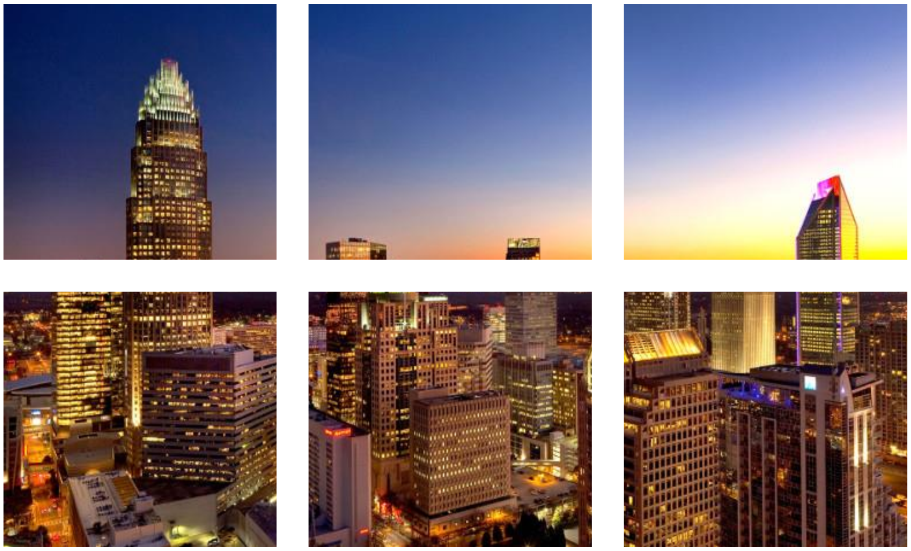

2019 SGIP ENERGY STORAGE MARKET ASSESSMENT AND COST-EFFECTIVENESS REPORT

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SGIP Working Group

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1 EXECUTIVE SUMMARY

California's Self-Generation Incentive Program (SGIP) provides financial incentives for the installation of distributed generation and advanced energy storage technologies that meet all or a portion of a customer's electricity needs. The SGIP is funded by California's ratepayers and managed by program administrators (PAs) representing California's large investor owned utilities (IOUs). The Program Administrators are Pacific Gas and Electric (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), and the Center for Sustainable Energy (CSE), which implements the program for customers of San Diego Gas & Electric (SDG&E). The California Public Utilities Commission (CPUC) provides oversight and guidance on the SGIP.

This study is not an evaluation of storage within the SGIP program (a separate impact evaluation of the 2017 SGIP was completed in 2018 and an impact evaluation of the 2018 SGIP will be completed later in 2019). Rather, this study seeks to increase understanding of the current market conditions for storage and the key drivers associated with storage cost-effectiveness over time. This is a forward looking, *not retrospective analysis* of the potential cost-effectiveness of storage under a range of assumptions, forecasts, and scenarios including storage dispatch that is more optimal than that observed to date. This project was completed as a sensitivity analysis of the SGIP program benefits and costs to changes in either program design or tariff design. The purpose of this analysis is to test how various changes can impact the cost-effectiveness tests performed on the SGIP program. The results can be considered indicative of ways to improve the program but are not actual evaluations of the program.

Program evaluation and market assessments have been a regular part of the SGIP environment since the program's inception in 2001. This *2019 SGIP Energy Storage Market Assessment and Cost-Effectiveness Report* intends to provide information and analyses to help the CPUC, California policy makers, PAs, and stakeholders better understand storage-related costs, benefits, and market conditions. Some of the research questions pertain directly to legislative requirements set out in Senate Bill 700, while others are associated with ongoing CPUC proceedings on program budgets, goals, and requirements. This study addresses both behind-the-meter (BTM) storage and in-front-of-the-meter (IFOM) utility scale storage, with most of the research focused on the former (BTM storage). Key questions addressed in this study include:

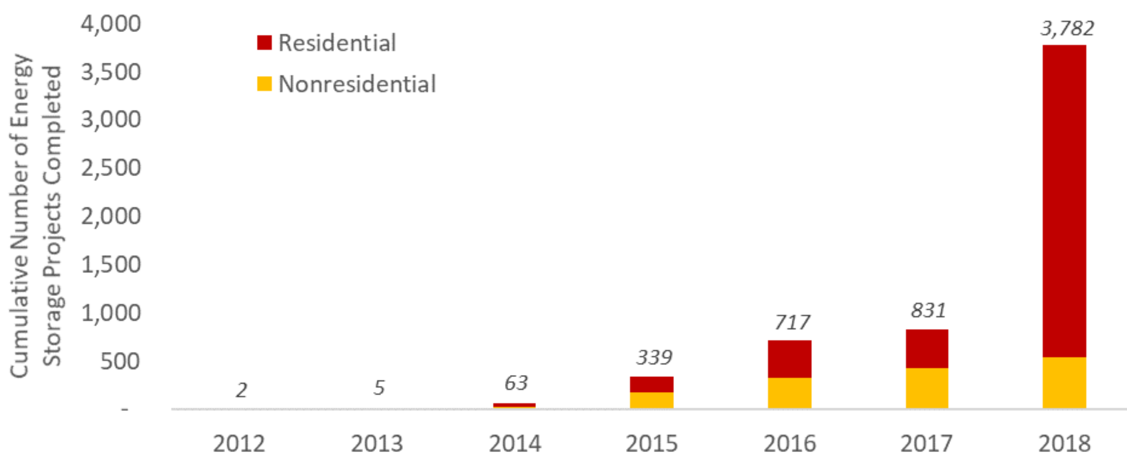
- What is the potential for cost-effectiveness of storage under California Standard Practice Manual (CA SPM) definitions of the key benefit-cost tests?
- How might cost-effectiveness change over time due to changes in storage costs, electricity rates, incentive levels, federal tax rules, and other relevant factors?
- How do BTM storage costs compare to other resources providing the same or similar value to the grid (e.g., IFOM storage)?

- What is the state of the current BTM storage market in California?
- What are the key characteristics of current and prospective adopters of BTM storage?
- What are the key drivers and barriers to storage adoption for both end user and supply-side market actor perspectives (i.e., storage developers and manufacturers)?
- How do price signals and modeled expectations of storage behavior combine with grid costs and marginal greenhouse gas (GHG) emissions profiles to impact grid impacts and GHG emissions?

1.1 STORAGE WITHIN THE SELF GENERATION INCENTIVE PROGRAM

The SGIP offers storage incentives for both residential and nonresidential customers. By the end of 2018, the SGIP had provided incentives for 3,782 storage projects representing 112 MW of rebated capacity. Growth in SGIP storage as a function of upfront payment year is summarized in Figure 1-1, which also shows the breakdown of SGIP participants by customer class. The overwhelming majority of SGIP energy storage projects are residential; however, nonresidential projects are considerably larger and represent a larger share of the program's rebated capacity.

FIGURE 1-1: NUMBER OF SGIP ENERGY STORAGE PROJECTS BY UPFRONT PAYMENT YEAR AND CUSTOMER CLASS



Growth in SGIP energy storage has not been consistent across the residential and nonresidential sectors. Beginning in 2017, and most dramatically during 2018, the number of completed residential projects greatly exceeded the number of nonresidential projects by more than one order of magnitude. In addition, the pipeline for new nonresidential projects decreased significantly in 2018.

Beginning in May 2017, the SGIP adopted an incentive structure based on five Steps. Each step offers a declining incentive proportional to the number of applications received. The program also has segment-based budget allocations, with the largest budget set aside for nonresidential storage. The nonresidential budget was undersubscribed for 2017-2018, while the residential budget was highly subscribed.

1.2 MARKET ASSESSMENT FINDINGS

The market assessment portion of this study addresses questions about drivers and barriers for storage adoption. It is intended to help policy makers, program administrators, and stakeholders understand key trends in the energy storage market, as well as SGIP participants' experiences with energy storage. The market research relies on interviews and surveys with three manufacturers, 34 developers, 765 residential end users with storage, 19 nonresidential end users with storage, 115 residential end users with solar but without storage, and 42 nonresidential end users with solar but without storage to identify the key drivers and barriers to storage market adoption.

With respect to adoption drivers we investigate several potential influences on storage adoption including backup power, perceptions of solar self-consumption, perceptions of GHG and grid benefits, bill savings, and time-of-use (TOU) arbitrage. Interviews with host customers also identify key barriers to technology adoption including upfront cost, technology uncertainty, aesthetics, space constraints, safety and other factors. Section 3 provides additional details on the data sources and methods used for the market characterization.

Below we present high level findings from the market assessment element of this study. In-depth findings and analyses are presented in Sections 4 and 7 of this report.

Key factors driving early adoption of BTM storage. The very earliest residential adopters are driven by factors such as the desire for backup power and greater grid independence, desire for bill savings, increasing self-consumption of their solar generation, reducing GHG emissions, and load shifting. In the wake of the catastrophic fires in Northern California, consumer demand appears to have increased as customers have become interested in backup capability to address perceived increases in preventive outages. Project developers have employed this use case as a major selling point.

Characteristics of early adopters. In the residential sector, our analyses indicate that storage is generally not cost-effective to end users under the Participant Cost Test based on bill savings available from load shifting in response to the tariffs we modeled. Residential end users are motivated by highly individualized assessments of the value of storage for backup and have widely varying willingness to pay for it. Initial adopters are generally high-income homeowners with solar and tend to have strong environmental concerns and high levels of education. Some residential adopters are also motivated by the idea of being more energy independent and enabling better use of solar on the grid. Early residential adopters likely value backup generation at a level much greater than the average customer.

In the nonresidential sector, adoption was reported to be more driven by economic factors. Reducing demand charges was the key driver for initial nonresidential storage adopters. Over three-fourths of nonresidential storage customers reported having company goals addressing sustainability, climate change, greenhouse gas reductions or other environmental objectives.

Reasons for slowdown in nonresidential adoption. Our cost-effectiveness analysis indicates that BTM storage is marginally cost-effective under the Participant Cost Test based on bill savings to some nonresidential customers. Nonetheless, after an initial surge of nonresidential storage projects, the pipeline for new nonresidential projects appears to be stalling. As found in our interviews with developers and in some parties comments recently,[1] storage industry developers and trade groups tend to believe the drop off is due to a combination of declining SGIP incentive levels, transitions to new rate structures, uncertainty in program requirements, and perceived delays and transaction costs of program participation.

Role of the SGIP in storage adoption. Across both residential and nonresidential sectors, most developers believe it would be extremely difficult to sell storage projects without the SGIP incentive. Storage customers also reported that the incentive amount was very important to their decision to purchase storage. The SGIP program and incentives are strongly promoted by developers; however, some customers do decline to go through the program. Reasons for not participating in SGIP include being waitlisted, receiving outside funding such as grants, and avoiding the hassle of applying for incentives.

Market perceptions of rate structures. Developing dynamic electricity rate structures that are aligned across both avoided costs and GHG reductions was reported by many developers to be important. However, some developers believe strongly that dynamic pricing needs to be optional not mandatory, particularly for residential customers who are less sophisticated and thus, less able to respond to price signals on a real-time basis. Some developers would like to see a fully enabled market for aggregating residential BTM to provide transmission, distribution, and ancillary services, but believe such a market is still far off.

Perceptions of storage among existing solar end users. To assess the potential for continued adoption of storage, we asked end users that have solar systems but no storage a series of questions about their awareness and consideration of storage going forward. The vast majority (roughly 90 percent) of solar adopters are aware of storage.[2] The primary perceptions of storage among end users with solar was that it is costly, enables use of solar energy or greater grid independence (mostly residential respondents), can be used for backup, and offers potential bill savings (mostly nonresidential respondents). Most

[1] Assigned Commissioner's Ruling seeking comment on implementation of Senate Bill 700 and other program modifications, April 15, 2019. See party comments and reply comments.

[2] This statistic should not be considered indicative of non-solar end user awareness.

respondents indicated they had previously considered installing battery storage (57 percent) and that the high cost of storage was the dominant reason they had not installed it.

Potential for future (near term) adoption of storage among existing solar end users. When asked about their future intentions, a very high percentage of the solar end users who had heard of storage reported they were somewhat likely (61 percent) or very likely (12 percent) to install storage in their home or business. When asked when they anticipated installing storage, most higher likelihood customers indicated within one to five years. We also asked those end users how much they were willing to pay for storage. Based on the results, we estimated that as many as ten thousand residential end users per year could choose to adopt storage (contingent on availability of SGIP incentives and continuation of the ITC) over the next five years.

1.3 COST-EFFECTIVENESS FINDINGS

The cost-effectiveness results in this study are based on a set of prototypical end user load shapes combined with modeling of storage dispatch that is optimized with respect to rational economic response to a given tariff.[3] This is a forward looking, *not retrospective analysis* of the potential cost-effectiveness of storage under a range of assumptions, forecasts, and scenarios. This study is not an evaluation of the cost-effectiveness of the actual SGIP program. These analyses are performed on a 15-minute basis over the lifetime of the equipment for multiple segments and use cases. The resulting effects of storage dispatch on load shapes are then used to quantify the energy, demand, GHG, and economic impacts from various perspectives using the California Standard Practice Manual cost-effectiveness tests. Important inputs to these analyses include forecasts of utility avoided costs, utility rates, storage costs, incentives levels, and tax incentives.

Load shapes were chosen for the cost-effectiveness analysis to capture meaningful variation across utilities and market segments; however, because of the number of simulations required, the set of shapes is limited and is not a statistically representative sample of the diverse behavior of populations of end users. Instead, they produce prototypical results for specific cases across a range of use cases and scenarios. The use cases analyzed included:

[3] The use of a rational dispatch of storage approach in the modeling was chosen for this study to support the research objective of having a forward-looking perspective on storage given the fact that numerous changes in SGIP and tariff requirements were in progress during this research. Note that actual dispatch behavior for storage observed in the 2017 SGIP impact evaluation was far from optimal and often of limited grid value; the factors underlying these dispatch behaviors have been the subject of significant effort in 2019 by the CPUC, PAs, and stakeholders to change requirements and incentives to induce more optimal dispatch.

- **Base Case** – This case uses the storage end user's tariff as the sole basis for dispatch optimization. Two tariff cases are modeled, as well as multiple load shapes for different end user segments.
- **GHG Signal** –Storage dispatch is co-optimized for the end user's bill savings and a GHG price signal. Two GHG price signals are modeled, one with higher and one with lower GHG prices.
- **Distribution Deferral** – In this case, storage is assumed to be deployed where there are much higher than average local distribution avoided costs.
- **Backup** – In this case, an additional value of lost load (VLL) is added to the participant's benefits.
- **Demand Response** – This use case includes payment for participation in a demand response program, as well as any incremental effect on battery dispatch in response to the demand response price signal.

Detailed explanation and documentation of the cost-effectiveness modeling and input assumptions are provided in Section 5 of this report.

The results from this study indicate that the potential cost-effectiveness of behind the meter storage is highly variable and sensitive to the parameters and use cases tested. As shown in The Participant (PCT) test has important relevance to analyses of end user adoption, program participation, and incentive levels. For residential end users, PCT ratios vary widely depending on rate type (TOU vs. EV-TOU) and increase over time. Under the residential EV-TOU rates analyzed, residential PCT ratios increase significantly relative to the TOU rates analyzed and estimated participant benefits exceed costs in the mid- (2024) and later (2028) years. Nonresidential end user's PCT ratios under the Base use case with traditional rates exceed 1.0 for most of the prototypical load shapes chosen for the analysis and are as high as 3.0 or more for some segments and utilities in the later years. PCTs are highest for the EV Charging Station load shape.

Program Administrator (PA) benefit-cost ratios are much higher than TRC results. This is often the relationship between the TRC and PA tests (PA significantly higher) since the PA test includes only incentives and administrative costs but does not include the participant's costs, as does the TRC. PA ratios for BTM storage are well above 1.0 in many of the residential mid- and out-year cases as well as some of the first-year cases (e.g., the GHG High Signal and Distribution Deferral cases). Nonresidential PA ratios are generally above 1.0 in 2018 and average roughly 2.0 in 2024 and 3.0 in 2028.

Figure 1-2 and Figure 1-3, from a Total Resource Cost (TRC) test perspective, using the full cost of battery systems in the TRC analysis, storage is not cost-effective under the Base use case for the residential load shapes analyzed across the entire time frame of the analysis (out to 2028). For the nonresidential cases analyzed, estimated benefits exceed costs (positive TRC with the TRC ratio above 1.0) in the out years of the analysis (2028) and are mixed in the mid-years (2024). Under the other use cases analyzed, TRCs increase by around a third in the residential sector for the case with a high GHG signal and are roughly double for the distribution deferral case. TRCs do not change significantly under the backup generation and demand response cases.

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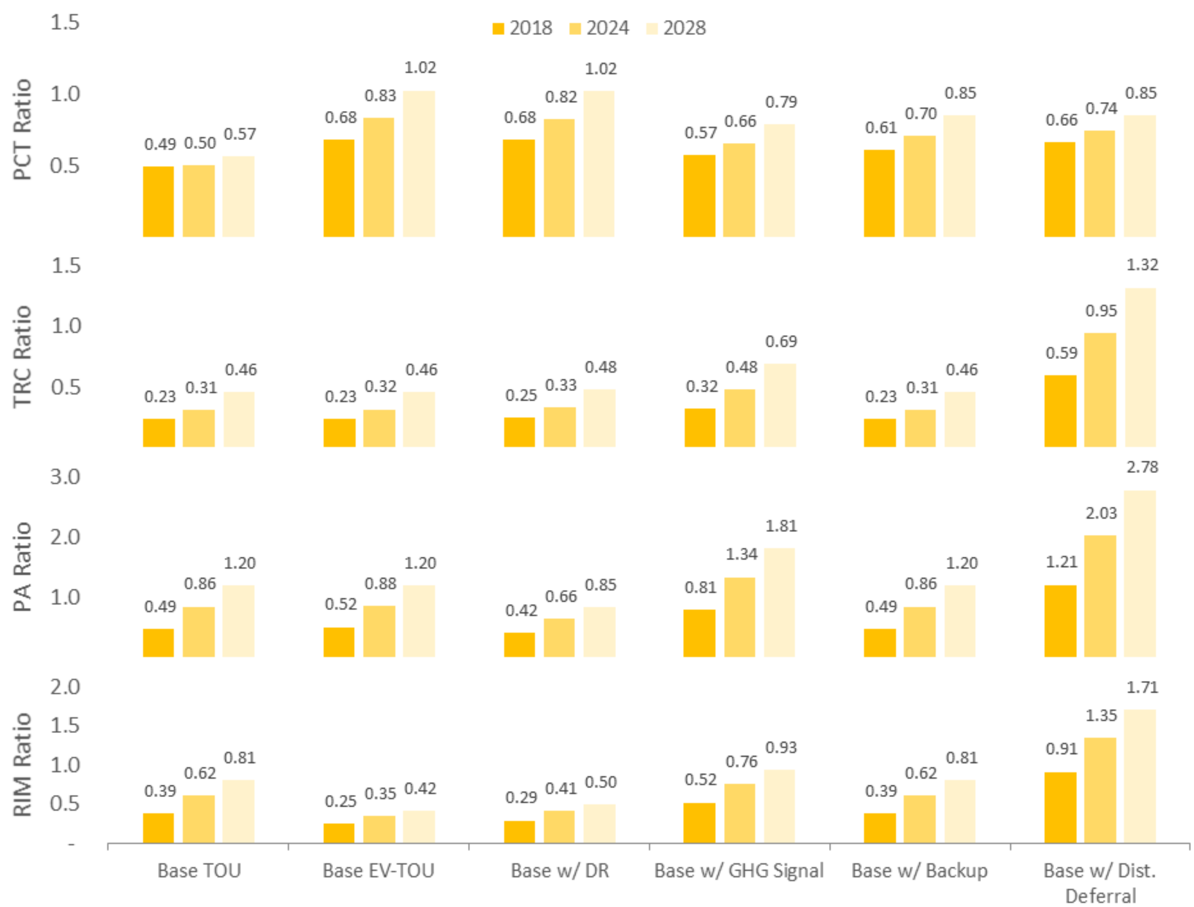
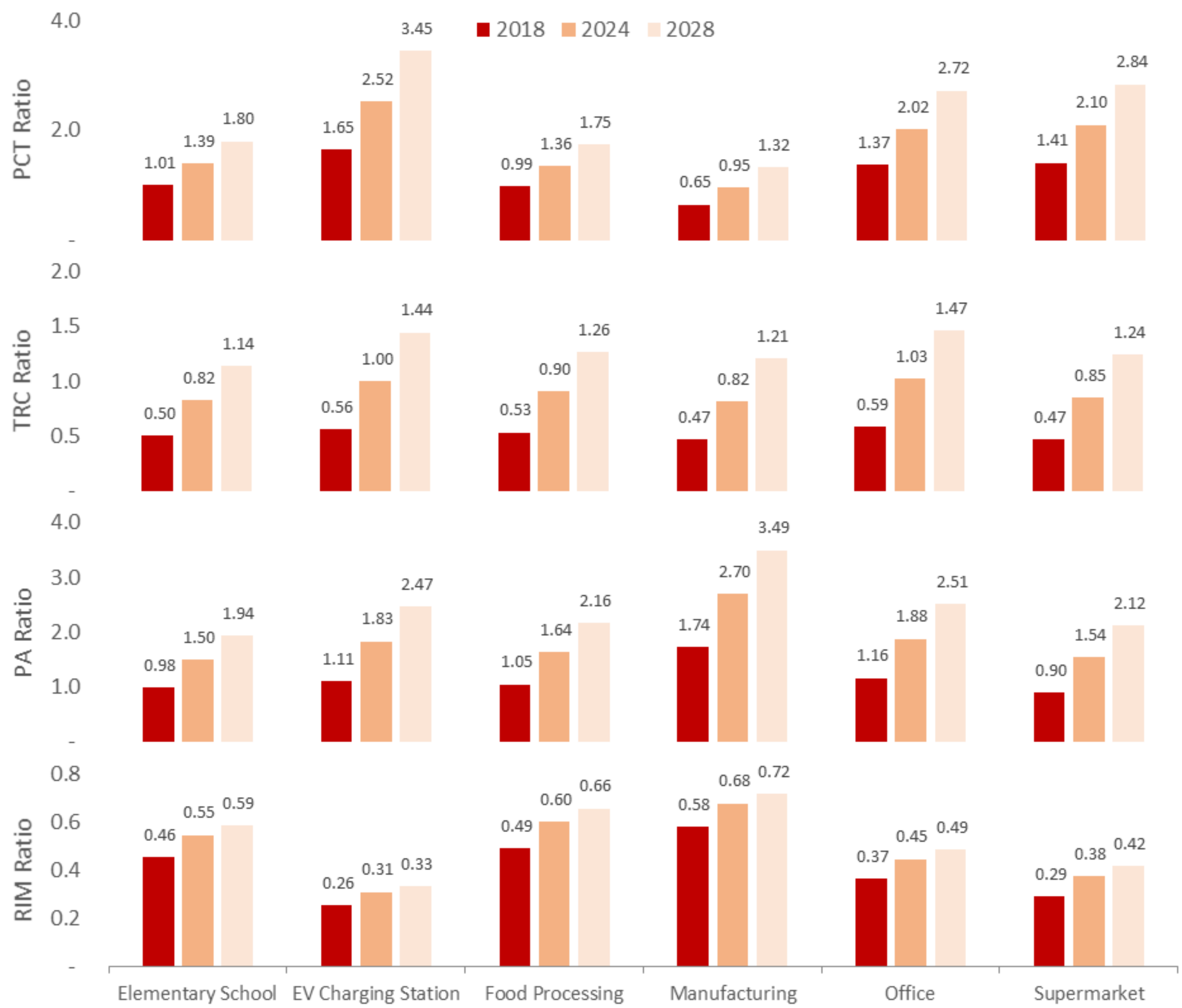
FIGURE 1-2: AVERAGE RESIDENTIAL BTM STORAGE COST-EFFECTIVENESS RESULTS – BY USE CASE



Ratepayer Impact Measure (RIM) benefit-cost ratios are below 1.0 for most cases analyzed with a few exceptions. RIM results tend to be inversely related to PCT results, that is lower when PCT results are higher due to more favorable tariffs for storage bill savings and higher when PCT results are lower due to tariffs with more limited bill savings opportunities for storage.

The in front of meter (IFOM) utility scale simulations consider an energy storage system installed on the distribution system that is arbitraging the utility avoided costs. By being in-front of the meter, utility scale energy storage is not bound by the customer's retail rate or load shape. Instead, the energy storage system is free to maximize benefits to the utility. The standard cost-effectiveness tests for evaluating DERs were not designed for evaluation of utility scale in-front of meter resources. However, to create a like-for-like comparison, we leverage the TRC test for use with utility scale storage. Simulated 2018 utility scale in-front of meter TRC ratios are above 2.5 for all IOUs, increasing above 4.0 by 2028.

FIGURE 1-3: AVERAGE NONRESIDENTIAL BTM STORAGE COST-EFFECTIVENESS RESULTS – BY LOAD SHAPE



1.4 FUTURE OUTLOOK AND CONSIDERATIONS

BTM storage is still very early in its market development. BTM storage products, services, and capabilities are relatively new and primarily niche segments of end users are aware and knowledgeable of the technology. Within this context, policy makers are faced with questions and choices regarding when, how, and to what extent to intervene in the BTM storage market. Based on California's storage-related legislation and CPUC proceedings, interventions could be aimed at supporting several goals, for example:

- Improving actual performance and closing the gap between observed and optimal battery dispatch
- Accelerating storage cost reductions, driving deeper, more rapid price reductions

- Improving product features, such as maximizing controllability, round trip efficiency, battery life, responsible sourcing, and end-of-life reuse and recycling
- Contributing to California's GHG goals through net positive GHG shifts in storage charging and discharge, increasing the value of solar and other intermittent renewable generation
- Creating a cost-effective, self-sustaining market for grid- and GHG-beneficial BTM storage

Below are several considerations based on this study's findings and related sources:

Continue to refine current incentives, program features and tariff requirements to align grid and end user benefits. The CPUC has recently adopted SGIP requirements and program features that seek to address study findings that show a need for increased alignment between GHG, grid, and participant benefits. Continued monitoring of the effects of time differentiated economic incentives and refinement of such signals are a key element of BTM storage value maximization.

Consider shifting the relative weight of incentives from upfront rebates to tariff/performance-based over time. Paying larger upfront incentives (e.g., non-performance-based incentives) while providing lower bill savings opportunities through rate differentials may increase adoption in the short term but might produce fewer long-term benefits, which shifts more risk onto ratepayers. On the other hand, providing lower initial incentives and higher bill savings opportunities through favorable tariffs shifts risks to those adopting storage but may not generate the pace and scale of adoption needed for market transformation and the achievement of long-term policy goals. Shifting from a more first-cost weighted to more tariff-focused incentive approach may help to optimally balance these competing pressures and objectives.

Consider adjusting budget allocations between sectors. The residential portion of the SGIP budget is highly subscribed but the nonresidential portion is underutilized. SGIP funding has been purposefully allocated to pre-set shares of the SGIP storage budget for each sector, with the residential sector disproportionately smaller than the nonresidential sector. From a market transformation perspective, to the extent that market demand shifts from one sector to another and market actors adapt to maintain viability, some portion of program funding may also need to shift between sectors to help smooth and stabilize the overall BTM storage market.

Consider increasing focus on near-term performance demonstration. A more targeted approach to funding storage projects might help to further align in situ BTM storage performance with policy goals and load expectations prior to or in parallel with allocation of funds for generalized widespread deployment. Under this approach, BTM storage systems might be geographically concentrated to address one or more of the high cost, high need areas of the grid, such as distribution or transmission constrained areas, areas facing de-energization, or areas with high concentration of renewable resources. On the performance side, different types of price signals or access to grid markets could be tested (perhaps through aggregation), as well as more advanced controls for grid services. Such an approach might accelerate the pace of alignment between BTM performance and GHG and grid value, albeit with perhaps a smaller total footprint in the short term, with the tradeoff being a potentially larger, more cost-effective, higher value market in the long term.

Market interventions could await further cost reductions and performance improvements or try to shape the market as it is emerging. The stationary storage market's share of the global lithium-ion battery market has represented a very small share as compared to EVs, which have been the principal market driver of global production. This could be taken to suggest that State-level actions are less likely to impact battery cost reductions, and that there is time to wait and see how these markets evolve before scaling ratepayer-funded BTM storage interventions. On the other hand, it is likely that niche BTM storage markets will continue to emerge and grow. California has an opportunity to direct this evolving market towards more rather than less grid- and GHG-beneficial capability and performance.

Continue to assess and align value streams of storage and demand response. While storage can be utilized to contribute to peak demand reduction, compensation for peak load reductions through demand response programs must consider concurrent storage load shaping incentives such as TOU rates, as well as associated baselines, in order to avoid unintended double payments and to incentivize incremental effects.

Assess the use of performance-based incentives and TOU requirements associated with municipal utility storage projects that receive SGIP incentives. While municipal utilities represent only a small portion of SGIP storage projects, CPUC jurisdictional limits restrict the reach of tariff and performance requirements for projects funded by IOU gas ratepayers and implemented by municipal electric customers. It is unclear to what extent storage projects funded by gas IOU ratepayers that are installed in municipal electric service territories are required to be on time-differentiated or other performance-based mechanisms to encourage desired dispatch behavior. An analysis of actual electricity tariffs and other requirements and incentives associated with SGIP municipal storage projects should be conducted to inform the CPUC and legislature and to access the value and performance of these projects as compared to the electric IOU storage projects under full CPUC jurisdiction.

Consider complementing comprehensive evaluation and market studies with quarterly or bi-annual quick turnaround assessments. Because the BTM storage market is evolving and the requirements and incentives for SGIP adapt in response to policy and market considerations, quick turnaround impact and market assessments may be useful to help shorten the time lag between program and policy changes and estimation of the resulting impacts and market effects. Possibilities include impact analyses to assess whether changes in participation and load performance are occurring in response to changes in program targets, rules, and requirements; as well as periodic assessments of market trends (e.g., changes in product and installation prices, marketing activities and product offerings, end user awareness, etc.).

Consider further study of future BTMS adoption. A comprehensive analysis of the potential market for BTMS would consider the entire population of residential and nonresidential end users and a more in-depth estimation of willingness-to-pay. The results could be used to inform budgets, incentive levels, forecasts for grid planning, and market effects indicators.

