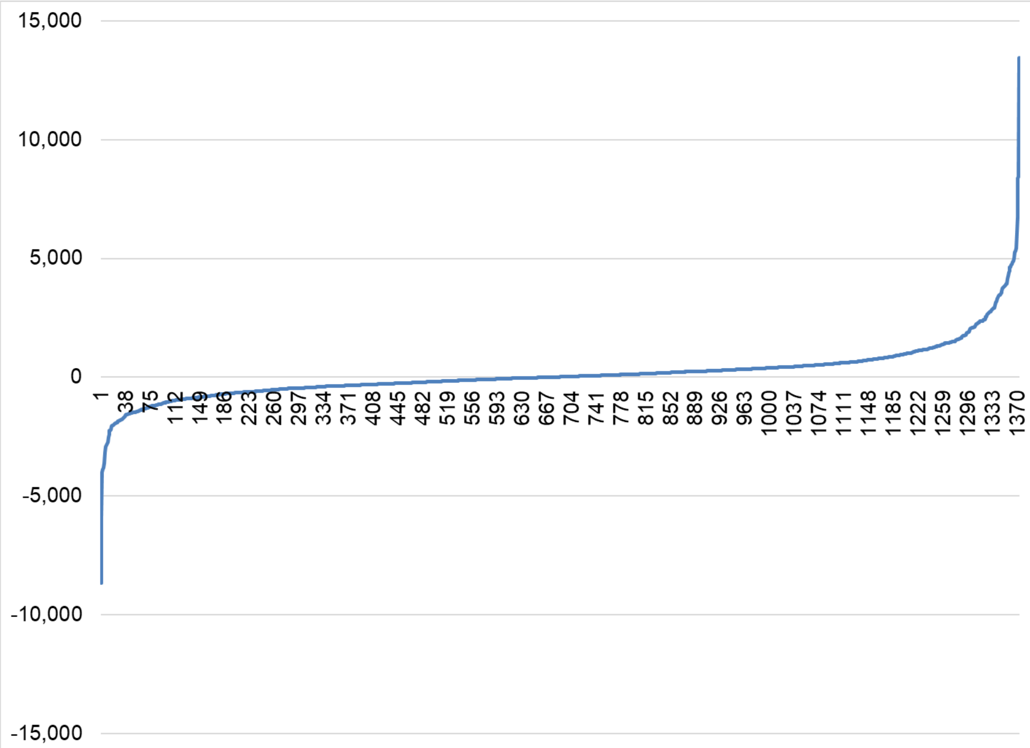
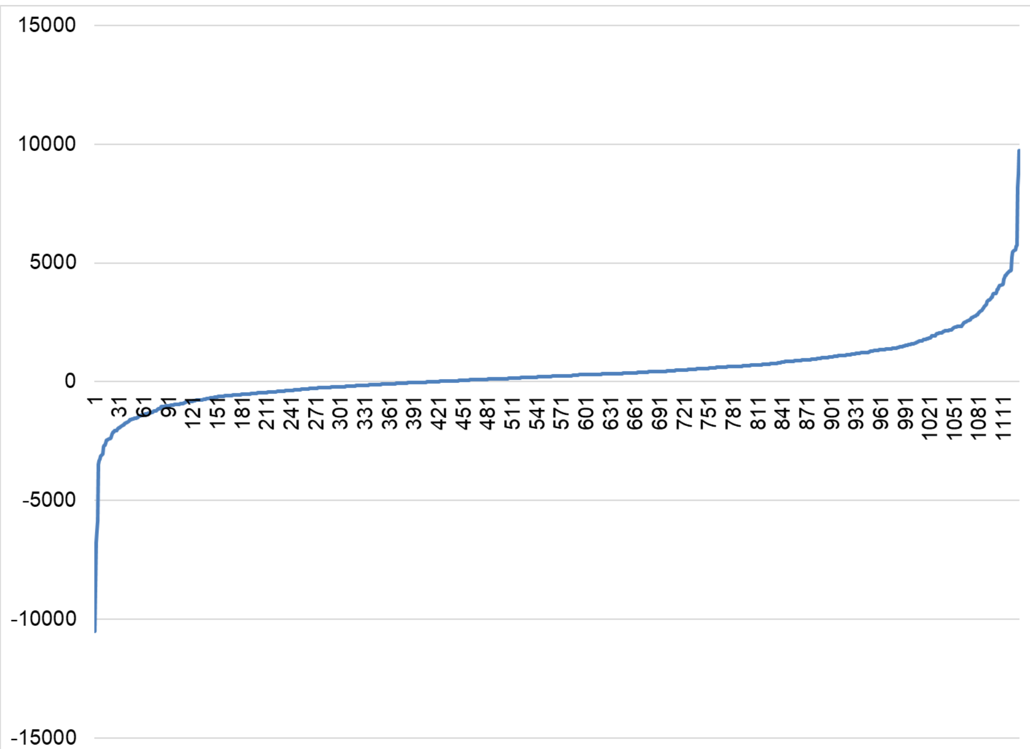


Figure 4-37 Tenant change in annual kWh used, during COVID

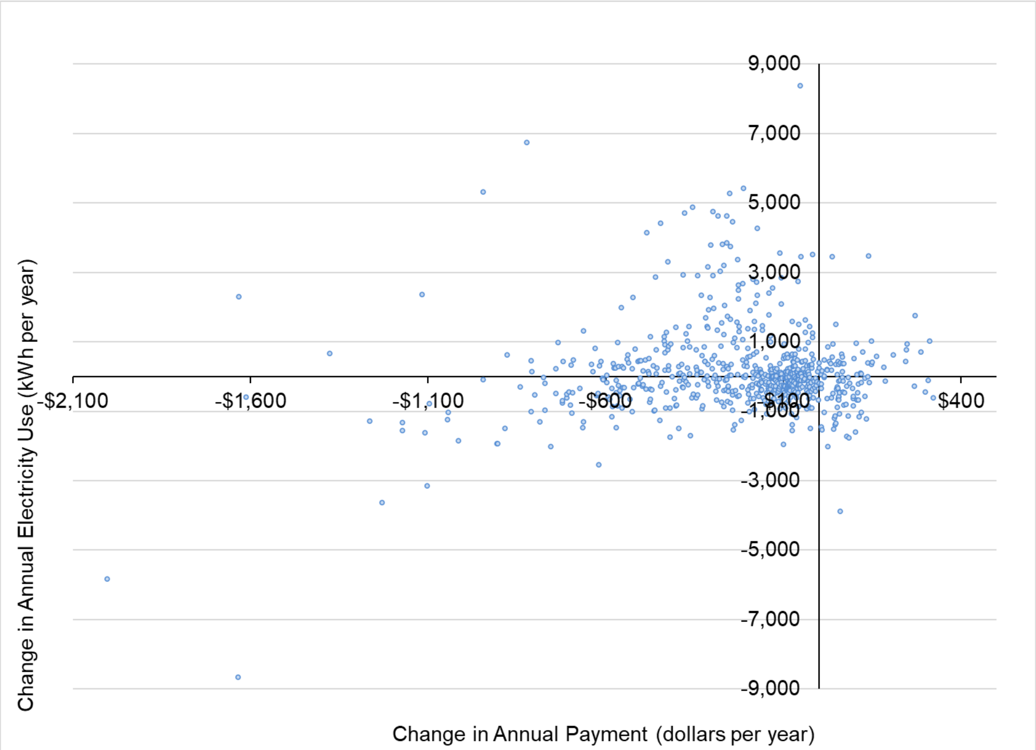


To interpret the next sets of graphs, it is important to keep in mind that tenants that have annual energy use plus meter charges that are less than their share of kWh provided by the MASH system will receive a payment. Referred to as the credit of surplus energy, it provides an incentive to conservation. Rates changed substantially during the deployment of MASH. During most of the program, energy buy back was at retail prices. At current rates, PG&E's minimum residential charge is $0.38 cents per meter per day, and the net surplus compensation is 0.09 cents per kWh[56]. This translates into needing approximately 1,600 kWh of credited (not used) solar generation per year to cover these minimum charges. To qualify for a monetary refund, the credit must be $1 or more — approximately 115 kWh.

Figure 4-38 and Figure 4-39 illustrate the relationship between annual changes in kWh used and in dollars paid per year. Most customers pay less than they did prior to their access to the MASH system, and about half use more energy. In the period prior to COVID, 26 of 786 tenants received payments. These annual payments ranged from $2 to $478 dollars and averaged $276 dollars. In the period after COVID, only two of 1,130 tenants received payments, for $12 and $39, respectively.

Figure 4-40 and Figure 4-41 show first year kWh used (from the Grid and from the solar system) compared to kWh purchased (from the Grid). There were 213 of 1,373 tenants in the phase prior to COVID that had net negative kWh. These ranged from -7 to -9,554 kWh. In the period impacted by COVID, there were 151 customers that had negative kWh ranged from -3 to -4,687 kWh.

Figure 4-38 Tenant change in annual kWh Vs change in annual bill, before COVID



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https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_NEM.pdf
https://www.pge.com/pge_global/common/pdfs/solar-and-vehicles/green-energy-incentives/AB920_RateTable.pdf
accessed on 12-April-2023

Figure 4-39 Tenant change in annual kWh Vs change in annual bill, during COVID

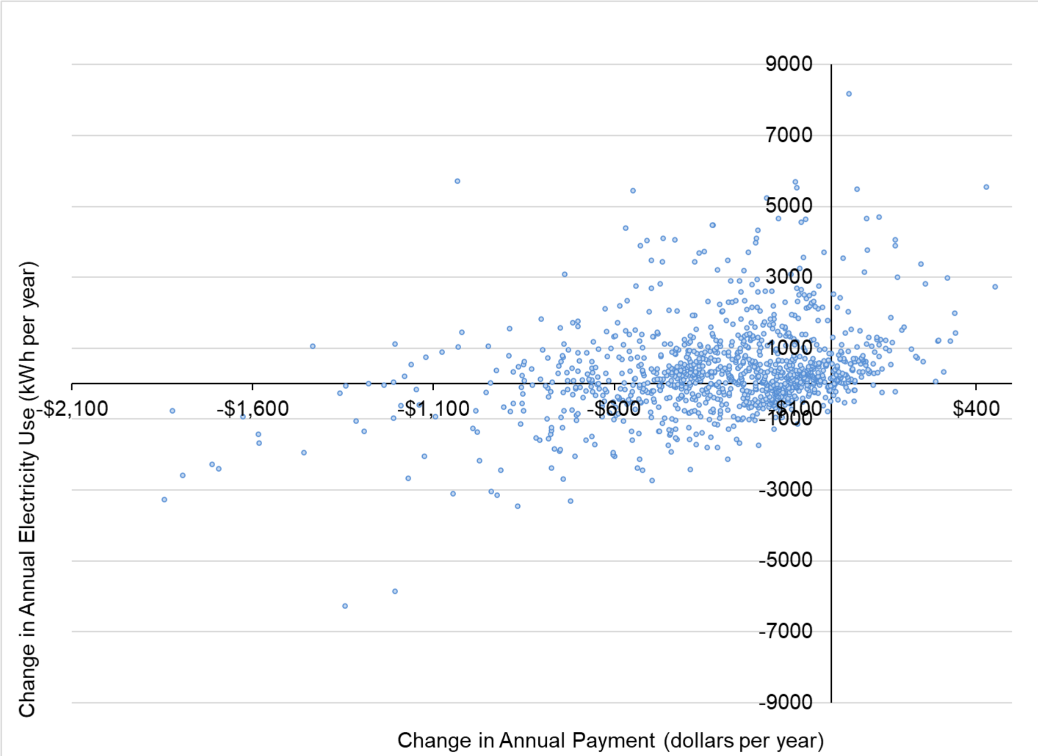


Figure 4-40 Tenant kWh used (from solar and grid) Vs kWh purchased (from grid), before COVID

