RESEARCH PLAN

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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Glossary

This section describes some of the terms that are used throughout this workplan.

Behind the meter refers to the position of a feature (for this study, solar systems) with respect to the utility's meter. "Behind the meter" is frequently referred to as "the customer side of the meter". The solar systems installed with the MASH program are all behind the meter. **Figure 1** illustrates the positioning of the MASH solar systems with respect to their meters and the Grid. The VNEM system energy produced flows through the meter, only in one direction. The multi-family building with onsite PV meters has energy flowing in both directions, to and from the Grid.

Common area is the part or parts of multi-family 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 (MM) service is supplied to a multifamily accommodation through one meter on a single premise where all of the residential dwelling units are not separately metered. This schedule also applies to residential hotels and to residential RV parks which rent at least 50 percent 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 installations and additions to existing meters. Master meters currently being served under this schedule will be allowed to continue on the rate schedule following a change of ownership provided that no additional units or submeters are added. Most master-metered service was granted legacy status in 1978 – 1981.[1]

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 is fed back into the power grid for use by other utility customers over the course of a billing cycle. The credits are valued at the "same price per kilowatt hour" (kWh) that customers would otherwise be charged for electricity consumed.[2]

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 submetered to all individual tenants. In the Decision Establishing Multifamily Affordable Solar Housing Program within the California Solar Initiative (Decision 08-10-036), submetering was discussed as a way for landlords to be able to allocate the benefits of solar among tenants in master-metered buildings[3].

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. Virtual net metering is a very flexible arrangement that was originally designed for use in the MASH program (which ran from 2008 to 2021). It continues to be available to multi-family 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.[4]

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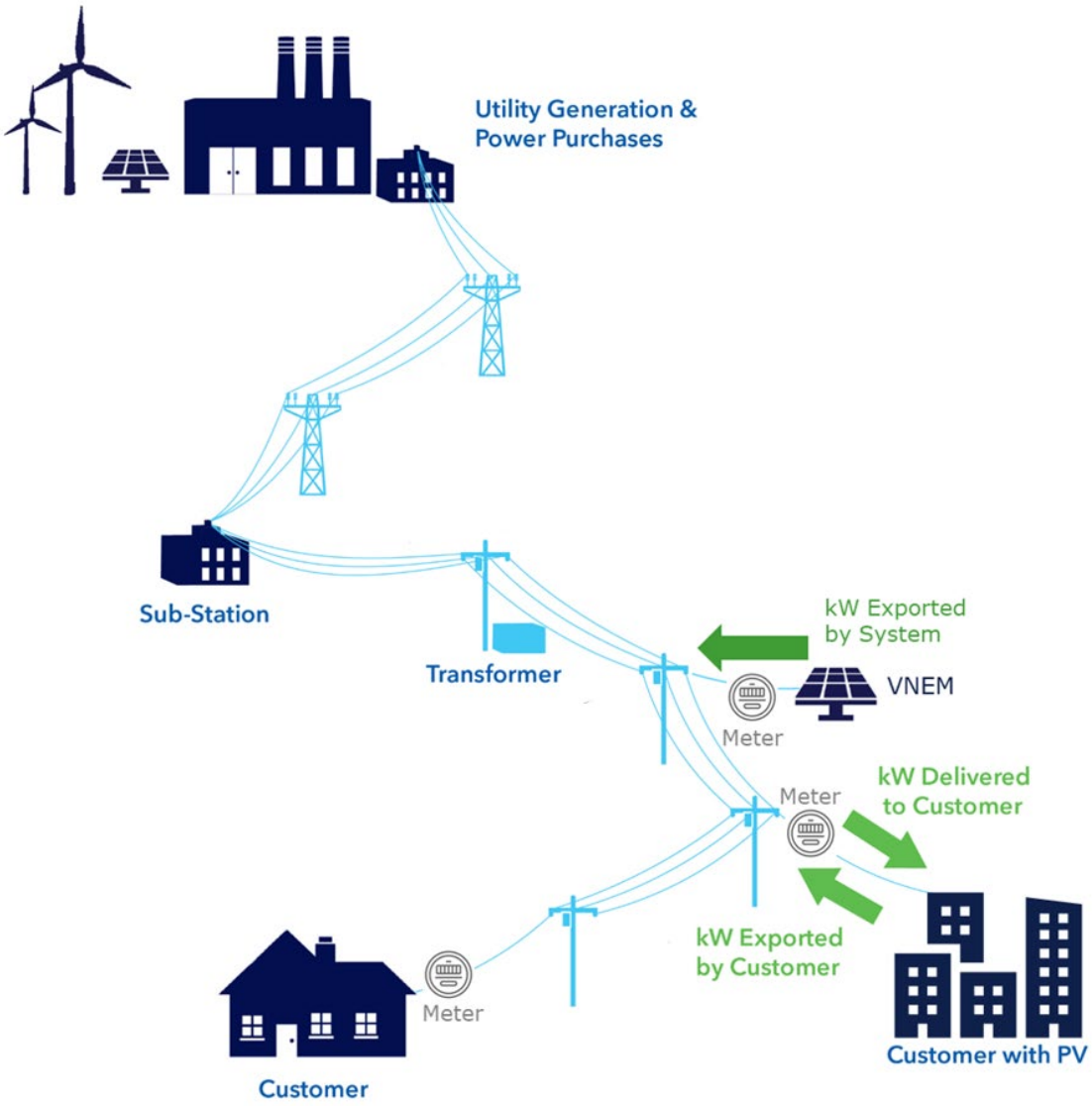
[1] Source: https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EM%20(Sch).pdf
[2] Source: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/net-energy-metering
[3] Source: https://docs.cpuc.ca.gov/published/FINAL_DECISION/92455-07.htm#P232_51045