Consider battery reuse, recycling, and sourcing issues and associated end-of-life economic effects. As the production of lithium-ion batteries grows, lifecycle environmental and social impacts become increasingly important. Potential issues such as responsible sourcing, re-use/re-purposing, recycling, and disposal should be addressed proactively to avoid unintended environmental and social impacts.

2 INTRODUCTION AND OBJECTIVES

Established legislatively in 2001 to help address peak electricity problems facing California, the Self-Generation Incentive Program (SGIP) represents one of the longest-lived and broadest-based distributed energy resource (DER) incentive programs in the country. Since its inception, the SGIP has provided incentives to a wide variety of DER technologies including fuel cells, combined heat and power (CHP), solar photovoltaics (PV), wind turbines, and advanced energy storage (AES) systems.

This section provides an overview of the SGIP, identifies the study objectives, summarizes potential drivers and barriers for energy storage in California, and presents the overall approach to fulfilling the study objectives.

2.1 PROGRAM OVERVIEW, HISTORY, AND OBJECTIVES

In response to the electricity crisis of 2001, the California Legislature passed several bills to help reduce the state's electricity demand. In September 2000, Assembly Bill (AB) 9702 (Ducheney, September 6, 2000) established the SGIP as a peak-load reduction program. In March 2001, the California Public Utilities Commission (CPUC) formally created the SGIP and received the first SGIP application in July 2001.

The SGIP provides financial incentives for the installation of distributed generation (DG) and AES technologies that meet all or a portion of a customer's electricity needs. The SGIP is funded by California's ratepayers and managed by program administrators (PAs) representing California's major investor owned utilities (IOUs). The PAs are Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and the Center for Sustainable Energy (CSE), which implements the program for customers of San Diego Gas & Electric (SDG&E). The CPUC provides oversight and guidance on the SGIP.

The SGIP was originally designed to reduce energy use and demand at host customer sites. The program included provisions to help ensure that projects met certain performance specifications. Minimum efficiencies were established, and manufacturer warranties were required. Originally, the SGIP did not establish targets for a total rebated capacity to be installed, reductions in energy use and demand, or contributions to greenhouse gas (GHG) emissions reductions.

By 2007, growing concerns with potential air quality impacts prompted changes to the eligibility of technologies under the SGIP. In particular, approval of AB 2778 (Lieber) in September 2006 limited SGIP project eligibility to "ultra-clean and low emission distributed generation" technologies. Beginning January 1, 2007, only fuel cells and wind turbines were eligible under the SGIP. Passage of Senate Bill (SB) 412 (Kehoe, October 11, 2009) refocused the SGIP toward GHG emission reductions and led to a re-examination of technology eligibility by the CPUC. As a result of that re-examination, the list of technologies eligible for the SGIP expanded to again include CHP, pressure reduction turbines, energy storage paired with renewables, and waste heat-to-power technologies. In addition, SB 412 required fossil fueled combustion technologies to be adequately maintained so that during operation they continue to meet or exceed the established efficiency and emissions standards. The passage of SB 412 marked a significant change in the composition of SGIP applications toward fuel cells and advanced energy storage projects. Eligibility requirements for AES projects changed during subsequent years, most significantly during 2011 when standalone AES projects (in addition to those paired with SGIP eligible technologies or PV) were made eligible for incentives.

On July 1, 2016 the CPUC issued Decision (D.) 16-06-055 revising the SGIP pursuant to Senate Bill 861, AB 1478, and implementing other changes.[1] Among the changes was a revision to how the SGIP is administered. Beginning in 2017, the SGIP is administered on a continuous basis and the incentive collections represent allocations through the end of 2019. This change was made largely to curb potential issues with incentives being depleted during program openings, as the program has historically been oversubscribed. D. 16-06-055 also replaced the first come, first-served reservation system with a lottery. AES projects paired with renewables, energy storage projects located in the Los Angeles Department of Water and Power (LADWP) service territory, and AES projects located in SCE's West LA Local Capacity Area are given priority in the lottery.

In addition to the changes described above, D. 16-06-055 formalized the program's goals:

1. **Environmental:** The reduction of GHGs, the reduction of criteria air pollutants, and the limitation of other environmental impacts such as water usage.
2. **Grid Support:** Reduce or shift peak demand, improve efficiency and reliability of the distribution and transmission system, lower grid infrastructure costs, provide ancillary services, and ensure customer reliability of DERs.
3. **Market Transformation:** To create lasting change that increases the adoption and penetration of DER technologies through strategic intervention in defined markets.

Most recently, SB 700 (Wiener, September 27, 2018) authorized the continuation of SGIP through 2025. In the course of implementing SB 700, the CPUC has expressed its intention to consider other program modifications including: Overall collection levels for years 2020-2024, funding allocations among technology and customer sectors, and incentive levels for each technology.[2] Finally, on August 1st, 2019,

1 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M163/K928/163928075.PDF

2 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB700

the CPUC issued its decision approving greenhouse gas emissions reduction requirements for the SGIP storage budget.[3] This decision modified the SGIP to ensure that eligible SGIP energy storage systems reduce GHGs. The decision requires SGIP PAs to provide a digitally accessible GHG signal that provides marginal GHG emissions factors to project developers. The decision also:

- Directs the PAs to offer performance-based incentives (PBI) to new commercial SGIP projects regardless of system size and requires such systems to annually reduce GHG emissions by five kg/kWh or be subject to PBI payment reductions;
- Requires customers with new residential storage projects to enroll in an approved time-varying rate if one is available. If such a rate is not available, the customer may install storage with solar-only charging or a solar self-consumption system; and,
- Require PAs to verify the GHG emissions performance of new residential developers and post-PBI developer fleet performance using the SGIP impact evaluation sampling procedure.

2.2 STUDY OBJECTIVES

The scope and timing of SGIP measurement and evaluation (M&E) activities is driven by the CPUC SGIP M&E plan.[4] The 2019 SGIP Energy Storage Market Assessment and Cost-Effectiveness Report intends to inform CPUC decisions implementing SB 700. Below we present a list of key research questions addressed by this report. These questions were developed in consultation with the CPUC and the SGIP PAs. Unless otherwise specified, the research questions address the residential and non-residential sectors separately.

2.2.1 Key Research Questions

- What evidence do we have that behind-the-meter (BTM) storage will achieve market transformation, i.e. thrive without subsidies, in the next ten years?
- What evidence do we have that BTM storage will be cost-competitive with other resources (e.g. in front of meter (IFOM) storage) in providing societal value in the next ten years?

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3 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M309/K988/309988017.PDF

4 https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/SGIPMeasEvalPlanFINAL.PDF

- BTM storage costs:
  - How much does BTM storage cost, and how have these costs changed over time?
  - How much does SGIP-incentivized BTM storage cost, and how have these costs changed over time?
  - How do BTM storage costs compare to other resources providing the same or similar value to the grid (e.g., IFOM storage)?
  - How are BTM storage costs likely to change over the next ten years and how will these changes affect storage cost-effectiveness?
- Value of BTM storage to the grid:
  - What value does BTM storage currently provide to the grid?
  - What value could BTM storage provide to the grid in the future given the right conditions, and what are those conditions?
  - Could we achieve the same or similar grid benefits more cost-effectively with other resources (e.g., IFOM storage)?
- Drivers and barriers to energy storage adoption:
  - What are the main drivers and motivations for customers to install energy storage?
  - What are the perceived benefits after installing energy storage? To what extent are customers realizing the benefits they expected?
  - What are the main barriers for energy storage adoption, particularly in the nonresidential sector?
- To what extent are customers installing energy storage systems without the SGIP incentive?
- Energy storage paired with solar PV customer decision making:
  - What is the general sales approach for customers that ultimately decide to install energy storage paired with PV?
  - How are storage/PV developers marketing the technology, and what are the incremental costs of storage paired with PV relative to standalone PV (or standalone storage)?

2.3 SUMMARY OF APPROACH

This section summarizes the approach used to answer the study's research questions. We pursued two separate but related research activities: cost-effectiveness analysis and market research.

- The **cost-effectiveness analysis** addresses questions related to the costs and benefits associated with installation of energy storage technologies, both BTM and IFOM. By evaluating cost-effectiveness for prototypical applications, we can understand to what extent incentives are needed to promote adoption of energy storage, and how assumptions about cost-trends influence the technology's cost-effectiveness going forward.
- The **market research** addresses questions about drivers and barriers for storage adoption. It will also help policy makers, program administrators, and stakeholders understand key trends in the energy storage market and learn about SGIP participants' experiences with energy storage.

After conducting the cost-effectiveness and market research activities, we combine the findings and provide a comprehensive assessment of the energy storage market. Below we provide brief summaries of the cost-effectiveness and market research approaches. Additional details are provided in Section 3 (Market Research Approach) and Section 5 (Cost-Effectiveness Approach).

2.3.1 Summary of Cost-Effectiveness Analysis Approach

The cost-effectiveness analysis leverages the SGIP cost-effectiveness (SGIPce) model first developed in 2011 to evaluate the cost-effectiveness of all SGIP eligible technologies. It was updated in 2015 to reflect changes in technology costs and eligible technologies. For this research we updated SGIPce again with an exclusive focus on energy storage costs and benefits.

SGIPce is a highly flexible economic model that quantifies the various cash flows associated with the purchase and operation of DERs including PV, CHP, fuel cells, and energy storage. The model calculates the bill impacts of technologies throughout their lifetime and the associated acquisition costs including financing, insurance, and tax costs (or credits). Looking from the grid's perspective, SGIPce will quantify the changes in the utility's marginal operating costs and will consider incentive payments and program administration costs. The model will quantify the present value of all cost and benefit streams for the entire life of the technology and for new technologies installed ten years into the future accounting for changes in retail rates, technology capital and operating costs, and changes in utility marginal costs.

The cost-effectiveness analysis is based on ideal dispatch of battery energy storage technologies. Battery storage system dispatch is optimized against specific, prototypical customer load shapes and retail rates. We then quantify the economic impact of this dispatch from various perspectives. Section 5 provides a comprehensive overview of the cost-effectiveness methodology, including details on all the inputs and calculations. Below we provide a brief listing of key model components:

- **Load shapes.** Residential and nonresidential customer load shapes were selected from the 2017 SGIP Impact Evaluation Report sample. We selected load shapes that reflect a variety of customer types currently participating in the SGIP.
- **Retail rates.** We selected the most appropriate, forward looking retail rates available from PG&E, SCE, and SDG&E. We also identified alternate rates such as electric vehicle (EV) tariffs or real-time pricing (RTP) rates that might influence customer and grid benefits.
- **Technology characteristics.** We defined the characteristics of the energy storage systems installed at each customer location, including storage medium (lithium ion, flow battery), system size (kWh/kW), round trip efficiency (RTE), degradation rate, and capital cost assumptions.
- **Utility avoided costs.** We used the 2018 CPUC avoided cost calculator to develop representative marginal costs for PG&E, SCE, and SDG&E. All avoided costs components were accounted for, including generation energy, generation capacity, ancillary services, transmission and distribution (T&D) capacity, environment, and renewable portfolio standard (RPS) costs.
- **SGIP assumptions.** We defined the incentive levels offered by SGIP and the implied program administration costs to closely match recent program actuals at the outset of the analysis. Incentives are then reduced over time.
- **Global assumptions.** We updated marginal tax rates/credits, discount rates, and other financing assumptions. We also defined the characteristics of other market mechanisms like demand response (DR) program design and customer value of lost load.
- **Storage dispatch shapes.** Ideal dispatch simulations are created with Energy and Environmental Economics' (E3) RESTORE storage dispatch model based on the specific load shape and retail rate.

We use SGIPce to calculate the cost-effectiveness of various energy storage / load shape combinations using the cost-effectiveness tests established in the Standard Practice Manual.[5] Specifically, we use the participant test, the ratepayer impact measure test, the total resource cost test, the societal total resource cost test, and the program administrator cost test. We evaluate cost-effectiveness using 2018 as a base year and for each year ten years into the future (through 2028). A cost-effectiveness value for 2028 represents the present value of all costs and benefits of a storage system installed in 2028.

5 https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

IFOM storage is modeled similarly to BTM storage – we first define technology characteristics and cost assumptions. When looking at IFOM storage, we assume utility ownership of a storage system on the distribution system. Additional details on the modeling approach and assumptions for both BTM and IFOM use cases is provided in Section 5.

2.3.2 Summary of Market Research Approach

For this study we define market actors into four broad categories:

- Residential or nonresidential **host customers** who install energy storage systems and receive an incentive from the SGIP.
- Energy storage equipment **manufacturers** who build and sell storage systems to developers or installers.
- Energy storage project **developers** who market, install, and possibly also operate energy storage systems.[6] In certain cases, a developer may also be a manufacturer.
- **Solar non-storage host customers** are residential or nonresidential customers that have installed solar but have not installed energy storage.

The market research relies on interviews and surveys with host customers, manufacturers, developers, and solar non-storage host customers to identify the key drivers and barriers to storage market adoption. When thinking about drivers we consider what the primary motivations are for customers to install energy storage in terms of desired outcomes (e.g., backup power, solar self-consumption, grid benefits (civic duty), or time-of-use (TOU) arbitrage).

Interviews with host customers also identify key barriers to technology adoption. We investigate the major barriers to energy storage adoption (e.g., upfront cost, technology uncertainty, aesthetics, space constraints, etc.) and ask what would need to be done in order to mitigate, compensate for, or remove these barriers.

An important aspect of this analysis is developing an understanding of the energy storage sales strategies and messages to customers. Much has been said about the relationship between on-site solar and energy storage, but little evidence exists. As part of the host customer interviews, we ask storage customers about the decision-making that drove them to install energy storage or to decide not to install. If the customer installed storage paired with solar, we ask about the timing of their decision and how one may have influenced the other. If they were installed at the same time, was the customer initially looking to

[6] The SGIP may have other definitions of a developer for program eligibility and budget purposes. Here we define developers for research purposes only.

install solar, and then added storage? Was the marginal cost of the storage low enough that they considered it viable? Or did they always want to install the solar plus storage package together? What were the primary benefits and costs they perceived about adding storage? In what ways are they intending or were they considering using storage? How did vendors convey or not the benefits, costs, requirements, advantages, and disadvantages of BTM storage? Are installers educating customers that the new TOU rates decrease the value of PV by itself and they use this to encourage storage installation?

Manufacturer interviews emphasize the features, capabilities, requirements, benefits, barriers, and costs of BTM storage, both current and near, mid, and long-term. Developer interviews focus on current and near-term drivers and barriers to customer adoption, sales strategies, sales messages (what benefits and costs of storage are emphasized and how are they communicated), and sales results. Developers are also asked for suggestions on mitigating perceived barriers to adoption or realization of end user and grid benefits.

All interviews are segmented by customer class (e.g., residential, non-residential). Section 3 provides additional details on the data sources and methods used for the market characterization.

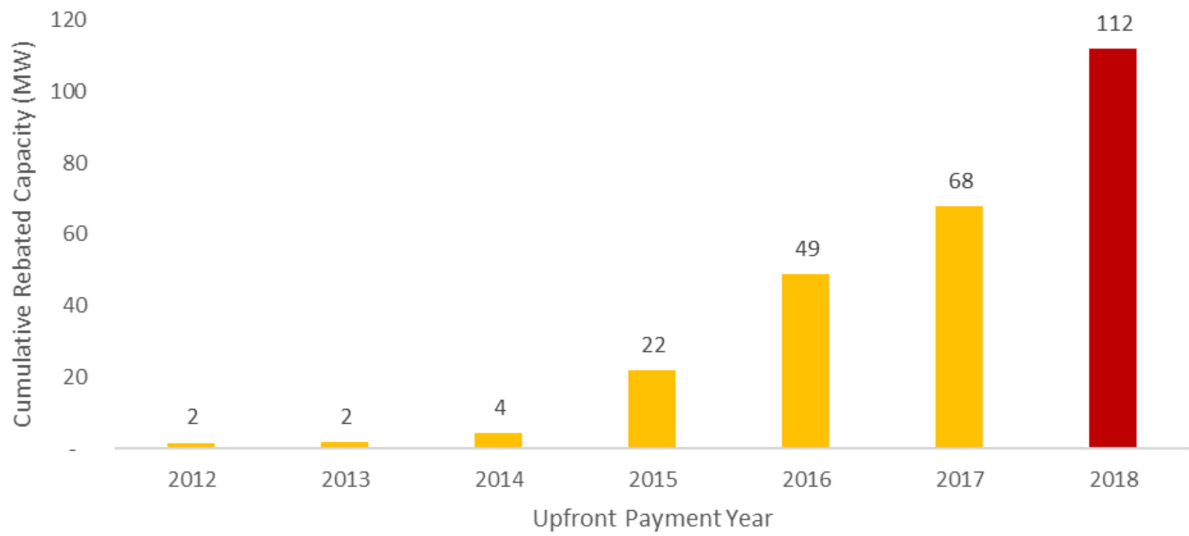
2.4 SGIP ENERGY STORAGE POPULATION SUMMARY AND KEY TRENDS

By the end of 2018, the SGIP had provided incentives for 3,782 projects representing 112 MW of rebated capacity.[7] Growth in SGIP storage as a function of upfront payment year is summarized in Figure 2-1.[8] The first SGIP energy storage application to receive an incentive was submitted on September 2009, and was paid its upfront incentive on March 2012. Growth in energy storage remained relatively flat through the early years, with a total of 4 MW installed by the end of 2014. Beginning in 2015, there was considerable growth in completed SGIP storage applications. The SGIP added approximately 20 MW of rebated capacity each year between 2015 and 2017. An additional 44 MW of rebated capacity were added during 2018.

[7] SGIP rebated capacity is defined as the average discharge over a two-hour period. For two-hour batteries, SGIP rebated capacity is often equal to the inverter nameplate capacity.

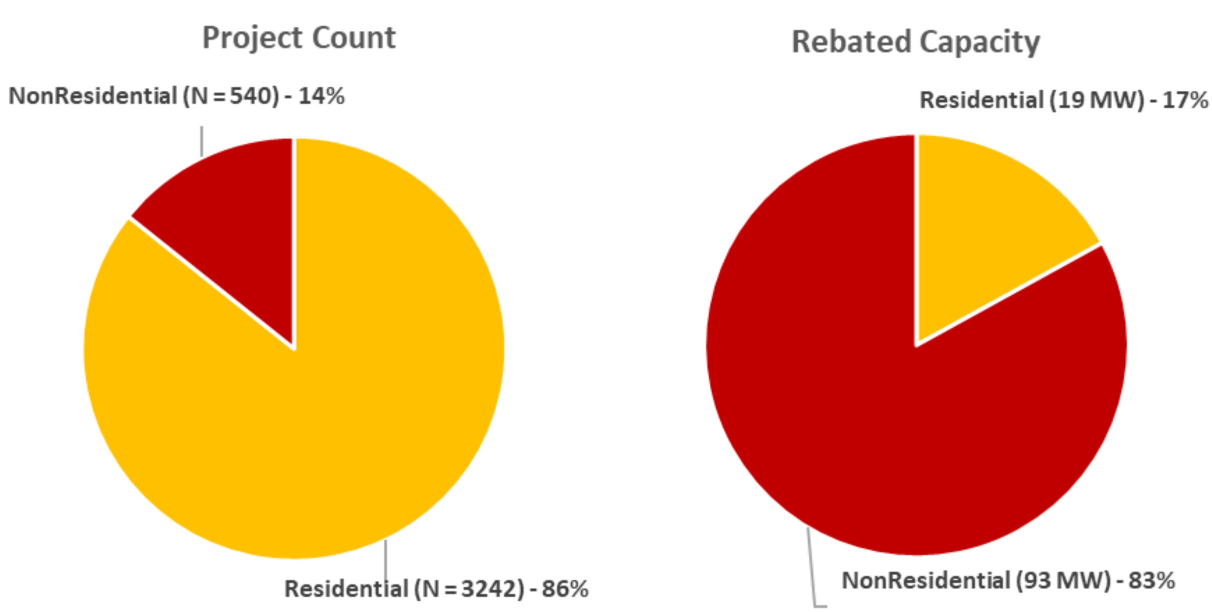
[8] Throughout this report we present SGIP program statistics as a function of program year or upfront payment year. The program year represents the calendar year the application was submitted. The upfront payment year is the calendar year during which the incentive was paid. The program year indicates what program rules were applicable during the SGIP application, whereas the upfront payment year is a proxy for when the system was interconnected and operational. The upfront payment year is often one or more years after the application program year.

FIGURE 2-1: GROWTH IN SGIP ENERGY STORAGE REBATED CAPACITY BY UPFRONT PAYMENT YEAR



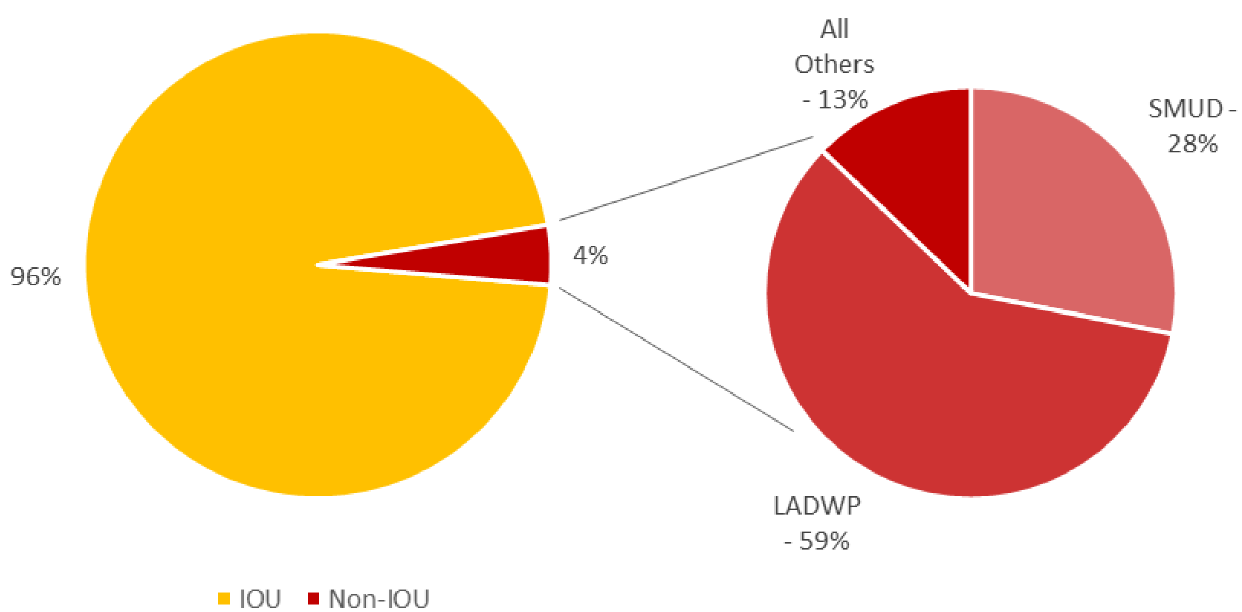
The SGIP offers incentives for both residential and nonresidential customers. Figure 2-2 shows the breakdown of SGIP participants by customer class with regards to rebated capacity (right) and project count (left). The overwhelming majority of SGIP energy storage projects are residential (3,242 projects, 86 percent), compared to 14 percent for nonresidential customers. However, nonresidential projects are considerably larger and therefore represent a larger share of the program's rebated capacity (83 percent).

FIGURE 2-2: SGIP ENERGY STORAGE, PROJECT COUNT AND REBATED CAPACITY BY CUSTOMER CLASS, 2018



SGIP energy storage systems can be installed by customers served by an electric or gas IOU. Customers served by a non-IOU electric utility are eligible for SGIP incentives if they are served by a gas IOU. As of the end of 2018, 96 percent of energy storage systems were installed by electric IOU customers. The remaining four percent of energy storage systems were installed by non-IOU electric utility customers (e.g., municipal utilities or cooperatives). Of the four percent of energy storage systems installed at non-IOU electric utility customers, the majority (59) are installed by Los Angeles Department of Water and Power (LADWP) customers. The Sacramento Municipal Utility District (SMUD) represents the second largest non-IOU storage customers, with 28 percent of all non-IOU energy storage. All other non-IOU customers represent 13of the share of non-IOU energy storage.

FIGURE 2-3: SGIP ENERGY STORAGE, PROJECT COUNT BY ELECTRIC UTILITY TYPE



Growth in SGIP energy storage has not been consistent across the residential and nonresidential sectors. Figure 2-4 shows the number of completed energy storage projects by customer class and upfront payment year. The ratio of residential to nonresidential projects remained approximately 50/50 through 2016. Beginning in 2017 and most dramatically during 2018, the number of completed residential projects greatly exceeded the number of nonresidential projects by more than one order of magnitude.

FIGURE 2-4: NUMBER OF COMPLETED SGIP ENERGY STORAGE PROJECTS BY CUSTOMER CLASS AND PAYMENT YEAR

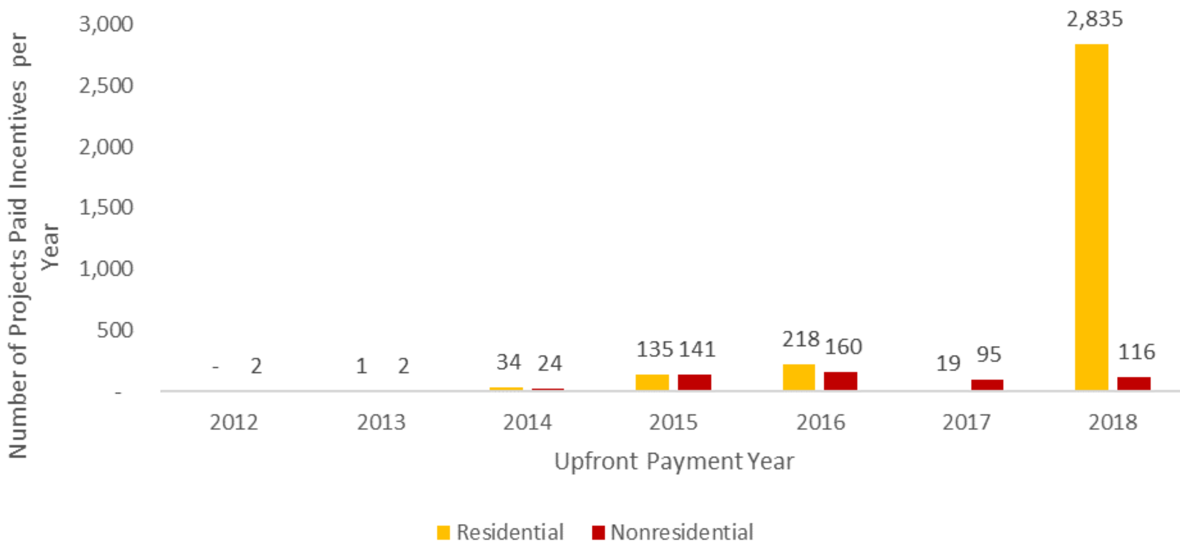
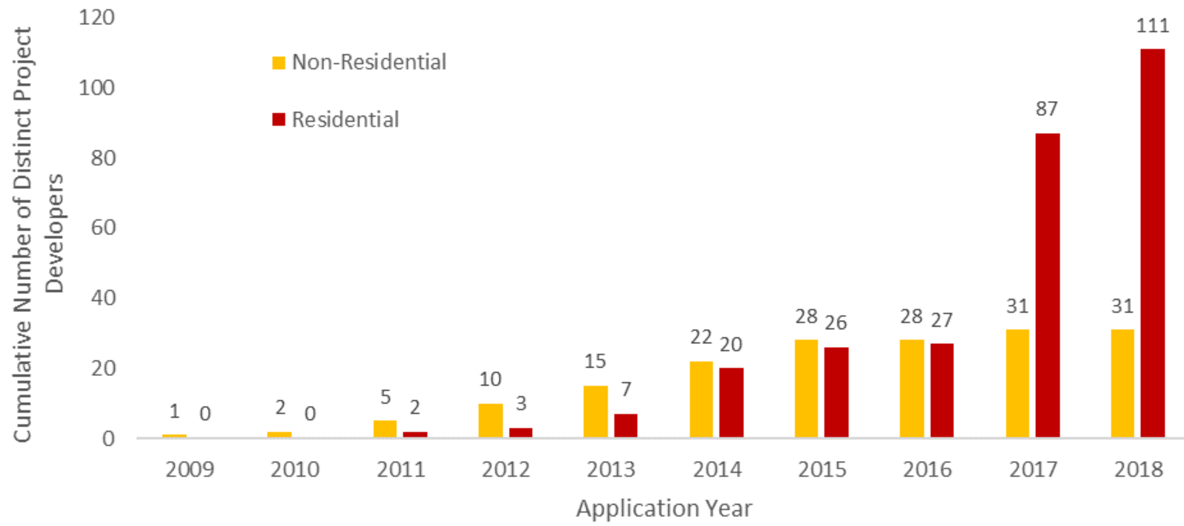


Figure 2-5 shows the cumulative number of distinct project developers submitting SGIP applications over time. The first energy storage applications submitted to the SGIP were for nonresidential projects. The number of nonresidential developers exceeded residential developers through 2016. The first residential application was submitted in 2011 – only two residential developers were active that year. The number of residential and nonresidential developers increases steadily through 2015, at which point growth stagnates. Since 2015 the number of nonresidential developers participating in SGIP has remained flat – only three new developers submitted nonresidential SGIP applications between 2015 and 2018. However, the number of residential developers increases dramatically in 2017 from 27 developers to 87 developers. The developer count increases again in 2018 from 87 to 111 distinct residential project developers.

FIGURE 2-5: CUMULATIVE NUMBER OF DISTINCT SGIP PROJECT DEVELOPERS BY CUSTOMER CLASS



The number of applications received by each PA is summarized in Figure 2-6 and Figure 2-7. In each figure we show the total number of applications received each month, along with indication on when each PA opened or closed various budget steps. Prior to May 2017, the program operated on a first come first-served basis and was often oversubscribed. The total number of applications received prior to May 2017 is shown in red for each PA and budget category. During 2016, the SGIP offered an incentive rate of $1.31/W for advanced energy storage.[9] If we assume a prototypical two-hour energy storage system, this would result in an incentive rate of $0.66/Wh.