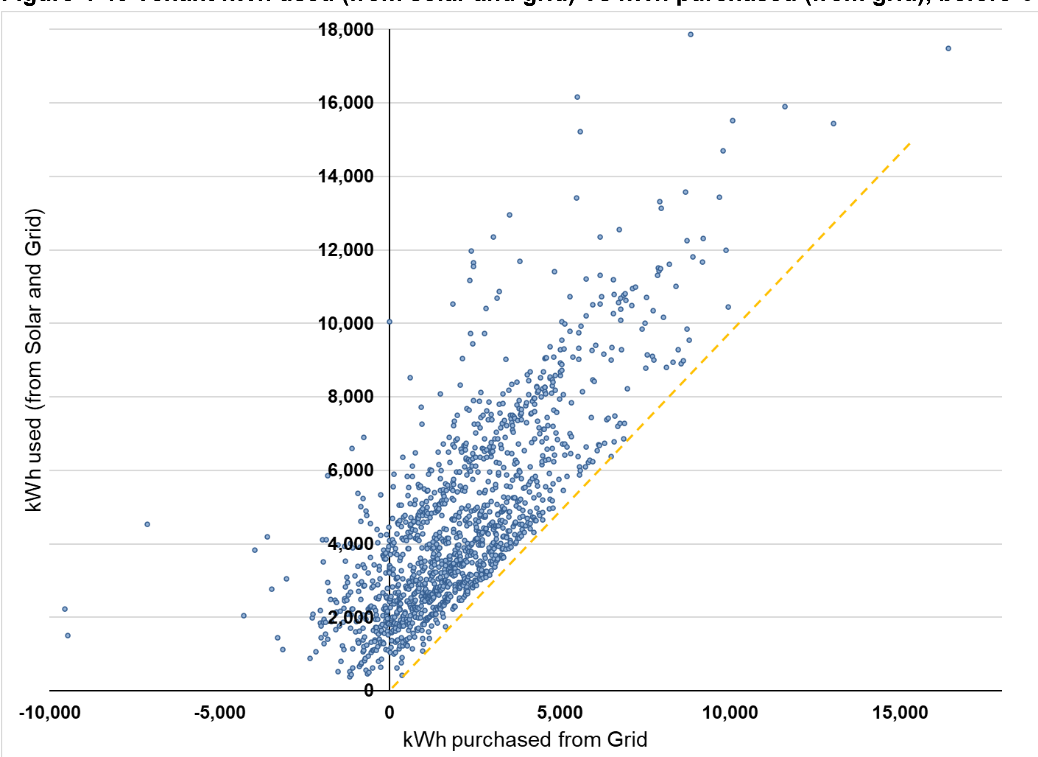
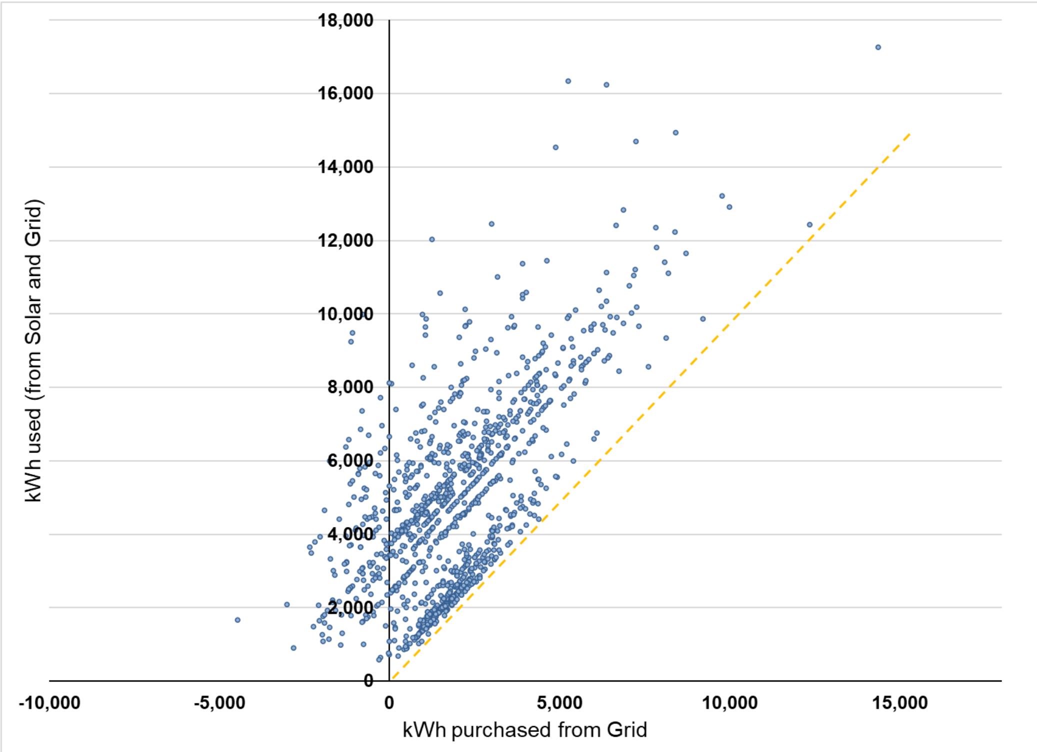


Figure 4-41 Tenant kWh used (from solar and grid) Vs kWh purchased (from grid), during COVID



The change in energy use (kWh per year) for Common Areas in both periods is not statistically significant. In other words, the change in energy use cannot be distinguished from zero. However, the difference in customer bills (dollars per year) is statistically significant. It was $309 dollars per year in the period before COVID, and $869 dollars per year in the period that includes COVID. Of the 35 common areas with bills in the pre-COVID period, 31 of them received payments ranging from $16 to $1,413 dollars per year. In the COVID period, 87 of 88 common areas received payments, which ranged from $7 to $11,470 dollars per year.

Figure 4-42 Common area daily kWh, before and after, before COVID

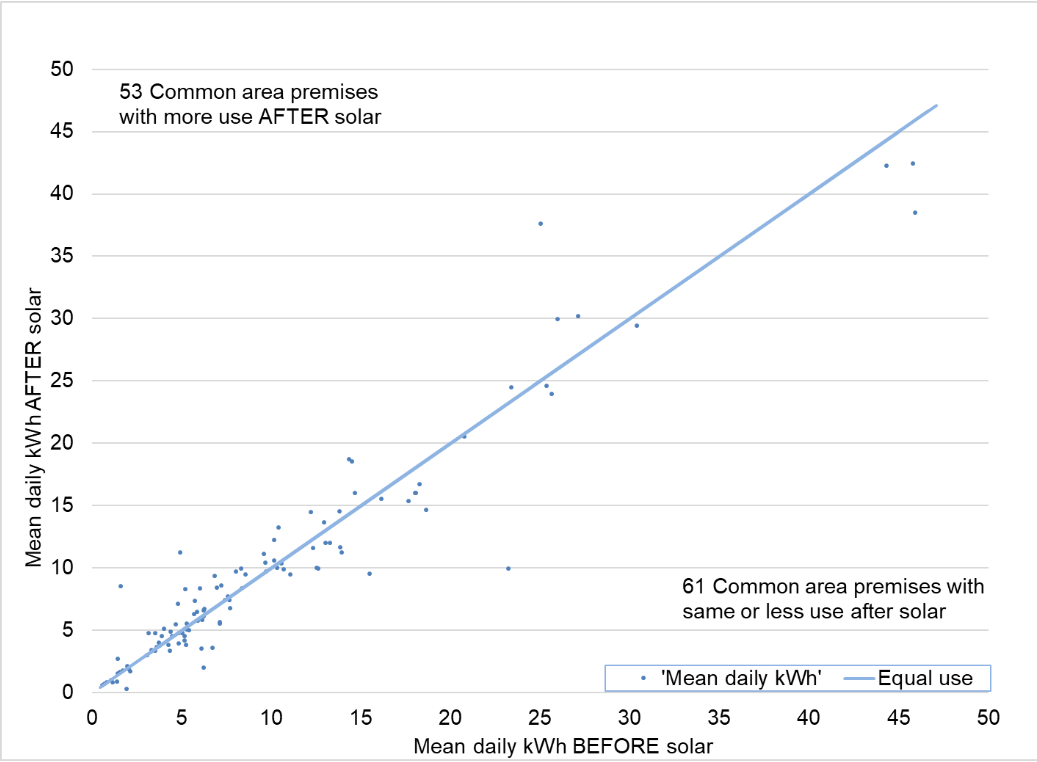


Figure 4-43 Common area daily kWh, before and after, during COVID

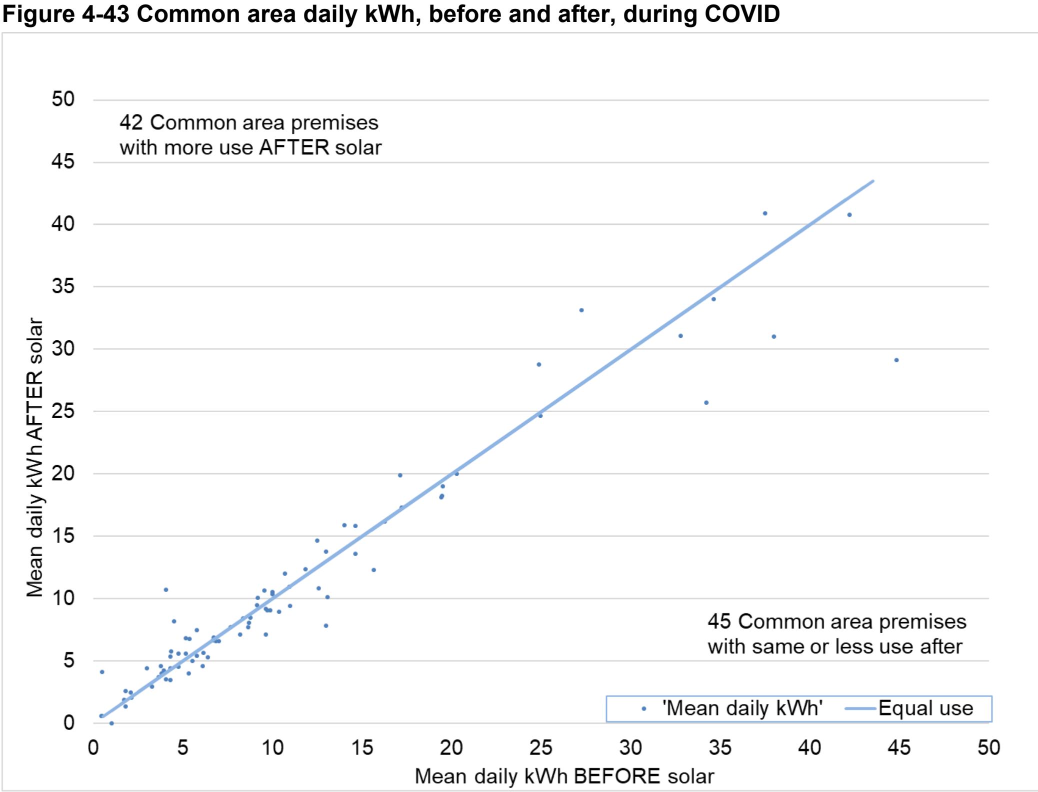


Figure 4-44 Common area change in annual kWh used, before COVID

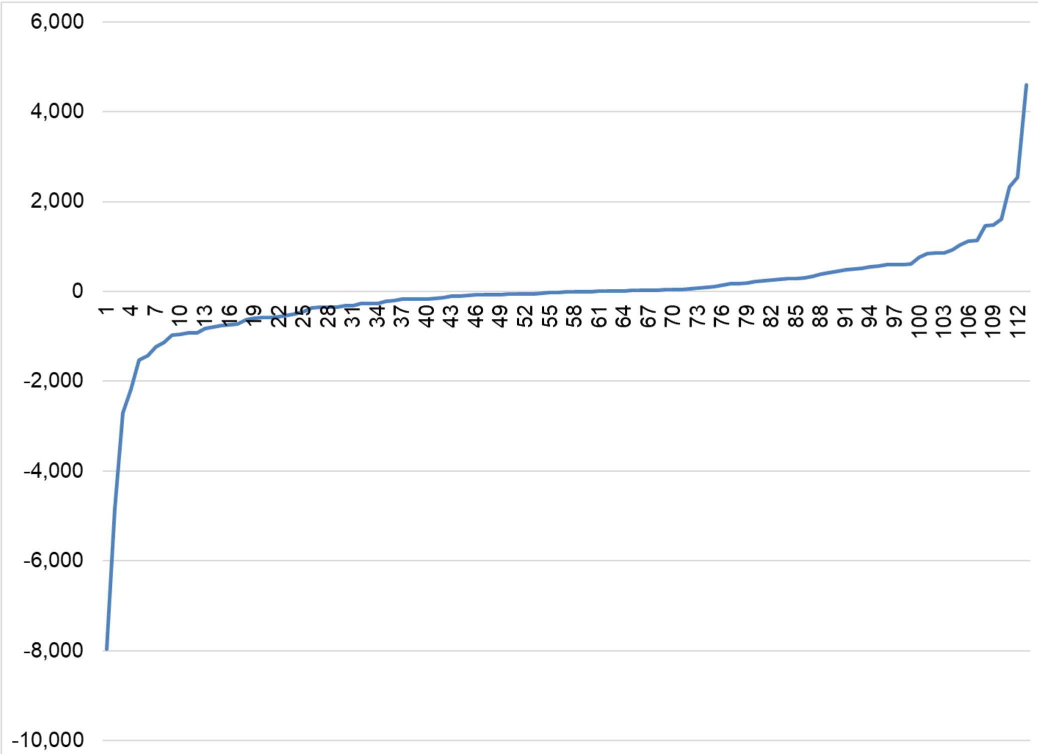


Figure 4-45 Common area change in annual kWh used, during COVID

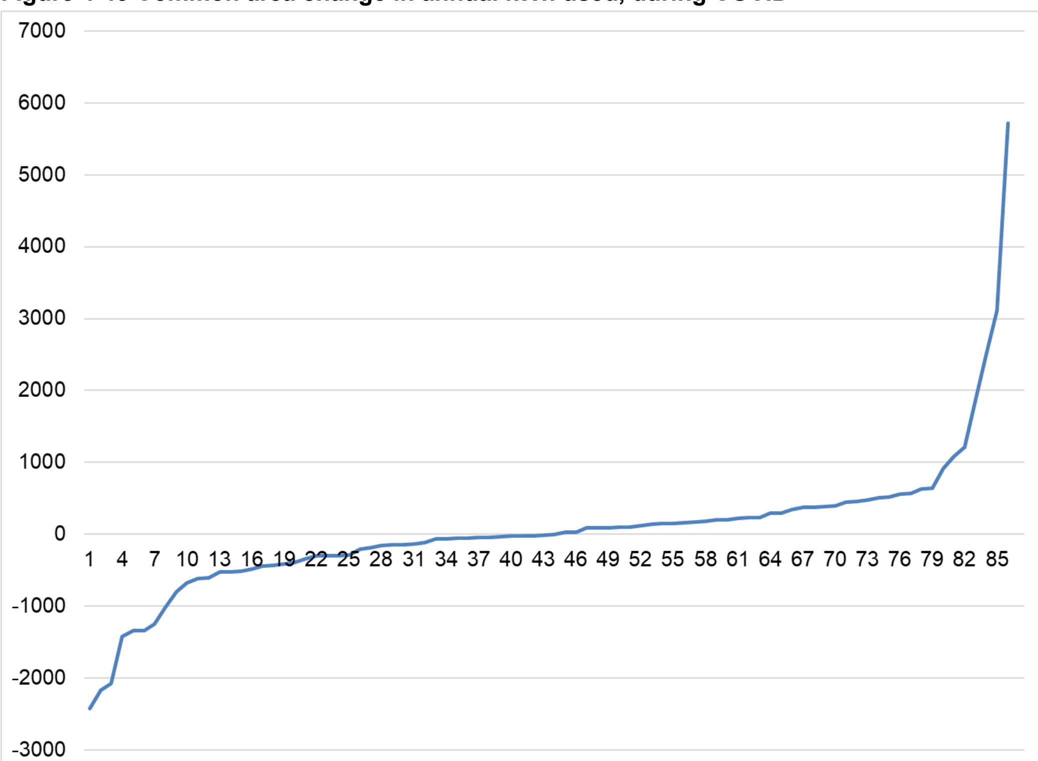


Figure 4-46 Common area change in annual kWh vs change in annual bill, before COVID