Figure 1: Interconnection Examples



1 INTRODUCTION

This document presents DNV's proposed research plan for an evaluation of the California Solar Initiative (CSI) Multifamily Affordable Solar Housing (MASH) program for the entire duration of the program (2008-2021). The program was previously evaluated in 2011 by Navigant in the CSI SASH and MASH Program Administrator Performance Assessment Report from the start of the project through 2010.[4]

The state of California has established itself as a leader in equitable access solar policies. Under the ratepayer-funded California Solar Initiative (CSI), the MASH program has helped make carbon-free solar energy more accessible to many low income residents in California. In addition to reducing their utility bills, it also helped reduce capital costs for building owners through rebates.

The MASH program was established in 2008 to provide upfront solar incentives in the form of a one-time rebate paid at the time of project completion to qualifying affordable multifamily housing residences. The program was overseen by the CPUC and administered by Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and The Center for Sustainable Energy in San Diego Gas & Electric (SDG&E) territory. 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 building occupants; and
- Increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.

In 2013, the program was extended by AB 217, which also set additional goals to:

- 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.

MASH 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 project interconnection. There were two tracks in the program, 1C and 1D. Track 1C was for 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. Track 1D was for systems that offset VNEM tenant load with at least 50% tenant benefit (Table 1-1).

[4] https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/c/4285-csimashandsashpaassessmentreport-2011.pdf

Table 1-1. MASH – Program descriptions by track

Track	Incentive Rate per Installed Watt (Calculated Using EPBB Methodology)	Eligibility Requirements

1C: PV System Offsetting Common Area Load, Non-VNEM Tenant Load, or VNEM Tenant Load with less than 50% Tenant Benefit[5]	$ 1.10	• 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 system allocated to offsetting one of the following:
		  ○ Common Area Load
		  ○ Non-VNEM Tenant Load
		  ○ VNEM Tenant Load where tenant receives less than 50% of 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: ○ VNEM Tenant Load where tenant receives at least 50% of economic benefit of allocated generation

With a $54,000,000 budget, the program adopted capacity target was 35 MW. In order to meet this goal within budget, Track 1D was not offered after the 80% incentive budget cap was reached.

[5] Note, Common Area Load and Non-VNEM Tenant Load may be master metered.

2 EVALUATION GOALS AND OBJECTIVES

The key goals and objectives of the evaluation are summarized below. A Glossary that defines some of the terms used in this section is included in the following Section.