Beginning in May 2017, the SGIP adopted an incentive structure based on five Steps. Each step offers a declining incentive rate proportional to the number of applications received. As the quotas for each step are filled, the PA's incentive rate steps down from an initial rate of $0.50/Wh by $0.05/Wh.[10]

[9] https://www.selfgenca.com/documents/handbook/2016

[10] The incentive will step down by $0.10/Wh if the step closes (i.e., budget is exhausted) within ten days of opening across all PA service territories.

FIGURE 2-6: NUMBER OF SGIP RESIDENTIAL STORAGE APPLICATIONS BY YEAR, MONTH, AND PA

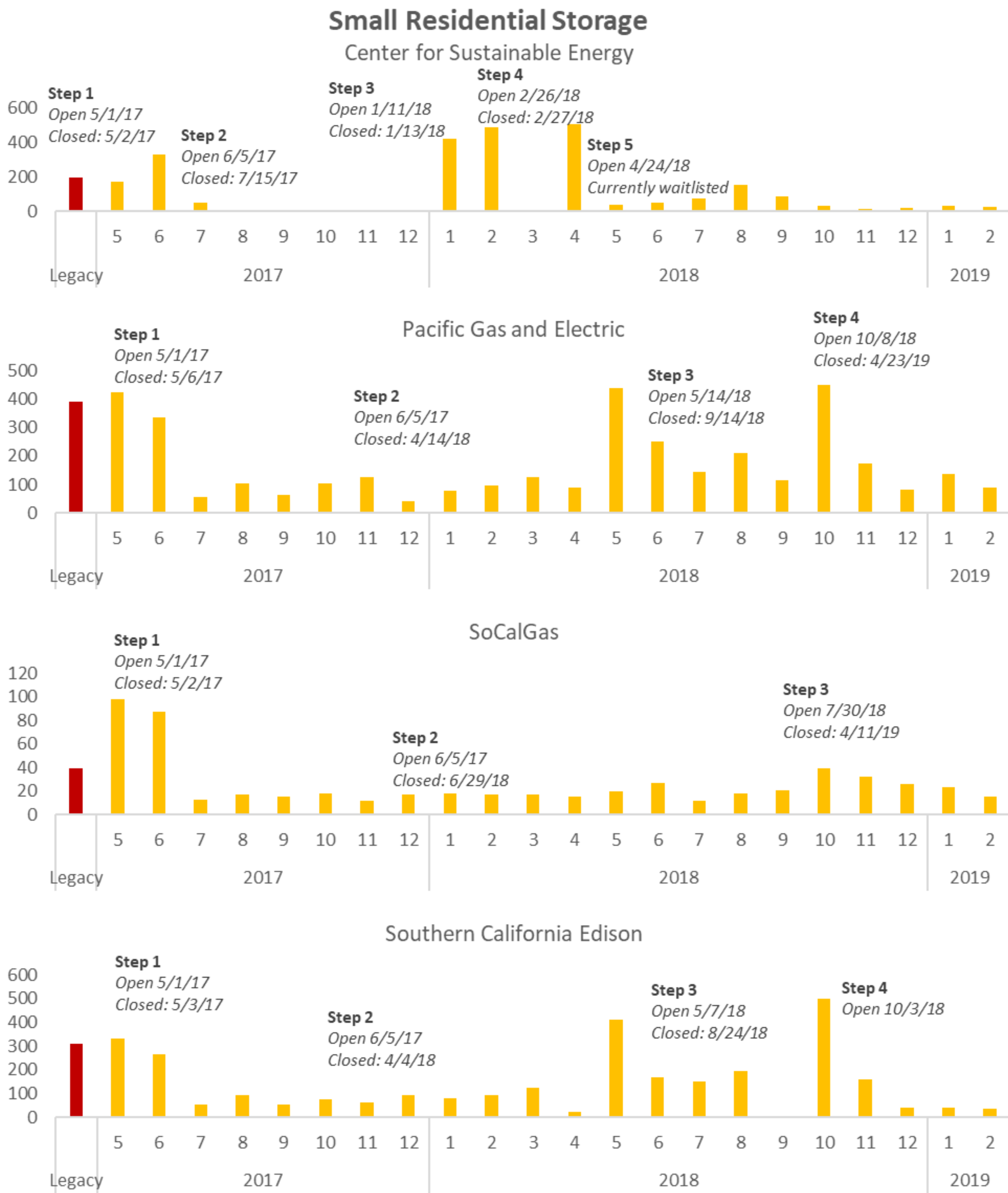
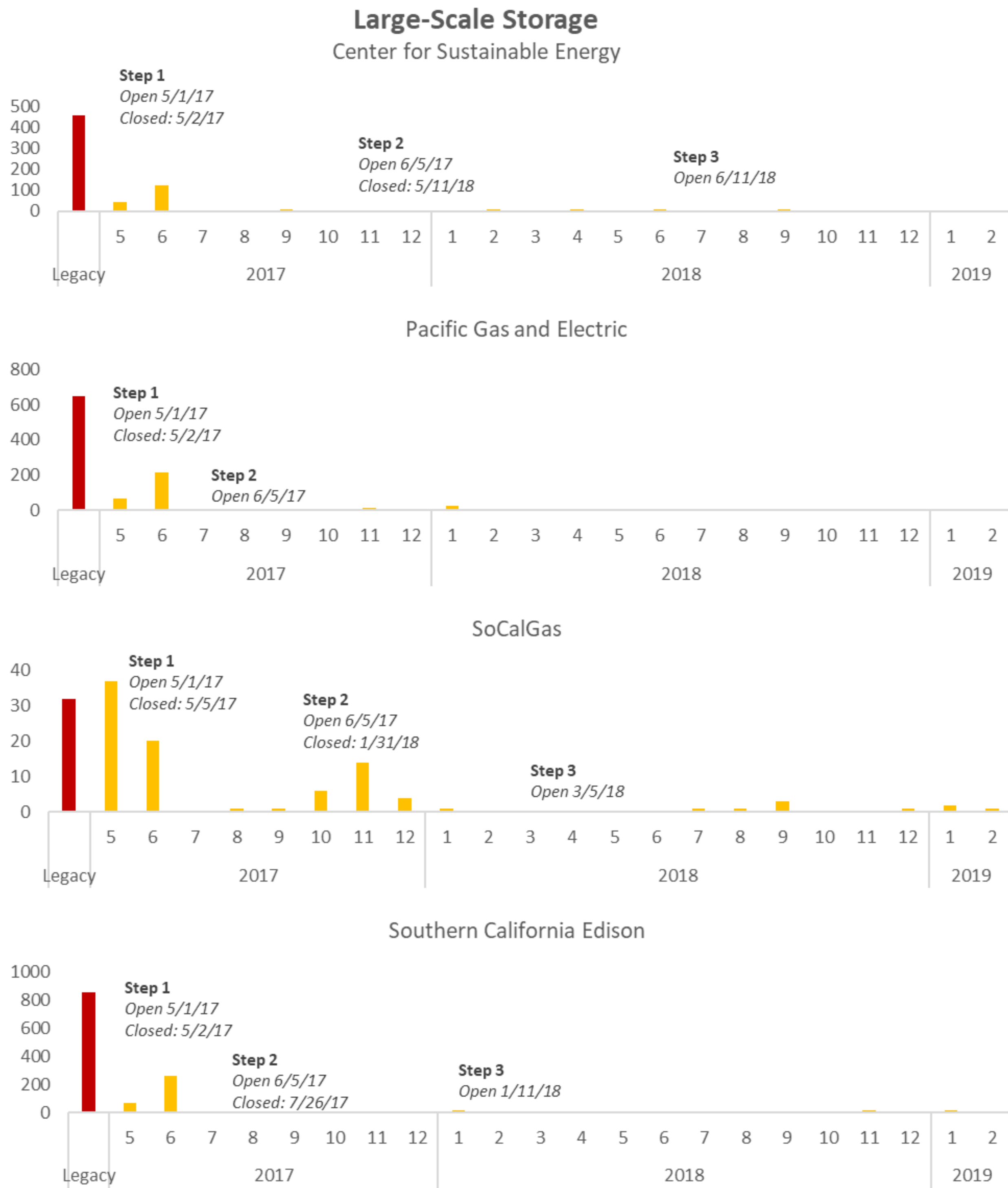


FIGURE 2-7: NUMBER OF SGIP LARGE-SCALE STORAGE APPLICATIONS BY YEAR, MONTH, AND PA



Since adopting new program rules in May 2017, the PAs have moved through the various steps at different rates. CSE was first to move through all residential steps, opening the final step (Step 5) on April 2018. Since the opening of Step 5, CSE's residential budget has been oversubscribed and projects that apply are added to a waitlist (as of June 2019). The nonresidential budget categories follow a different trend – all PAs have received far fewer applications for large-scale storage compared to residential storage. PG&E has received the least number of applications for large-scale storage incentives – as of June 2019 it remains at Step 2.

2.5 STATE AND FEDERAL POLICY INTERVENTIONS AND KEY DRIVERS/BARRIERS

In the United States, energy storage policy is primarily being developed at the state level. In December 2010, the CPUC opened Rulemaking (R.) 10-12-007 to set policy for California utilities and load-serving entities (LSEs) to consider the procurement of viable and cost-effective energy storage systems. In October 2013, the CPUC adopted an energy storage procurement framework and established an energy storage target of 1,325 MW for PG&E, SCE, and SDG&E by 2020, with installations required no later than the end of 2024. Of those 1,325 MW, 200 MW (15 percent) are to be interconnected BTM. The remaining 1,125 MW are expected at the transmission or distribution level.[11] An additional 500 MW BTM storage target was later put in place on top of the existing 1,325 MW requirement.[12]

At the federal level, energy storage investments are eligible for two key incentives: the investment tax credit (ITC) and the Modified Accelerated Cost Recovery System (MACRS). The ITC and the MACRS depreciation deduction apply to energy storage systems depending on who owns the battery and how the battery is used. If owned directly by a public entity, such as a public university or federal agency, battery storage systems are not eligible for tax-based incentives. If owned by a private party (i.e., a tax-paying business), battery systems may be eligible for some or all of the federal tax incentives.[13]

MACRS. Without a renewable energy system installed, battery systems are eligible for the seven-year MACRS depreciation schedule. If the battery system is charged by the renewable energy system more than 75 percent of the time on an annual basis, the battery qualifies for the five-year MACRS schedule. Accelerated depreciation can improve the economics of an energy storage system.

ITC. Battery systems that are charged by a renewable energy system more than 75 percent of the time are eligible for the ITC, currently 30 percent for systems charged by PV and declining to 10 percent from

[11] CPUC. 2013. Decision Adopting Energy Storage Procurement Framework and Design Program. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K912/78912194.PDF

[12] California Assembly Bill No. 2868 Chapter 681. 2017. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB2868

[13] https://www.nrel.gov/docs/fy18osti/70384.pdf

2022 onward. Battery systems that are charged by a renewable energy system 75 percent–99.9 percent of the time are eligible for that portion of the value of the ITC. Battery systems that are charged by the renewable energy system 100 percent of the time on an annual basis can claim the full value of the ITC.

2.5.1 Other Potential Drivers and Barriers

The independent research and analysis performed in this study is meant to identify key drivers and barriers in the energy storage market. This section discusses potential drivers and barriers in order to give the reader context for the subsequent sections.

Time-of-Use Rates

Time-of-use (TOU) is a rate plan in which rates vary according to the time of day, season, and day type (weekday or weekend/holiday). Higher rates are charged during certain hours and lower rates during other hours. Rates are also typically higher in summer months than in winter months. This rate structure provides price signals to energy users to shift energy use from the high TOU period to the low TOU period.

Currently, all commercial, industrial, and agricultural IOU customers in California are required to be on a TOU rate. While TOU rates have been commonplace for nonresidential customers for many years, the IOUs have recently shifted or made plans to shift their peak TOU period to later in the day. SCE and SDG&E's commercial TOU periods have already changed – business TOU on-peak periods will be 4 p.m. to 9 p.m., instead of noon to 6 p.m. PG&E has also indicated that commercial customers will shift to a similar on-peak period. All California IOUs are now offering residential TOU rates with late afternoon / early evening on-peak periods.

TOU rates present the opportunity for storage systems to arbitrage energy rates. Customers can potentially reduce their energy bills by using storage systems to charge during off-peak periods and discharge during on-peak periods. This use-case is particularly novel for residential customers that historically have been exposed to tiered volumetric rates.

Net Energy Metering

Customers who install small solar, wind, biogas, and fuel cell generation facilities to serve all or a portion of onsite electricity needs are eligible for net-energy metering (NEM). NEM allows customers who generate their own energy to serve their energy needs directly onsite and to receive a financial credit on their electric bills for any surplus energy fed back to their utility. Changing TOU rates and NEM policies may combine to create a potential driver for energy storage. Until recently, customers on TOU rates with NEM eligible generators such as solar PV were charged the highest energy rates (e.g., "on peak") during the early afternoon hours when solar PV output is high. Any energy that is not used on-site is exported to the grid and the customer is credited for the export at the highest on-peak energy rate. Recent changes to TOU rates shifting on-peak periods to later in the afternoon make export of solar PV generation less lucrative for solar customers. Furthermore, NEM policies have also changed such that NEM exports are charged the retail rate minus non-bypassable charges (rather than the full retail rate). These changes to the way customer bills are calculated create a potential incentive for energy storage to maximize the on-site consumption of solar PV generation. The CPUC recently decided that customers with energy storage systems may receive NEM credits for storage energy that is sent back to the grid as long as the storage system charges entirely from a NEM-eligible solar PV system.[14]

The CPUC is currently addressing several issues related to the NEM successor tariff as part of R. 14-07-002. In 2019 Energy Division staff will explore compensation structures for customer-sited distributed generation other than NEM, as well as consider an export compensation rate that considers locational and time-differentiated values. Uncertainty surrounding the future of NEM tariffs may drive customers to adopt energy storage if they feel the value of NEM exports from existing PV generators will decrease.

Reliability and Wildfire Risk

California experienced the deadliest and most destructive wildfires in its history in 2017 and 2018. Fueled by drought, an unprecedented buildup of dry vegetation and extreme winds, the size and intensity of these wildfires caused the loss of more than 100 lives, destroyed thousands of homes and exposed millions of urban and rural Californians to unhealthy air.[15] On May 15th 2019 the California Department of Forestry and Fire Protection (CAL FIRE) determined that PG&E electrical transmission lines near Pulga, California were a cause of the Camp Fire. In a news release, PG&E accepted this determination.[16]

In response to the tragic wildfires in 2017 and 2018, Senate Bill 901 (Dodd, 2018) requires electric utilities to prepare and submit wildfire mitigation plans that describe the utilities' plans to prevent, combat, and respond to wildfires affecting their service territories. The plans propose to clear vegetation, inspect power lines, install sensors and cameras, and invest in efforts to prevent recurrence of wildfires.[17] The CPUC issued several decisions in R.08-11-005 that together adopted dozens of new fire-safety regulations. Several of the adopted fire-safety regulations apply only to areas, referred to as "high fire-threat areas," where there is an elevated risk for power line fires igniting and spreading rapidly. The CPUC also developed

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14 CPUC Decision 19-01-030.

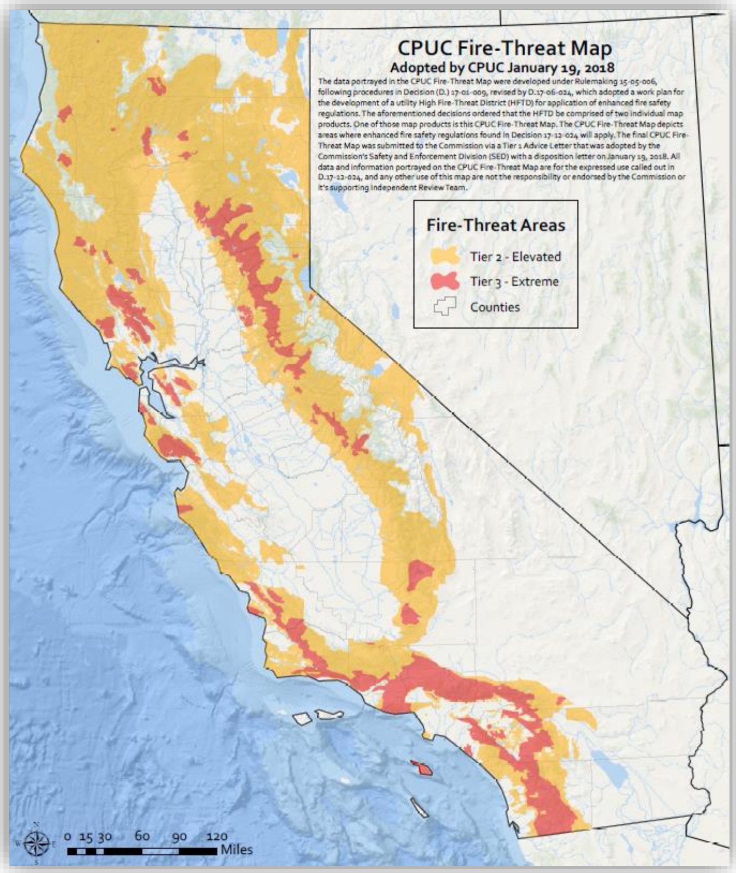
15 https://www.fire.ca.gov/incidents/

16 https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20190515_pge_responds_to_camp_fire_announcement_from_cal_fire

17 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB901

a single statewide fire-threat map to designate areas where (1) there is an elevated risk for destructive power line fires, and (2) where stricter fire-safety regulations should apply.[18] Figure 2-8 shows the most recent CPUC fire threat map, indicating the extent of the Tier 2 (elevated) and Tier 3 (extreme) fire risk areas.

FIGURE 2-8: CPUC FIRE-THREAT MAP



Beginning in 2019, utilities may dramatically expand the scope of planned grid outages, which are intended to pre-empt the risk of sparking wildfires. As an additional precautionary measure to further reduce wildfire risks and keep its customers and communities safe, PG&E will be expanding its Public Safety Power Shutoff (PSPS) program to include all electric lines that pass through high fire-threat areas — both distribution and transmission. While customers in high fire-threat areas are more likely to be affected, any of PG&E's more than five million electric customers could have their power shut off if their

18 https://www.cpuc.ca.gov/FireThreatMaps/

community relies upon a line that passes through a high fire-threat area.[19] This increased frequency of power outages may be a driver for residential or nonresidential customers who seek to improve their reliability of electricity supply.

The value of lost load (VLL) is a useful metric for estimating the amount that customers would be willing to pay to avoid an interruption in their electricity service such as a PSPS event. Researchers have leveraged survey data to estimate the VLL by customer segment and interruption duration. Table 2-1 summarizes estimated interruption costs from a January 2015 Lawrence Berkeley National Lab (LBNL) study.[20]

TABLE 2-1: ESTIMATED INTERRUPTION COST PER EVENT, AVERAGE KW, AND UNSERVED KWH (U.S. 2013$) BY DURATION AND CUSTOMER CLASS (ADAPTED FROM LAWRENCE BERKELEY NATIONAL LAB)

Interruption Cost	Interruption Duration					
	Momentary	30 Minutes	1 Hour	4 Hours	8 Hours	16 Hours
Medium and Large C&I (Over 50,000 Annual kWh)						
Cost per Event	$12,952	$15,241	$17,804	$39,458	$84,083	$166,482
Cost per Average kW	$15.9	$18.7	$21.8	$48.4	$103.2	$203.0
Cost per Unserved kWh	$190.7	$37.4	$21.8	$12.1	$12.9	$12.7
Small C&I (Under 50,000 Annual kWh)						
Cost per Event	$412	$520	$647	$1,880	$4,690	$9,055
Cost per Average kW	$187.9	$237.0	$295.0	$857.1	$2,138.1	$4,128.3
Cost per Unserved kWh	$2,254.6	$474.1	$295.0	$214.3	$267.3	$258.0
Residential						
Cost per Event	$3.9	$4.5	$5.1	$9.5	$17.2	$32.4
Cost per Average kW	$2.6	$2.9	$3.3	$6.2	$11.3	$21.2
Cost per Unserved kWh	$30.9	$5.9	$3.3	$1.3	$1.4	$1.3

* Adapted from Ernest Orlando Lawrence Berkeley National Laboratory, Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States

Medium and large commercial and industrial (C&I) customers have the highest interruption costs, but when normalized by average kW, interruption costs are highest in the small C&I customer class. On both an absolute and normalized basis, residential customers experience the lowest costs as a result of a power interruption. According to the LBNL study, household income has a relatively modest impact on interruption costs. Between a household income of $50,000 and $100,000, the difference in interruption

[19] https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/Public-Safety-Power-Shutoff-Policies-and-Procedures.pdf

[20] Ernest Orlando Lawrence Berkeley National Laboratory. Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States. January 2015. https://emp.lbl.gov/sites/all/files/lbnl-6941e.pdf

costs is only around ten percent for all durations. Interruption costs increase even further for a household income of $200,000.

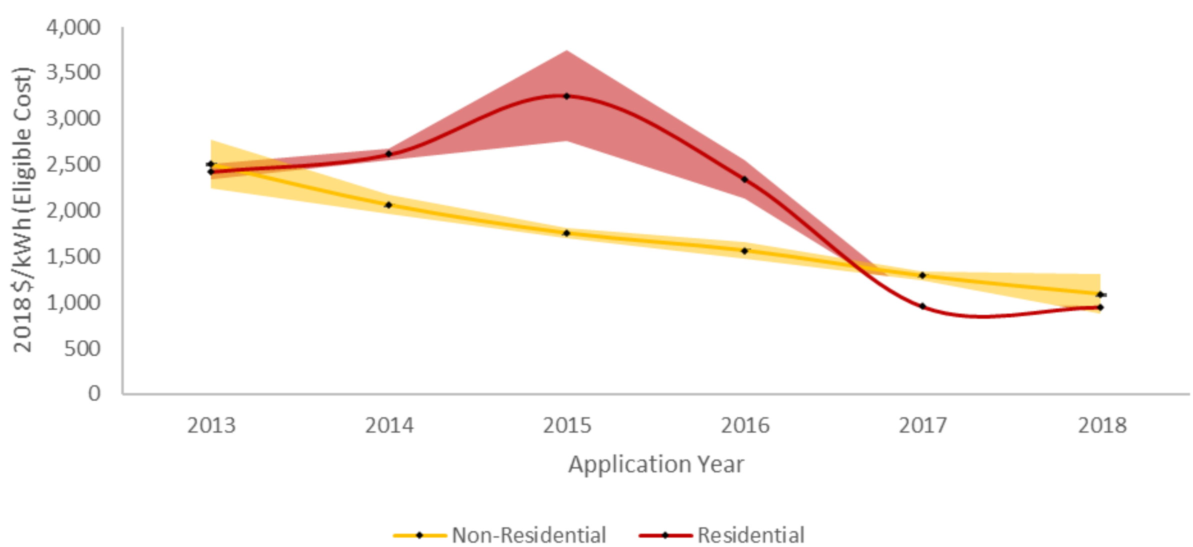
California Fire Code

Several organizations offer codes, standards, and best practices for energy storage technology. These cover installation, certification, fire protection, outreach to first responders, and other topics. Section 608 of the California Fire Code covers stationary storage battery systems. On July 1, 2018 the California Building Standards Commission adopted a supplement to the California Fire Code, including new requirements to section 608. The new code now applies to systems 20 kWh and greater – previously the code applied to 250 kWh and greater systems. Among other things, the code adds requirements for vehicle impact protection and fire suppression requirements. These changes to the fire code may create barriers for prospective commercial storage customers.

Cost Trends

The market for BTM energy storage is relatively nascent and limited data are available on installed costs. SGIP program application data provide a useful glimpse into energy storage costs trends. All SGIP incentive applications are required to report total eligible project costs which include but are not limited to equipment capital costs, engineering feasibility and design costs, environmental and building permitting costs, construction and installation costs, interconnection costs, maintenance contract costs, and system metering. Figure 2-9 summarizes total eligible costs for SGIP energy storage applications by customer class. Solid lines represent mean eligible costs and the shaded areas indicate the 90 percent confidence intervals.

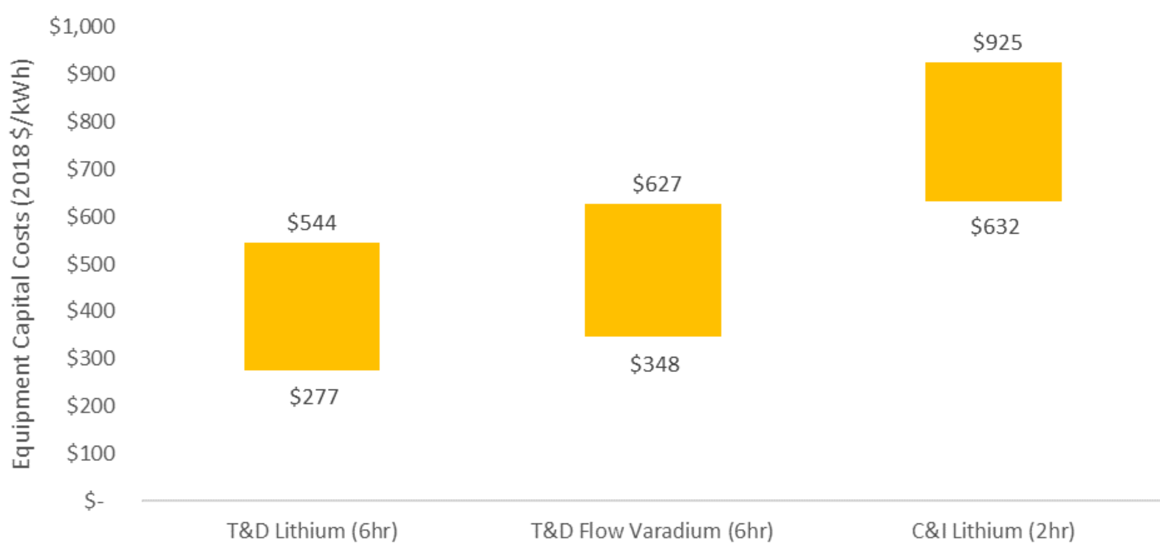
FIGURE 2-9: SGIP ENERGY STORAGE ELIGIBLE COST TRENDS BY CUSTOMER CLASS



Self-reported SGIP eligible costs have generally declined from approximately $2,500/kWh in 2013 to $1,000/kWh in 2018. However, self-reported SGIP eligible costs are not always representative of actual installed costs. We find that in many instances a single developer will report the same total SGIP eligible cost for all installations of the same equipment. This suggests that developers are submitting representative or average expected costs rather than actual installed costs when reporting eligible costs. Individual project costs can vary significantly depending on the storage system manufacturer, the installing company, and the complexity of the installation. For example, a battery system installation that requires an upgrade to a residential customer's electrical panel will result in considerably higher installation costs when compared to a storage installation that does not require major electrical work.

We considered other secondary data sources to better understand energy storage cost trends. The Lazard Levelized Cost of Storage Analysis is a widely cited reference for energy storage cost assumptions.[21] Figure 2-10 summarizes the capital cost comparison for transmission and distribution (T&D) sited energy storage, and C&I energy storage. The $/kW values presented in the study are converted to $/kWh based on the assumed energy storage duration. We exclude the residential costs since the Lazard study reports capital costs paired with solar PV and this study is interested in isolating energy storage cost trends. However, based on the information included in Appendix A of the Lazard Study, Lazard estimates the initial capital costs of residential storage (excluding PV) to be approximately 33 percent higher than the costs for C&I storage.

FIGURE 2-10: EQUIPMENT CAPITAL COST ASSUMPTIONS FROM LAZARD LEVELIZED COST OF STORAGE ANALYSIS VERSION 4.0

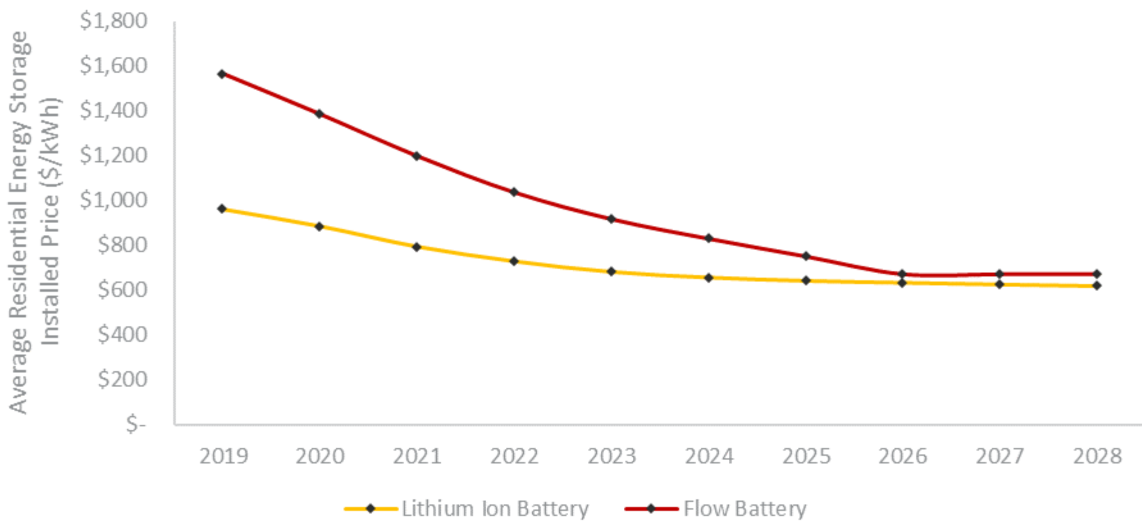


* Adapted from Lazard's Levelized Cost of Storage Analysis – Version 4.0

[21] https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf

Figure 2-11 presents installed cost projections from Navigant Research's Residential Energy Storage Research Report. In general, Navigant Research forecasts average residential lithium ion energy storage installed costs for 2019 at approximately $960/kWh. Flow battery technologies have considerably higher forecasted costs at over $1,500/kWh. Navigant expects the compound annual growth rate (CAGR) of installed prices for Li-ion and flow batteries are expected to be -4.8 percent and -9.0 percent, respectively.