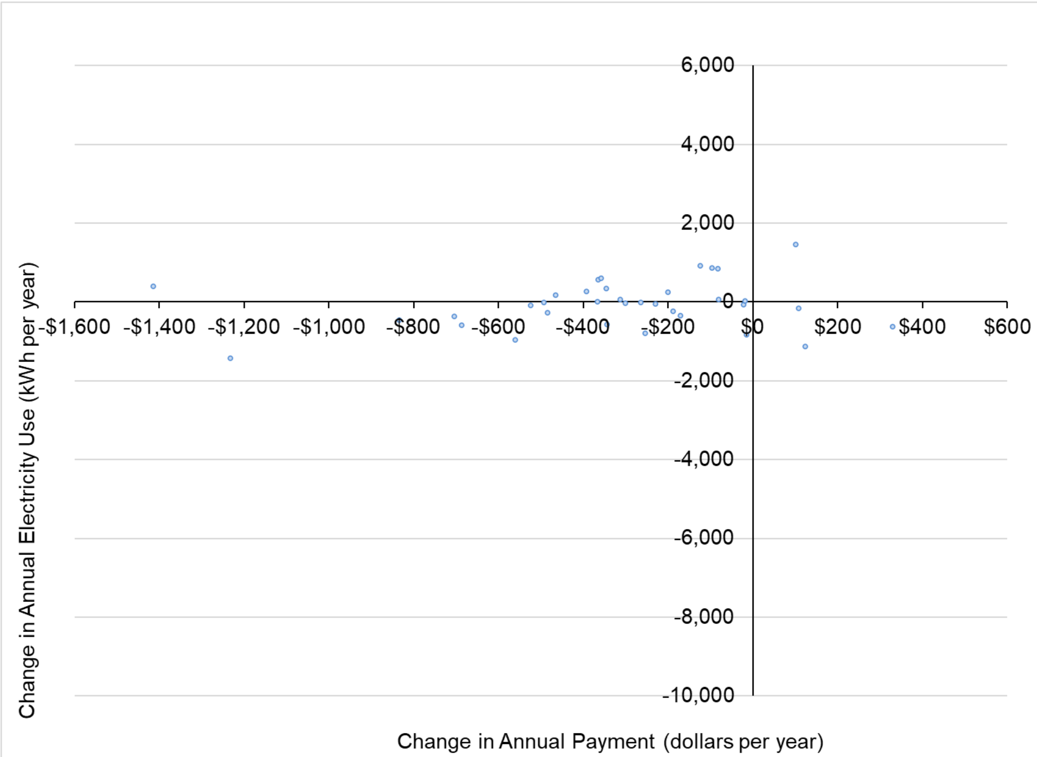


Figure 4-47 Common area change in annual kWh vs change in annual bill, during COVID

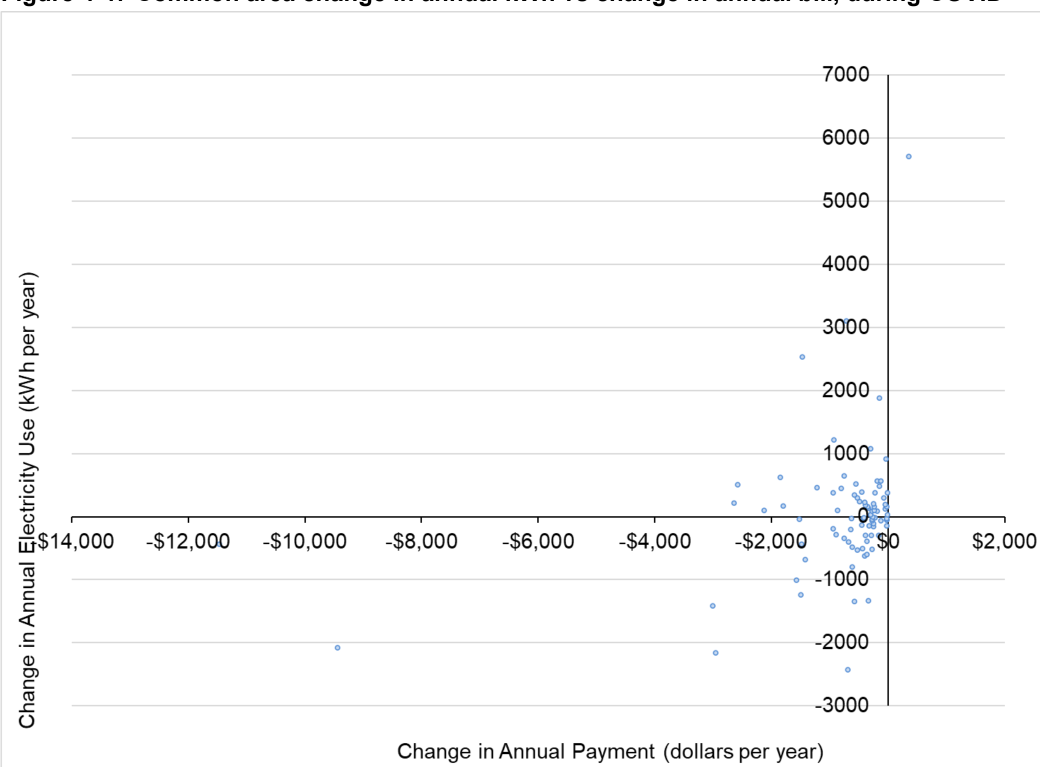


Figure 4-48 Common area kWh used (from solar and grid) vs kWh purchased (from grid), before COVID

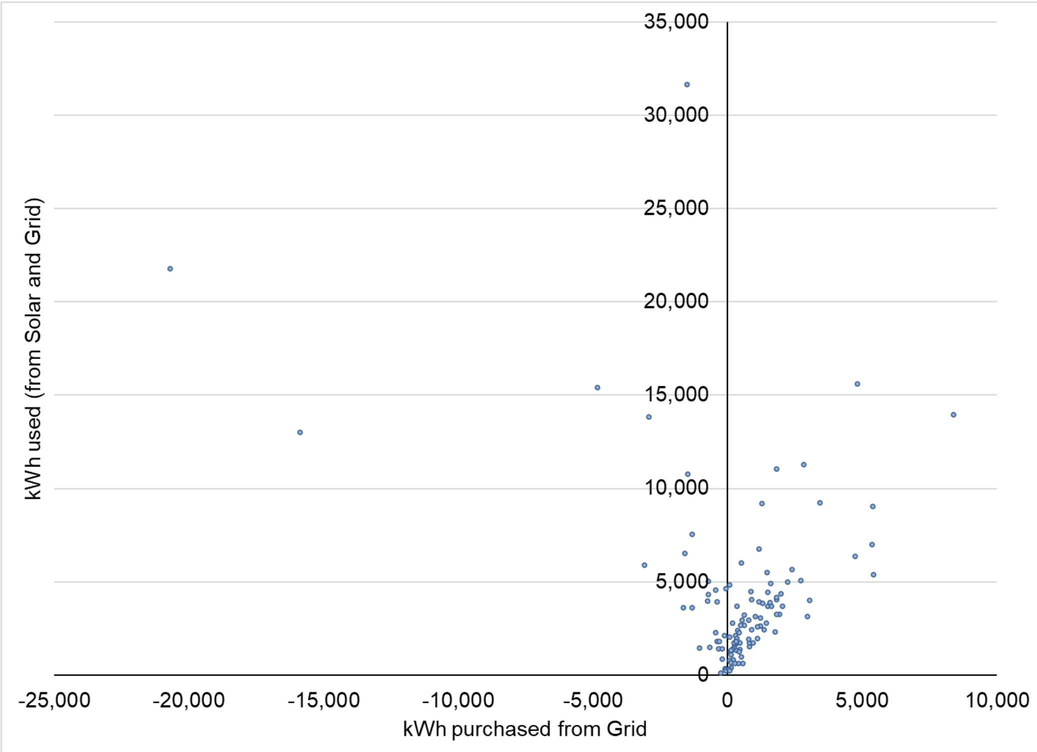
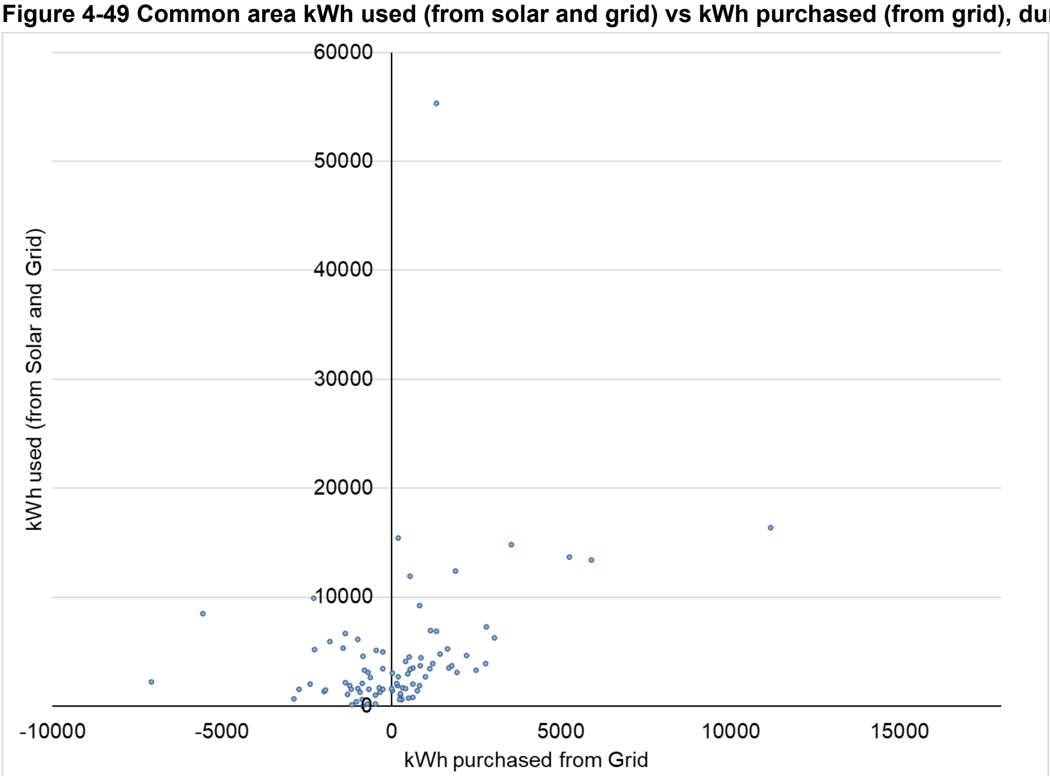


Figure 4-49 Common area kWh used (from solar and grid) vs kWh purchased (from grid), during COVID



The CARE program provides discounts of 20% or more on gas and electricity. Customers enroll in CARE on an annual basis and can start on any month. For example, customers that enroll in May are enrolled until April of next year and can renew their enrollment at that time. For the purposes of this analysis, we used the CARE status of the most recent billing month in the analysis period, regardless of status in prior periods.

During the non-COVID period, non-CARE customers used 271 kWh more after program installation. The pre-/post difference for CARE customers is small and not statistically significant (we cannot conclude that it is different than zero.) During the COVID period, CARE customers used 404 kWh more energy after program implementation, compared to 359 kWh for non-CARE customers. Both are statistically significant, but the difference between the two is not statistically significant. In other words, we cannot conclude that CARE and non-CARE customers increased energy use differently.

In terms of expenses, during the pre-COVID period, CARE and non-CARE customers reduced their expenses by $222 and $240 dollars per year, respectively. Both reductions are statistically significant, but they are not statistically different from each other. During the COVID period, CARE and non-CARE customers reduced their expenses by $288 and $341 dollars per year, respectively. Both reductions are statistically significant, but they are not statistically different from each other.