1. Assess program costs including program expenditures and uncommitted balances by program component (i.e., administration, marketing, incentives, etc.) and calculate cost effectiveness. (Task 3)
2. Determine the total electrical system benefits due to the program. (Task 4)
3. Determine the total environmental benefits due to the program, using the SGIP/SOMAH and CARB methodologies. (Task 5)
4. Determine the total workforce outcomes due to the program. (Task 6)
5. Summarize program activity by the number of multifamily affordable housing buildings 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. Categorize results by size and type of multifamily property. (Tasks 7)
6. Summarize dollar value of awards, electrical generating capacity of the qualifying renewable energy system, and conduct the following analyses (Task 8):
    a) Compare Common Area Load, Non-VNEM Tenant Load, and VNEM Tenant Load (Track 1C Projects)[6]
    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 CARE/FERA vs. Non-CARE/FERA customers. (Task 9)
8. Summarize program metrics including total number of applications received, applications approved, applications declined by program administrator, and applications withdrawn by customer. (Task 10)
9. Determine progress made toward reaching the stated goals of the program. (Task 11)

3 DATA SOURCES

This section lists the data sources that will be utilized in this evaluation to support the proposed tasks and arrive at robust, accurate, and defensible results. Some are already in the possession of the Energy Division.

Individual solar system data. The CSI Program maintains the California Distributed Generation Statistics (DGStats) website that provides both detailed program data and easily accessible high-level data gathered through the MASH online application tool, PowerClerk. This evaluation requires the confidential version of the PowerClerk data to be able to link each system to its physical address and customer characteristics.

[6] 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.

Job training affidavits. In order to avail of the program incentive, contractors must adhere to MASH job training requirements prescribed by the program. These job training opportunities are laid out in terms of the number of trainees and hours of paid work by size of installation in job training affidavits filed for each site. These affidavits will be a key input to determining workforce outcomes of the program.

Solar production data. Solar production data is a key input to the system benefits, environmental benefits, and bill reduction outcome analyses. Program participants (i.e., the Host Customer and/or System Owner) with systems 10 kW or more are responsible for ensuring the transfer of solar production data from the Performance Monitoring and Reporting Service (PMRS) Providers to the Program Administrators[7].

Energy Consumption data. This evaluation will use two types of energy use data: billing data, and interval data ("AMI data"). Electric consumption history and post installation consumption will be key inputs for this evaluation. Pre-installation history will be obtained from the utilities' billing data, which the utilities provide to the ED on an annual basis. For behind the meter systems, post-installation electric use cannot be obtained from billing data, as the billing data shows only what was billed to the customer from energy taken from the grid, not from total energy use. Therefore, post-installation electric consumption will be calculated at the site level using interval data and the PMRS data described above to determine the program's system, environmental, and bill impacts. The PMRS data and the AMI data will be requested specifically for this evaluation.

Post-installation electric consumption is defined as:

Post-installation electric consumption = Energy produced by the solar system (from PMRS) + Energy taken from the Grid (Energy "delivered", from AMI data) – Energy sold back to the Grid (Energy "received", from AMI data)

For VNEM systems, post-installation electric use can be obtained from billing data[8] of tenants receiving allocations, as the billing data shows what was billed to the customer from energy taken from the grid, and a credit for VNEM generation. The program's system, environmental, and bill impacts for VNEM systems will be based on total generation using the PMRS data.

Site-specific information. Program requirements include submission of tenant addresses within the apartment complex as part of participants' application. This information is used to enroll tenants in the Energy Savings Assistance (ESA) program. For VNEM projects, the VNEM allocation form will be used to collect data on the allocation of benefits to each tenant. Collectively, this data will provide information on the total number of tenant units, size of the properties served, total number of multifamily buildings served by the program, and whether the customer is in a DAC or non-DAC area.

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[7] The MASH handbook states:
Page 44: 4.1.2 PMRS Requirements. PMRS is required for all projects> 10 kW; however, exemptions are allowed for MASH projects provided the cost of the PMRS exceeds the program cost limits .For MASH systems up to 30kW, the total cost of the metering, communication and PMRS for the first five years following final project approval shall be less than 1%of total PV system eligible project costs (exclusive of metering, communication and PMRS costs). For MASH systems 30kW and above, the total cost of the metering, communication and PMRS for the first five years following final project approval shall be less than 0.5% of total PV system eligible project costs (exclusive of metering, communication and PMRS costs).
Page 50: All systems installing PMRS must contract with the provider for a minimum of 5 years and must report 15 minute interval production data quarterly to the PAs. The System Owner must provide a copy of the PMRS contract upon request of the PA; however, it is not a requirement to submit the contract in the Incentive Claim package.

[8] There is a discrepancy between the AMI data and the billing data. The amount of the discrepancy is the energy assigned to the customer from the VNEM. DNV has established load data analytics protocols to address this issue.