FIGURE 2-11: AVERAGE RESIDENTIAL ENERGY STORAGE INSTALLED PRICE FORECAST (ADAPTED FROM NAVIGANT RESEARCH)

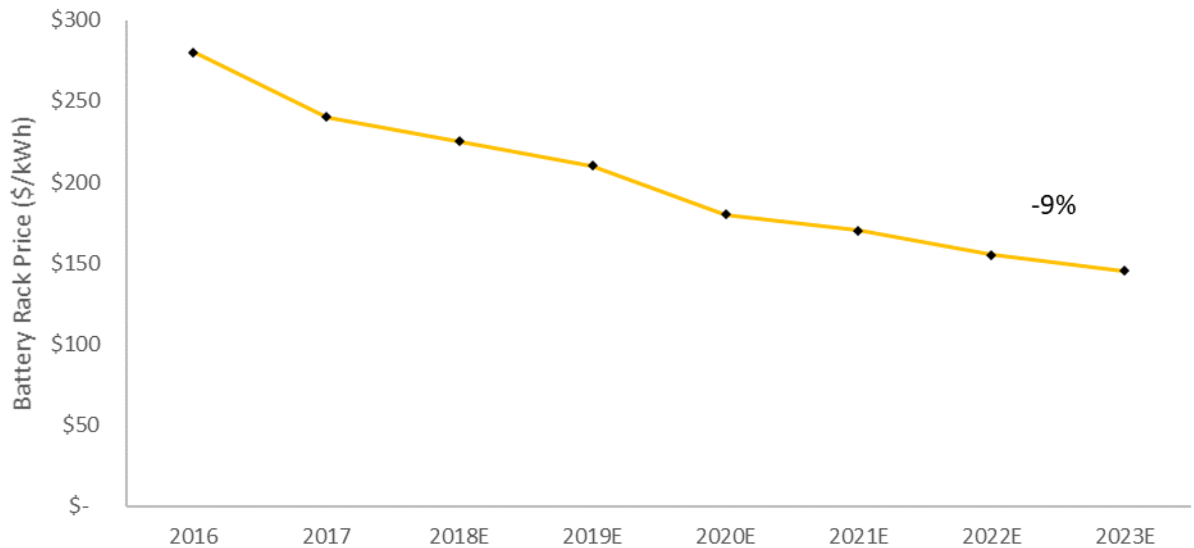


* Adapted from Navigant Research Residential Energy Storage Research Report. Q1 2019.

Cost trends from energy storage system components also provide insights into storage system trends. The battery rack is the component of an energy storage system where electrical energy is stored. Figure 2-12 shows historical and forecasted battery rack prices from Wood Mackenzie's U.S. energy storage monitor.[22] Wood Mackenzie reports that with vendors realizing economies of scale, improvements in battery energy density, and increasing market competition, battery prices will come down quickly in 2019. Wood Mackenzie's battery rack price forecast shows that over the next five years battery rack prices will drop below $150/kWh, from approximately $225/kWh in 2018. Battery racks represent a significant proportion of energy storage capital costs. A reduction in battery rack prices represents a significant reduction in the capital costs of the overall energy storage system.

[22] Wood Mackenzie Power & renewables. U.S. energy storage monitor – 2018 Year in review and Q1 2019 executive summary. March 2019.

FIGURE 2-12: BATTERY RACK PRICE FORECAST (ADAPTED FROM WOOD MACKENZIE)



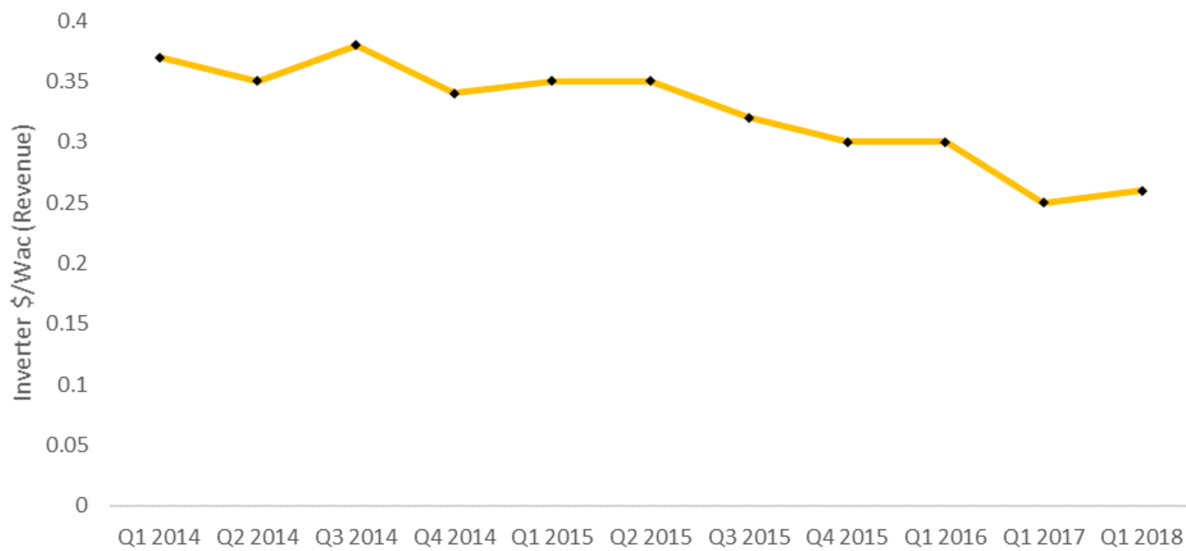
* Adapted from Wood Mackenzie Power & Renewables/ESA U.S. energy storage monitor. March 2019.

Bi-directional inverters are another key component cost in an energy storage system. The inverter is responsible for converting energy from AC to DC for charging, and from DC to AC when discharging. The National Renewable Energy Laboratory (NREL) published historical inverter prices in its U.S. Solar Photovoltaic System Cost Benchmark Report.[23] Figure 2-13 presents historical inverter prices based on SolarEdge's revenue per inverter capacity shipped. SolarEdge revenue includes sales from DC power optimizers, string inverters, and monitoring equipment. While not all these technologies apply to energy storage, they are indicative of the overall trend in storage inverter costs.

In addition to battery rack and storage inverter costs, other typical energy storage system costs include energy storage containerization (e.g., climate control, thermal management, monitoring and control, fire suppression), installation costs (e.g., wiring, panel upgrades, mounting), and other soft costs including customer acquisition, interconnection, permitting, and ongoing monitoring and control.

[23] National Renewable Energy Laboratory. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018. November 2018. https://www.nrel.gov/docs/fy19osti/72399.pdf

FIGURE 2-13: HISTORICAL INVERTER PRICES (ADAPTED FROM NREL)



* Adapted from NREL U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018.

In general, energy storage installed costs are difficult to predict. A residential system installation with backup functionality may require extensive electrical work if the customer's main panel requires an upgrade. The industry is in early stages and robust public data on system costs are scarce. For the most part, studies on system costs have focused on utility or grid scale energy storage. However, the literature and historical SGIP trends suggest that future prices will be lower than they are today. As installed costs decline, energy storage may become attractive to a growing proportion of the population.

2.6 REPORT CONTENTS

This report is organized into the following sections:

- Section 1 is the executive summary
- Section 2 provides an introduction, lays out the objectives of this study, and provides relevant background on the SGIP and other elements
- Section 3 describes the research methods and data sources used for the market characterization component of this study
- Section 4 presents the findings from the market characterization analysis
- Section 5 describes the research methods and data sources used for the cost-effectiveness component of this study

- Section 6 presents the findings from the cost-effectiveness analysis
- Section 7 summarizes all evaluation findings and provides overarching takeaways
- Appendix A presents the survey instruments used for the Manufacturer and Project Developer in-depth-interviews, and the host customer and solar non-storage participant web surveys
- Appendix B presents the host customer and solar non-storage participant web survey response frequencies
- Appendix C includes the results from all cost-effectiveness tests calculated in this study

3 MARKET RESEARCH DATA AND METHODS

This section summarizes the research activities and sources of data used in the market research component of this study. The primary data sources used in this evaluation included:

Pre-existing data sources:

- The SGIP Statewide Project Database[1] managed by the PAs – this dataset was used to create the sample frame for the developer interviews and host customer surveys.
- California Solar Initiative (CSI) Participant Database – this dataset includes CSI incentive application data from PG&E, SCE and CSE service territories. It was used to create the solar non-storage sample frame.
- The 2009 Residential Appliance Saturation Study (2009 RASS) – this dataset was used to extract demographic information representative of the PG&E, SCE, and SDG&E customer population for comparison to the SGIP host customer respondent population.
- The 2016 American Community Survey – this dataset was also used to extract demographic information representative of the PG&E, SCE, SCG, and SDG&E customer population for comparison to the SGIP host customer respondent population.

Data from research activities:

- In-depth interviews (IDIs) with behind-the-meter (BTM) storage manufacturers by Itron professional evaluation staff (Section 3.2)
- In-depth interviews with BTM storage project developers by Itron professional evaluation staff (Section 3.2)
- Web and phone surveys completed by SGIP storage host customers (Section 3.4)
- Web surveys completed by solar non-storage participants (Section 3.5)

The four research activities outlined above enabled the evaluation team to learn about SGIP participants' experiences with the SGIP and perceptions of energy storage technologies. In particular, the IDIs with project developers and storage manufacturers provided their perspectives on the key drivers, barriers, and trends in the storage market. The phone and web surveys with host customers were used to obtain

1 Accessed February 26, 2019.

feedback on the factors influencing their decision to install storage, the role of SGIP in their decision-making, and their experiences to-date participating in the SGIP.

3.1 SGIP STATEWIDE PROJECT DATABASE

A copy of the SGIP statewide project database was downloaded from www.selfgenca.com on February 26, 2019. All completed SGIP BTM residential and nonresidential electrochemical storage projects from program years 2009 through 2018 are included in this evaluation.[2] The breakout of completed projects, developers, and host customers included in this study, by PA, is shown in Table 3-1 below. Some developers and host customers have applications in multiple PA territories and so the SGIP developer and host customer totals do not equal the sum of each PA's subtotals. A total of 3,562 residential and 600 nonresidential completed storage projects were included across all PA service territories.

TABLE 3-1: SGIP COMPLETED PROJECTS, APPLICANT, AND HOST CUSTOMER COUNT BY MARKET SECTOR AND PROGRAM ADMINISTRATOR

Market Sector	PA	# Completed Projects	# Developers	# Host Customers
Residential	PG&E	1,587	51	1,587
	SCE	1,162	43	1,162
	SCG	149	15	149
	CSE	664	40	664
Residential Total		**3,562**	**149**	**3,562**
Nonresidential	PG&E	216	47	69
	SCE	233	50	81
	SCG	8	5	5
	CSE	143	34	57
	Multi	N/A	N/A	19
Nonresidential Total		**600**	**136**	**231**
SGIP Total		**4,162**		**3,795**

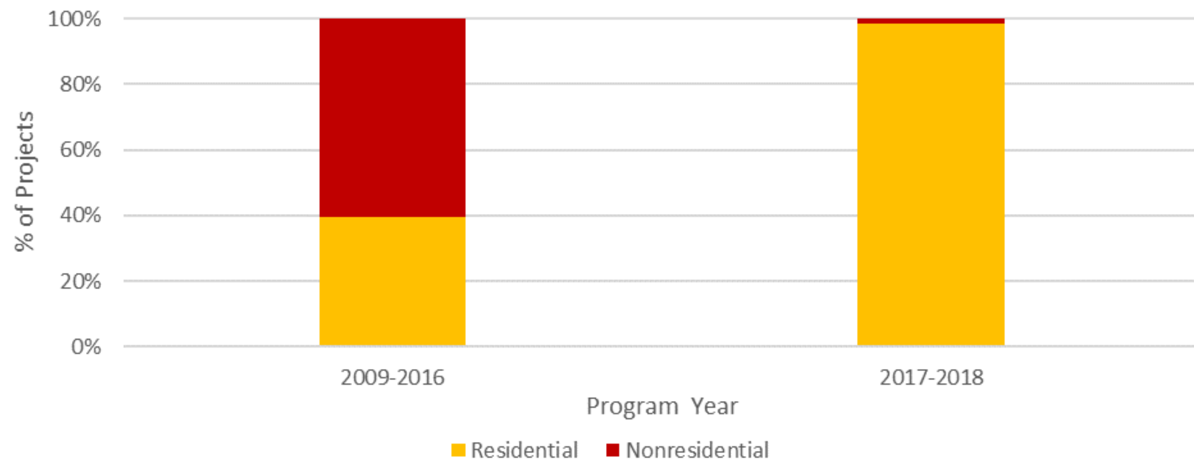
Of the 3,562 completed residential storage projects shown in the table above, 3,201 (90 percent) had program year equal to 2017 or 2018 in the SGIP database.[3] This contrasts with the nonresidential market where only 49 of the 600 nonresidential projects (8 percent) were applied for in 2017 or 2018. This shift in BTM storage projects from nonresidential to residential over the last two years is a primary focus of this evaluation. Figure 3-1 below shows that during program years 2009 through 2016, nonresidential

[2] As of February 2019, there were no thermal or mechanical energy storage projects completed in the SGIP. Consequently, this report considers only electrochemical storage.

[3] The program year variable corresponds to the year portion of the Date Received (aka application date) variable in the SGIP database.

completed projects outnumbered residential completed projects, however in 2017 and 2018 nearly all new project growth has been in the residential sector.

FIGURE 3-1: DISTRIBUTION OF COMPLETED PROJECTS BY SECTOR, PROGRAM YEARS 2009-2016 AND 2017-2018



3.2 BTM STORAGE MANUFACTURER IN-DEPTH INTERVIEWS

Itron conducted in-depth interviews with three manufacturers of BTM storage systems. The purpose of these in-depth interviews was to learn about current and future markets for each manufacturer's energy storage products. This represented a high-level view of the business, both current and future. Key areas of focus were their current energy storage system product line, current and future market trends for energy storage systems, and the effect of the SGIP program on their sales of energy storage systems. Appendix A.1 presents the list of questions used to guide the BTM storage manufacturer interviews.

3.2.1 Sample Design

The manufacturer sample was pulled from the "Equipment Manufacturer" field within the SGIP tracking database. There were originally eight manufacturers in the sample, but three were dropped from the sample due to the manufacturer being acquired by another manufacturer or the manufacturer filing for bankruptcy. We attempted a census with the remaining five manufacturers in the sample, however one manufacturer cancelled a scheduled interview due to staff turnover, and another declined the interview. The three manufacturers that completed interviews accounted for 94 percent of the batteries sold within the SGIP sample, as interviews were completed with the two largest manufacturers, who respectively made up 51 percent and 42 percent of the batteries sold through the program. The sample design for manufacturers is included alongside the developer sample design in Table 3-2 on page 3-5 below.

3.3 DEVELOPER INTERVIEWS

SGIP project developers were interviewed by phone by Itron professional staff. Interview questions covered topics relating to developers' methods for marketing and selling energy storage systems, their projections of current market trends, and their descriptions of the effect the SGIP program has had on the sales of energy storage systems. These interviews included several open-ended questions that allowed detailed descriptions of each developer's experiences and enabled follow-up questioning depending on the answers provided. Appendix A.2 presents the interview guide used for the developer interviews.

3.3.1 Sample Design

The sample for the developer interviews was designed so that results could be reported with high confidence across the wide variety of developers that worked with host customers to complete projects through the SGIP program.

For the developer interviews, the overall sample was subdivided into three groups based on how many SGIP projects each developer had completed. Developers who had completed 100 or more projects were classified as "High Volume" developers, those completing between 5 and 100 projects were "Mid Volume" developers, and those completing fewer than five projects were classified as "Low Volume" developers. While the "High Volume" developers accounted for only 15 of the 98 developers in the sample (15 percent), they accounted for 90 percent of the 4,162 completed projects. Conversely, the "Low Volume" developers accounted for 68 of the 98 developers in the sample (69 percent), but only 3 percent of the completed projects. The "Mid Volume" developers accounted for 15 of the 98 developers in the sample (15 percent) and 6 percent of the completed projects.

A census was attempted with the group of "High Volume" developers (our goal was to complete 13 interviews out of the sample of 15 developers since we knew completing interviews with 100 percent of these developers was highly unlikely). The Itron survey team completed interviews with 12 of the 15 targeted high volume developers. One high volume developer declined to complete the survey, another did not respond to phone or email requests, and a third cancelled the scheduled interview due to staff turnover. The targeted completes for the "Mid Volume" and "Low Volume" developers were much lower (47 percent and 22 percent of the sample, respectively), and while we fell short in the "Mid Volume" category (5 of the target of 15 were completed), we were able to surpass our target in the "Low Volume" category (17 of 68 were completed). In total, 37 interviewers were completed with battery manufacturers and SGIP project developers. Table 3-2 below summarizes the manufacturer and developer population, the targeted completes, and the achieved completes for each of the manufacturer and developer strata. As this table shows, in total, interviews were conducted with developers who accounted for 86 percent of the SGIP projects within our sample.

TABLE 3-2: TARGET AND ACHIEVED MANUFACTURER AND DEVELOPER SAMPLE DESIGN

Manufacturer/Developer Strata	Population Definition	Population	Target Completes	Completes	% Completed Projects in Strata
Manufacturer	Large Recent Manufacturers	5	5	3	NA
High Volume Developer	Completed > 99 Projects	15	13	12	89%
Mid Volume Developer	Completed 5 - 99 Projects	15	7	5	50%
Low Volume Developer	Completed < 5 Projects	68	15	17	29%
Total		**103**	**40**	**37**	86%

3.4 HOST CUSTOMER WEB SURVEY

Host customers were contacted through a web survey. Survey questions covered topics relating to a host customer's reasons for installing battery storage, the messaging they received from the vendor who sold/leased them the system, their experience and satisfaction with the SGIP, and the key decision influences that led to their purchase of a battery storage system. The host customer survey focused primarily on quantitative, scalar questions, with some selected follow-up open-ended questions. A survey invitation with a web link was emailed to all host customers in the participant population. Following the initial round of completed surveys, a reminder email was sent to all host customers that had not yet responded. Appendix A.3 presents the full survey instrument used for the host customer web survey.

3.4.1 Sample Design

The sample design for the host customer survey was designed so that results were representative of the population of customers who had installed electrochemical storage in their home or business and received an incentive through the SGIP program. For sampling purposes and to account for those who had installed multiple storage systems through the program, host customers were aggregated based on customer name, contact information, and location.[4]

Residential host customers were grouped by PA and Program Year. SGIP participants were grouped into two program periods, program years 2009 through 2016 and program years 2017 and 2018. This allowed for customer segmentation by whether they applied to the SGIP during the program's early years (2009 to 2016) or more recently (2017 or 2018). Table 3-3 summarizes the targeted residential host customer sample design and the number of surveys completed for each PA and program period. As this table shows, most residential customers in the sample applied to the program in 2017 or 2018 (90 percent) and were either PG&E, SCE, or SDG&E (PA is CSE) customers (45 percent, 33 percent, and 19 percent, respectively). The overall response rate to the residential host customer survey surpassed our projections. We had

[4] For example, applications across all locations of large retailers were aggregated to a single host customer.

anticipated a 14 percent response rate based on the results of the host customer web surveys completed as part of the 2017 PA Performance Evaluation, however the final response rate was 21 percent. The response rate varied slightly across PAs, however, more noticeably across program periods, with the 2009 to 2016 period achieving a 13 percent response rate and the 2017-2018 period achieving a 22 percent response rate. This was not unexpected as the contact information for recent participants is more likely to be up-to-date and these participants are less likely to have been previously contacted by other SGIP surveying efforts (and thus less likely to suffer from survey fatigue).

The achieved sample distribution closely mirrored the residential participant population distribution and thus the host customer responses presented throughout the report are unweighted.

TABLE 3-3: RESIDENTIAL HOST CUSTOMER SAMPLE DESIGN AND COMPLETED SURVEYS

Program Administrator	Program Year	Host Customer Population	% of HC Population	Host Customer Target Completes	n Completes	Achieved RP[5]	Achieved Sample Distribution
PG&E	2009-2016	134	4%	19	22	16.0%	3%
	2017/2018	1,453	41%	203	334	3.9%	44%
SCE	2009-2016	134	4%	19	12	22.7%	2%
	2017/2018	1,028	29%	144	201	5.2%	26%
SCG	2009-2016	1	0%	0	0	N/A	0%
	2017/2018	148	4%	21	36	11.9%	5%
CSE	2009-2016	92	3%	13	14	20.2%	2%
	2017/2018	572	16%	80	146	5.9%	19%
Total	**2009-2016**	**361**	**10%**	**13**	**48**	**11.1%**	**6%**
	2017/2018	**3,201**	**90%**	**80**	**717**	**2.7%**	**94%**
	All Years	**3,562**	**100%**	**499**	**765**	**2.6%**	**100%**

Nonresidential host customers were grouped by PA and the number of projects they had completed (a single project vs. two or more projects). Table 3-4 summarizes the nonresidential host customer sample design, including both the number of targeted and actual completed surveys. As this table shows, most nonresidential customers in the sample were SCE customers (35 percent), followed by PG&E (30 percent) and SDG&E (PA was CSE, 25 percent). Eight percent of the nonresidential host customer sample had multiple sites that were the customers of multiple PAs and only two percent were SCG customers. The overall response rate for the nonresidential host customer survey was eight percent, which was similar to the response rate achieved in 2018 for the nonresidential PA performance evaluation host customer web

5 Achieved relative precision was calculated based on the sample population and the number of completes assuming a conservative error ratio (calculated as the standard deviation/mean) of 0.5 and a 90 percent confidence interval.

surveys. To increase the response rate of this surveying effort, Itron staff placed calls to host customers who had not responded to the web survey in order to remind them of the survey and, if desired, complete it with them over the phone. The response rates varied by PA, with a high of twelve percent of the SCE sample, but only two percent of the CSE sample. The response rates for customers who had completed single versus multiple SGIP projects were similar (eight percent and nine percent, respectively). While the achieved sample distribution didn't mirror the nonresidential participant population distribution as close as desired, the host customer survey responses were not weighted due to the small number of total responses (n=19).

TABLE 3-4: NONRESIDENTIAL HOST CUSTOMER SAMPLE DESIGN AND COMPLETED SURVEYS

Program Administrator	# Projects	Host Customer Population	% of HC Population	Host Customer Target Completes	n Completes	Achieved RP[6]	Achieved Sample Distribution
PG&E	Single	50	22%	4	4	39.4%	21%
	Multiple	19	8%	2	2	55.0%	11%
SCE	Single	61	26%	5	6	31.9%	32%
	Multiple	20	9%	2	4	36.8%	21%
SCG	Single	5	2%	0	1	73.6%	5%
CSE	Single	41	18%	3	1	81.2%	5%
	Multiple	16	7%	1	0	N/A	0%
Multiple PAs	Multiple	19	8%	2	1	80.1%	5%
Total		**231**	**100%**	**19**	**19**	**18.1%**	**100%**

Response frequency tables for each closed-end question in the host customer survey are included in Appendix B.1.

3.5 SOLAR NON-STORAGE PARTICIPANT SURVEY

Solar non-storage participants were contacted through a web survey. Survey questions covered topics relating to solar non-storage participants' awareness and familiarity with battery storage technology and the SGIP, their perceptions about the barriers and benefits of installing battery storage, and their likelihood of installing a battery storage system in the future. Like the host customer survey, the solar non-storage participant survey focused primarily on quantitative, scalar questions, with an opportunity to enter open-ended responses if the respondent did not feel that any of the pre-defined responses were appropriate. A survey invitation with a web link was emailed to all contacts in the sample. Following the

6 Achieved relative precision was calculated based on the sample population and the number of completes assuming a conservative error ratio (calculated as the standard deviation/mean) of 0.5 and a 90 percent confidence interval.

initial round of completed surveys, a reminder email was sent to all solar non-storage participants that had not responded to the first email. Appendix A.4 presents the full survey instrument used for the solar non-storage participant web survey.

3.5.1 Sample Design

The sample frame for the solar non-storage participant survey was constructed from a database of PG&E, SCE, SDG&E, and SCG customers who had installed solar in their homes or businesses, had received a rebate for this solar from the CSI program, and had not installed storage based on the SGIP participant database. The solar non-storage participant population was selected as a proxy for a true nonparticipant sample due to evaluation time constraints making it difficult to develop a residential and nonresidential nonparticipant sample frame for each of the four PAs. Surveying the solar non-storage population allowed the evaluation to collect data from customers who had not installed storage but were experienced with distributed energy resources. These customers were more likely than the general population to be at least somewhat familiar with battery storage and thus able to provide insights into customer motivations and barriers to battery storage adoption.[7]

The sample design for this survey considered the age of some of the CSI email addresses and thus the increased likelihood of a low response rate due to a high percentage of emails being undeliverable. To account for this, emails were sent to all available nonresidential customers (2,982) in the sample[8] and 3,000 randomly selected residential customers (out of nearly 110,000 available solar non-storage customers) in the sample. The goal for this surveying effort was 140 completed surveys (70 residential, 70 nonresidential) in order for both residential and nonresidential survey results to be presented at a 90/10 confidence/precision level. As shown in Table 3-5, the desired number of residential surveys completed exceeded the target and the resulting relative precision was 7.5 percent. Despite multiple contacts to all customers within the nonresidential sample/population, the number of completes fell short of the 70 targeted, resulting in a final relative precision of 12.6 percent.

Response frequency tables for the closed-ended questions in the solar non-storage participant survey are included in Appendix B.2.

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7 SGIP impact evaluations have shown that most nonresidential energy storage installations are not co-located with BTM PV. We recognize that selecting a nonresidential sample of solar non-storage participants is not truly representative of historical nonresidential SGIP energy storage adopters. However, we believe this group is a useful proxy nonetheless given the time constraints of this evaluation.

8 As with the SGIP nonresidential sample, solar non-storage participants were aggregated based on customer name, contact information, and location when necessary.

TABLE 3-5: TARGET SOLAR NON-STORAGE PARTICIPANT SAMPLE SIZE BY CUSTOMER TYPE

Customer Type	SNS Population[9]	% SNS Population	SNS Participant Sample	% of SNS Population Sampled	n Completes	Achieved RP[10]	Achieved Sample Distribution
Residential	109,314	97%	3,191	3%	115	7.5%	73%
Nonresidential	2,982	3%	2,982	100%	42	12.6%	27%
Total	**112,296**		**6,173**		**157**	**6.5%**	**100%**

[9] This is the population of solar non-storage customers from the CSI program having a unique email address. There was a total of 174,341 CSI records in the original file pulled from the CSI application tracking dataset.

[10] Achieved relative precision was calculated based on the sample population and the number of completes assuming a conservative error ratio (calculated as the standard deviation/mean) of 0.5 and a 90 percent confidence interval.

4 MARKET RESEARCH RESULTS

This section presents findings from the primary data collected through on-line surveys of customers and in-depth interviews of developers and manufacturers during this evaluation. Results are organized thematically by:

- *Key Characteristics of Storage Customers and Market Actors*, i.e., who is buying storage and who is selling it.
- *Storage Product Characteristics*, i.e., what types of products are being sold and installed.
- *Storage Sales and Marketing,* i.e., what sales approaches are being used to reach target customers, and what marketing messages are being used to persuade them to buy.
- *Perceived Benefits of Storage Systems*, i.e., what factors motivate customers to purchase storage.
- *Perceived Barriers to Storage System Adoption*, i.e., what factors impede storage system purchases.
- *Storage System Costs*, i.e., what are the typical all-inclusive costs of installing storage.
- *Storage System Performance,* i.e., to what extent are customers realizing the benefits they expected based on perceived performance.
- *Effect of SGIP Program on Storage Market,* i.e., how has the SGIP influenced the market for storage to-date and how important is it for near term adoption and potential future market transformation?

Data and analysis from the Manufacturer and Project Developer In-Depth Interviews[1] (IDIs) and Host Customer (HC) and Solar Non-Storage Participant web surveys are presented as they pertain to each section.

4.1 KEY CHARACTERISTICS OF STORAGE CUSTOMERS AND MARKET ACTORS

This section provides a snapshot of buyers and sellers of storage systems and highlights key demographic and firmographic characteristics of program participants.

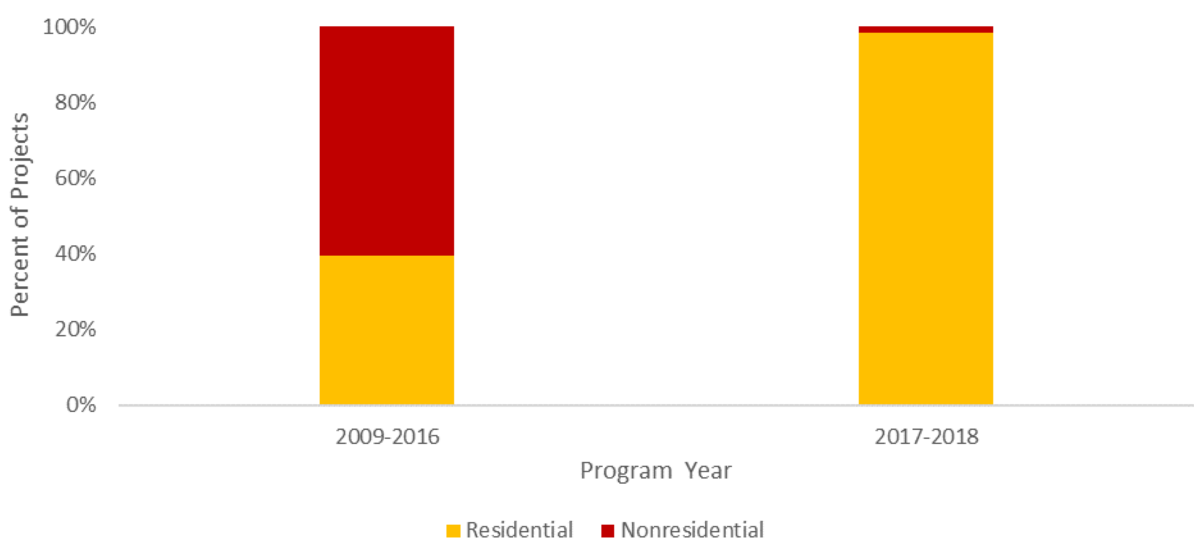
As discussed in Section 2, there has been a significant shift in the number of completed storage projects during Program Years 2009 through 2016 and those completed in Program Years 2017 and 2018. In the

1 For purposes of this study, a manufacturer is the entity that manufactures the battery storage equipment and a Project Developer is the entity who handles a substantial amount of the project's development activities. In most cases the Project Developer and Applicant are the same entity.

earlier program years, nonresidential projects made up nearly 40 percent of the overall projects, whereas more recently they have accounted for less than 1 percent of all projects.