Table 4-28 PG&E customer electric use impacts for CARE Vs Non-CARE customers

Time period	Number of customers	Mean first year electricity use change, weather-normalized (kWh per year)	Standard error of mean	95% confidence level	
				Lower	Upper
		CARE			
Before COVID	549	-56 (1)	35	-129	10
During COVID	454	404	53	300	508
		Non-CARE			
Before COVID	824	271	48	177	365
During COVID	676	359	59	244	474

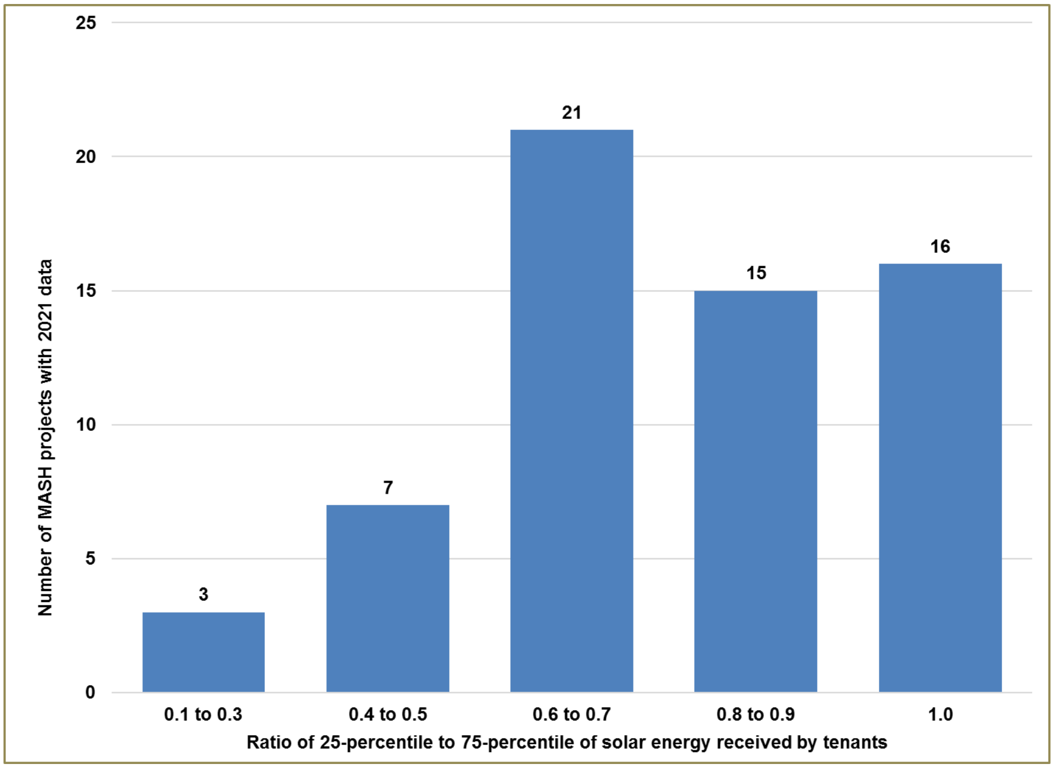
(1) kWh for CARE is not statistically significant

Table 4-29 PG&E customer electric bill impacts for CARE Vs Non-CARE customers

Time period	Number of customers	Mean first year electric bill change (dollars per year)	Standard error of mean	95% confidence level	
				Lower	Upper
		CARE			
Before COVID	472	-$222	$13	-$248	-$197
During COVID	454	-$288	$15	-$317	-$260
		Non-CARE			
Before COVID	208	-$240	$21	-$282	-$199
During COVID	676	-$342	$25	-$391	-$293

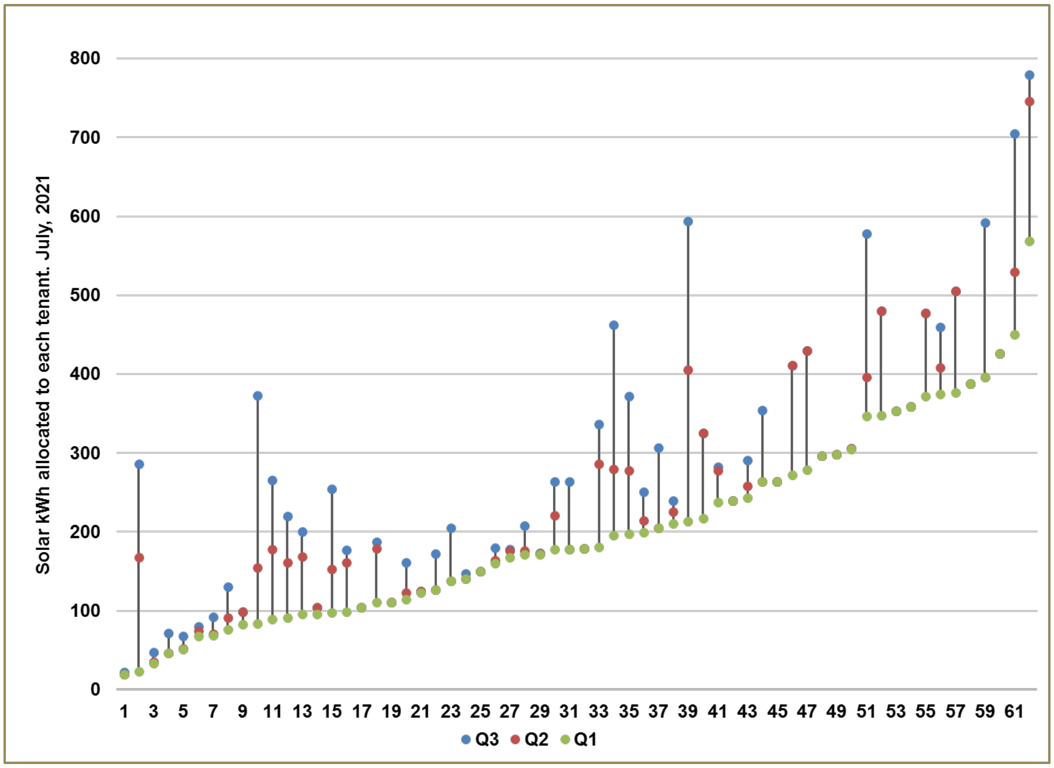
On average, MASH installed capacity is 3.4 kW per household or common area served (see Tables 4-16 and 4-18). Actual allocations varied from project to project, and within projects. In addition to applying MASH rules regarding the allocation of energy produced among tenants (larger units receive larger allocations), the IOUs can allocate only one VNEM meter to any given residential customer. In cases where there is a VNEM meter with more production than another, the customers allocated to that meter will receive more kWh than customers allocated to VNEM meters with lower production. DNV examined 62 MASH projects with interval and billing data for the calendar month July of 2021, and 5 or more tenants. Given that the number of projects with data varied from month to month, this month was chosen as one with high solar production and a relatively high number of projects with available data. These 62 projects include data for 3,608 tenants. The ratio of energy allocated from the solar system to the tenant at the 25-percentile and the tenant at the 75-percentile of each project varied from 0.1 to 1.0. This means that in the case with the largest difference, the tenant at the 25-percentile received 10% of the energy allocated to the tenant in the 75-percentile (23 kWh Vs 286 kWh). Sixteen of the 62 projects allocated the same amount of solar energy to all tenants. This is illustrated in Figure 4-50.

Figure 4-50 Ratio of allocation of solar energy among tenants (Q1/Q3, July 2021)



On average, each of these tenants received 256 kWh of solar energy for the month of July of 2021. The allocations varied widely. At the project level, the allocation average ranged from about 40 kWh to 660 kWh. At the tenant level, it ranged from about 20 kWh for some tenants to over 700 kWh for others. This is illustrated in Figure 4-51, where the green dots represent the solar allocation for the bottom 25-percentile, and the red dot represents the median allocation, and the blue dot represents the 75-percentile.

Figure 4-51 Distribution of Solar kWh per Tenant (July 2021)



4.9 Program process metrics

DNV summarized PA application data to determine the number of applications received, completed, cancelled, and withdrawn. We have presented the results by utility, summarized in Figure 4-52. In some instances, the PA captured and recorded the reason for an application being withdrawn or cancelled. That data was categorized and summarized by PA.

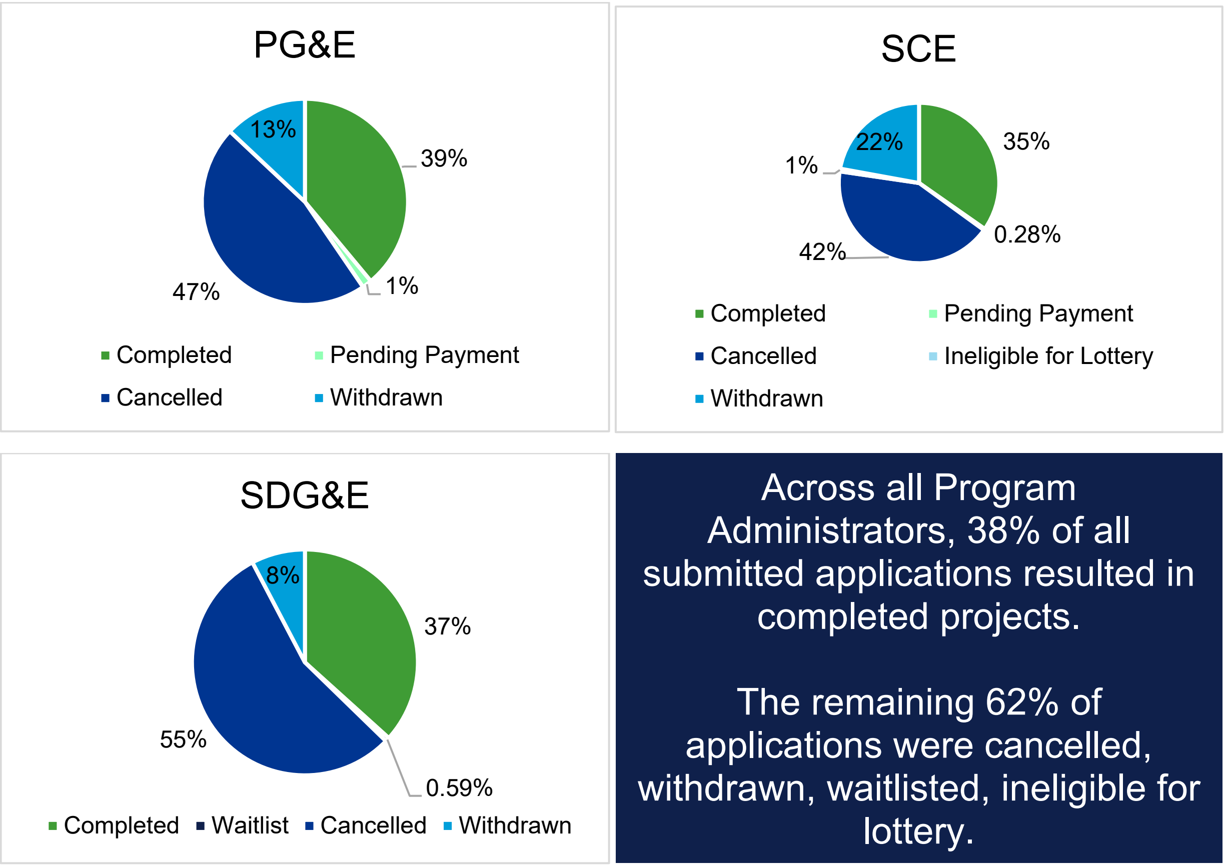
In total, 1,685 applications were received across all PAs for MASH 1.0 and MASH 2.0. The quantity of cancelled or withdrawn projects exceeded completed projects overall: 1,048 applications were cancelled or withdrawn, representing 62% of all applications. Evaluating data for each individual PA shows a similar trend. Most applications were cancelled or withdrawn in 2015 and 2016 which is likely due to the transition from MASH 1.0 to MASH 2.0. The January 2015 CPUC decision states:

> "44. MASH and SASH projects on the waitlist should be given 30 days from the date requested by the Program Administrator to provide documentation of meeting the new program requirements and shall be given an additional 10 days to cure from the date the Program Administrator notifies them that their documentation was insufficient or incomplete before being removed from the queue."[57]

The above excerpt from the CPUC decision caused applications to be cancelled or withdrawn is supported by the most common reasons stated for cancelling or withdrawing an application included missing or incomplete application, duplication, and unsubmitted MASH 1B/1C application.

[57] Decision 4280-145938475.pdf (ca.gov), page 74

Figure 4-52 Application status by PA



Across all PAs, 38% of all submitted applications resulted in completed projects. This overall percentage was fairly representative of each individual's PA's percentage of completed projects. Projects were not completed for a variety of reasons including cancellation, withdrawn, waitlist, or ineligibility. Refer to Table 4-30 for specific percentages by PA.

Table 4-30 Percent projects completed versus not completed

	PG&E	SCE	SDG&E
Completed	39%	35%	37%
Not completed	61%	65%	63%

Figure 4-53 presents a status summary of submitted applications by year. The largest number of applications were submitted in 2015 and 2016. These years were also the program years with the highest administrative expenditures. 2016 was the year in which the most applications were either cancelled or withdrawn. Evaluators suspect the large number of cancelled and withdrawn applications may be the result of the 2015 Decision that created Tracks 1C and 1D (i.e., MASH 2.0).