Master Metered Account details not found in the Energy Division's annual billing data from the IOUs. Master-metered residential accounts refer to service being supplied through one meter to multiple dwelling units that do not have meters from the utility to the individual units. This data request includes, but is not limited to, number of units, number of occupied units, whether the units are sub-metered, and how does the account owner distribute the master metered charges among the occupants (by unit, by number of occupants, or another formula).

4 WORK PLAN TASKS

This section summarizes the evaluation tasks and the related activities that will be undertaken as part of the evaluation.

4.1 Task 1: Kickoff and Research Plan

The present document, the draft research plan, is a step in the research plan development process. The evaluation team will present the research plan at a public webinar and the final research plan will incorporate edits, suggestions, and modifications provided by ED and industry stakeholders.

Deliverables: Draft and Final Research Plan

4.2 Task 2: Data Request and Data Review

The data that will be utilized in this evaluation is listed in Section 3. The evaluation team will make a data request for information that is not already in the Energy Division's possession. Examples of such data include:

- The confidential version of PowerClerk
- Master metered details
- Interval data

The goal for the initial data review will be to identify the strengths and the weaknesses of the data with respect to providing meaningful information on program activities and related impacts. Initial data review will allow us to explore the full range of available data and how it can be analyzed to address evaluation goals and objectives. These findings will inform analysis approaches that capture program effects in the consumption data.

Deliverables: Data request and memorandum of data inventory and data review

4.3 Task 3: Program Cost Assessment

In order to measure the financial success of the program, DNV will perform a cost assessment to examine project expenditures and evaluate program cost effectiveness using the total resource cost test.

We will begin by reviewing spending across program components, including administration, marketing and incentives. To complete this task, we will collect relevant data from all resources, possibly including:

- Program Implementation Plan
- Program Tracking Data
- DGStats Data
- Program Staff Interviews (4)

The information will be analyzed to determine planned versus actual spending. Interviews with experienced program staff will provide valuable context to understand marketing and administrative costs, as well as any changes that occurred over the course of the program.

The table below summarizes the inputs required to conduct the Total Resource Cost test according to the standard practice manual and associated CPUC policy decisions for the MASH program. While DG Stats data will provide key inputs for the program's TRC, DNV will recalculate TRC based on updated values computed in the course of this evaluation related to electrical system benefits, environmental benefits, and bill reduction outcomes (see Tasks 4, 5, and 9 below).

Table 4-1. Inputs for TRC test for the MASH program

TRC Inputs	Description
Administrative costs	Program administration costs from CSI data, as reported by IOUs
Avoided costs of electricity – energy	Values computed as described in Task 4
Avoided costs of electricity – generation capacity	
Avoided costs of electricity - T&D	
Avoided costs - avoided ancillary services procurement	
Avoided costs of electricity – GHG	Values computed as described in Tasks 4 and 5
Bill Increases/Reduction	Values computed as described in Task 9
Incentives paid	Data filed by IOUs
Participant Costs - Equipment/Installation (Measure Costs)	Costs are self-reported by applicants/developers and may not be accurate. Includes financing costs and taxes.
Investment Tax Credits	Federal tax credit will be treated as a reduction in system cost rather than a benefit. If explicit tax credit information is unavailable through program tracking, we will calculate the value based on the credit available in the year of system completion.
Other: copayments (LI only), non-bypassable charges (DG only), reliability benefits/costs, etc.	Non-bypassable charges included as part of customer bill savings (NEM customers pay all regulatory charges on a net basis)

The cost test could be expanded to a societal cost test through the inclusion of non-energy impacts (societal, utility, or participant), if those data are readily available. The budget does not include hours to develop NEIs.

4.4 Task 4: Total Electrical System Benefits

Electrical system benefits encompass many different areas. For example, solar systems can reduce or increase distribution losses depending on their physical location on the grid. This evaluation will focus on the electrical system benefits at the participants' premises. These benefits have two major components: electricity generation at the premises and avoided costs. Both of these are highly time-dependent.

4.4.1 Electricity Generation

To address solar generation's time dependency, the first step to valuing total electrical system benefits is to convert PV system capacities (from the tracking data) to an 8760 profile of energy generated. DNV has identified three methods to do this, alone or in combination, depending on the data available.