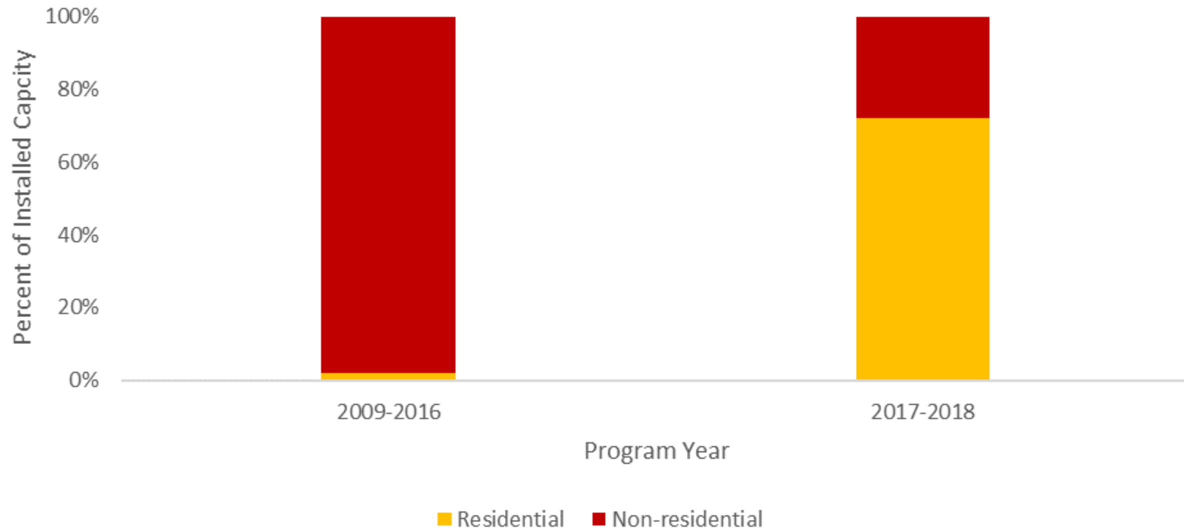
Figure 4-1 and Figure 4-2 below compare the distribution of completed projects and the installed capacity by market sector (residential and nonresidential) that applied between 2009[2] and 2016 and in 2017 and 2018. As these figures show, the activity in the nonresidential sector, which dominated the program both in terms of completed projects and installed capacity in the earlier period, dropped off significantly after Program Year 2016. It was around the same time that the number of residential projects increased dramatically. While nonresidential projects made up less than two percent of the completed projects that applied to the program since the start of 2017, they continued to account for nearly forty percent of the installed capacity as their average size was about 158 kW compared to residential projects that averaged around 5.8 kW.

FIGURE 4-1: RESIDENTIAL VS. NONRESIDENTIAL COMPLETED PROJECTS, PROGRAM YEARS 2009-2016 VS. 2017-2018



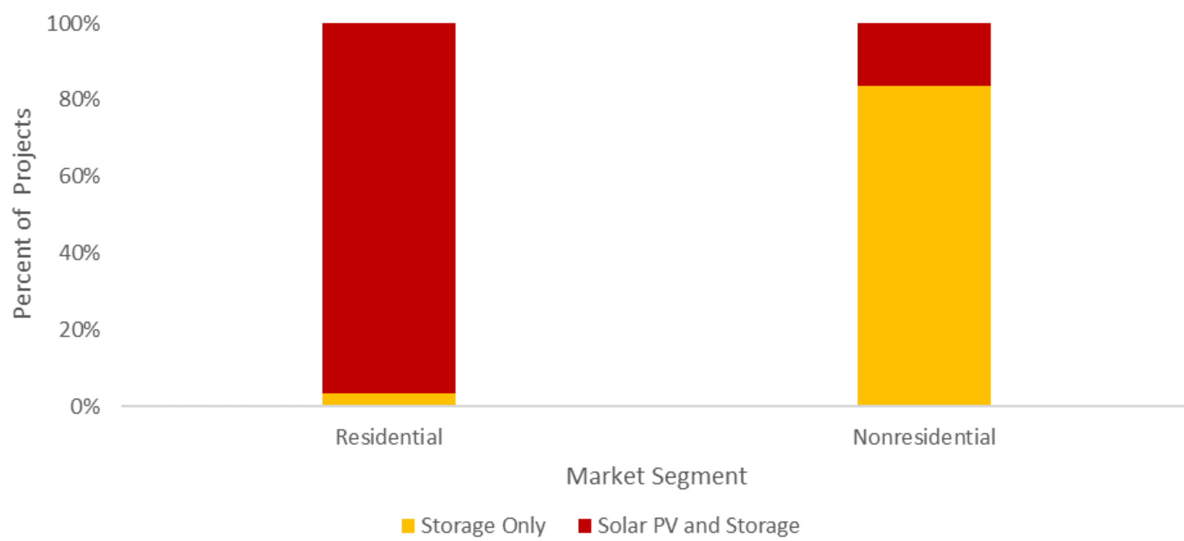
[2] The first residential application was received in 2011.

FIGURE 4-2: RESIDENTIAL VS. NONRESIDENTIAL INSTALLED CAPACITY (KW), PROGRAM YEARS 2009-2016 VS. 2017-2018



Another interesting difference between residential and nonresidential SGIP storage participant populations was the frequency with which storage was installed on its own versus in combination with solar (the solar and storage systems were not necessarily installed at the same time). As shown in Figure 4-3 below, nearly all of the SGIP residential storage projects completed to date were paired with solar PV (97 percent based on program tracking data) compared to only 17 percent of the nonresidential storage projects.

FIGURE 4-3: STORAGE ONLY VS. SOLAR PAIRED WITH STORAGE, RESIDENTIAL VS. NONRESIDENTIAL MARKETS



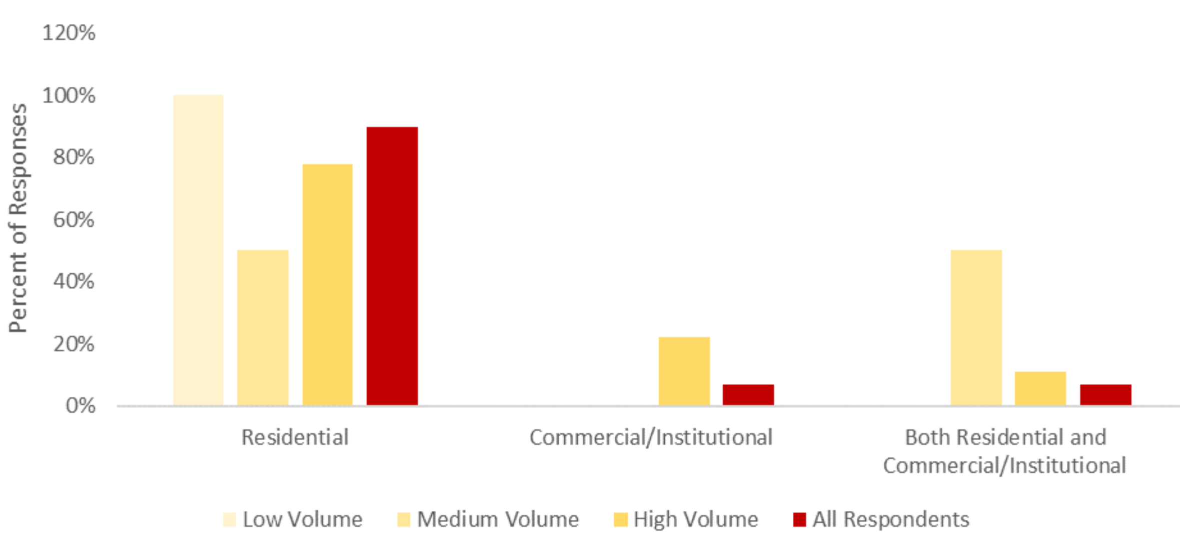
Interviews with project developers reinforced our findings from tracking data review. While only a very small number of the developers interviewed sell to nonresidential customers, most of those firms are selling storage-only systems. In contrast, those selling in residential markets, who comprised the majority of those interviewed, primarily sell combined storage/solar or solar-only systems.

Detailed findings from the developer, host customer, and solar non-storage customer data collection efforts are organized by customer type below.

4.1.1 Residential

Developers working in the residential sector either sell combined solar/storage systems or solar-only, and most combined solar/systems are sold to residential customers. None of the residential developers interviewed reported selling standalone storage systems, and most of the solar/storage systems are installed by residential customers. These findings mirror the patterns shown in the figures above. Most of the project developers interviewed *(18 of 20 Low/Medium Volume developers and 5 of 7 High Volume developers[3])* sell exclusively to residential customers. Two High Volume developers – those offering leasing-type arrangements - sell exclusively to nonresidential customers, such as commercial real estate, colleges and universities, and public schools. The remainder focus on the residential market.

FIGURE 4-4: PRIMARY CUSTOMER TARGETS FOR BTM STORAGE SYSTEM SALES (N=34)



[3] Developers who had completed 100 or more projects were classified as "High Volume" developers, those completing between 5 and 100 projects were "Mid Volume" developers, and those completing fewer than five projects were classified as "Low Volume" developers.

Residential combined solar/storage system sales focus on certain niche segments. Both the host customer survey and the developer interviews found that candidates for combined solar/battery storage systems are a small subset of the overall residential customer population. They tend to be customers that fit a certain profile based on factors such as their income level, their energy/environmental attitudes, and their level of sophistication with regard to energy bill reduction strategies, among others. Table 4-1 below compares findings from the developer interviews and the residential host customer surveys and Table 4-2 compares the residential demographic responses gathered as part of both the host customer and solar non-storage participant surveys. These responses are also compared to similar demographic data pulled from the most recent CA RASS[4] (2009) that are representative of the entire PG&E, SCE, and SDG&E customer population.

TABLE 4-1: CHARACTERISTICS OF STORAGE/SOLAR PURCHASERS

Characteristics of Storage Purchasers	Residential Host Customer Findings	Developer Findings
High income customers	79 percent of respondents reported income > $100,000 compared to 26 percent of residential customers based on the 2009 RASS.	Customers with at least $100-150 monthly electric bills, and a load profile with heavy usage in the peak period. *["If we see a $300 plus per month bill, that is the trigger to talk about energy storage."]*
Concerned about environment	74 percent reported environmental benefits of storage were very important in decision to purchase storage (4 or 5 on an importance scale of 1-5, 5 percent said it was not at all important). 80 percent reported environmental benefits of solar were very important in decision to purchase storage (4 or 5 on an importance scale of 1-5, 5 percent said was not at all important).	Those with environmental concerns are far more likely to purchase combined solar/storage systems.
Early adopters	45 percent of respondents reported being the first or among the first to try a new product.	Subset - early adopter homeowners that have decided that this is their final home.
Cool Factor	A number of host customers also reported in open-ended answers they decided to install storage because it was "cool".	Another driver mentioned by Small and Medium Volume firms was the "cool" factor of owning a storage system (paired with solar).
Seek alternative to grid power	Host customers reported installing storage for reasons such as "*to avoid relying solely on the utility*", "*To get off the grid*", and "*backup in case of grid failure.*"	Those seeking alternatives to utility sourced power are likely storage candidates *["And, they don't want to deal with their utility."]*.
Sophisticated customers	82 percent have a college degree or higher	Those with the knowledge and the means to maximize bill savings are likely candidates.

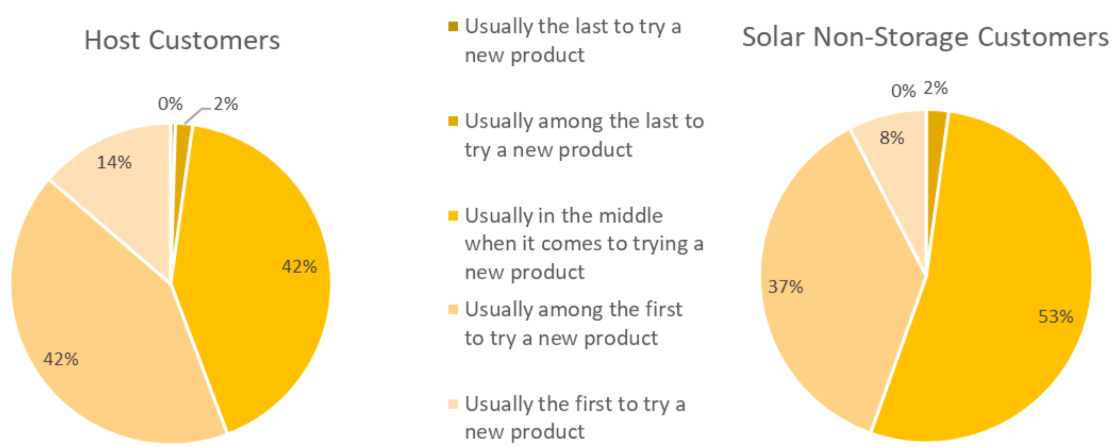
[4] The Residential Appliance Saturation Study (RASS) is a comprehensive study of residential sector energy use. It is the primary method of collecting residential sector energy consumption and appliance profiles to support the California Energy Commission's residential sector energy demand forecast model. More information can be found here: https://www.energy.ca.gov/appliances/rass/ .

TABLE 4-2: RESIDENTIAL CHARACTERISTICS: HOST CUSTOMER RESPONDENTS VS. SOLAR NON-STORAGE PARTICIPANTS VS. 2009 RASS

Residential Characteristics	SGIP Host Customer Respondents	Solar Non-Storage Respondents	2009 RASS
Household Income > $100,000	79%	68%	26%
Education Level: College +	82%	87%	52%
Single Family Home	97%	98%	61%
Owned Home <5 years	21%	6%	18% of homeowners
Owned Home >= 25 years	24%	34%	23% of homeowners
Urban/Suburban/Rural	24%/62%/14%	21%/60%/19%	Unknown
Household with Kids (0-18 years)	33%	16%	39%
Household with resident >= 65 years	38%	54%	28%
Self-reported Early Adopter	56%	45%	Unknown
Self-reported Wildfire Risk High	20%	14%	Unknown

Analysis of the demographic responses provided by host customers paints a picture of SGIP residential storage respondents as older, highly educated, high income households who own single family homes and tend to classify themselves as "early adopters" (either the first or among the first to try a new product). They live in suburban neighborhoods and are more likely than solar non-storage participants to report that their home was in an area they classified as having a high risk of wildfires (although only 26 percent recall losing power due to preventative fire outages[5]). Figure 4-5 below compares SGIP participants' and solar non-storage participants' self-reported responses regarding their adoption of new products.

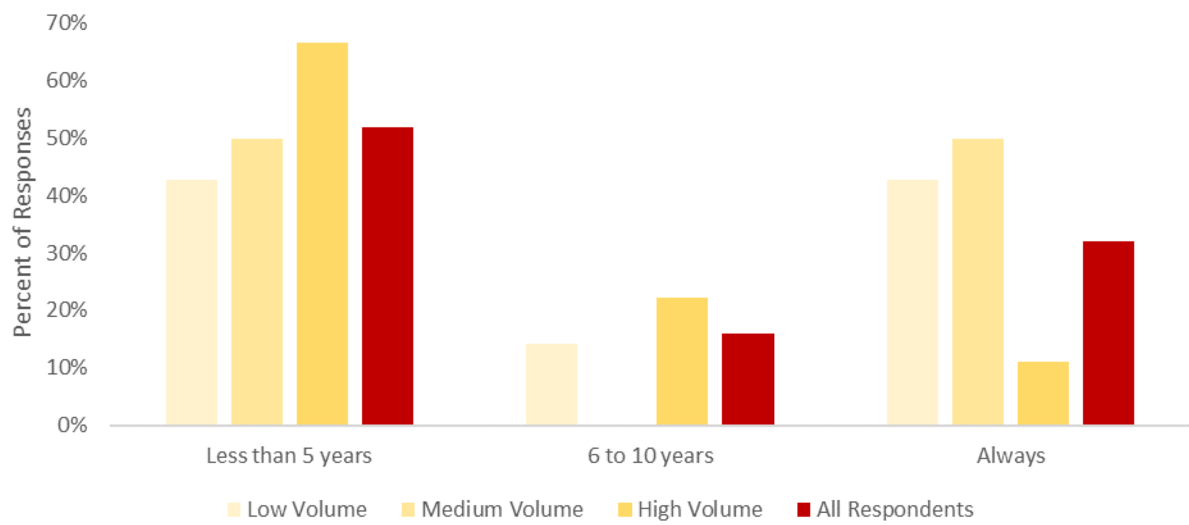
FIGURE 4-5: SELF-REPORTED "EARLY ADOPTER" CLASSIFICATION – HOST CUSTOMERS VS. SOLAR NON-STORAGE PARTICIPANTS



[5] 58 percent were unsure whether they had lost power due to preventative outages.

Most developers interviewed reported they have been in the markets they serve for several years. The majority began to offer storage recently, within the past five years, as highlighted in Figure 4-6 below.

FIGURE 4-6: LENGTH OF TIME SELLING BTM STORAGE SYSTEMS (N=34)



4.1.2 Nonresidential

Developers that sell storage systems to commercial/institutional customers seek out customers with the potential to save significantly on demand charges. This is consistent with findings from host customer surveys of nonresidential respondents, where reducing demand charges is one of the primary drivers for installing battery storage. Additionally, storage appears to be effective for meeting this goal, since 93 percent of nonresidential respondents on rates with demand charges reported they were successfully able to deploy their storage to reduce their demand charges.

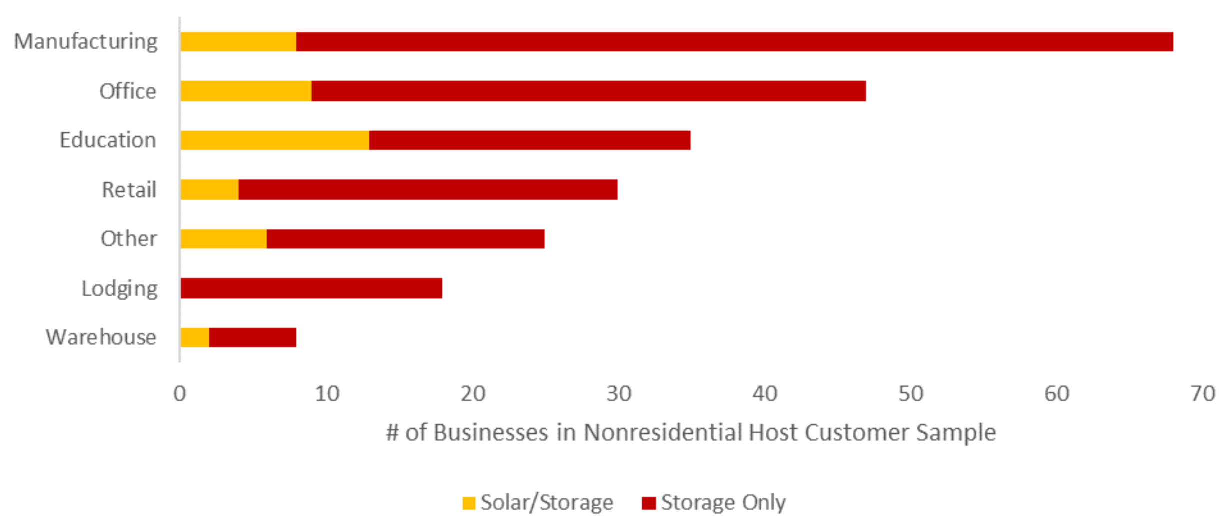
Other characteristics of surveyed nonresidential SGIP participants (n = 19) include:

- Overall, 78 percent of nonresidential SGIP participants own the facility where the storage system is installed and 72 percent occupy the entire building. Participants who only had storage installed were less likely to own the building where the storage was installed (57 percent owned) than those with storage and solar installed (91 percent owned). The solar non-storage participants that installed solar through the CSI program nearly all owned the building where the solar was installed (97 percent). Storage has a smaller footprint than solar and thus some nonresidential renters might feel more comfortable installing standalone storage relative to solar and PV (the footprint of a standalone storage installation is comparable to a moderately sized server room).

- Nearly one-third (32 percent) are small businesses, employing 50 or fewer employees and one-fifth (21 percent) are large, employing more than 250. By comparison, the solar non-storage participants are predominantly small businesses (78 percent) and only 6 percent are large (> 250 employees).
- Over three-fourths (79 percent) of nonresidential host customers reported having company goals addressing sustainability, climate change, greenhouse gas reductions or other environmental objectives, such as using 100 percent renewable energy, using biodegradable packaging or focusing on scrap recycling. In contrast, solar non-storage participants are significantly less likely to have such goals and over half (55 percent) reported having no goals.

The most common business sector of nonresidential SGIP storage participants (based on NAICS code) was the manufacturing sector,[6] accounting for 29 percent of nonresidential SGIP storage projects. The second most prevalent sector was office buildings (20 percent), followed by educational facilities (15 percent). Educational facilities made up most of the combined solar/storage installations (31 percent) and lodging projects were all storage only. Figure 4-7 below shows the number of completed projects across the primary business sectors where storage was installed.

FIGURE 4-7: NONRESIDENTIAL BUSINESS SECTORS WHERE SGIP STORAGE IS INSTALLED



6 All manufacturing NAICS codes were include so this category ranges from chemical and fabricated metal manufacturing to food and beverage manufacturing.

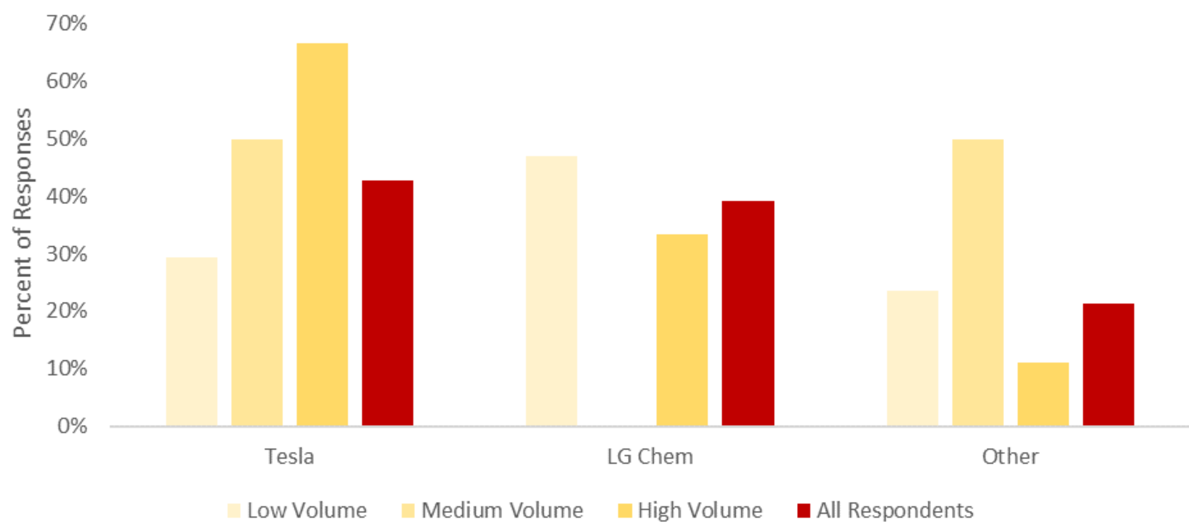
4.2 STORAGE PRODUCT CHARACTERISTICS

The specific types of behind-the-meter storage hardware sold by developers and manufacturers are described in this section. Key findings regarding storage systems sold and installed are:

Two manufacturers account for the primary share of the behind-the-meter storage systems sold. Overall, these two product lines comprise more than 85 percent of the systems sold to host customers.

- Several developers discussed one manufacturer's (Manufacturer A) supply problems and indicated that they could have sold more of Manufacturer A's units if not for those problems. *["We've sold more [Manufacturer A Units]. But we've installed more [Manufacturer B] because we are waiting for [Manufacturer A] to get us the batteries." "We like the [Manufacturer A] batteries, but the supply is a problem."}*

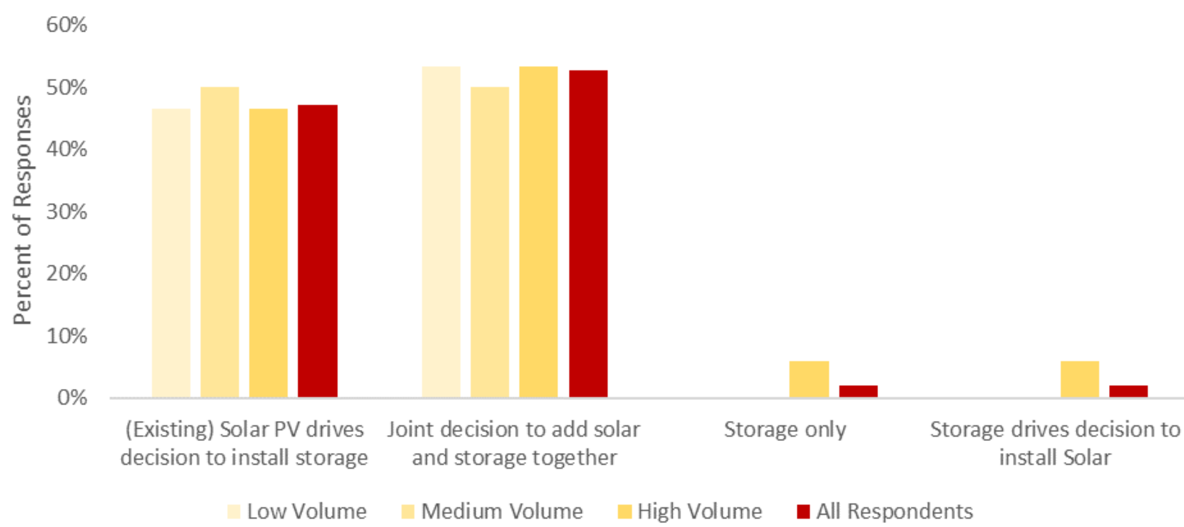
FIGURE 4-8: BTM STORAGE SYSTEM PRODUCTS SOLD BASED ON DEVELOPER SELF-REPORTS



Program tracking data analysis found Tesla and LG Chem accounted for 98 percent of the residential storage systems sold and 27 percent of the nonresidential systems sold, which was consistent with what the developers interviewed were reporting. The leading nonresidential storage system manufacturer (Stem) made up 45 percent of the nonresidential systems sold, followed by Tesla (28 percent). The leading residential storage system manufacturer (Tesla) made up 51 percent of the residential systems sold, followed by LG Chem (46 percent).

Developers believe that most residential customers elect to install or add storage only in combination with a solar PV installation. This aligns with program tracking data that indicated 96 percent of residential storage customers had storage paired with solar PV (as compared to only 18 percent of nonresidential storage customers). Developers in all size ranges reported that storage installations either occur in cases where the customer already has a solar PV system installed, or in combination with a new solar PV system installation. For a very small fraction of their business, High Volume developers have observed either storage-only installations or cases where storage drives the installation of solar. Below we provide additional details on the relative influence of solar PV in deciding to install energy storage.

FIGURE 4-9: STORAGE DECISION INFLUENCE AND THE EFFECT OF SOLAR



Host customer survey findings are consistent with developer findings. Host customers who have both storage and solar PV installed were asked a number of questions to better understand the timing of their solar and storage purchases and the influence of the decision to purchase one of the technologies on their decision to purchase the other. As shown in Table 4-3 below,[7] roughly half of residential respondents reported they purchased the two technologies at the same time (52 percent[8]), and just less than half reported they had purchased the solar PV before the storage (44 percent). The remaining 3 percent reported they purchased solar PV after they purchased storage.

[7] The results shown below are for residential host customers only as there were only 11 nonresidential customers asked this series of questions.

[8] A portion of these respondents (8 percent) reported having some solar installed prior to installing the storage and then adding additional solar at the time the storage was installed.

This table also shows host customers reported influence of their decision to purchase one of the technologies on their decision to purchase the other. As this table shows, the largest share of customers reported that solar influenced their decision to install storage (solar they purchased before storage, 37 percent, or solar purchased at the same time as storage, 15 percent). Another third of the respondents (31 percent) reported they made a joint decision to purchase the two technologies. The remaining host customer respondents reported that either the storage influenced their decision to get solar (7 percent) or that neither of the technologies influenced their decision to purchase the other technology (10 percent). About half of the respondents who reported that solar influenced their decision to install storage also stated that without the solar they would not have purchased storage.

TABLE 4-3: RESIDENTIAL HOST CUSTOMER TIMING AND REPORTED INFLUENCE BETWEEN SOLAR AND STORAGE PURCHASES

Timing of Solar and Storage Purchases	% of Respondents	Reported Influence of One Technology on the Other	% of Respondents
Solar and Storage Purchased Together	52%	Was a Joint Decision to Purchase Solar and Storage	31%
		Solar Influenced Storage	15%
		Storage Influenced Solar or the Amount of Solar installed	6%
Solar Purchased before Storage	44%	Solar Influenced Storage	37%
		Solar did not Influence Storage	7%
Storage Purchased before Solar	3%	Storage Influenced Solar	1%
		Storage did not influence solar	2%

4.3 STORAGE SALES AND MARKETING

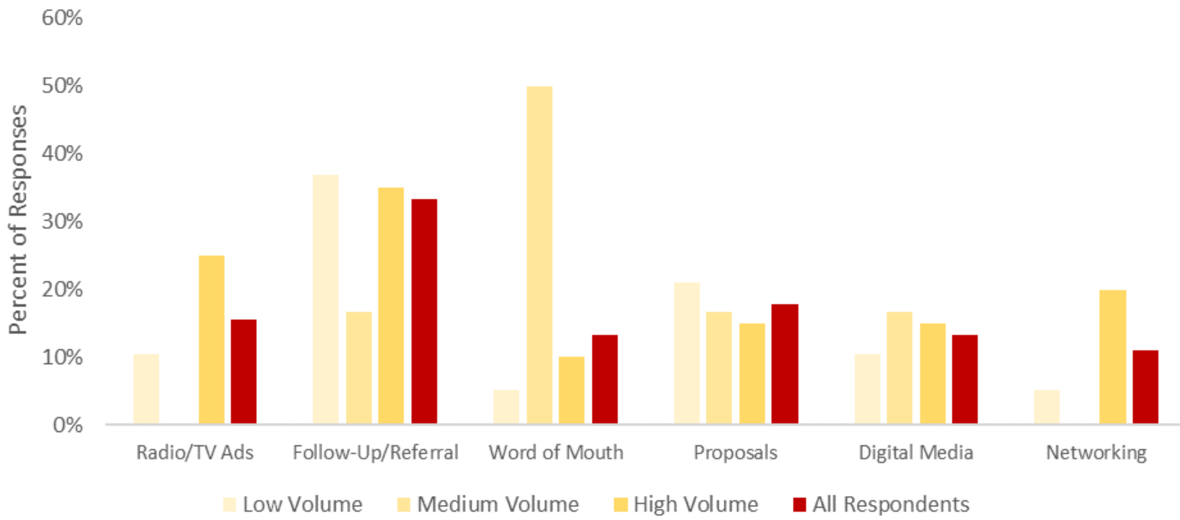
Specific sales strategies/tactics, and the key messaging used by developers to sell storage systems are highlighted in this section.