Figure 4-53 Application status by year

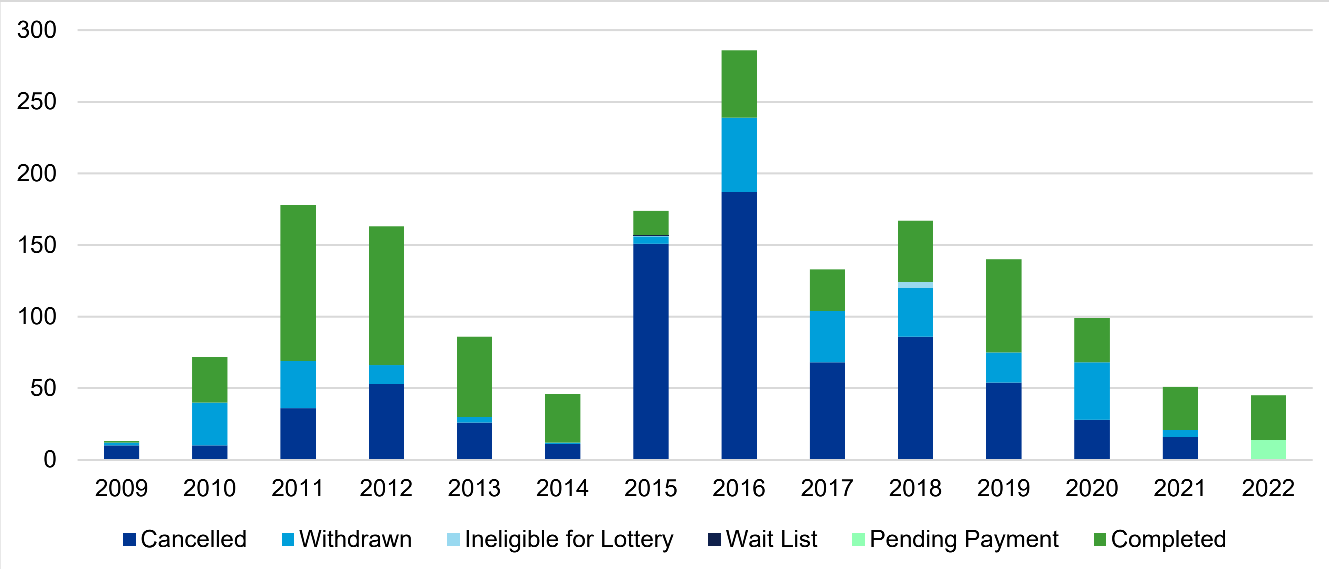


Table 4-31 shows the same application status data presented in Figure 4-53 individually for each PA. Overall, SCE had the highest percentage of submitted applications being cancelled or withdrawn.

Table 4-31 Application status by year

Year	PA	Completed[1]	Withdrawn[2]	Cancelled[3]
2009	PG&E	—	2	8
	SCE	1		2
	SDG&E	—	—	—
2010	PG&E	20	4	5
	SCE	7	24	4
	SDG&E	5	2	1
2011	PG&E	54	12	22
	SCE	30	19	14
	SDG&E	25	2	—
2012	PG&E	39	4	51
	SCE	52	9	2
	SDG&E	6	—	—
2013	PG&E	25	—	24
	SCE	28	4	1
	SDG&E	3	—	1
2014	PG&E	26	—	10
	SCE	8	—	1
	SDG&E	—	1	—
2015	PG&E	10		90
	SCE	7	5	40
	SDG&E	—	—	22
2016	PG&E	24	11	66
	SCE	16	38	97
	SDG&E	7	3	24

Year	PA	Completed[1]	Withdrawn[2]	Cancelled[3]
2017	PG&E	8	18	7
	SCE	12	14	49
	SDG&E	9	4	12
2018	PG&E	20	24	28
	SCE	21	13	56
	SDG&E	2	1	2
2019	PG&E	38	20	33
	SCE	23	1	21
	SDG&E	4	—	—
2020	PG&E	9	4	12
	SCE	21	36	16
	SDG&E	1	—	—
2021	PG&E	21	4	13
	SCE	9	1	3
	SDG&E	—	—	—
2022	PG&E	27	—	—
	SCE	18	—	—
	SDG&E	—	—	—
Total		**636**	**280**	**737**

(1) includes pending payment status (12 for PG&E and 2 for SCE in 2022)
(2) includes ineligible for lottery status (4 for SCE in 2018)
(3) includes waitlist status (1 in 2015 for SDG&E)

Figure 4-54, Figure 4-55, and Figure 4-56 show, by PA, reasons for an application cancellation or an application being withdrawn. Reasons were sorted into the following three broad categories: administrative, cancelled by applicant, and missed due dates. Most applications were cancelled for administrative reasons which included missing or incomplete application, duplication, and unsubmitted MASH 1B/1C application. Other applications that did not result in completed projects provided reasons, which did not fit into the broad categories listed above; therefore, the counts for each reason do not sum to the total applications cancelled or withdrawn.

During interviews, one PA reported that lack of access to financing was also a factor for some projects. In terms of applications being declined, the PAs cited a variety of reasons, including the inability to meet the timeline, lack of response, failing to pay the application fee, and not meeting the eligibility requirements. The PAs noted that they tried to be flexible with deadlines and give extensions, if possible.

Figure 4-54 PG&E application cancellation/withdrawn reasons

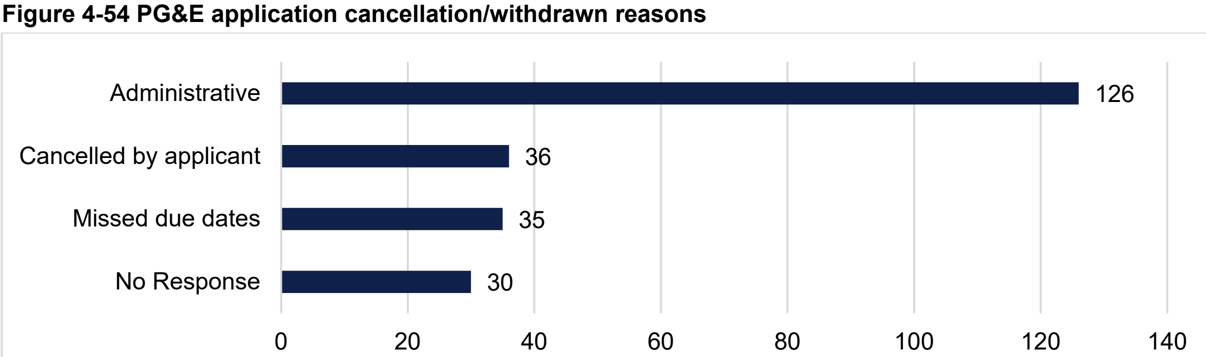


Figure 4-55 SCE application cancellation/withdrawn reasons

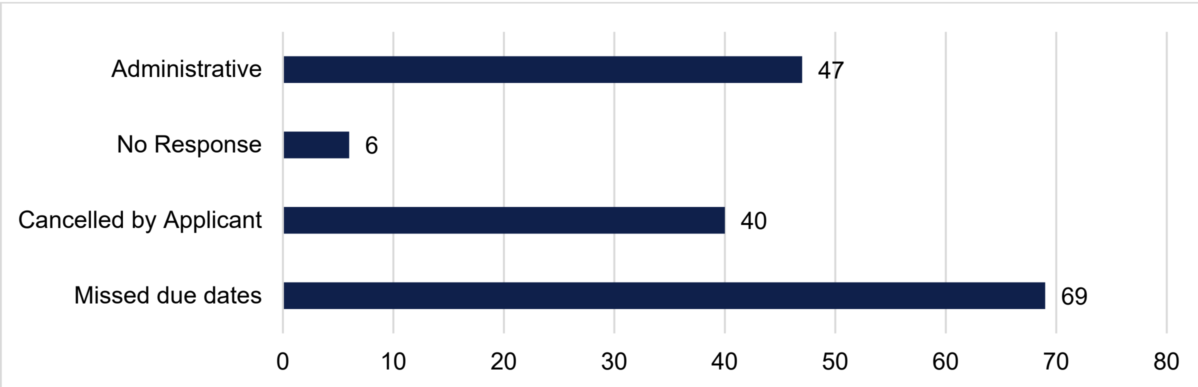
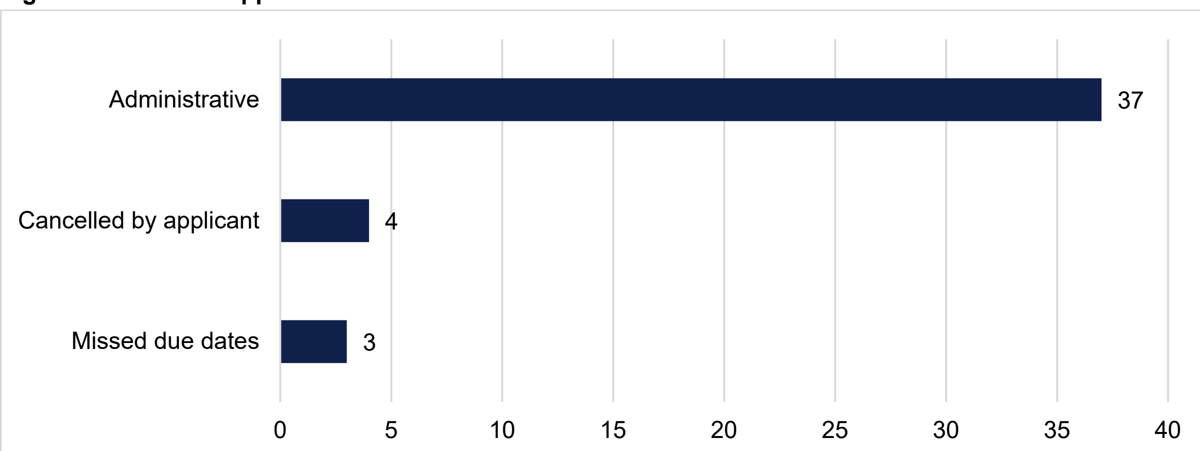


Figure 4-56 SDG&E application cancellation/withdrawn reasons



If application submissions on a single day exceeded available funding in a PA's territory, a lottery was initiated. This only occurred five times over the course of the program, across all territories. PAs observed the biggest barriers to customer participation included property owners' reliance on knowledgeable contractors during the application process and access to financing. Interconnection was also noted as a challenge for some sites, as VNEM was a new type of interconnection to developers that had specific rules and standards. Also, some of the larger projects required additional services and upgrades, such as a transformer, which caused delays in interconnection to the system. The PAs noted that COVID had minimal impacts, but they did provide flexibility to applicants due to the related supply chain and administrative delays.

4.10 Overall program performance

In this section, we have summarized the insights gleaned from the evaluation activities DNV performed. Using program data, information collected from staff interviews, and completed evaluations, DNV measured the overall success of the program as related to the stated MASH program goals. Through this evaluation, we determined the following:

- 636 solar PV projects were incentivized and completed, including 12 with pending payments at the end of 2022.
    - 578 (91%) serve multifamily properties
    - 57 (9%) serve mobile home properties
- Installed over 65 MW of solar capacity (62.7 MW for completed projects which capacity increases to 65.535 MW if projects pending payment as of the end of 2022 are included).

- The sum of first year energy production for all projects is 57.4 GWh.
- Estimated GHG avoided across all projects is 175,680 MT and equivalent to $5,829,469 (2022$) from 2011 through 2022.
- Cost of solar decreased over time, in 2022 the installation cost was $3,634/kW
- 16,356 households were served in the affordable housing sector.
  - Tenant bills were reduced over 40% on average on the year after installation. Savings over the lifetime of the MASH projects will vary with factors such as rates, changes in energy use resulting from opposite effects such as energy conservation and electrification, and climate and environmental effects.
  - NEM systems had a total capacity of 29,107 kW.
  - VNEM systems had a total capacity of 32,371 kW with 11,898 kW, or 37%, of total capacity dedicated to tenants
  - Projects with both NEM and VNEM systems at the same site had a total capacity of 1,404 kW.
  - VNEM systems studied benefit 5,563 tenant and 2,177 common area accounts.
- Program tenants maintained or increased electricity usage without increasing household expenses.
- 933 people received training for a total of 17,799 hours supporting employment opportunities in the solar sector.
- Program had a TRC value of 0.43. Participants ability to co-leverage tax credits was a significant program benefit.
- Program had a realization rate of 0.65. On average, small (<100 kW) and medium PV systems (100kW-500kW) had better realization rates than large systems (>500 kW).
- PAs reported exceeding their MW install goals and meeting their workforce goals. They also noted that their application waitlists were a sign of success.

Table 4-32 Program goals verses outcomes

Program goal	Goal outcome	Summary
Stimulate the adoption of solar power in the affordable housing sector.	Goal achieved entirely	Solar projects were completed via the MASH program serving 636 multifamily properties.
Decrease electricity use and costs without increasing monthly household expenses for affordable housing building occupants.	Goal achieved entirely	The program reduced costs and decreased electricity use from the grid.
Provide job training and employment opportunities in the solar energy and energy efficiency sectors of the economy.	Goal achieved entirely	We were able to confirm that the program did meet its workforce training goals, but whether these led to permanent positions was not a part of this study
Maximize the overall benefit to ratepayers.	Goal not achieved	The program results indicate that positive benefits were generated in the form of avoided electricity costs and environmental costs; however, based on the total resource cost (TRC) test, the benefits to ratepayers were less than the value of the investment. This value might shift if non-energy benefits similar to those used for the Energy Savings Assistance cost-effectiveness test.
Require participants who receive monetary incentives to enroll in the ESA program.	Goal not achieved	In interviews, the PAs noted that the MASH program was not a useful tool for enrolling participants in the ESA program.
Improve energy utilization and overall quality of affordable housing through the application of solar and energy efficiency technologies.	Unable to determine outcome	MASH resulted in increased energy use and lower bills. This evaluation did not address the energy efficiency or overall housing quality goals of the program.
Increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.	Unable to determine outcome	We are unable to determine outcomes in this area without a primary data effort. However, one PA was able to hold an education session with participants.