Method 1 – Individual System Data. Depending on the type of solar system, DNV will calculate energy system output from PMRS data or VNEM data obtained directly from the IOUs. This method is highly preferred over Methods 2 and 3 (presented below) but is dependent on the availability of the PMRS data.

DNV will obtain the PMRS data for all installations that are required to have it and that will provide it for this evaluation[9]. The PMRS data reflects the system's energy generation at the 15-minute interval level (8760 x 4 = 35,040 15-min intervals per year) which can be aggregated to match hourly AMI data.

Only program participants with system sizes of 10 kW or more have to report their solar production data to PMRS. Even if we can get PMRS, we will need to supplement this approach with Method 2 or 3 to assess smaller systems that are not VNEM.

Method 2 – PV System Modeling. DNV will utilize aggregate PV system characteristics to model energy output.

Software such as HelioScope, PVsyst, PVWatts (a publicly available tool from NREL) and the DNV Solar Resource Compass can generate an hourly simulation ("8760") of energy generation given details about system size, type, location, tilt, and orientation. In its evaluation of the SOMAH Program,[10] Verdant used PVWatts to simulate hourly PV generation for every system in the tracking data. We will follow the same approach–modeling individual installations using modeling software–but we will use the DNV Solar Resource Compass (DNV SRC) software. There are two reasons for this: the first is that the DNV SRC can use actual year solar irradiation (as opposed to using typical meteorological year, or TMY, solar irradiation), and the second one is that the DNV SRC can use more system details if they are available, which results in more nuanced and precise modeling.

This method is broadly applicable to all systems and will be the only option if PMRS data is not available. If PMRS data is available, Method 1 and Method 2 can be used in combination, using PMRS data for those systems that have it, and modeled data for those systems that do not.

Method 3 – Solar Output Factors. If PMRS data is available for a large number of representative systems, it is possible to use the data to generate regional performance factors – system output expressed as an hourly percent of system output to installed capacity:

Factor for hour h = Total generation in hour h / Total installed capacity

These factors can be used to estimate generation based on installed capacity for those premises that do not have PMRS. This approach has been used in a number of solar evaluations, including those performed for the California Solar Initiative. It is attractive because the factors produced can be easily used for subsequent estimations outside of this evaluation. The downside is that, in subsequent years, the factors will not be as precise as for the year they were developed. DNV tested this approach for an IOU by comparing existing regional factor estimates prepared by a third party with those of actual system output. The results were mixed. The factors worked well for some regions and not for others. This approach may work better for this evaluation because the system output data used to develop the regional factors would reflect actual weather conditions.

This method is an alternative to simply using PMRS data for those systems that have it, and modeled data for those systems that do not. DNV will analyze the data available and make a recommendation to the CPUC team regarding the best way to create these output factors, and whether we recommend using Method 2 or Method 3. While it may be possible to have some estimates based on each of the three methods, it is likely that we will recommend a combination of Method 1, and Method 2 or Method 3, instead of a combination of all three methods.

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[9] For a prior project, the evaluation team could not obtain relevant PMRS data that was not in the possession of the IOUs.
[10] Verdant Associates, 2021. Solar on Multifamily Affordable Housing Phase II Report. October. somah_phaseii_report_20211013_final.pdf (ca.gov)

4.4.2 Avoided Cost Estimates

The 2021 Distributed Energy Resources Avoided Cost Calculator[11] provides 8760 avoided cost by year 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 will assess separately as environmental system benefits rather than electricity system benefits.

Generating 8760 avoided costs is a straightforward multiplication of the 8760 energy generation array with the 8760 avoided cost array (with appropriate unit conversion). Annual avoided costs are estimated as the sum of the hourly avoided costs.

4.5 Task 5: Total Environmental Benefits

Task 5 will assess the environmental benefits associated with solar generation installed under the program. Following the approach used by Verdant for the SOMAH evaluation, we will use marginal carbon dioxide (CO_2) emissions data available for each of California's grid regions through the California Self-Generation Incentive Program (SGIP).[12] These data are provided by WattTime, a nonprofit that uses real-time power generation data to deliver marginal emissions at up to a 5-minute resolution.

We will combine hourly marginal emissions with the hourly solar generation profiles developed in Task 4, to accurately estimate avoided carbon emissions by season and by year.