4.3.1 Storage Sales Strategies

Most developers serve Residential markets and use various methods to reach prospective customers. The most common approach leverages transactions with previous (existing) customers and involves either following up to see if they are interested in adding storage or asking them for a referral to attract other prospective customers. This was emphasized by all firm size segments. In addition, Low and Medium Volume firms rely on their company website and word-of-mouth to get the word out. High Volume firms tend to rely more heavily on mass market advertising methods such as TV, radio and online ads. Email blasts to those who had purchased a solar system during the recent past were also mentioned. One High

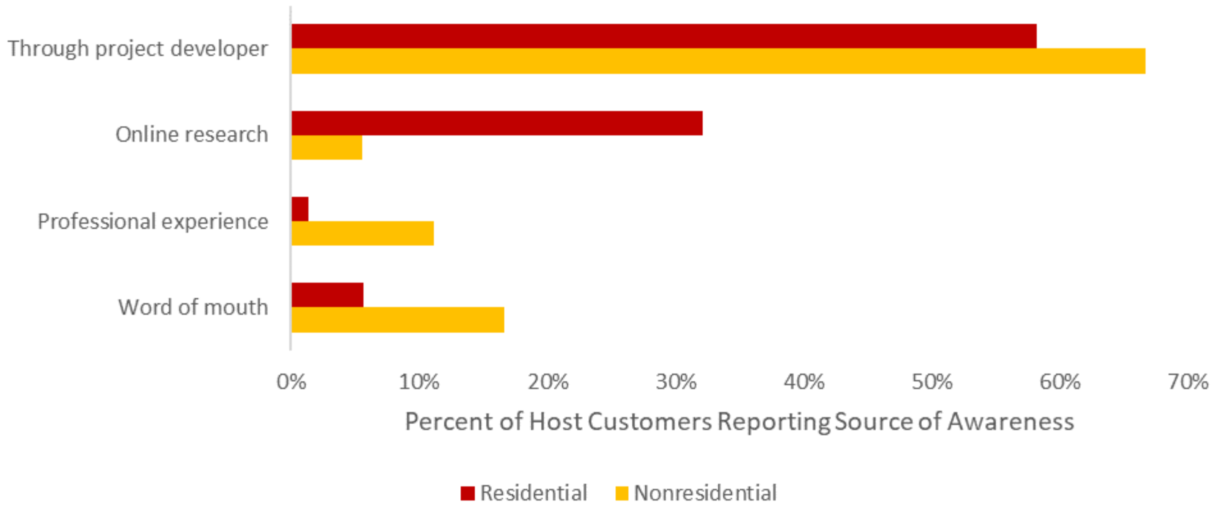
Volume firm that primarily serves the public sector cited heavy use of case studies and presentations at trade shows.

FIGURE 4-10: SALES APPROACHES USED BY DEVELOPERS



Host customers most frequently reported first learning about energy storage systems through their project developer (58 percent of residential and 67 percent of nonresidential). The second most common source of storage awareness is online research for residential customers (32 percent) and word of mouth for nonresidential customers (17 percent). Professional experience was also reported by 11 percent of nonresidential respondents.

FIGURE 4-11: SOURCES OF HOST CUSTOMER STORAGE AWARENESS



Awareness of storage was very high amongst the solar non-storage population, with 92 percent of solar non-storage customers reporting they had heard of storage that can be installed in homes or businesses. It is important to keep in mind these solar non-storage participants are CSI participants and thus have a much higher level of familiarity with distributed energy resources than the general population of utility customers. The most common means of awareness were by word of mouth (33 percent), online research (29 percent), or via a solar or storage vendor (22 percent). The customer's utility was reported for nine percent of nonresidential solar non-storage respondents and media was reported for nine percent of residential solar non-storage respondents. Those who had heard of storage were asked a follow up question regarding their depth of knowledge. Customers reported they heard storage was 'expensive to install' (25 percent), 'allows you to use more of the solar you generate' (17 percent), and 'can be used as backup during utility outages or emergencies' (15 percent).

In terms of success [conversion] rates for the sales methods used by developers, 15 percent to 20 percent was frequently mentioned by those that used digital methods, such as targeted online ads or email blasts. This represents the percentage of those contacted that went on to purchase a storage system. Most respondents were from High Volume firms who are more dependent on proactive sales methods than are those from Low and Medium Volume firms.

The most common circumstance where customers approach developers regarding the purchase or lease of energy storage systems is by those with a solar system that the developer previously installed. Responses varied widely on the subject of customer inquiries about storage. High Volume developers reported very few instances of their customers asking about storage. Low and Medium Volume firms reported this to be a more regular occurrence.

Most behind-the-meter storage systems are purchased rather than leased. Just four of the developers interviewed, all High Volume, reported offering leasing or leasing-type arrangements to promote adoptions of solar/BTM storage systems.

- Two High Volume developers provide financing for systems to nonresidential customers. These are similar to energy efficiency shared savings contracts where the customer uses the bill savings cash flow from the solar/storage installation to pay off the capital and installation cost of the equipment.

The host customer survey found that most residential systems (93 percent) are purchased rather than leased. Conversely, nonresidential customers are more likely to lease the storage than purchase it (59 percent of those surveyed leased their system). Most storage adopters thought the cost of storage was reasonable (81 percent of residential host customers, 93 percent of nonresidential customers). A follow-up question asked host customers to describe the reasons why they felt the costs were reasonable or unreasonable. The most common explanation provided by respondents for why they thought the costs were reasonable included reference to "*the SGIP rebate and federal tax credit*". Other notable responses from host customers reporting the cost of storage was reasonable included:

- *I was willing to pay the full price of $6,150. After the incentive program, I ended up paying only $2,792.40. I am thrilled! (Residential Host Customer)*
- *One can't put a price on being without power. (Residential Host Customer)*
- *The reduction in demand charges pays for the lease with an additional savings beyond the charges. (Nonresidential Host Customer)*

Host customers who reported the cost was not reasonable gave the following reasons:

- *$6,200 for backup power just seems very expensive. Had the rebate not been offered I would not have purchased it. (Residential Host Customer)*
- *Although it doesn't quite make sense on a pure cost analysis basis, it makes sense to me in our efforts to help society and the planet. (Residential Host Customer)*
- *Although it was very expensive, I figure it may pay for itself in reduced line fees and help to use more of my stored solar instead of wasting it. (Residential Host Customer)*
- *The cost is higher than anticipated, and the payoff calculations are always forecasted to be better than reality. (Nonresidential Host Customer)*

The cost of storage was also assessed within the solar non-storage participant survey. Respondents were asked to report the maximum amount they would pay for battery storage that provides their power needs for several days or more during a power outage. The responses ranged from $0 to $10,000, but the average (with the $0 removed) was $3,800. It was surprising to find that the willingness to pay amount was slightly lower for those living in high/moderate wildfire areas ($3,200, n=21) and slightly higher for those who had considered purchasing backup generation ($4,400, n=19).

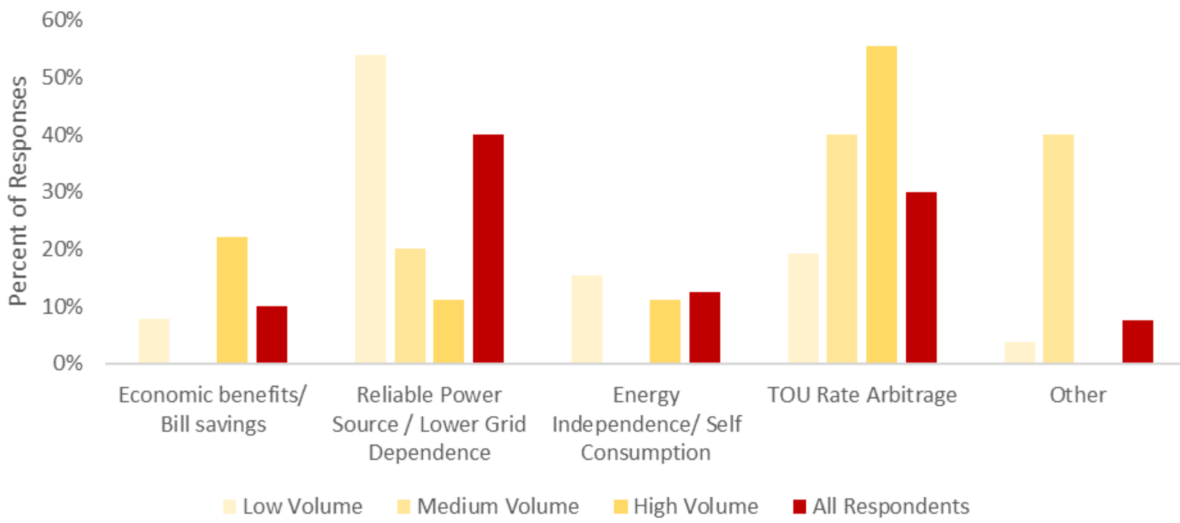
Most residential customers reported the length of their lease was between 10 to 20 years (97 percent), with 20 years being the most common response (70 percent). Nonresidential leases are shorter with 56 percent reporting lease periods of 10 years or less. Both residential and nonresidential customers estimated the lifetime of their storage systems to be around 18 years.

4.3.2 Storage Marketing Messages

Economic and reliability benefits are most often mentioned by developers of residential storage systems when promoting purchases of energy storage systems. Economic benefits include energy bill savings, TOU arbitrage/load shifting benefits, the SGIP incentive, and the federal Investment Tax Credit. Regarding TOU rate arbitrage, storage systems enable customers to offset loads when mandated TOU-based prices are highest during peak periods. Another benefit promoted less often through sales messaging is energy independence/self-consumption of solar generation. Developers tailor the sales message to the specific circumstances of the buyer.

It is interesting to note the differences between residential High Volume firms and Low/Medium Volume firms regarding sales messaging. High Volume firms are much more likely to mention the economic benefits, bill savings and TOU arbitrage ability afforded by storage, whereas Low/Medium Volume firms are more likely to highlight reliability and energy independence themes.

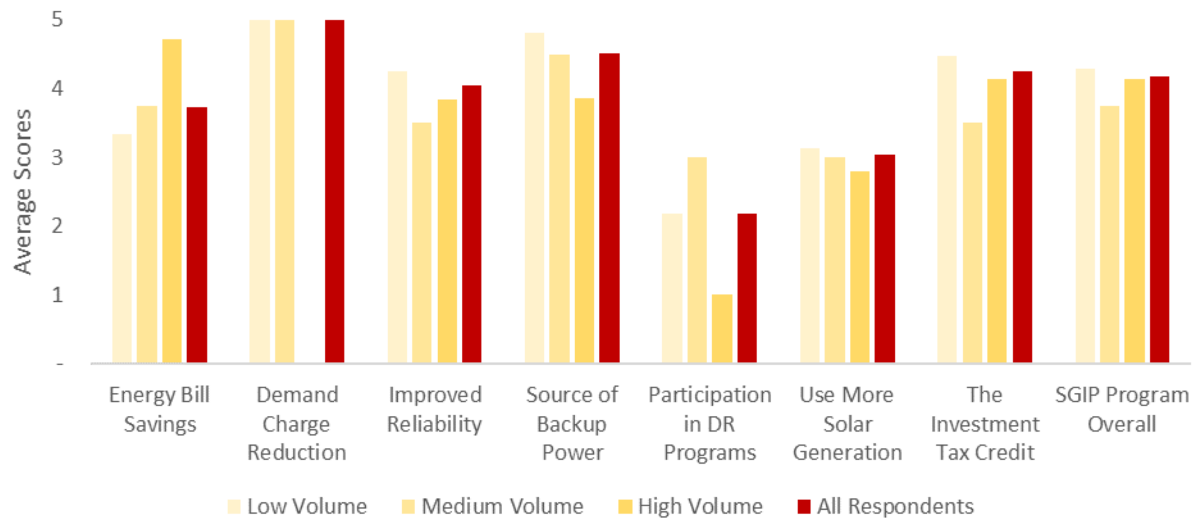
FIGURE 4-12: BENEFITS HIGHLIGHTED WHEN SELLING BTM STORAGE SYSTEMS



For firms selling nonresidential storage systems (n=2), the main messaging is regarding potential bill savings. Firms also highlight the availability of backup power, the clean energy technology aspects, and the resource flexibility afforded by storage.

These findings were corroborated by the importance ratings given by developers of residential storage systems to specific factors related to economic and reliability benefits, which were read to them during the survey process. The highest average scores were given to the demand charge reduction (note there were only two respondents), the SGIP program (and incentive), the federal Investment Tax Credit, and the provision of backup power during an outage as shown in Figure 4-13. These findings indicate the critical importance perceived by developers of residential storage of key economic and reliability factors in storage system purchases.

FIGURE 4-13: AVERAGE IMPORTANCE SCORES FOR SPECIFIC BENEFITS OF BTM STORAGE SYSTEMS



Benefits Described by Host Customers

Host customers were asked a series of questions to determine the primary benefits described by their vendor prior to their purchase of the energy storage systems that they went on to install. As shown in Table 4-4 below, the primary benefits recalled by residential customers were energy bill savings, improving the reliability of their electric supply, and the ability to use more of their own solar (all reported by 63 percent of respondents). For nonresidential customers, the primary benefit of storage they recalled their vendor describing was the ability to use the storage system to reduce their demand charges, which was reported by 89 percent of nonresidential respondents. This aligns with developers' statements regarding primarily targeting their nonresidential sales efforts to nonresidential customers that have a high potential for significant bill and demand charge savings by installing storage. Their targeting appears to have been successful, as 94 percent of nonresidential customers on rates with demand charges reported successfully being able to reduce them.

TABLE 4-4: PRIMARY BENEFITS DESCRIBED BY STORAGE EQUIPMENT VENDOR

Benefits of Storage	Residential Host Customers	Nonresidential Host Customers
Energy Bill Savings	63%	84%
Improving the reliability of your electric supply / backup	63%	37%
Ability to use more of your own solar	63%	21%
Investment tax credit	50%	26%
Environmental benefits such as a reduction in GHG emissions	38%	53%
Participation in a Demand Response program	16%	37%
Reduced Demand Charges	0%	89%

Estimated Energy Savings

Host customers who recalled their vendor describing energy bill savings as a benefit of installing storage were asked what percentage of bill savings they recalled the vendor claiming. Most respondents did not recall the estimated savings amount (72 percent). However, for those that did recall it, the potential bill savings reported they ranged from 1 percent to 400 percent.[9] The average bill savings percentage reported was just under 75 percent. These large values likely account for the contribution of solar to the savings of a solar + storage system.

Costs Described

The primary cost host customers recall equipment vendors describing across both residential and nonresidential customers was the cost of the storage system. Nonresidential customers were equally likely to recall vendors mentioning the cost of installing the storage and maintenance on the storage. The costs of nonresidential storage systems are much larger than for residential simply due to their size and complexity. Nonresidential customers are typically more focused on costs in their decision making and thus it is not surprising that vendors and customers are more likely to focus on, and remember, many of the individual component costs of storage.

9 Our hypothesis is that reported energy savings greater than 100 percent (which were provided by 2 respondents) are likely due to the respondents anticipated profits resulting from selling energy back to the IOU.

TABLE 4-5: PRIMARY RECALLED VENDOR DESCRIBED STORAGE COSTS

Recalled Vendor Described Costs of Storage	Residential Host Customers	Nonresidential Host Customers
Cost of storage system	74%	74%
Cost of installation	68%	74%
Interconnection costs	32%	63%
Maintenance costs	16%	74%

Economics of Alternative System Configurations

Most host survey respondents (67 percent residential, 79 percent nonresidential) did not recall the storage equipment vendor providing them with economic analyses for any system configuration other than the one they purchased. Nearly 30 percent of those who installed solar and storage reported the equipment vendor provided them the economics of solar PV only, and just 4 percent said they were provided the economics of storage only.

Payback and Rate of Return

Roughly 45 percent of host customers recalled that the vendor who sold or leased them their storage system calculated the payback period on the system, whereas only 14 percent reported the vendor calculated the rate of return. A somewhat higher percentage of nonresidential customers (26 percent) remembered being provided a rate of return. Most host customers who recalled the vendor providing the rate of return on the storage system did not remember what the estimate was (76 percent). Those who did recall it reported an average rate of return of 24 percent. The majority of host customers who recalled the estimated payback period for their storage system reported it was in the 10 to 15-year range.

Net Energy Metering Findings

For customers that purchase storage in conjunction with solar, virtually all developers discuss Net Energy Metering and explain how it works. For High Volume firms, this is part of a broader discussion about tariffs in general.

- *We tell them how the program works. You produce more during the day then that power is being sent to the grid and you get the retail rate for that. It balances out. So, Net Metering is kind of like a battery that way.*
- *How it works. How you get credit for the kWh you are not using. And, how it is dependent on time-of-use.*

Responses from the host customer survey support the developer findings regarding Net Metering being a selling point that vendors use when explaining the benefits of solar and storage to host customers. Three fourths (75 percent) of residential host customers and over half (57 percent) of nonresidential host customers recalled their vendor discussing Net Metering with them. Many residential customers reported that they already knew about Net Metering or already had it (with their previously-installed solar). Host customers offered the following statements regarding Net Metering:

- *Net metering reduces my electric bill by allowing me to obtain credits for exported power equal to my imported power for loads.*
- *That I could essentially sell the energy back to the grid at the highest value and use it at the lowest.*
- *One gets credit for excess electricity generated, since my meter can run backwards.*

Time of Use (TOU) Rate Findings

For customers that purchase storage in conjunction with solar, developers discuss the ability of storage to offset usage from 4 pm to 9 pm when solar production is reduced but high peak rates are still in effect.

Several offered the following comments:

- *We provide them with the information that instead of selling their energy to the utility they can store it and use it themselves during the peak period instead of purchasing expensive energy from the grid.*
- *Yes. I tell them how it has changed and that those rates can change, and it will have an effect on the payback. That it may have an effect on the payback in the future.*
- *Yes, and that with the most recent change to our Time of Use billing in California and with new customers being forced onto Time of use immediately, storage is the only way to avoid the negative impacts.*
- *We don't model changing TOU rate structures proactively, there's no good tool to do the modeling. Available models don't take into consideration current situation, interval data, solar data (real life). People don't have online access to interval data (can do for $10/pull, super expensive given 2000 pulls/month). We do use the changing Time-of-Use rates as a sense of urgency play for why to get battery in now.*

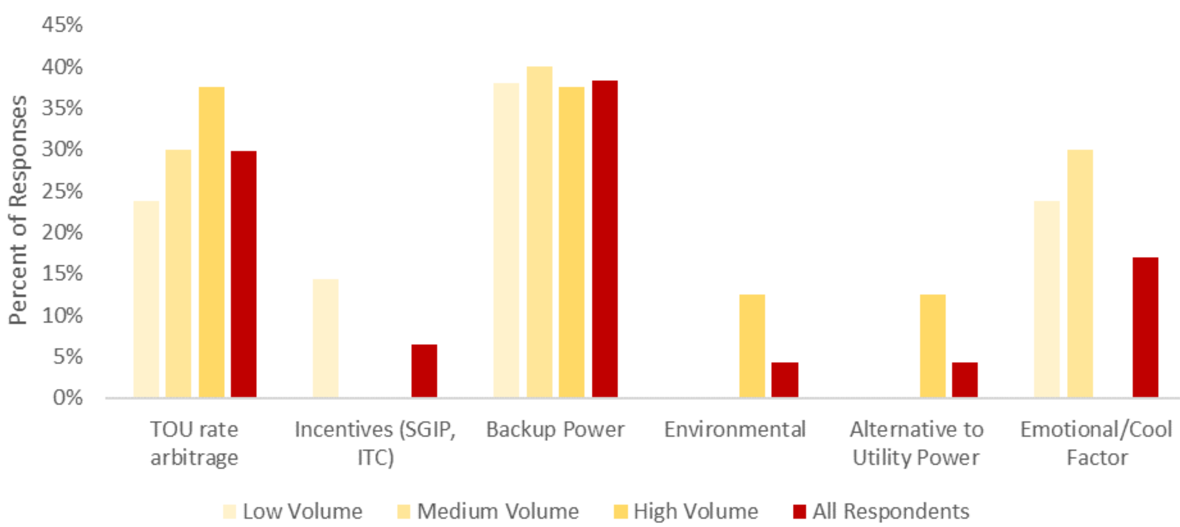
Roughly half of host customer respondents (53 percent) recalled their vendor providing them with information about the impact of TOU rates on the economics of their storage system.

4.4 PERCEIVED BENEFITS OF STORAGE SYSTEMS

The motivations for purchasing and installing storage are discussed in this section. Developer and Host Customer survey findings are consistent regarding the rationale for installing storage in general.

Developers of residential storage projects believe the most important current and near-term drivers to customer adoption of storage systems are centered around the perceived need for backup power and having the ability to respond to high TOU prices (see Figure 4-14 below). Another driver mentioned by Small and Medium Volume firms serving residential customers was the “cool” factor of owning a storage system (paired with solar). Backup power is perceived as a key driver of residential storage system purchases by all size categories, whereas TOU rate arbitrage is considered important more often by High Volume firms. This is consistent with sales messaging content where Low/Medium firms emphasize reliability, while High Volume firms highlight factors affecting project economics.

FIGURE 4-14: NEAR-TERM DRIVERS OF STORAGE SYSTEM PURCHASES (RESIDENTIAL DEVELOPERS)



In contrast, economic motivations drive storage system adoptions by nonresidential customers (n=2 completes). These customers’ decisions are primarily financial in nature, and if the project economics do not meet their requirements, they do not move forward. Secondary motivations by nonresidential customers are reliability and sustainability.

4.4.1 Main Drivers and Motivations for Installing Energy Storage

Host customers were asked the primary reasons they decided to install either standalone energy storage or energy storage paired with solar PV. The question was first asked as an open-ended question to isolate the primary driver they recalled without any prompts, and then followed up with a second close-ended question, that included a pre-defined list of additional potential motivations to capture all of the main drivers in their storage decision-making.

The top five primary motivations reported by residential customers to the open-ended question were:

- To provide resilient backup power for emergencies or outages (45 percent)
- To save money on their electric bill (31 percent)
- For environmental reasons (19 percent)
- To become less grid dependent (17 percent)
- To respond to TOU price signals (10 percent)

Nonresidential host customers reported the following factors as their top five motivations to the open-ended probe:

- To save money on their electric bill (53 percent)
- To reduce their demand charges (32 percent)
- For environmental reasons (16 percent)
- To save energy (16 percent)
- To shift load from on-peak to off-peak periods (16 percent)

It is interesting to note that of the top five reasons reported by residential and nonresidential customers, only two were reported under both question structures (bill savings and environmental reasons). The table below presents residential and nonresidential host customers' primary motivations, based on both open and closed-ended responses for installing battery storage in their homes or businesses.

TABLE 4-6: PRIMARY MOTIVATIONS FOR INSTALLING BATTERY STORAGE

Motivations for Installing Battery Storage	Residential Host Customers	Nonresidential Host Customers
To provide backup/emergency power	90%	11%
To save money on electric bill	77%	89%
To become less grid dependent	68%	21%
To receive the SGIP incentive or federal investment tax credit	61%	53%
To use more of the solar energy we generate	61%	16%
To reduce greenhouse gas emissions	59%	58%
To shift load in response to time-of-use price signals	46%	26%
To help the grid by shifting load from on-peak to off-peak times	46%	42%
To benefit from net energy metering	36%	21%

Roughly two-thirds of residential solar non-storage participants and 40 percent of nonresidential solar non-storage participants have considered installing battery storage in their home or business. The most frequently reported drivers reported by solar non-storage participants for considering storage were the same as those reported by host customers. It is interesting that only one-fifth of solar non-storage participants mentioned the SGIP incentive and only seven percent reported the federal investment tax credit (versus 43 percent of residential host customers), which likely indicates a lack of familiarity with the incentives that are available to significantly bring down the cost of storage to customers.

TABLE 4-7: SOLAR NON-STORAGE PARTICIPANT PRIMARY PERCEIVED STORAGE BENEFITS

Drivers for Installing Battery Storage	Residential Solar Non-Storage Participants	Nonresidential Solar Non-Storage Participants
To provide backup/emergency power	63%	45%
To save money on electric bill	47%	52%
To use more of the solar energy we generate	30%	12%
To become less grid dependent	27%	17%
To shift load in response to time-of-use price signals	23%	21%
To receive an incentive through the Self Generation Incentive Program	18%	21%
To reduce greenhouse gas emissions	14%	5%
To help the grid by shifting load from on-peak to off-peak times	13%	14%
To receive the federal investment tax credit	7%	7%
To benefit from net energy metering	36%	26%

4.4.2 Importance of Economic Factors

Host customers were also asked to rank how important economic factors were in their decision to install battery storage on a 1 to 5 scale, where 1 is not at all important and 5 is extremely important. As shown in the table below, both residential and nonresidential customers ranked economic factors very highly on average (4.4 and 4.7). Note that the 90 percent confidence interval for nonresidential customers is larger than for residential customers due to the small number of completed nonresidential surveys.

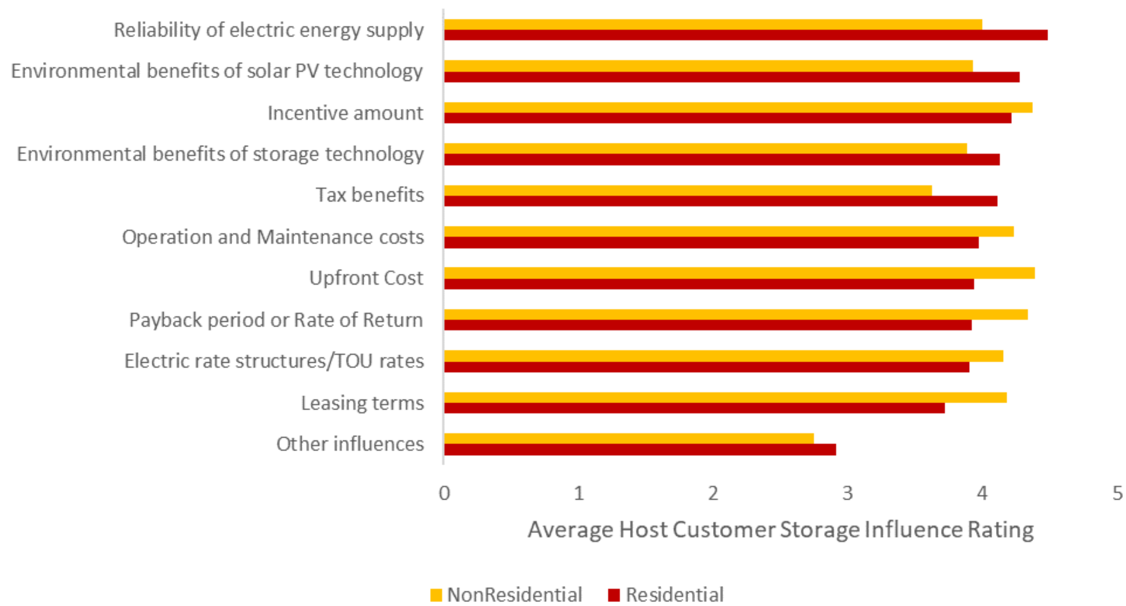
TABLE 4-8: HOST CUSTOMER REPORTED IMPORTANCE OF ECONOMIC FACTORS

Importance of Economic Factors	Average Score (1-5 Scale)	Lower 90% CI	Upper 90% CI	% of HC Ranking a 5
Residential	4.4	4.3	4.4	58%
Nonresidential	4.7	4.4	4.9	78%

4.4.3 Energy Storage Decision Influences

Host customers were asked to rate the importance of several factors in their decision to purchase storage or solar PV/storage, using the same 1-to-5 scale. As shown in the figure below, the highest scored factors for residential customers (reliability of the electric energy supply and environmental benefits of solar PV technology) were different from the highest scored factors for nonresidential customers (upfront cost and incentive amount). “Other influences” received the lowest scores and consisted of various decision factors such as the desire to self-use more of the clean renewable energy they produce, to have the latest technology, to increase the resale value of their home, and positive association from recommendations they received from friends and family.

FIGURE 4-15: AVERAGE HOST CUSTOMER STORAGE DECISION INFLUENCE IMPORTANCE RATINGS



4.5 PERCEIVED BARRIERS TO STORAGE SYSTEM ADOPTION

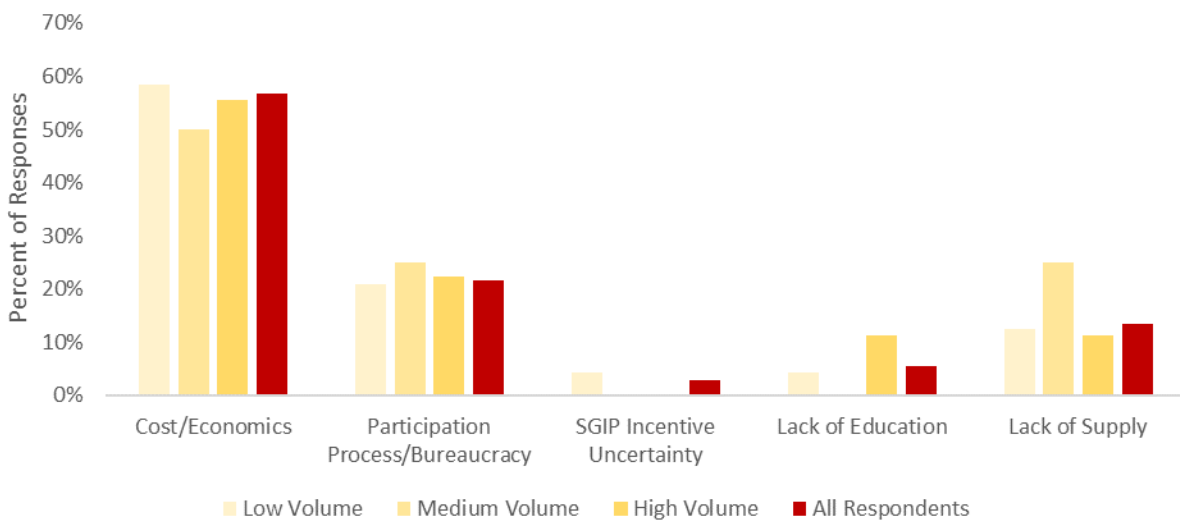
Another consideration for storage system developers and customers is the presence of barriers in the market, such as up-front cost, lack of awareness, program requirements, and other factors. This section summarizes developer and nonparticipating customer concerns in this area.