5 PROGRAM TRACKING AND DATA RECOMMENDATIONS

Because the MASH program has closed, we have provided recommendations to improve future solar programs. Evaluations would benefit from more comprehensive, clean, and uniform data. We have described the data issues our team experienced in the table below. We are providing this information to give greater context on assessing a solar program with multiple PAs and to improve efforts going forward. Please see APPENDIX B.

Issue	Recommendation
Disconnect between the billing system and program tracking system (PowerClerk).	Create mapping between different systems at start of program. In this case, a table in the billing system that mapped MASH applications to physical interconnected systems would have been extremely helpful.
Archived interval data that was unable to be provided.	One of the utilities could not provide archived data. Archived data should be easily accessible to fulfill data requests such as this one.
Solar systems breaking or going offline within 20 years.	The IOU should notify the Energy division of equipment failure.
Better way to document job training.	The program implementer should document employees' names in the same database as the hours worked. For MASH, these names were available in PDFs that would have been costly to identify, read, and tally. The names will help verify that the number of trainees is reasonable, and that each trainee had the expected amount of training.
Interval data (delivered and received signs) was inconsistent, this made analysis difficult or impossible, depending on the situation.	IOUs should fix this issue before providing data to the ED or future evaluators.
Sites that have mixed NEM and VNEM arrangements were not always reflected in the tracking data.	The IOUs should identify these sites before providing the data to the ED or future evaluators.
Confusion over who is responsible for fulfilling data request (IOU or PA).	In the case where the Implementer is not the IOU, there needs to be a clear understanding of who is responsible to fulfill which elements of the Energy Division's data request, and to what extent the PA must cooperate with the IOU to identify the customers that received the program's incentives.

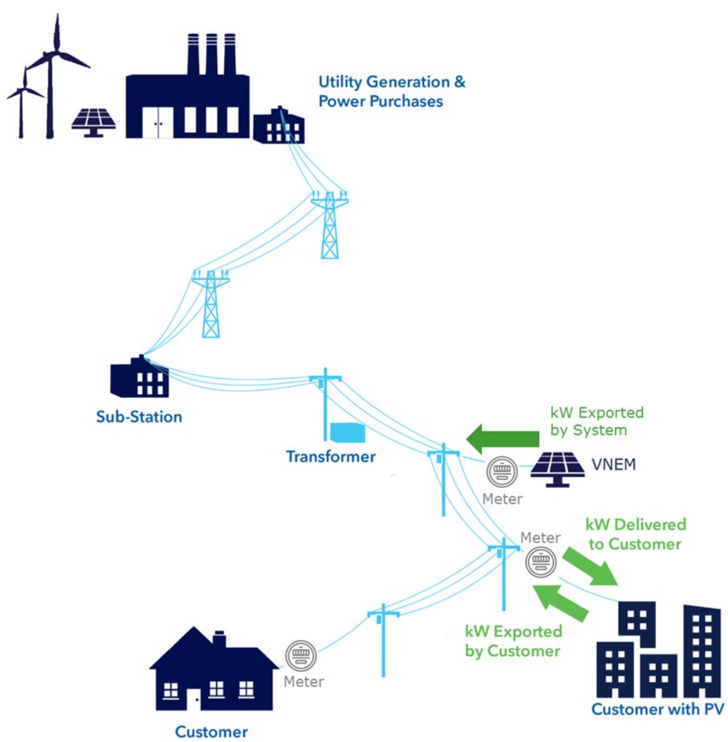
APPENDIX A. NET ENERGY METERING VS VIRTUAL NET ENERGY METERING

Net Energy Metering (NEM) is a tariff for eligible customer-generators with a renewable electrical generation facility that is a customer of a large electrical corporation. Under NEM, customer-generators offset their charges for any consumption of electricity provided directly by their renewable energy facilities and receive a financial credit for power generated by their on-site systems that feeds back into the power grid for use by other utility customers over the course of a billing cycle. The credits were valued at the “same price per kilowatt hour” (kWh) that customers would otherwise be charged for electricity consumed.[58]

Virtual Net Energy Metering or Virtual Net Metering (VNEM) are tariffs available to a combination of a renewable electrical generation facility, and a group of benefitting accounts, where the meters for the benefitting accounts do not connect directly to the generation meter. VNEM is a very flexible arrangement that was originally designed for use in the MASH program. It continues to be available to multifamily affordable housing solar programs, and it is also available to commercial customers, and non-income qualified residential customers, including those in single-family homes. For the purposes of MASH, the VNEM tariff enables owners of multitenant properties to allocate a solar system's benefits to tenants across multiple units. Tariff rules allow the system owner to allocate renewable generation bill credits between common load areas and tenants along a single service or multiple service delivery points.[59]

The energy produced by a VNEM system is distributed among tenants per the MASH rules, which were applied separately for each solar system meter. In some cases, this resulted in differences in energy use allocation among the tenants in the complex.

Figure 5-1 Interconnection examples



[58] Source: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/net-energy-metering
[59] Source: https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EM%20(Sch).pdf

DNV

APPENDIX B. EVALUATION DATA QUALITY AND AVAILABILITY

Energy consumption data and energy measures tracking data are the cornerstones of the evaluation of energy measures. Further, for the MASH program evaluation, it is necessary to have energy production data, and the records from the tracking data must match the records in the energy consumption data[60].

Energy data: consumption (for MASH benefiters) and production (for MASH generators)

While there are many different methods to analyze consumption data for evaluation, the underlying principle is the same: estimate the impact of the intervention (such as the installation of a PV system) by comparing consumption with and without the intervention.

The most common sources of energy consumption data are billing data and interval ("AMI") data. Customer and premises information, which contain fields that link the energy use and the tracking data, is part of the billing data system. Additionally, sound program design would assume that premise information is also collected and retained by the program.

Energy consumption for use in evaluation is usually from billing data. However, in the case of solar customers, billing data is not a reflection of customers' energy use. For these customers, billing data reflects how much energy was transacted with the utility, not how much energy was used at the customers' premises. "Net energy" is the sum of how much energy the utility delivered to the customer (a positive quantity in the computation of the customer's bill), and how much energy was received from the customer (a negative quantity in the computation).

Because of this, the energy consumption at premises that are Net Energy Metered (NEM) is usually unknown. As mentioned above, this is because the utilities meter only the data that flows into and from the premises, but not the energy produced by the PV system which may or may not be consumed, all or in part, at the premises, depending on schedules and other factors. This is not the case for Virtual Net Energy Metering (VNEM). In the case of VNEM, the PV system is metered separately from the customers that benefit from the energy produced. Barring other issues, the metering separation between VNEM and the corresponding benefiters provides an evaluation advantage that is not available for NEM facilities that do not have access to separate facility consumption metering, or to their solar production data.

Tracking data

Tracking data sets routinely contain hundreds of fields. At a minimum, impact evaluations such as MASH's require fields related to:

- Type of metering (NEM or VNEM) separately for each meter. For example, for sites that contain a mix of NEM and VNEM meters, these should be clearly separated in the tracking data.
- Expected output: kW and annual kWh.
- Detailed physical characteristics of the installation (coordinates, tilt, azimuth), which require separate records for each set of panels where the physical characteristics vary within the same facility.
- Detailed benefiter customer information at the meter level, for both the customer meters and the PV system meters, or the NEM meters if applicable.

[60] Large investments in single measures should be tracked in a manner that allows for full identification of the energy usage data. We do not expect to be able to match tracking records and energy consumption records for measures such as lightbulbs sold at retail stores. We do expect to be able to match the same for individual solar systems that received tens of thousands of dollars in incentives.

MASH evaluation data issues

Evaluations require energy consumption data, tracking data, and one or more common fields between these two types of data that identify the customers that participated in the program (from the tracking data) in the billing data. The MASH data is largely missing these common fields. The utilities, aided by DNV data diagnostics and analyses, attempted matches based on host addresses, rate schedules, and account or meter numbers provided in the applications. Ultimately, for most MASH projects, this did not lead to the full identification of the benefiters that are associated to the incentives paid. While the utilities submitted production data for a large share of projects, not all generators were identified.

It is important to keep in mind that the disconnect between the tracking and the billing data for MASH program participants does not interfere with the utilities' ability to bill customers accurately. This may have been one of the main reasons that contributed to the utilities disinterest in building and maintaining this connection.

Some of the issues encountered include the following:

a. The tracking system, an older version of PowerClerk that was discontinued as the MASH evaluation was kicking-off, was implemented to keep track of applications and incentives. It did not include features geared for verification or evaluation of the MASH projects. There were no fields that could be used uniformly and consistently to identify the incentivized generators in the billing data, including the fields related to the geographical location of the systems.

b. Unlike NEM, VNEM systems require the installation of new meters. Some of the MASH projects required multiple new meters. There was no process at the utilities to track these new meters in a manner that was consistent with the fields in PowerClerk.

c. The MASH tariffs, originally designed for this program, were deployed to other customers that qualify for the rate, even if they did not participate in the MASH program. Producing a tariff that can be used in this manner is a positive externality of the program, but the tariff could not be used to identify participants.

d. A subset of this issue is that there are premises that have a mix of MASH-incentivized and non-incentivized PV systems. It was not possible to identify which of these were the MASH systems.

e. This program ran from 2008 through 2021. During this period, all the utilities went through billing system changes. This complicated tracking across billing systems.

f. There were unexplained gaps in the interval data. For example, a generator would have data for two years, then a gap for two years, then data for another year.

g. In some cases, the earlier interval data had incorrect Received or Delivered flags, which denote whether the electricity is moving from the utility to the customer, or from the customer's PV system to the utility[61]. Data that should have had a negative sign was positive, and vice versa. The signs were corrected later in the data collection systems, but there were no retroactive corrections to the data that was recorded with the incorrect flags. This rendered the data useless for this evaluation because the analysis to individually identify these corrections to the data, and apply them retroactively, would have required a substantial number of hours that were out-of-scope for this evaluation.

h. Many residential customers started receiving MASH benefits prior to the installation of their AMI ("smart") meters. This is not a data defect, but these customers could not be included in the evaluation because of the lack of first year data. This does not apply to VNEM generators, which were individually metered from the project's onset.

[61] This means that kWh that was Delivered to customers by the utility was marked as if it had been Received from customers. In some contexts, these are jointly referred to as "Direction flags". In computations to estimate customer energy use, "Delivered" has a positive sign (because it increases the customer's bill) while Received has a negative sign (because it reduces the customer's bill.) Please see sections 1.3. "Approach" and 3.9. "Bill impacts" for additional discussion about these terms.

i. The MASH Handbook prescribes that a Performance Monitoring and Reporting Service (PMRS) provider be engaged for all projects greater than 10 kW. Part of the PMRS service consists of interval metering the PV system and transferring the data to the PA. Exemptions to the PMRS requirement are allowed based on cost. Most MASH projects applied for and received this exemption. While cost is a valid reason to grant this extension, these data would have helped the evaluation of MASH systems installed at NEM premises.

j. For some of the MASH projects where the PV systems and the benefiters could be matched, the number of benefiters did not match those in the application.

MASH data recommendations

The MASH program is now closed. Some of these recommendations may or may not apply to subsequent programs.

1. *Track incented program PV systems and program benefiters.* There should be a clean connection between the program tracking and the billing data, where all PV systems and benefiters that are associated with MASH incentives are easily and completely accounted for in both databases.

2. *Review of methods used to estimate generation, and require that the full generation estimation output be attached to the application*. One of the evaluation findings is that the realization rate (the ratio of actual kWh to expected kWh produced by the PV systems and stated in the applications) was lower than expected. We note that estimated kW (the estimate of the largest single-hour output in the year) was closer to actual kW than the estimated kWh was to actual kWh. This indicates that there is a potential issue with the method used to estimate kWh. It may be related to the item described below, where several PM systems comprise one entry into the program tracking data, or it may be caused by other factors.

3. *Separate records for each PV system.* Many of the MASH projects comprise separate systems that have separate meters and separate physical characteristics, such as installed capacity, tilt, and azimuth. However, these were entered as into a single record in PowerClerk, as the sum of the installed capacity, and with only one set of the other characteristics. This resulted in not being able to accurately model solar production from the program data. For VNEM systems, the models would have helped the evaluator team gauge what may have caused the difference between actual solar kWh and the estimated kWh reported in the applications. For NEM, in the absence of PMRS data, these models would have been the way to estimate actual benefits to customers. Program tracking would be more helpful if it included separate records for each part of the project where the physical characteristics of the system(s) vary. These detailed records may contribute to identify the source of the PV system production overestimation that is described in Section 4 and mentioned in (2) above.

4. *Generation metering for NEM systems*. A rigorous evaluation of NEM systems will require system metering. This can be permanent system metering, such as provided by a PMRS agent, or evaluators may be able to install temporary metering for the purposes of measurement and verification. This issue is detailed in *data issue (i)* in this Appendix.

5. *Revise bill credit method to allocate benefits to tenants where the complexes benefit from more than one system*. This is not a data quality issue, but DNV believes that it is a consideration for future project design. For MASH projects with multiple PV system meters, the installed capacity associated with each of the these meters can vary substantially from meter to meter. This evaluation found that each benefiter can be associated to only one VNEM meter in the billing system, which means that, for the same MASH project, some benefiters receive more energy than others by virtue of being associated to meters that represent a larger share of the project. It may be more equitable to pool all of the installed capacity, and allocate that to all of the tenants.