Additionally, we will use California Air Resource Board (CARB) calculators for solar photovoltaics developed for state agencies (notably the California Department of Community Services and Development). The advantage to these calculators is that they include estimates for other pollutants, including NOX, reactive organic gas, and particulates, where the above approach would only estimate CO2 emissions.

We will also develop a dollar value for avoided CO2 emission. As described in Task 4, the 2021 Distributed Energy Resources Avoided Cost Calculator provides the costs associated with CO2 emissions, broken into two parts. The first, the cap-and-trade carbon price forecast, is embedded in energy prices and therefore included as part of the avoided cost calculation in Task 4. The second part, the GHG adder, captures the difference between the cap-and-trade price and the full shadow price of CO2.

4.6 Task 6: Total Workforce Outcomes

In this task, we will determine the workforce outcomes attributable to the program. In order to avail of the program incentive, contractors must adhere to MASH job training requirements prescribed by the program. These job training opportunities are laid out in terms of the number of trainees and hours of paid work by size of installation. Contractors furnish job training affidavits to the MASH program staff that include details on types of jobs completed and the hours worked.

DNV will include in its data request the information contained in job affidavits and analyze these data to assess the total workforce outcomes of the program. Results will be summarized by the total number trained, hours worked, and broken out by the relevant North American Board of Certified Energy Professionals (NABCEP) task analysis categories as follows:

Directly work on solar installation

[11] https://willdan.app.box.com/v/2021CPUCAvoidedCosts/folder/136593940728
[12] http://sgipsignal.com/download-data

- Installing electrical components
- Installing Mechanical components
- Completing System Installation
- Conducting Maintenance and Troubleshooting Activities

Project Design/Project Engineering

- Designing Systems

Project Management/coordination

- Managing the project

In addition, we will break out the results by year and utility and look for trends over time or geographically. We will also examine the number of contractors/organizations that were eligible and how many submitted projects. This will tell us whether the program activated a larger market, and whether existing or new companies participated. The budget assumes that the job affidavit data are accessible electronically and digitalized.

4.7 Task 7: Total Customers Served

One of the most important aspects of this assessment is how the program ultimately benefited its customers. To do this, we will utilize program tracking data and customer data from the start of the program until its close in 2021, and we will hold discussions with the PAs. These data will be analyzed to determine the number of multifamily buildings and properties served, the number of low-income households served, and the location of properties served. The information will be parsed to determine if properties are in disadvantaged communities, and also sort properties by program (MASH 1.0 or MASH 2.0), and by type and size to provide more depth and context, such as those on CARE and non-CARE rates. Any existing customer feedback gathered from participants through the course of the program will be analyzed.

4.8 Task 8: System Characteristics by Customer Type

In this task, for each qualifying project DNV will summarize the dollar value of award (i.e., rebate amount) along with the program (MASH 1.0 or MASH 2.0), interconnected solar generation capacity (kW_{AC}), property type (i.e., large multi-family, small multi-family, or mobile), and interconnection meter type (i.e., common area, tenant, VNEM tenant). System generation capacity will be 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 summary list of all qualifying projects, DNV will present the minimum, maximum, and average incentive amounts ($) and capacity ($kW_{AC}$) for all projects and by program. Using site-specific information, similar metrics can be provided by property type and by interconnection meter type.

Post-installation electric consumption will be determined for each project based on the interconnection meter. Consumption will be 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)

Provided the data for each project includes an indication of the load being offset (e.g., common area load, non-virtual net metering tenant load, or virtual net metering (VNEM, which is not sub-metered and there are no customers behind the meter), the following analysis and comparisons can be performed:

- Compare minimum, maximum, and average incentive level/system capacity and export allocations by meter type (i.e., common area, tenant, VNEM tenant)
- Compute post-installation consumption for common area metered accounts, tenant accounts (non-virtual net metering, provided account is not master metered), and tenant metered accounts participating through VNEM.
- Compare pre-installation consumption to post-installation consumption by Program and by meter type.
- Quantify the number of participants who receive monetary incentives and enrolled in the Energy Savings Assistance (ESA) program.

4.9 Task 9: Bill Reduction Outcomes

Direct program benefits for customers include reductions in energy expenses, and in some cases, increased energy use. This task will analyze energy use before and after the solar installation to assess these benefits. For Common Area projects, energy expenses before and after project installation will be assessed. When assessing individual tenant load reductions or increases, before and after bill analysis can only be performed on individually metered accounts. Master metered project analysis will assume the projects meets the terms and conditions of the MASH program (i.e., allocation to tenants). The assessment will include a summary of how occupancy changes and vacancies during the program period were considered in the analysis.