The #1 barrier to storage system adoption reported by developers of residential storage systems is the up-front cost of the storage system and related unfavorable economics for the customer. High up-front cost and associated poor project economics is an issue for both residential and nonresidential systems. *[One firm mentioned: "it feels like we're only in the 2nd inning. Early solar had high cost also. The 10 kW battery cost is pretty high. CSI rebates really helped get the market going in California for solar, and to bring the cost down. We need something similar for SGIP, to get to 100 percent renewable." Another: "Cost. We have to make the math work. SGIP and ITC are incredibly helpful."]*

Other barriers of concern to residential system developers are the SGIP program's complex participation process, lack of customer education, and supply chain issues. The participation requirements and paperwork for the SGIP program are perceived as burdensome by all size firms. Lack of consumer education and the need to bring customers up what one firm referred to as the "steep learning curve" is primarily a concern for large size firms. Supply chain issues mainly relate to one manufacturer's supply shortages for their batteries, which have since been resolved.

Figure 4-16 below reports barriers of concern for residential storage system developers. Nonresidential storage developers (n=2 completes) spoke to concerns about the lack of education, and supply chain issues.

FIGURE 4-16: NEAR-TERM BARRIERS TO STORAGE SYSTEM PURCHASES (RESIDENTIAL DEVELOPERS)



Findings from the solar non-storage participant surveys are consistent with developer findings regarding up-front equipment costs being the primary barrier to installing storage. Roughly half of solar non-storage participants surveyed reported they had not considered installing storage (36 percent of residential solar non-storage participants and 60 percent of nonresidential solar non-storage participants). The primary reason provided for not installing storage was that it was too expensive (as shown in Figure 4-17). Solar non-storage participants were asked how significant various factors were in their decision not to install storage. The average significance ratings, on a scale of 1 to 5 where 1 is not at all significant and 5 is very significant, are provided in Figure 4-18 below. As this figure shows the most significant factor for both residential and nonresidential customers was cost (77 percent of residential solar non-storage participants and 82 percent of nonresidential solar non-storage participants ranked it a 5, mean rankings of 4.3 and 4.7). Space constraints were slighting more of a concern for residential customers than for nonresidential customers (2.9 vs 2.2, respectively). Energy reliability, safety, and the look of storage were also only moderate concerns (with mean significance ratings between 2.1 and 2.8).

FIGURE 4-17: MAIN REASONS SOLAR NON-STORAGE PARTICIPANTS PROVIDED FOR NOT INSTALLING STORAGE

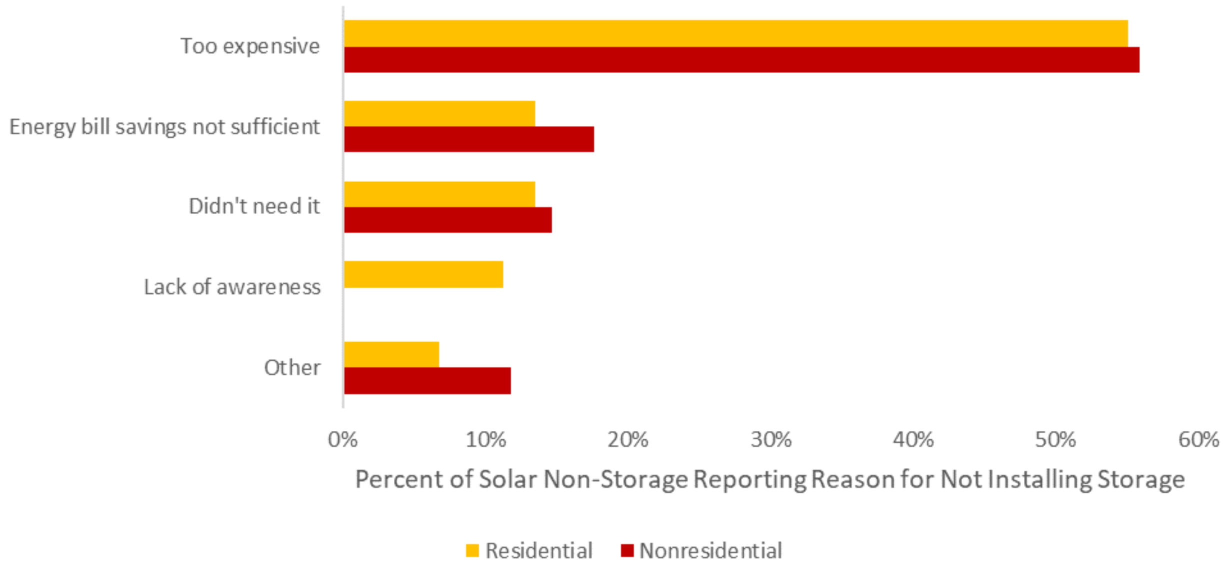
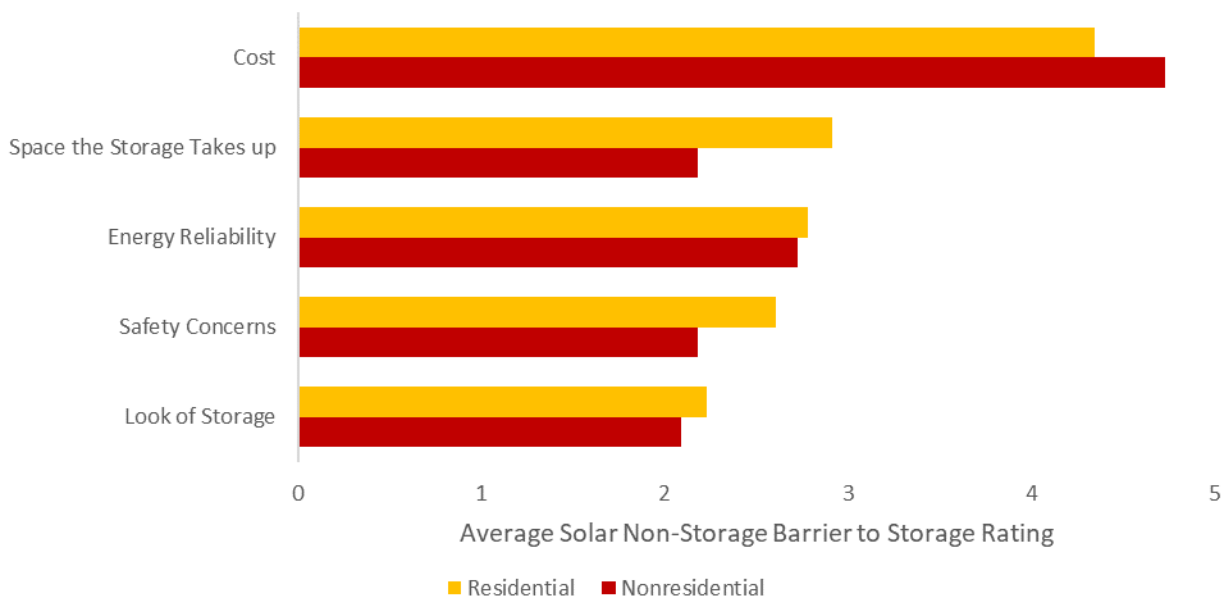


FIGURE 4-18: SOLAR NON-STORAGE SIGNIFICANCE RATING IN DECISION NOT TO INSTALL STORAGE



4.5.1 Nonresidential Decline in Nonresidential Storage Applications

Project developers offered their perspectives for the dramatic slowdown in the non-residential market. One developer suggested a combination of technology costs and nuances with the implementation of SGIP. According to this developer, most of the pre-2017 storage customers were early adopters that took advantage of the higher nonresidential incentives. The developer went on to say: "*SGIP incentives have dropped down fairly substantially from where they were initially. The remaining customers are more price sensitive. Also, there is uncertainty given the various staff proposals as to where SGIP is going. Current staff proposals are complex and exacerbate some of the problems. At the same time, various administrators are proposing some reforms to the handbook to streamline things."*

Another developer proposed an alternate theory on the commercial slowdown related to retail rates: "There's a *big problem - SCE option R - reduced demand charges and increased energy charges during the sunny part of the day."* Finally, a third developer cited changes in California's fire codes that *"made it nearly impossible to do indoor battery systems. This shrunk the available market to buildings that had sufficient outdoor space."*

4.6 STORAGE SYSTEM PERFORMANCE

Another important consideration is the performance of the storage system. This speaks to whether customers are realizing the benefits they expected based on the actual operation of their storage system. Findings are discussed below.

Host customers who reported being very (51 percent) or somewhat (45 percent) knowledgeable about the operation of the storage systems operation since installed were asked a series of questions regarding how it has performed to date.

Most host customers are realizing the benefits they expected from their storage systems. Around 90 percent of host customer reported they were getting all or most of the benefits they expected from their storage (and solar) system. Approximately 5 percent of host customers reported it was too soon to tell. The primary benefits residential host customers reported realizing included:

- Backup
- Saving money
- Positive impact on ability to shift load or respond to time-of-use rates
- Reduced grid dependence

Benefits reported by nonresidential host customers included:

- Reducing demand charges
- Saving money on their electric bill
- Continue with operations during outages
- Helped with demand response performance

Residential host customers that were not getting all of the benefits expected from their storage systems reported:

- *Would really like to fill system during off-peak and supply grid in on-peak. Do not like the requirement to only fill system from solar. This is especially troublesome in the winter.*
- *Does not provide as much an energy as I thought it would have.*
- *I was expecting to see lower electric bills and am not happy with the number of solar panels we are allowed to install.*
- *I am only getting some of my expected benefits, as [my utility] has changed the TOU rates at least four times (to enhance their profits) since I originally purchased my solar system.*
- *I don't think so. I generate a lot more power than I use, yet every year I have to pay a huge amount in the true up. I think [my utility] is ripping me off or something is off.*
- *I would like the ability to charge the Powerwall from the grid to help with peak shaving.*
- *No, [developer] limits battery usage to summer peak time hours only. The rest of the days and year it is idle. Big waste of money. [Developer] provides misinformation regarding battery usage and benefit. The CPUC should crack down on solar companies for false advertising.*

Nonresidential host customers that were not getting the benefits expected from their storage system reported:

- *Our power demand has varied significantly in magnitude during the expected peak hours and also in YOY demand. Our machine learning has not been monitored by in-house staff until recently. The savings were about equal to fees in the first year, but the second year saw significant reductions in savings. In fact, [developer] is now selling energy back to the grid on our behalf to help offset their losses on our savings guarantee. I believe savings can be returned to an amount that covers our fee and more with more input from our engineering staff to keep the [developer] bank informed on a weekly basis of our expected power usage. We will be testing this theory soon.*

- *No. [Developer A] went out of business and [Developer B] has chosen to remove the [Site Location A] battery. The [Site Location B] battery has sat idle for two years. No savings. We are hoping to activate, but [Developer B] is requiring us to purchase the system and pay an annual service fee.*

Nearly all nonresidential customers have been able to successfully reduce their demand charges (94 percent). As mentioned above, demand charge reduction is a primary reason that nonresidential customers install battery storage and also a selling point used by vendors to promote storage. Some customers went so far as to say that their bill savings from reducing their demand charges were enough to offset the cost of the storage. Analyzing the demand charge portion of customers' bills may be an effective way of targeting good candidates for nonresidential storage installation and increase the uptake in this budget category. Most nonresidential customers surveyed reported they were on rates with demand charges.

The majority of residential customers (86 percent) reported they had programmed their energy storage systems to shift their load from on-peak to off-peak and nearly all (96 percent) perceived they had been successful. Nonresidential customers are much less likely to report having storage systems programmed for TOU arbitrage (30 percent) and were also less successful when they did (only 25 percent were successful).

TABLE 4-9: HOST CUSTOMER SELF-REPORTED[10] ABILITY TO SHIFT LOAD OFF-PEAK

Load Shifting to Off-Peak	Residential	Nonresidential	Storage and Solar	Storage Only
Have successfully shifted load to off-peak	84%	8%	82%	65%
Have not successfully shifted load to off-peak	3%	23%	3%	18%
Have not attempted to shift load to off-peak	13%	69%	14%	18%

4.6.1 Loads Tied to Storage

Host customer respondents were asked about the fraction and types of loads tied to their storage system. The majority of respondents reported either their whole home/building was connected or that their whole home/business minus one specific load was connected. Most frequently the excluded load was an air conditioner, but car chargers and pool pumps were also called out as the one load not connected. About one-third of respondents reported they only had select or "essential" loads connected to their storage.

[10] This was self-reported by survey respondents and has not been verified by the evaluators.

4.6.2 Alternatives to Storage

Overall, only 20 percent of host customers considered other alternatives to storage. The rate amongst the Storage Only population was significantly higher at 30 percent. Nonresidential customers were asked what alternatives to storage they considered, and they reported backup generation,[11] solar PV, and fuel cell technology. More than one-third (36 percent) of residential host customers and 50 percent of residential solar non-storage participants reported they had considered installing a backup generator. Environmental reasons were most commonly cited for why storage was chosen over other alternatives.

4.6.3 Emergency Power

Overall, 68 percent of host customers reported having experienced power outages since installing storage. The reported outage rate is significantly higher for those with storage only versus those with both storage and solar (88 percent compared to 67 percent). The performance of the storage during outages varies significantly between residential and nonresidential customers. The majority (84 percent) of residential host customers reported that the storage "worked perfectly" or "as expected" and only 7 percent reported it did not work. Notably, a higher share of nonresidential customers said it didn't work (25 percent) and only 42 percent reported it worked as expected.

4.6.4 Satisfaction with Operation of Storage Systems

Host customers were asked to rate their satisfaction with the operation of their storage system and overall, they reported being extremely satisfied as indicated by an average satisfaction rating of 4.5 on a 5-point scale. Only 3 percent of respondents reported they were not satisfied (score of 1 or 2 out of 5) and the primary reason for their dissatisfaction was that the storage system is not working as expected. Other reasons for dissatisfaction included:

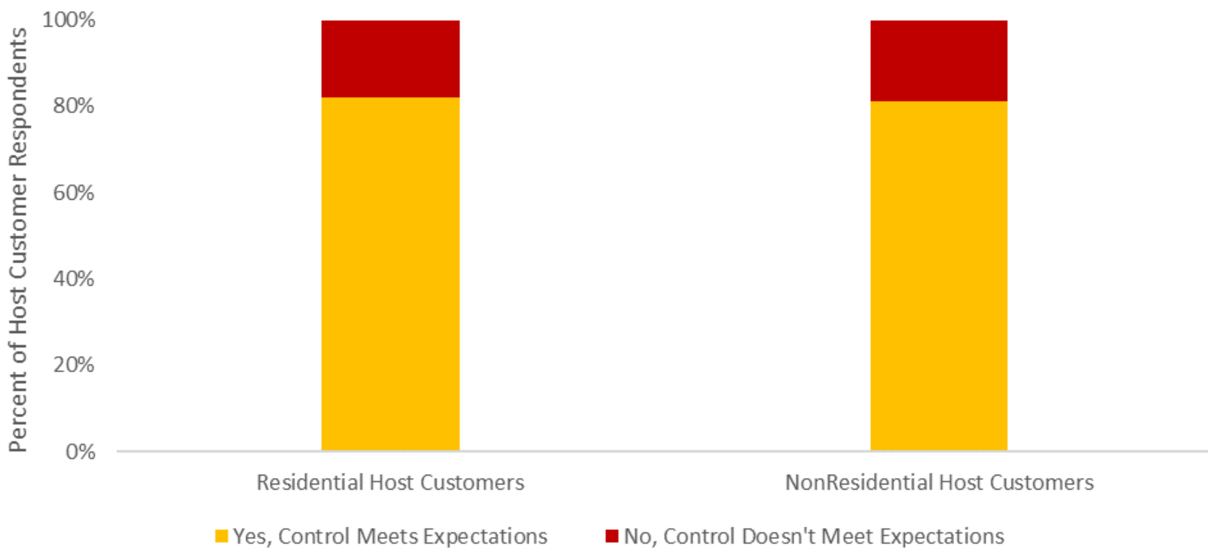
- *Would like more control over their system and independence from the grid*
- *Time of use issues*
- *Not seeing expected financial savings*
- *Dealer misrepresentation of battery storage capabilities*

[11] Roughly one-third of nonresidential solar non-storage customers reported they had considered installing a backup generator. They were not asked about other alternatives to storage.

4.6.5 Controllability of Storage System

While some customers are displeased with their level of control over the operation of their storage system, overall more than 80 percent of both residential and nonresidential host customer respondents reported that the controllability of their systems meets their expectations.

FIGURE 4-19: SATISFACTION WITH LEVEL OF CONTROLLABILITY OF STORAGE SYSTEM



4.6.6 Satisfaction with Storage System as Installed

Respondents are extremely satisfied with their storage systems as installed (i.e. the aesthetics/size/location of the system), with an average satisfaction rating of 4.6 on a 5-point scale. Only 3 percent of respondents are not satisfied (score of 1 or 2 out of 5) and the primary reason for their dissatisfaction is that the unit is aesthetically unappealing or overly bulky.

4.7 EFFECT OF SGIP ON STORAGE MARKET

The presence of the SGIP is a major factor that has influenced the market for behind-the-meter energy storage in California. Specific findings related to SGIP program influence are presented below.

The SGIP program is an extremely important part of project developers' business models in California. Virtually all Low and Medium Volume firms and over half of High Volume firms reported that 100 percent of their storage installations are in California. On average, California installations account for 100 percent of Small and Medium Volume firms' storage sales, and 89 percent of Large Volume firms' storage sales.

Project developers report that most California storage projects are incentivized through the SGIP. By firm size, the reported share of projects incentivized through SGIP are: Low Volume – 87 percent, Medium Volume – 100 percent and High Volume – 98 percent. The SGIP program and incentive are strongly promoted by developers, however, some customers decline to go through the program. Reasons for not participating in SGIP include being waitlisted, receiving outside funding such as grants, and avoiding the hassle of applying for incentives.

Most developers believe it would be extremely difficult to sell storage projects without the SGIP incentive. Among their comments:

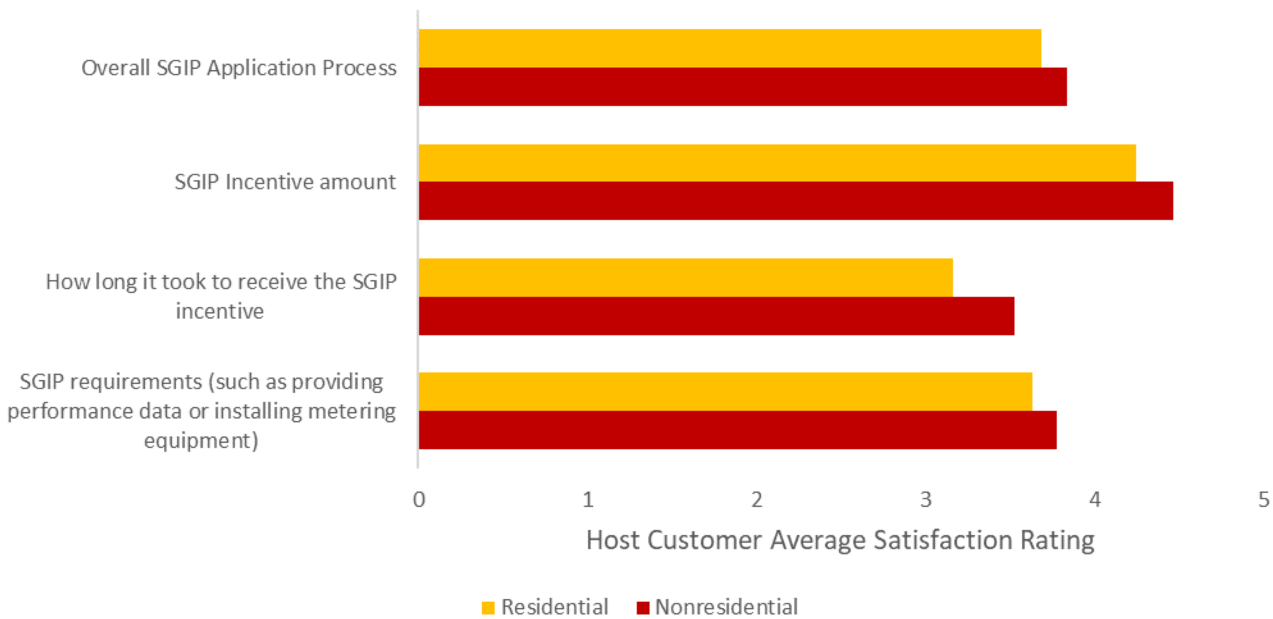
- *It would be very challenging. Even with the SGIP incentive, it is hard to sell. On the commercial side, economics is the driver, if SGIP goes away, would crash the Commercial market and be a big step back for the industry. On the residential side – it helps sell systems, but some customers would still buy (those that want resilience and solar self-consumption). To the extent CPUC has keen interest in keeping digital divide, the program keeps storage within reach of average consumer. (High Volume developer)*
- *We would have close to zero sales. If SGIP never existed, probably five percent sales, by those that have the money. (High Volume developer)*
- *Gut says it would be twice as hard to sell, but still see decent adoption for folks that are going on the waitlist. (High Volume developer, referencing the exhausted residential budget in CSE's service territory)*
- *It was harder a couple years ago, getting easier. (High Volume developer)*
- *We are selling them all without SGIP. But, we would be selling twice as much if SGIP was better. (Low Volume developer)*
- *It wouldn't be a game changer. But, 40 percent-50 percent wouldn't install storage without the rebate. (Low Volume developer)*

Host customers reported the incentive amount was very important to their decision to purchase storage. Nearly 80 percent of residential host customers and 90 percent of nonresidential host customers ranked the incentive amount a 4 or a 5 on a 1-5 importance scale.

4.7.1 Satisfaction with Program Elements

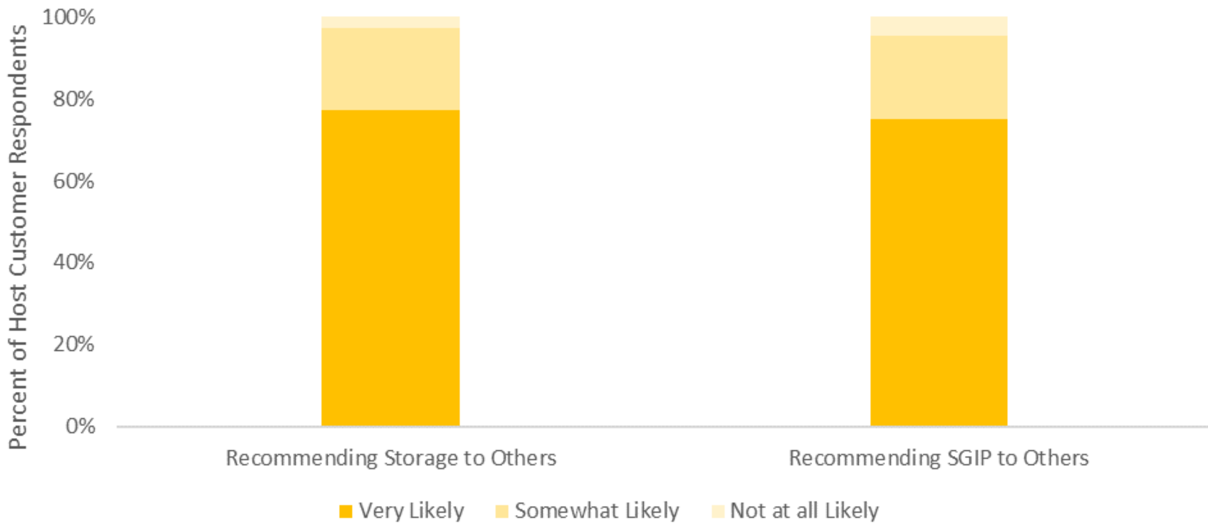
Host customers were queried regarding their satisfaction with several SGIP elements, including the SGIP application process, the SGIP incentive, the time it took to receive the incentive, and the program requirements. They were asked to rate each of these elements on a 1 to 5 satisfaction scale with 5 being "extremely satisfied" and 1 being "not at all satisfied". The average satisfaction ratings are shown below in Figure 4-20. While respondents are generally satisfied with the incentive amount (4.3 on a scale of 1 to 5), they are less satisfied with the length of time it took to get the incentive (3.2 out of 5).

FIGURE 4-20: HOST CUSTOMER SATISFACTION WITH VARIOUS SGIP ELEMENTS



Past SGIP Participants Highly Likely to Recommend Storage and the SGIP to others. This study found host customers experiences with the energy storage systems installed through the SGIP were overwhelmingly positive and led nearly all host customer respondents (97 percent) to report they would likely recommend storage to others (the vast majority, 77 percent, are very likely to recommend it). The high levels of satisfaction with various SGIP elements are corroborated by host customers reporting high likelihood of recommending the SGIP to others (95 percent).

FIGURE 4-21: HOST CUSTOMER LIKELIHOOD OF RECOMMENDING STORAGE OR THE SGIP TO OTHERS



5 COST-EFFECTIVENESS APPROACH

This section summarizes the sources of data and methodologies used in the cost-effectiveness component of this study. The discussion of the cost-effectiveness approach is divided into the following sub-sections:

- Overview of approach
- Discussion of cost-effectiveness tests
- Key Inputs

5.1 OVERVIEW OF APPROACH

This project was completed as a sensitivity analysis of Self-Generation Incentive Program (SGIP) benefits and costs in response to changes in program or tariff design. The purpose of this analysis is to test how various changes can impact the cost-effectiveness tests performed on the SGIP. The results can be considered indicative of ways to improve the program but are not actual evaluations of the program. The analysis can help determine whether specific elements of an incentive program should be continued in their current form or be altered in some way to achieve desired outcomes. More broadly, this cost-effectiveness analysis allows insights into the effects of rate structures, incentive levels, and other policies on costs and benefits of storage technologies being implemented by the SGIP. The results of this analysis can inform future program design as to possible tools that could improve cost-effectiveness results.

In 2009, the CPUC adopted an evaluation framework and methodology for assessing cost-effectiveness of distributed generation (DG) technologies.[1] The DG cost-effectiveness methodology is derived from the Standard Practice Manual (SPM) first published in the 1980s and used for several decades in evaluating energy efficiency technologies and programs.[2] The 2009 CPUC decision on DG cost-effectiveness provides specific guidance on the tests to be used, the costs and benefits to be included in each test, and the avoided cost inputs to be used when calculating program costs and benefits. While the 2009 CPUC decision on DG cost-effectiveness does not reference energy storage, we have followed the guidance in this decision and adopted it accordingly for energy storage.[3]

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[1] CPUC, "Decision Adopting Cost-Benefit Methodology for Distributed Generation," Decision D.09-08-026, August 20, 2009

[2] CPUC, California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects, October 2001: https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

[3] This approach was implemented for the first time in the Itron 2015 SGIP Cost-Effectiveness Report. https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7889

This analysis considered the cost-effectiveness of energy storage using five distinct tests:

- The Participant Test (PCT) is the measure of the quantifiable benefits and costs to the customer due to participation in the program.
- The Ratepayer Impact Measure (RIM) Test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program.
- The Total Resource Cost (TRC) Test measures the net costs of a program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.
  - The Societal TRC (STRC) is a variant of the TRC test that uses a lower societal discount rate.
- The Program Administrator (PA) Cost Test measures the net costs of a program as a resource option based on the costs incurred by the PA (including incentive costs) and excluding any net costs incurred by the participants.

The May 2019 CPUC cost-effectiveness decision (D. 19-05-019) designated the TRC test as the primary cost-effectiveness test and adopted modified versions of the TRC, PA, and RIM tests for all distributed energy resources starting July 2019.[4] The cost-effectiveness analysis undertaken for energy storage is consistent with Decision 19-05-019, highlighting the TRC and presenting results from the five distinct tests (TRC, STRC, PA, RIM and PCT).

The five cost-effectiveness tests listed above were applied to a variety of uses cases involving SGIP-eligible storage systems. Each use case represents the ideal dispatch of an energy storage system based on a combination of the following factors:

- Customer class (residential, nonresidential)
- Customer load shape
- Technology characteristics (e.g., storage system size, efficiency)
- Customer retail rate
- Other factors such as participation in demand response (DR) or the presence of a greenhouse gas (GHG) co-optimization signal

[4] CPUC, Decision 19-05-019, Decision Adopting Cost-Effectiveness Analysis Framework Policies for all Distributed Energy Resources, May 2019. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF

This cost-effectiveness analysis explores multiple combinations of these factors and quantifies the costs and benefits of each case using the five tests described above. The following subsections describe the key inputs to the cost-effectiveness tests in more detail.

5.2 KEY INPUTS

This subsection provides additional details on the following aspects of the cost-effectiveness analysis:

- Load shape characteristics
- Energy storage technology characteristics
- Customer retail rates and other signals
- Customer incentives and tax credits
- Utility avoided costs
- Program administrator costs
- Energy storage dispatch shapes

5.2.1 Load Shapes

We selected six nonresidential load shapes and two residential load shapes as the basis for this analysis. The load shapes were selected from the sample of customers included in the 2017 SGIP Energy Storage Impact Evaluation Report. Each customer had installed an SGIP energy storage system and had metered data available for the evaluation. Nonresidential customers in our sample had metered load data from the utility (including the effects of BTM storage) and storage charge/discharge data from vendors available in 15-minute intervals. We added the metered energy storage data to the consumption to reconstruct the customer's actual consumption, or the customer load in the absence of the energy storage. This then allowed us to apply a new simulated storage charge/discharge shape for this analysis. None of the nonresidential customers selected for the analysis had BTM PV installed – this allowed us to add solar PV generation shapes as a model input rather than have them embedded in the underlying load shape.