APPENDIX C. 25-YEAR BCA MODEL

Table 5-1 Net present value, net present cost, and cost benefit ratio by PA (WACC)

Rate	NPV	PG&E	SCE	SDG&E	Description
WACC	Benefits	$44,082,628	$49,148,797	$10,315,434	NPV of total avoided costs and environmental benefits, Federal tax credit
WACC	Costs	$104,360,135	$112,405,153	$29,485,087	NPV of total administrative cost, total incentives, reported project costs, and estimated O&M costs
WACC	Benefit cost ratio	0.42	0.44	0.35	Ratio of net present value of benefits relative to costs

The evaluation spans 2009-2022, the years in which costs or benefits were incurred in the program. Costs are the sum of total system costs, program administration costs, and estimated operation expenses. The analysis assumed a 25-year life of the installed system. Operating expenses were estimated annually at 1% of the total system costs for 30 years starting in the completion year. The costs were converted to 2022 dollars by using the GDP Price Deflator. The GDP Price Deflator is a “measure of inflation in the prices of goods and services produced in the United States, including exports. The GDP Price Deflator closely mirrors the GDP price index, although they are calculated differently.” Federal tax incentives are included in the model as a benefit to the system owner. The federal tax incentives assumed to be 30% of the total system costs. Any state tax credits received were treated as transfers and not explicitly accounted for in the calculation.

To assess the cost-effectiveness of the program, we obtained the present value by discounting the benefits and costs — for each PA — to the first year of the program. Discounting the benefits and costs back to the first year allows for comparison of the value generated by the program (benefits) relative to the costs incurred by the utility and program participants. The analysis uses two discount rates: the utility WACC as prescribed in CPUC D.09-08-026. The annual program benefits and costs are discounted to generate streams of annual benefits and costs for the life of the systems installed. The present value of the benefits and costs are presented below for each PA.

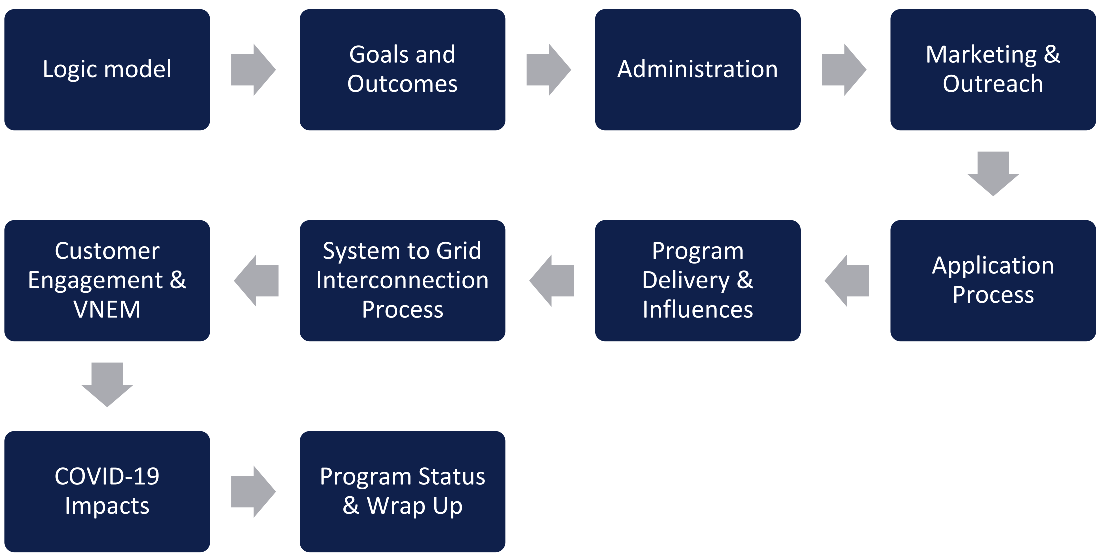
In Table 5-1, the present value of benefits and cost were compared to develop the benefit-cost ratio. The total present value of the benefits across the life of the program was $103.5M. Approximately 47% ($49.1M) of the total benefits were attributed to SCE service territory, 43% ($44M) to PG&E service, and the 10% ($10.3M) to SDG&E. The total present value of the costs across the life of the program was $246.2M. Approximately 46% ($112.4M) of the total costs are in the SCE service territory, 42% ($104.3M) in the PG&E service, and the 12% ($29.4M) to SDG&E. The WACC for each utility PG&E (7.44%), SCE (7.68%), and SDG&E (7.55%) were used to discount the benefits and costs. We used the present values to calculate the benefit cost ratio (BCR) — present value of benefits divided by present value of costs) for each utility. Table 5-1 shows the BCR for each utility. The present value of costs exceeds the net present value of benefits for each utility resulting in a BCR of less than 1. SCE had the highest BCR of 0.42; followed by PG&E with 0.44, and SDG&E with 0.35. The total net present value (present value of benefits minus present value of costs) is negative for the program with a value of -$142.7M or a BCR of 0.42.

APPENDIX D. PA INTERVIEW GUIDE

This is an interview to discuss the CSI Multifamily Affordable Solar Housing (MASH) Program. DNV is conducting a summative evaluation of the MASH program which concluded in December 2021, and to this end we would like to conduct program staff interviews. The objective is to supplement the information available in the program data and program plans and learn more about how the program was designed and how it functioned.

Our questions will follow the chronology of the program itself, with the first few questions starting with the foundational program logic model and then moving on to the goals and outcomes established for the program and so on, as summarized in the graphic below.

We anticipate this interview will take 45 minutes to an hour.



1. Logic model
    a. Could you describe the logic model for this program?
    b. How does this compare with SOMAH?
2. Goals & outcomes
    a. How would you characterize the performance of the MASH program with respect to its goals?
    b. Was the program effective in providing job training and employment opportunities? Or enrolling tenants in the Energy Savings Assistance Program?
    c. Do you feel the administrative and marketing budgets for the program were sufficient for the success of this program?
3. Administration
    a. Could you describe your organization’s team structure with regards to this program? Did you feel it was appropriately staffed?
    b. What were the challenges in implementing this program?
    c. What about your administration do you think made this program successful?
4. Marketing & outreach
    a. What types of marketing and program outreach did your program do? Was the marketing done by the utility, program administrator or solar contractors?
    b. Did MEO change when new program goals were introduced in 2013?
    c. What languages were used in marketing materials?

d. How did the marketing/outreach budgets change year to year? And what were the key drivers of the changes?
e. How did you measure marketing and outreach success?
f. Which of these marketing and outreach activities were most successful?
g. Did you advertise and/or recruit certain solar developers/installers, and if so, could you please describe this?

5. Application & enrollment
   a. How was program application status communicated to applicants?
   b. What were the most common reasons applications were withdrawn? Was the program administrator involved with applicants to seek solutions for issues or support re-applying?
   c. What were the most common reasons applications were declined? Was the program administrator involved with applicants to seek solutions for issues or support re-applying?
   d. What are steps necessary to “turnaround” (approve) an application?
   e. What was the average application turnaround time? Did this vary by year or season, and if yes, how?
   f. In the event that application submissions on a single day exceeded available funding, a lottery would be initiated. How often did that occur?
   g. Were there improvements to the application process over the course of the program? For example, streamlined paperwork.
   h. What did you perceive to be the greatest barriers to participation?
   i. What could have been done to solve barriers?
6. Program delivery & points of influence
   a. Could you tell us about the solar contractors involved in each program track? How did they support property owners?
   b. In your opinion, how or why did developers choose track 1C or 1D?
   c. What influenced property owners to participate in the program?
   d. Did the utility conduct any marketing or outreach? If yes, please describe.
7. System to grid interconnection process
   a. Where there any challenges with MASH projects’ interconnection?
   b. How long did the interconnection application process take, from submission to approval?
   c. Were any projects not developed due to high interconnection costs? If yes, how many?
   d. Did program administrators support MASH projects through the interconnection process, and if yes, how?
8. Customer engagement & VNEM credits
   a. Did the program materials or messaging offer MASH VNEM customers the opportunity to visit/see the community solar installation? Did the customers feel it was part of their community?
   b. What was the customers perceived environmental value of their participation?
   c. From the perspective of participants, do you believe the program helped increase awareness and appreciation of the benefits of solar?
   d. Are the credits clearly stated on the customer’s bill?
   e. Were there any challenges with setting up or implementing MASH VNEM solar credits? How did the IOU address any issues?
   f. How long on average did it take from commercial date of operation until the credit appeared on the customer’s bill?
   g. On average, what was the amount of the credit?
9. Impacts of COVID-19 on the program
   a. How did program implementation change due to COVID-19?
   b. Did COVID-19 impact job training?
   c. Did COVID-19 impact the number of projects installed?
   d. Any other noted impacts?
10. The program was slated to end at by 12/31/2021 unless there were additional funds. Are there more projects in the approval pipeline or has the program ended?
11. Is there anything else important we did not cover?

APPENDIX E. JOB TRAINING

Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
PGE-MASH-00394	2019	No	Yes	228.328			40	5		
PGE-MASH-00397	2018	No	Yes	155.59	40	5				
PGE-MASH-00399	2018	No	Yes	46.966			40	5		
PGE-MASH-00401	2018	No	Yes	141.419	40	5				
PGE-MASH-00405	2016	No	Yes	30.752	0	0	0	0	0	
PGE-MASH-00495	2019	No	Yes	925.934	80	2	80	2	40	
PGE-MASH-00499	2019	No	Yes	132.466	0	0	40	5	0	
PGE-MASH-00502	2019	No	Yes	153.311					40	
PGE-MASH-00510	2017	No	Yes	107.53	8	1	23	1	238	
PGE-MASH-00511	2018	No	Yes	176.227	80	2	130	3		
PGE-MASH-00520	2019	No	Yes	94.251			8	1	160	
PGE-MASH-00525	2018	No	Yes	15.264	20.5	1	0	0	24	
PGE-MASH-00529	2021	No	Yes	83.209	0	0	40	5	0	
PGE-MASH-00531	2019	No	Yes	36.562			32	4		
PGE-MASH-00535	2016	No	Yes	427.361					40	
PGE-MASH-00536	2017	No	Yes	542.071					40	
PGE-MASH-00543	2021	No	Yes	67.631	0	0	40	5	0	
PGE-MASH-00555	2018	No	Yes	133.357		0		0	40	
PGE-MASH-00559	2019	No	Yes	184.207	0	0	70	3	169	
PGE-MASH-00562	2019	No	Yes	25.045			24	3		
PGE-MASH-00565	2020	No	Yes	73.731	0	0	40	5	0	
PGE-MASH-00566	2019	No	Yes	60.139					145	
PGE-MASH-00568	2018	No	Yes	24.342					24	
PGE-MASH-00577	2019	No	Yes	54.831	0	0	20	1	180	
PGE-MASH-00586	2018	No	Yes	21.042		0	25	2	60	
PGE-MASH-00588	2018	No	Yes	22.661		0	36	1	66	
PGE-MASH-00591	2018	No	Yes	33.382					40	
PGE-MASH-00600	2018	No	Yes	58.349					40	
PGE-MASH-00605	2018	No	Yes	88.639					40	
PGE-MASH-00608	2019	No	Yes	23.601	0	0	0	0	24	
PGE-MASH-00609	2019	No	Yes	9.619					57.25	
PGE-MASH-00611	2018	No	Yes	21.861	0	0	0	0	119	
PGE-MASH-00614	2019	No	Yes	5.555					21	
PGE-MASH-00617	2018	No	Yes	57.269					40	
PGE-MASH-00621	2019	No	Yes	33.698			10	1	109	

Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
PGE-MASH-00622	2019	No	Yes	46.294	0	0	8	1	32	
PGE-MASH-00623	2019	No	Yes	12.088	0	0	0	0	16	
PGE-MASH-00624	2019	No	Yes	60.63					489.333	
PGE-MASH-00627	2018	No	Yes	34.758	0	0	0	0	262.5	
PGE-MASH-00629	2019	No	Yes	6.564			25	1		
PGE-MASH-00630	2019	No	Yes	55.604	40	1	120	3	40	
PGE-MASH-00631	2019	No	Yes	78.643	0	0	40	5	0	
PGE-MASH-00633	2020	No	Yes	63.231	0	0	40	5	0	
PGE-MASH-00635	2019	No	Yes	153.848	240	6	240	6	240	
PGE-MASH-00638	2021	No	Yes	57.611					40	
PGE-MASH-00640	2020	No	Yes	26.918					24	
PGE-MASH-00648	2019	No	Yes	18.198					16	
PGE-MASH-00649	2019	No	Yes	252.367					40	
PGE-MASH-00651	2021	No	Yes	24.347	0	0	8	1	50.08	
PGE-MASH-00659	2019	No	Yes	21.939					88	
PGE-MASH-00662	2021	No	Yes	20.624			40	1	160	
PGE-MASH-00666	2019	No	Yes	26.025					44	
PGE-MASH-00668	2021	No	Yes	8.516	8	1				
PGE-MASH-00676	2019	No	Yes	21.747					28	
PGE-MASH-00679	2019	No	Yes	126.299			10	1	165.25	
PGE-MASH-00681	2021	No	Yes	54.732			40	1	200	
PGE-MASH-00691	2019	No	Yes	32.264					36	
PGE-MASH-00692	2021	No	Yes	62.278			10	1	228	
PGE-MASH-00693	2021	No	Yes	6.621			20	1		
PGE-MASH-00695	2021	No	Yes	5.968			10	1		
PGE-MASH-00698	2020	No	Yes	67.554	200	5				
PGE-MASH-00704	2021	No	Yes	62.893					40	
PGE-MASH-00705	2019	No	Yes	19.196					24	
PGE-MASH-00717	2021	No	Yes	39.361	0	0	32	4	0	
PGE-MASH-00719	2019	No	Yes	104.305	0	0	40	5	0	
PGE-MASH-00721	2021	No	Yes	35.274	0	0	36	4	0	
PGE-MASH-00722	2022	No	Yes	18.119	0	0	16	2	0	
PGE-MASH-00723	2019	No	Yes	24.112	0	0	24	3	0	
PGE-MASH-00724	2020	No	Yes	884.707	0	0	40	5	0	
PGE-MASH-00726	2020	No	Yes	50.354	0	0	40	5	0	
PGE-MASH-00727	2021	No	Yes	246.152	0	0	40	5	0	
PGE-MASH-00732	2020	No	Yes	23.769	0	0	24	3	0	
PGE-MASH-00736	2021	No	Yes	79.997	0	0	0	0	0	

Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
PGE-MASH-00738	2022	No	Yes	32.611	0	0	32	4	0	
PGE-MASH-00742	2019	No	Yes	9.482			8	1		
PGE-MASH-00757	2022	No	Yes	50.2					40	
PGE-MASH-00758	2021	No	Yes	5.14	8	1				
PGE-MASH-00759	2022	No	Yes	71.404					40	
PGE-MASH-00761	2021	No	Yes	349.682	138	3	82	2		
PGE-MASH-00762	2021	No	Yes	37.838	40	1	120	3	40	
PGE-MASH-00764	2021	No	Yes	36.774			10	1	73	
PGE-MASH-00765	2022	No	Yes	807.894					40	
PGE-MASH-00766	2022	No	Yes	386.653					40	
PGE-MASH-00767	2021	No	Yes	100.758	0	0	40	5	0	
PGE-MASH-00769	2022	No	Yes	111.297					40	
PGE-MASH-00772	2022	No	Yes	11.241	0	0	16	2	0	
PGE-MASH-00773	2021	No	Yes	492.543					120	
PGE-MASH-00774	2022	No	Yes	526.898					40	
PGE-MASH-00775	2022	No	Yes	505.569					40	
PGE-MASH-00778	2022	No	Yes	138.995	0	0	40	5	0	
PGE-MASH-00782	2022	No	Yes	109.786	0	0	40	5	0	
PGE-MASH-00786	2022	No	Yes	123.344	0	0	40	5	0	
PGE-MASH-00788	2022	No	Yes	126.114					40	
PGE-MASH-00789	2022	No	Yes	117.258					40	
SCE-MASH-00223	2017	Yes	No	180.917					40	5
SCE-MASH-00227	2017	No	Yes	124.75					40	5
SCE-MASH-00228	2017	No	Yes	106.298					40	5
SCE-MASH-00231	2016	No	Yes	510.692			40	5		
SCE-MASH-00234	2016	No	Yes	110.432			40	5		
SCE-MASH-00254	2017	No	Yes	384.834					40	5
SCE-MASH-00256	2016	No	Yes	75.307	16	2	24	3		
SCE-MASH-00262	2016	No	Yes	990.954			40	5		
SCE-MASH-00268	2017	No	Yes	165.157	0	0	0	0	40	5
SCE-MASH-00272	2017	No	Yes	162.86					40	5
SCE-MASH-00327	2018	No	Yes	780.255	80	2	80	2	40	1
SCE-MASH-00328	2018	No	Yes	152.84	60	2	120	3	0	0
SCE-MASH-00329	2019	No	Yes	451.162	0	0	40	5	0	0
SCE-MASH-00330	2018	No	Yes	165.674	8	1	16	2	16	2
SCE-MASH-00331	2018	No	Yes	15.636	0	0	16	2	0	0
SCE-MASH-00333	2019	No	Yes	192.544			40	5		
SCE-MASH-00339	2019	No	Yes	190.732	0	0	40	5	0	0

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Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
SCE-MASH-00340	2020	No	Yes	187.01	0	0	40	5	0	0
SCE-MASH-00342	2019	No	Yes	14.047	0	0	16	2	0	0
SCE-MASH-00343	2018	No	Yes	9.115			40	1	40	1
SCE-MASH-00344	2019	No	Yes	22.968	0	0	24	3	0	0
SCE-MASH-00345	2018	No	Yes	108.922	40	1	160	4		
SCE-MASH-00348	2020	No	Yes	64.714	0	0	40	5	0	0
SCE-MASH-00350	2019	No	Yes	121.404			40	5		
SCE-MASH-00351	2018	No	Yes	88.849					112	5
SCE-MASH-00368	2018	No	Yes	342.904					80	5
SCE-MASH-00369	2018	No	Yes	38.69					80	4
SCE-MASH-00375	2018	No	Yes	127.507					40	5
SCE-MASH-00384	2017	No	Yes	186.565			40	5		
SCE-MASH-00385	2019	No	Yes	315.919					40	5
SCE-MASH-00387	2017	No	Yes	89.954			40	5		
SCE-MASH-00391	2017	No	Yes	124.654			40	5		
SCE-MASH-00406	2017	No	Yes	56.222			40	5		
SCE-MASH-00436	2018	No	Yes	6.375			8	1	8	1
SCE-MASH-00445	2019	No	Yes	31.043			40	2	160	2
SCE-MASH-00457	2019	No	Yes	39.045	0	0	80	2	120	3
SCE-MASH-00458	2019	No	Yes	21.195	0	0	80	2	120	3
SCE-MASH-00459	2019	No	Yes	23.426	0	0	80	2	120	3
SCE-MASH-00462	2018	No	Yes	49.622	0	0	0	0	200	5
SCE-MASH-00476	2018	No	Yes	269.385	0	0	0	0	104	5
SCE-MASH-00477	2018	No	Yes	162.984	0	0	0	0	104	5
SCE-MASH-00479	2020	No	Yes	471.422			120	3	80	2
SCE-MASH-00480	2018	No	Yes	204.202			50	1	139	4
SCE-MASH-00481	2018	No	Yes	116.935					120	5
SCE-MASH-00487	2019	No	Yes	20.02			32	2		
SCE-MASH-00489	2019	No	Yes	39.627	80	2			120	3
SCE-MASH-00492	2019	No	Yes	65.593			40	3	80	2
SCE-MASH-00493	2019	No	Yes	40.282			64	3	64	2
SCE-MASH-00494	2019	No	Yes	59.75			62	1	236	4
SCE-MASH-00500	2018	No	Yes	152.268					72	5
SCE-MASH-00503	2020	No	Yes	32.75					128	4
SCE-MASH-00504	2018	No	Yes	127.243	80	2	80	2	40	1
SCE-MASH-00505	2019	No	Yes	17.074			80	2		
SCE-MASH-00507	2018	No	Yes	188.598	80	2	80	2	40	1
SCE-MASH-00515	2019	No	Yes	16.597			32	2		

Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
SCE-MASH-00520	2019	No	Yes	96.645			120	3	80	2
SCE-MASH-00522	2020	No	Yes	23.936			80	2	40	1
SCE-MASH-00525	2019	No	Yes	28.365			40	2	24	1
SCE-MASH-00534	2020	No	Yes	41.96	80	2	80	2	40	1
SCE-MASH-00546	2020	No	Yes	97.941	80	2	120	3		0
SCE-MASH-00556	2020	No	Yes	47.016	120	3	80	2	40	1
SCE-MASH-00557	2020	No	Yes	58.716	120	3	80	2	40	1
SCE-MASH-00560	2020	No	Yes	38.388			120	3	40	1
SCE-MASH-00561	2020	No	Yes	134.208					200	5
SCE-MASH-00569	2020	No	Yes	71.151	0	0	40	5	0	0
SCE-MASH-00580	2020	No	Yes	64.647			160	4	40	1
SCE-MASH-00596	2020	No	Yes	115.754	0	0	40	5	0	0
SCE-MASH-00598	2020	No	Yes	922.107					40	5
SCE-MASH-00600	2021	No	Yes	347.632			40	5		
SCE-MASH-00603	2022	No	Yes	457.052	0	0	24	3	16	2
SCE-MASH-00609	2021	No	Yes	206.968			160	4	80	2
SCE-MASH-00610	2019	No	Yes	192.632			160	4	40	1
SCE-MASH-00615	2021	No	Yes	204.214			40	1	176	4
SCE-MASH-00617	2021	No	Yes	489.241					40	5
SCE-MASH-00618	2020	No	Yes	313.986					40	5
SCE-MASH-00620	2020	No	Yes	61.632	160	4			80	2
SCE-MASH-00622	2021	No	Yes	211.861	0	0	40	5	0	0
SCE-MASH-00623	2020	No	Yes	84.622	0	0	40	5	0	0
SCE-MASH-00629	2021	No	Yes	114.217					40	5
SCE-MASH-00630	2022	No	Yes	30.013	138	3	42	1		
SCE-MASH-00631	2022	No	Yes	31.235	0	0	24	3	0	0
SCE-MASH-00632	2020	No	Yes	62.015			40	1	176	4
SCE-MASH-00634	2019	No	Yes	89.966	0	0	40	5	0	0
SCE-MASH-00635	2019	No	Yes	81.299	0	0	40	5	0	0
SCE-MASH-00638	2021	No	Yes	113.985					40	5
SCE-MASH-00654	2020	No	Yes	63.051	40	1	40	1	40	3
SCE-MASH-00659	2020	No	Yes	226.387	0	0	40	5	0	0
SCE-MASH-00667	2022	No	Yes	142.555	0	0	24	3	16	2
SCE-MASH-00668	2022	No	Yes	572.961	0	0	40	5	0	0
SCE-MASH-00669	2022	No	Yes	276.104	0	0	40	5	0	0
SCE-MASH-00673	2022	No	Yes	76.791					40	5
SCE-MASH-00674	2022	No	Yes	125.66					40	5
SCE-MASH-00694	2022	No	Yes	380.86					40	5

Application Number	Year	MASH 1A/1B	MASH 1C/1D	CEC PTC Rating (KW)	MASH Project Design/ Engineering Hours	MASH Project Design/ Engineering Trainees	MASH Project Mgmt/Coor Hours	MASH Project Mgmt/Coor Hours Trainees	MASH Solar Install Hours	MASH Solar Install Trainees
SCE-MASH-00697	2021	No	Yes	158.153		0		0	40	5
SCE-MASH-00698	2022	No	Yes	262.923					40	5
SCE-MASH-00699	2022	No	Yes	63.359	0	0	40	5	0	0
SCE-MASH-00707	2022	No	Yes	45.921	160	4	40	1		
SCE-MASH-00712	2021	No	Yes	29.716					120	3
SCE-MASH-00723	2022	No	Yes	51.233					40	5
SCE-MASH-00665	1900	No	Yes	114.397	0	0	40	5	0	0
SCE-MASH-00717	1900	No	Yes	241.056			40	5		
SD-MASH-00058	2017	No	Yes	282.3545	16	2	24	3		
SD-MASH-00059	2017	No	Yes	156.4829	16	2	24	3		
SD-MASH-00061	2017	No	Yes	161.8152	16	2	24	3		
SD-MASH-00062	2017	No	Yes	483.4904	24	3	16	2		
SD-MASH-00064	2017	No	Yes	179.4099	16	2	24	3		
SD-MASH-00065	2017	No	Yes	38.38075	16	2	24	3		
SD-MASH-00066	2017	No	Yes	81.98168	16	2	24	3		
SD-MASH-00067	2017	No	Yes	57.19896	16	2	24	3		
SD-MASH-00069	2017	No	Yes	297.3845	16	2	24	3		
SD-MASH-00071	2019	No	Yes	57.86942			40	5		
SD-MASH-00116	2018	No	Yes	249.9991					40	5
SD-MASH-00117	2018	No	Yes	107.3265					40	5
SD-MASH-00119	2019	No	Yes	107.0527	0	0	40	5	0	0
SD-MASH-00136	2020	No	Yes	372.7873	0	0	40	5	0	0
SD-MASH-00132	2019	No	Yes	51.64668			24	3		
SD-MASH-00138	2019	No	Yes	23.84721	0	0	40	5	0	0

APPENDIX F. COMMENTS AND RESPONSES TO THE DRAFT REPORT

Comment #	Commenter	Page	Comment/feedback/change requested	Evaluator's Response
1	PG&E	13	Could you please provide more detail into how the "energy produced by the solar system" was modeled? I understand DNV's in-house irradiance database was utilized. What is the relationship assumed between irradiance and solar generation? Is it related to nameplate capacity, peak demand, and/or temperature? These are in cases when it was not directly metered.	Energy produced by the solar system is from the system's AMI interval data for VNEM, and from modeled energy production for NEM. Energy production was modeled using the DNV Solar Resource Compass (DNV SRC). The SRC uses physical system characteristics reported on the application (installed capacity, tilt, and azimuth) and combines them with geographical location (latitude and longitude supplied by the utilities) and satellite solar irradiance data that is within 50 km of each site.
2	PG&E	25	Could some more explanation be provided as to why TRC was the selected metric of interest for the cost-effectiveness instead of the other two? Any pros or cons to this choice?	The TRC has a broad scope—captures the participant costs, utility costs, and the impact on all ratepayers—participants and non-participants. The TRC's benefits and costs are, generally, consistently applied across programs so it allows for comparison of DSM programs with other resource options. Also, some other tests have a narrower perspective or include benefits that may be different across jurisdictions.
3	PG&E	28	Could you label the x-axis of figure 4-14 day 1-30? At first glance I expected average 24 hour load profile for the entire month.	Labels have been added to the figures
4	PG&E	47	Could you provide more explanation in all the price scenarios handled by the bill calculator? You list differences in tiered and TOU rates, medical discounts, taxes. Any more details considered?	We did not use a bill calculator. The main point is that there are many reasons why $/kWh is different from customer to customer, and from region to region.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.