The installation of solar will likely generate snapback (higher use of energy due to the reduction in energy expenses). For households that utilize energy below the "essential service quantity which is necessary for health, comfort, and safety"[14] because they cannot afford to use more, this higher consumption is very desirable. While this evaluation will not assess whether individual participants could be characterized as being below essential use, we will provide a program-wide assessment of the proportion of participants that may have benefited from their increased energy use above the essential use threshold due to program participation. DNV is currently leading the Essential Use Study to define these essential use thresholds for the California IOUs. While the Essential Use Study is expected to be completed in early 2023, DNV will use preliminary thresholds to provide the CPUC with approximate results.

DNV will determine the average amount energy bills are reduced per building/tenant (both in dollars and kilowatt hours). This analysis requires either solar output data from PMRS (the best option from a data quality perspective) or "solar normalization" – a process by which we estimate solar output in average solar conditions in order to compare two periods on an apples-to-apples basis. This analysis will require:

[13] Directly metered solar systems include VNEM -which requires a standalone meter-, PMRS -required by MASH-, and potentially, load research sampling -which may or may not be available from the IOUs-.
[14] Definition from the Affordability Rulemaking ALJ Ruling, April 12, 2019

- Program tracking data including system size, climate zone, property type, and information identifying which billing accounts are benefiting from the system.
- Pre- and post-installation billing data and interval data (including PMRS data) for all program participants, including tenant units and common areas benefiting from the program that includes the electricity and dollar amount billed, rate class and CARE participation, and virtual net metering. The utilities provide the billing data to the Energy Division annually, but the interval data will be requested especially for this project.
- For VNEM projects, interconnection date and start date of utility credits to virtual metered accounts.
- Actual weather data with solar exposure for the period after the installation.
- Normal weather data (TMY) with expected solar exposure.

DNV will analyze the difference in bills normalized pre- and post-installation on an annual and seasonal basis for program participants. DNV will further analyze the bill reduction outcomes of the program for participants for groups of interest. Specifically, we will analyze the energy bill reduction outcomes for CARE vs. Non-CARE and DAC vs. non-DAC participants as well as how energy bill reduction outcomes are impacted by climate zone, property type, and size of installation.

Based on preliminary MASH project data review, DNV expects that approximately 1/3 of all participants are master-metered (Table 4-2).

Table 4-2. Q1 2021 Master-Metered Premises

Q1 2021 Master-Metered Premises				Estimated number of dwellings based on RASS average
	NEM	CARE	Total	
PG&E	0	0	15,062	195,806
PG&E	0	1	1,247	16,211
PG&E	1	0	1,448	18,824
PG&E	1	1	123	1,599
SCE	0	0	6,077	79,001
SCE	1	0	377	4,901
SDG&E	0	0	2,774	36,062
SDG&E	0	1	535	6,955
SDG&E	1	0	397	5,161
SDG&E	1	1	92	1,196
TOTAL			**28,132**	**365,716**
CARE			**1,997**	**25,961**
NEM			**2,437**	**31,681**
CARE and NEM			**215**	**2,795**
Submetered			**689**	**8,957**

For master-metered projects, bill reductions cannot be estimated at the tenant level because we do not have visibility into these transactions. Instead, the analysis will assume the project complies with all MASH program terms and conditions, including how to allocate solar production among tenants. Accessing tenant data will require coordinating with data owners at the site-level and this is beyond the scope of this evaluation.

4.10 Task 10: Program Process Metrics

Using IOU program tracking data and information collected from staff interviews, DNV will summarize the program process in terms of the number of applications received, approved, declined, and withdrawn in total and by year. We will glean insights related to the most common reasons for denial or withdrawal of applications and application processing time from program staff interviews. We will compare program achievements against goals stated in the program implementation plan.

4.11 Task 11: Summarize Overall Program Performance: Reporting

The core goals of the MASH Program[15] are:

- 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 building occupants; and
- Increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.

In 2013, AB 217 set the additional goals for the program;

- 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.

In this task, we will summarize the insights gleaned from the activities DNV has performed in Tasks 1 through 10 and identify whether the above goals were reached or not. Using program data, information collected from staff interviews, and evaluations completed, DNV will measure the overall success of the program as related to the stated MASH Program goals. DNV will evaluate:

- The number of multifamily buildings and properties served and
- The number of low-income households served in the affordable housing sector and
- Summarize program metrics including total number of applications received, applications approved, applications declined by program administrator, and applications withdrawn by customer

to illustrate how MASH programs influenced adoption and have improved energy utilization and the quality of affordable housing through the implementation of solar and energy efficiency technologies.

Through the evaluation performed under Task 9, DNV will analyze programs' impacts on electricity use and costs, for example by maintaining or increasing electricity usage without increasing household expenses for occupants. Workforce impacts such as training and employment opportunities in solar sector are evaluated under Task 6 and results will show progress towards this goal.

To evaluate the degree of increased awareness and appreciation of the benefits of solar, additional primary research focus on customers and developers is necessary to garner a more holistic understanding. When evaluating the program's benefits, DNV will focus its analysis on participating customers. A broader project scope is required to determine the overall benefits of the MASH program to all ratepayers as it requires an in-depth understanding and quantification of the costs and benefits for both participating and non-participating ratepayers, and more detailed analysis to consider the program related solar and

[15] CSI Multifamily Affordable Solar Housing (MASH) Program (ca.gov)

energy efficiency impacts on the overall grid and energy markets among other criteria. For the purposes of this study, DNV will summarize results of overall environmental benefits (task 5) and electrical system benefits (Task 4).

In addition, DNV will analyze the impact of reduced CARE credits due to the offset (net) impact of the solar generation/credit on CARE customers' bills and quantify the impact of those savings on ratepayers.

4.12 Task 13: Project Management

Under this task, the Project Sponsor (Gomathi Sadhasivan), Project Manager (Megan Ovaska), and other assigned team members will conduct all activities associated with managing the project. This includes active communications in addition to monitoring and control of schedule, budget, resources, quality, and risk to meet the needs of the scope.

5 SCHEDULE

The estimated project schedule, including key project milestones and deliverables, is presented below.

Table 5-1. MASH Evaluation Schedule

Month/Year	Milestone/Deliverable
May 2022	• Draft research plan
June 2022	• Webinar
July 2022	• Finalize research plan
July 2022	• Data request and review
August 2022 – December 2022	• Analysis
January 2023	• Draft report for ED review
February 2023	• Draft report for stakeholder review
February 2023	• Final report, webinar(s) and posting

APPENDIX A: RESPONSE TO COMMENTS

Comment #	Commenter (self- identify by Party, PA, etc.)	Page (as shown in at bottom of document page); or "Overarching" for general comments	Comment/feedback/change requested	Evaluator's Response
1	PG&E	15	Task 9 states it would require PMRS data. The MASH PAs do not have the PMRS data, this would need to be requested from the System Owner.	Yes. DNV has had no success requesting these data for other work, but we will try again. The IOUs have system production data for a limited number of systems, and DNV plans to employ simulation software to supplement the gaps.
2	PG&E	16	Task 9 states it would break out bill reduction outcomes between CARE/FERA and non-CARE/FERA customers. Would there be interest to identify customers in disadvantaged communities and provide a DAC vs non-DAC break out of bill reduction outcomes as well?	Yes. Thank you for the suggestion. Edits made to the research plan to indicate that DNV will identify customers in disadvantaged communities (DACs) vs non-DACs and report results by this segmentation lens as well.
3	PG&E	14	Task 7 mentions it will utilize data from the start of the program until its close in 2021. Following guidance from a CPUC letter dated November 5, 2021, the MASH PAs are allowing viable projects to complete in 2022. As such, there are a few projects pending completion and payment, which means those projects may not have full data at the time data is requested.	DNV will evaluate all projects that have been completed and have full available data. We will note in the final study when, and if, some projects are not included and why.
4	Sunrun	Overarching	Please obtain tenant unit counts for properties served by the MASH program. DGStats data shows meter counts only. Properties where MASH-funded PV serves common areas still provides important indirect benefits to residents.	Thank you for the suggestion. We will include this in our data request. The number of tenants served by the MASH program is available in the public semi-annual progress report by IOU territory. See Table 10 in Section 3.4 at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/csi-progress-reports/pge-mash-semiannual-progress-report-january-2022_public.pdf

About DNV

Driven by our purpose of safeguarding life, property and the environment, DNV enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.