Residential load shapes were treated similarly to nonresidential shapes – the only difference is that since almost all residential SGIP customers also have BTM PV, the selected load shapes all have BTM PV installed as well. Therefore, the reconstructed shape is not the customer's actual consumption but the consumption minus BTM PV generation. Therefore, the cost-effectiveness results reflect the incremental costs and benefits of energy storage relative to a baseline that includes the effects of BTM PV generation.

We selected load shapes that demonstrate the diversity of customers that have installed energy storage through the SGIP. However, this sample of load shapes should not be considered representative of all California IOU customers. Table 5-1 presents summary statistics on the two residential and six nonresidential load shapes selected. The load factor is calculated as the average load divided by the maximum load during the entire year. It is a measure of efficiency of electrical energy usage. Nonresidential customers with low load factors might have greater opportunities for demand charge reduction.

TABLE 5-1: LOAD SHAPES USED IN COST-EFFECTIVENESS ANALYSIS

Customer Class	Load Shape Name	Total Usage* (kWh)	Minimum Summer Load (kW)	Maximum Summer Load (kW)	Load Factor
Residential	Residential HVAC	1,519	-5	9	2%
	Residential No HVAC	5,429	-3	5	13%
Nonresidential	Elementary School	495,636	14	333	17%
	EV Charging Station	1,305,833	0	889	17%
	Food Processing	377,739	2	119	33%
	Manufacturing	5,064,119	311	874	64%
	Office	2,531,836	157	695	42%
	Supermarket	1,947,996	47	302	66%

* Total usage for residential load shapes is reduced by the impact of BTM PV generation. The 'Residential HVAC' load shape has an 8.46 kW_{DC} PV system installed. The 'Residential No HVAC' load shape has a 4.23 kW_{DC} PV system installed.

The two residential load shapes differ primarily in their peak summer load. The 'Residential HVAC' shape has a larger afternoon load. This customer also has a larger BTM PV system installed, resulting in lower total energy consumption. The nonresidential shapes represent a diversity of customer types. The manufacturing shape has the largest total annual usage at over five GWh. This shape also has the second highest load factor, after the supermarket. The EV Charging Station shape has the highest maximum summer load at 889 kW and a 17 percent load factor. This shape represents a dedicated EV charging station with minimal load except when a vehicle arrives for charging.

Solar PV Shapes

The residential load shapes all have solar PV impacts embedded into them (i.e., the load shape reflects the impacts of BTM PV). Since almost all residential energy storage is installed alongside PV, we elected to only simulate residential storage cases with PV.

The nonresidential shapes do not have any influence of solar PV (the customers we selected did not have BTM PV installed), but we wanted the option to model cases with and without the influence of PV. In order to do this, we developed simulated PV generation shapes for each load shape based on typical meteorological year (TMY) weather. Since there was no PV installed, we first had to develop representative PV system characteristics for each load shape. As a first attempt at PV system sizing, we chose a system size that would offset 50 percent of the customer's annual energy generation. We then capped the size of the system at one MW and rounded to the nearest 10 kW. Table 5-2 summarizes the final PV system size selection for each load shape.

TABLE 5-2: PV SYSTEM SIZING

Load Shape Name	Total Usage (kWh)	Implied PV System Size (DC kW, 50% of kWh)	Final PV System Size (DC kW)
Elementary School	495,636	141	140
EV Charging Station	1,305,833	373	370
Food Processing	377,739	108	110
Manufacturing	5,064,119	1,445	1,000
Office	2,531,836	723	720
Supermarket	1,947,996	556	560

In the cost-effectiveness analysis, each load shape is modeled in all three IOU service territories. Average annual irradiance varies by IOU service territory and climate zone, therefore simulated PV generation for each customer must account for each IOU's climate zones. We developed the PV simulations using the PV Lib toolbox using TMY 3 weather.[5] Table 5-3 lists the TMY 3 weather stations selected for the PV simulations. All systems were modeled with a 180-degree azimuth (facing south) and 30-degree tilt.

TABLE 5-3: WEATHER STATIONS FOR PV MODELING

IOU	TMY 3 Weather Station Location	TMY 3 Weather Station ID
PG&E	San Jose Intl Airport	724945
SCE	Santa Monica Muni	722885
SDG&E	San Diego Montgomery	722903

5 The PV Lib Toolbox provides a set of well-documented functions for simulating the performance of photovoltaic energy systems. The toolbox was developed at Sandia National Laboratories. The toolbox is available in Matlab and Python versions. https://pvpmc.sandia.gov/applications/pv_lib-toolbox/

5.2.2 Storage Technologies

Each load shape was assigned a storage system technology and size (kW and kWh). The storage sizing was based on experience with the SGIP program – in many cases we chose the same system size as the energy storage system that was originally installed by the SGIP customer. In other cases, we modified the system characteristics to create more variety in the results.

The two residential load shapes and five of the six nonresidential load shapes were assigned a Lithium-Ion (Li-Ion) energy storage system. Lithium ion energy storage is the dominant storage medium in the SGIP therefore we find it reasonable to allocate most of our cost-effectiveness simulations to Li-ion technologies. Each Li-Ion system is modeled as 2hrs in duration based on historical observed energy storage to power ratios in the SGIP program data. Finally, we assign each Li-ion system an 80 percent round-trip efficiency (RTE). The RTE is defined as the total kWh discharge of the system divided by the total kWh charge. This value is based on the 2017 SGIP Impact Evaluation Report, which found that the mean observed RTE was 81 percent for PBI Li-ion projects.[6]

Note that by calculating the RTE over the course of several months, the average RTE reported in the 2017 SGIP Impact Evaluation Report not only captures the losses due to AC-DC power conversion but also the parasitic loads associated with system cooling, communications and other power electronic loads. Parasitic loads can represent a significant fraction of total charging energy (the denominator in the RTE calculation), especially for systems that are idle for extended periods. In our cost-effectiveness modeling the RTE is implemented as a single cycle RTE (the ratio of discharge to charge during a single cycle). However, the energy storage systems in our model are not assigned a parasitic loss, therefore the modeled RTEs are meant to account for both the single cycle losses and the effects of parasitic losses.

In order to add some diversity to the modeled technologies, we assign a flow battery to the manufacturing load shape. Flow batteries are the second most common type of energy storage system in the SGIP to date. Unfortunately, limited performance data were available from the 2017 SGIP Impact Evaluation Report to inform modeling decisions. Lacking actual data, we leverage specification sheets for SGIP eligible flow battery technologies. Primus power lists a 70 percent DC to DC RTE and five-hour duration for their

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6 https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/2017_SGIP_AES_Impact_Evaluation.pdf

ENERGYPOD 2 zinc bromide flow battery.[7] In our modeling, we assign a five-hour duration to the flow battery case. However, the 70 percent RTE value reported must be converted to AC – AC in order to be used in the model. Similar specification sheets for Li-ion storage indicate a typical first year RTE of 90 percent.[8] In our model we assign an 80 percent RTE to Li-ion technologies, which represents an 11 percent reduction from the specification sheet value. We apply this same discount factor to the flow battery specification sheet and arrive at a 62 percent RTE used in our modeling.

Table 5-4 summarizes the system sizing and RTE assumptions for each load shape.

TABLE 5-4: STORAGE SYSTEM SIZE AND EFFICIENCY CHARACTERISTICS

Customer Class	Load Shape Name	Total Usage (kWh)	Storage System Size (kW)	Storage System Size (kWh)	Storage System Duration (hours)	Round Trip Efficiency
Residential	Residential HVAC	1,519	5	10	2	80%
	Residential No HVAC	5,429	5	10	2	80%
Non-residential	Elementary School	495,636	200	400	2	80%
	EV Charging Station	1,305,833	200	400	2	80%
	Food Processing	377,739	100	200	2	80%
	Manufacturing	5,064,119	400	2,000	5	62%
	Office	2,531,836	90	180	2	80%
	Supermarket	1,947,996	30	60	2	80%

SGIP energy storage systems are required to have a minimum ten-year warranty. Lithium ion battery product warranties cite ten-year coverage, guaranteeing energy retention of 70 percent at ten years following initial installation date. On the other hand, flow battery systems are touted as having a longer useful life with little to no degradation. Primus Power lists a 20-year life for their ENERGYPOD 2 zinc bromide flow battery and suggests no loss of energy capacity. For this cost-effectiveness analysis, we assume a 10-year life for Li-ion systems and a 20-year life for flow battery systems as the base case. We also consider a sensitivity case where Li-ion systems are assigned at 15-year life.

As a simplifying assumption, we use a linear degradation rate of 3.33 percent for Li-ion technologies (based on the assumption that energy capacity will be approximately 70 percent of nameplate capacity by the 10th year. Product specification sheets for flow batteries suggest no degradation, but as a

7 http://www.primuspower.com/assets/pdf/EnergyPod-2-Spec-Sheet.pdf

8 https://www.tesla.com/sites/default/files/pdfs/powerwall/Powerwall%202_AC_Datasheet_en_northamerica.pdf

conservative estimate we set the flow battery degradation rate at 1.00 percent. The effect of degradation is implemented as a reduction in the technology's bill and avoided cost impacts as follows:

$$Impact_{Year} = Impact_{Nominal} \cdot (1 - DegradationRate)^{Year-1}$$

Utility Scale Storage Sizing and Dispatch

Utility scale energy storage can serve multiple purposes. Utility owned systems can be used for T&D system upgrade deferral. Merchant PV power plants can be paired with energy storage to shift the sale of electricity to times with higher energy prices. Increasingly, energy storage systems are being considered to replace peaker power plants that operate limited hours during the year. Energy storage systems can also provide capacity, voltage/frequency regulation, and overall resource adequacy (RA) if those products are available through wholesale markets. The intent in our modeling is to simulate utility scale cases that are somewhat equivalent to the current opportunities available to BTM storage. To that end, we consider two utility scale storage cases: utility marginal cost arbitrage and distribution deferral.

In the utility marginal cost arbitrage case, we simulate a utility-owned energy storage system installed on the distribution system. The storage system has perfect visibility and foresight into the utility marginal costs. When the storage system charges, it increases the utility marginal costs (using the full stack of avoided costs described in section 5.2.7). When the storage system discharges, it reduces the utility avoided costs. Each day the storage system charges and discharges to optimize the utility marginal costs. The costs and benefits to the utility are associated with marginal costs impacts when charging and discharging.

The distribution deferral case also performs avoided cost arbitrage, but it is exclusively reducing the distribution upgrade deferral avoided costs described in Section 5.2.4. The system will discharge exclusively to provide capacity during the limited hours of high distribution avoided costs. The system will then charge during low avoided cost hours.

In all utility scale cases we model a 1 MW / 4 MWh energy storage system. All other technology parameters such as the RTE, degradation rate, and system life are consistent with the BTM Li-Ion cases.

System Costs

Energy storage system installed costs can vary significantly depending on the complexity of the installation and myriad other factors. A residential energy storage system installation requiring a panel upgrade will result in a higher installed cost than a similar system requiring no panel upgrade. Furthermore, a high-volume developer is likely able to procure energy storage systems at a lower cost compared to a low-volume developer. Given the variability in installed costs within each customer class, we consider a base case and a high case for residential, nonresidential, and utility scale storage.

Section 2 provides background on secondary research related to energy storage costs. Navigant Research provides a 2019 installed cost estimate of $962/kWh for residential energy storage. If we apply the expected cost reduction rate between 2019 and 2020 back to 2019, we arrive at a 2018 installed cost of $1,037/kWh. We use this value as the base case for residential energy storage. For a high case, we increase the base case costs by 50 percent - this would represent a highly complex installation requiring a panel upgrade, or equipment costs provided from a smaller manufacturer offering a higher-end product. This results on a high case residential 2018 installed cost of $1,553/kWh.

For nonresidential lithium ion storage, we leverage the Lazard report which suggests that capital costs for residential storage are approximately 33 percent higher than nonresidential capital costs. Therefore, we work backwards from the 2018 residential installed costs and reduce them by 33 percent. The 2018 base case installed cost for nonresidential Li-ion storage is $695 and the 2018 high case installed cost for nonresidential Li-ion storage is $1,041. For the nonresidential flow battery case, we reference the Navigant Research report that finds flow battery installed costs to be 63 percent higher than Li-ion storage. Therefore, we set the 2018 base case installed cost for nonresidential flow battery storage at $1,133/kWh and the 2018 high case installed cost at $1,697/kWh.

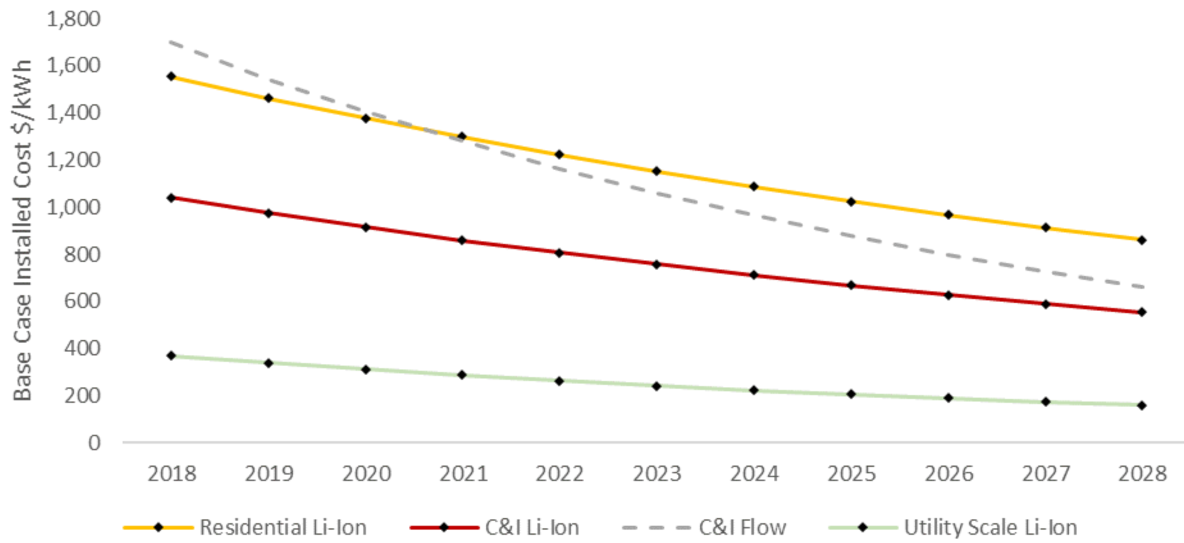
Finally, for utility scale lithium ion storage, we again leverage the Lazard report which finds transmission and distribution connected storage costs are 47 percent lower than nonresidential Li-ion storage. Therefore, we set the base case 2018 utility scale Li-ion storage cost at $368/kWh, and the high case 2018 Li-ion utility scale energy storage cost at $552/kWh.

When projecting lithium-ion installed costs into the future beyond the 2018 base case, we separate costs into three components: 1) battery rack costs, 2) inverter costs, and 3) other costs. Other costs include containerization, climate control, fire suppression, metering/monitoring, energy management system costs, freight, installation, profit, and other soft costs such as permitting and interconnection. For 2018, we start with the total installed costs listed above for residential, C&I, and utility scale storage and calculate the implied proportion that each component (battery rack, inverter, and other costs) would represent in 2018.[9] We then use the reductions in these components to project total installed costs through 2028. Based on information provided in Section 2, battery rack $/kWh prices decline at a rate of 9 percent per year and inverter $/kW prices decline at a rate of 8 percent per year. Other costs are assumed to decline at 5 percent per year. Cost reductions for the C&I flow battery case are based on the 9 percent reduction in installed cost values reported in Section 2. Figure 5-1 shows the base case installed

9 Section 2 presents 2018 and future projections for battery rack and inverter prices.

costs used in SGIPce for 2018 through 2028. The same methodology is applied to project installed costs in the high cost case, the only difference in the high cases is the 2018 installed cost.

FIGURE 5-1: BASE CASE MODELED INSTALLED COSTS - 2018 THROUGH 2028



5.2.3 Retail Rates, Demand Response, and Other Rate Modifiers

Each load shape was modeled in each of the IOU service territories. For residential customers we modeled two rate options – a TOU rate with a 4-9 pm peak period and an electric vehicle (EV) rate. For nonresidential rates we modeled three rate options: 1) a base TOU rate with 4-9 pm peak periods, 2) a TOU rate with the appropriate option for BTM PV, and 3) a more dynamic rate with either real-time-pricing (RTP) or peak-day-pricing (PDP) components. Table 5-5 summarizes the residential rates included in this analysis.

TABLE 5-5: LIST OF RESIDENTIAL RATES MODELED

IOU	Residential TOU Rate with PV	Residential EV Rate
PG&E	E-TOU-B[10]	EV-A
SCE	TOU-D Option 4-9 PM	TOU-D Option PRIME
SDG&E	DR-SES	EV-TOU-5

In general, the residential EV rates offer a broader TOU price differential and therefore a greater opportunity for arbitrage compared to the standard TOU rate. For example, PG&E's EV-A rate has a $0.52/kWh summer on peak rate and a $0.13 summer off peak rate.[11] In contrast, the PG&E E-TOU-B rate has a summer on peak rate of $0.38/kWh and a summer off-peak rate of $0.28/kWh.[12] The rate differential on PG&E's standard TOU rate is $0.10/kWh, compared to $0.39/kWh on PG&E's EV TOU rate. A greater TOU price differential translates to improved economics for energy storage systems performing TOU arbitrage. Note that some but not all utilities allow energy storage systems to enroll in EV TOU rates without owning an EV.

This study does not include an analysis of LADWP or SMUD residential rates. LADWP's R-1B residential TOU rate has a 1 – 5 pm on-peak period and 8 pm – 10 am off-peak period.[13] During July through September 2018, the TOU differential for R-1B is approximately $0.09/kWh. This differential is comparable to PG&E's E-TOU-B rate, therefore the participant cost-effectiveness test results might be similar across these two rates. The summer TOU differential on SMUD's residential TOU rate is approximately $0.17/kWh, which would allow greater opportunity for TOU arbitrage.[14]

Table 5-6 summarizes the nonresidential rates included in this analysis. As with the residential rates, all modeled nonresidential TOU rates have 4-9 pm on-peak periods. Unlike the residential rates, all modeled nonresidential TOU rates have monthly demand charges. Some modeled nonresidential TOU rates also have peak-period demand charges in addition to the monthly demand charges.

10 CPUC Decision 19-08-001 requires all new residential SGIP systems to enroll in a time-varying rate with a peak period starting at 4 pm or later and with a summer peak to off-peak price differential of 1.69 or more. PG&E's E-TOU-B rate does not meet this minimum price differential threshold. Nevertheless, we include this rate in the analysis for illustrative purposes.

11 https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EV%20(Sch).pdf

12 https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_E-TOU.pdf

13 https://www.ladwp.com/ladwp/faces/ladwp/residential/r-customerservices/r-cs-understandingyourrates/r-cs-ur-electricrates

14 https://www.smud.org/en/Rate-Information/Residential-rates

TABLE 5-6: LIST OF NONRESIDENTIAL RATES

IOU	TOU Rate	TOU rate with PV	RTP/PDP Rate
PG&E	A10S	A10S	A10S PDP
	E19S	E19S Option R	E19S PDP
SCE	TOU-8 Option D	TOU-8 Option E	TOU-8-RTP
	TOU GS-3 Option D	TOU GS-3 Option E	TOU-GS-3-RTP
SDG&E	ALTOU	DG-R	Power Your Drive

The RTP/PDP rate options vary by IOU. For PG&E nonresidential rates, the modifier is an adder that increases the energy rate by $1.2/kWh. The higher PDP rates are charged from 5 – 8 pm on the 15 summer days with highest load.[15] SCE's RTP rate is an hourly rate based on weather at downtown Los Angeles as recorded by the National Weather Service.[16] Finally, SDG&E's Power Your Drive RTP rate is an hourly pricing plan that varies based on the forecasted energy demand. Each day, around 6 pm, the next day's forecasted pricing is posted.[17]

Residential and nonresidential energy storage systems were optimized using E3's RESTORE energy storage dispatch model for bill savings according to the retail rate assigned to the simulation.[18] However, the energy storage dispatch simulations were not optimized to claim the federal ITC or the SGIP incentive (the ITC and the SGIP incentive are discussed in further detail below). In certain cases, it's possible that ideal dispatch based on retail rate price signals results in losing eligibility for the ITC (i.e., less than 75 percent charging from PV) or not capturing the full SGIP incentive (i.e., the system fails to meet SGIP cycling requirements). It's possible that customer economics might improve if a system charges from PV and captures the ITC, even if a lower retail rate is available overnight.

Retail rates are modeled to increase based on the California Energy Commission (CEC) demand forecast and an implied inflation rate of 2.3 percent.[19]

PV Charging Constraint (Residential Only)

In the base case, residential storage systems are optimized to perform unconstrained bill savings. This means that the energy storage system is free to charge and discharge at whatever hours are optimal to produce customer bill savings. For residential customers, we consider a scenario where the energy storage

[15] The details of PG&E's rates and rate modifiers were developed in consultation with PG&E.

[16] https://www1.sce.com/NR/sc3/tm2/pdf/ce78-12.pdf

[17] https://www.sdge.com/pyd-day-ahead-pricing

[18] https://www.ethree.com/tools/restore-energy-storage-dispatch-model/

[19] https://ww2.energy.ca.gov/2017_energypolicy/documents/2018-02-21_business_meeting/2018-02-21_middemandcase_forecst.php

system is required to charge from PV. This may not always be the most optimal time to charge depending on the retail rate being modeled, but it reflects a real-world operating mode for residential energy storage. All residential simulations are run with and without the PV charging constraint to test the influence of this parameter.

Residential Backup

If the backup modifier is selected, the energy storage system is forced to discharge during three distinct events throughout the year, each lasting four hours. In Section 2 we provide background on national average values for value of lost load (VLL). For cost-effectiveness purposes, under this scenario, customers are assigned a benefit value of $1.4/kWh for backup. This value represents the inflation adjusted national average VLL for a four-hour outage during 2018. The VLL benefit is reported as a bill savings in the model output as the product of the VLL and the kWh discharged by the energy storage system during the outage. The VLL is assumed to increase using a 2.3 percent inflation rate. In Section 6 we also explore what value of VLL would set the participant cost test benefit ratio to 1.0.

Demand Response

Both residential and nonresidential customers in our model can participate in DR should that option be selected. The modeled DR program is based loosely around the demand response auction mechanism (DRAM) in that a single price signal is provided to all IOU customers at the same time based on CAISO load. The intent in our modeling is to understand how overriding price signals influence the cost-effectiveness of energy storage. We are not attempting to model all the nuances of IOU-specific DR programs. We simply seek to understand how cost-effectiveness changes when customers are presented with a price signal outside of the retail rates.

We modeled six distinct one-hour DR events during the year, each aligned with top hours of the CAISO load. One event was created during each month between May and October. The $/kW value assigned to DR participation varies by month and is similar to the Capacity Bidding Program (CBP).[20] Table 5-7 summarizes the DR incentive payment amounts by IOU and month.

TABLE 5-7: DEMAND RESPONSE INCENTIVE PAYMENTS BY MONTH AND IOU

IOU	Demand Response $/kW					
	May	June	July	August	September	October
PG&E	$2.86	$3.49	$14.67	$20.29	$12.51	$2.04
SCE	$2.97	$4.46	$15.10	$17.58	$9.36	$1.74
SDG&E	$2.93	$7.79	$16.93	$20.92	$13.86	$4.19

[20] https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_E-CBP.pdf

As a simplifying assumption, SGIPce issues payments for DR participation directly to customers.[21] Incentive payments are not taxed at the state or federal level. When calculating incentive payments, we consider the load reduction during the DR event relative to the load reduction that the energy storage system would have delivered in the absence of DR. In other words, DR payments are issued for the incremental load reduction beyond the naturally occurring load reduction without DR. We calculate this by comparing the load reduction in the simulations with DR relative to the same simulations without DR.

In general, energy storage simulations are constrained to not export. In many cases, we find that energy storage system discharge (particularly in residential simulations) is limited by the total available load. Since the modeled DR program is driven by CAISO load, we assume that energy storage discharge in excess of customer load would be beneficial at the system level. Therefore, for the DR cases, we allow energy storage to export during DR events. This allows for incremental value to be delivered beyond the naturally occurring discharge.

5.2.4 Distribution System Upgrade Deferral

Energy storage systems can be used to defer expensive improvements or capacity additions to distribution equipment by providing capacity value. In this scenario, we consider a case where peak demand on a distribution feeder node is at or near the distribution equipment's load carrying capacity (limit) and a relatively small amount of energy storage capacity located downstream (electrically) from the congested node can serve a portion of peak demand, on the margin, such that an upgrade of the distribution equipment is deferrable.

The first step in this scenario is to estimate the installed cost for the distribution feeder equipment to be deferred. That is the cost to design, purchase, and install the distribution equipment. Typical values fall within the range of $25 to $250 per kW of distribution capacity installed.[22] For this analysis, we considered a value of $250/kW-year as a high-end edge case of potential distribution deferral value. We selected two distribution feeder load shapes from an actual California IOU feeder in 2017 – one that consisted of mostly residential customers for residential simulations, and another for nonresidential simulations.

We assigned a distribution avoided cost value of $250/kW-year to the shape and used the peak capacity allocation factor (PCAF) methodology to assign hourly values to the top hours of distribution feeder load. Finally, we supplied that price signal to the energy storage system to co-optimize with bill savings. We

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[21] In programs like the DRAM payments are issued by aggregators rather than directly by the electric utility of the CAISO.

[22] https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2009/094070.pdf

also replaced the actual distribution avoided costs in the CPUC avoided cost calculator with the higher costs generated in this case. Note that this replacement was only performed for the distribution deferral cases. All other simulations are performed with the standard set of avoided costs.

This scenario represents a case where a customer is participating in a program that is designed to offset local distribution issues, or perhaps a case where the customer and IOU agree to joint control of the energy storage system (the customer may use the battery for bill savings except during hours of distribution system deferral). In Section 6 we discuss the influence of distribution deferral on cost-effectiveness and explore the potential to issue greater incentives to customers participating in distribution deferral.

5.2.5 Greenhouse Gas Signal

The CPUC Decision approving greenhouse gas emission reduction requirements for the SGIP storage budget calls for the creation of a GHG signal to provide storage developers and customers with storage the information they need to charge storage during low-GHG emission periods and to discharge during high-GHG emission periods. The decision directs the SGIP PAs to create a digitally accessible, real-time, marginal GHG emissions factor in units of kg CO_2/kWh. This signal will provide the marginal emissions per kWh calculated based on a natural gas-fired power plant producing energy at a price equaling the real-time (five-minute) CAISO Locational Marginal Price with costs equal to the most recent publicly available data on gas prices, CO_2 prices, and variable operating costs constrained by reasonable maximum and minimum efficiencies. When the calculated heat rate is zero or below, instead it is assumed that the marginal generator is renewable and the marginal emissions rate is zero.

We created a kg CO_2/kWh GHG emissions shape following the methodology described in the CPUC Decision. The emissions shape was converted to a $/kWh price signal using an implied $/MT CO_2 value. For purposes of this analysis, we considered two values for $/MT CO_2:

- $15/MT CO_2 based on average cap-and-trade market prices (GHG – Low Signal)
- $65/MT CO_2 based on the cap-and-trade market price ceiling (GHG – High Signal)

The signals were provided to the storage dispatch algorithm which co-optimized this value along with customer bill savings. In both cases, the signal serves exclusively to influence storage dispatch. The value of the signal does not affect the customer’s incentive in any way. Storage customers do not earn revenue from the GHG signal in any way. In our modeling, the GHG signal is available to both residential and nonresidential energy storage customers.

5.2.6 Incentives and Tax Credits

All energy storage systems are assigned a base SGIP incentive rate of $0.35/Wh. SGIP incentive rates vary by PA and budget classification, but we chose this value as a prototypical base case. The base incentive amount is modified accordingly for the manufacturing use case which has a 5-hour duration and therefore receives a lower $/kWh incentive.[23] Residential customers receive the entire incentive upfront. Nonresidential customers are paid 50 percent of the incentive upfront and the remaining 50 percent over five years based on the utilization of the energy storage system. We use 130 full discharge cycles as the expected output of the energy storage system to calculate the $/kWh performance-based incentive (PBI). However, we do not force the energy storage system to dispatch 130 cycles in order to receive the full incentive. We allow the energy storage system to dispatch optimally to reduce customer bills. If that results in fewer than 130 cycles, then the incentive payment is reduced accordingly based on actual system output. This provides insight into the optimal number of cycles for each use case. The SGIP incentive is modeled as decreasing by 10 percent each year.

The Federal Investment Tax Credit (ITC) is available to residential and nonresidential customers with energy storage systems charging at least 75 percent from onsite renewable generation. We assign the ITC dynamically to customers according to their share of energy charging from PV. If the simulation results in 75 – 100 percent storage charge from the onsite PV system, then the customer is assigned that portion of the ITC. If the simulation results in less than 75 percent charging from the onsite PV system, then the customer foregoes the ITC. Residential cases with the PV charging constraint will always receive the full value of the ITC. Other residential and nonresidential cases without this constraint may receive some, all, or none of the ITC based on the actual proportion of charging coincident with PV generation. The ITC is set to 30 percent in 2018, declining to 10 percent from 2022 onward. Nonresidential customers receiving all or a portion of the ITC also benefit from the 5-year Modified Accelerated Cost Recovery System (MACRS). Nonresidential customers that do not receive the ITC are eligible for 7-year MACRS.

5.2.7 Avoided Costs

Storage systems are modeled as charging using power supplied from the grid and discharging to reduce customer usage of power supplied from the grid. Even when energy storage charge/discharge is coincident with onsite PV generation, we consider the baseline where onsite PV would be used to serve onsite loads. Onsite PV energy that is used to charge energy storage systems displaces energy that would otherwise have been used to serve customer loads. Therefore, charging from PV still results in an increase in grid usage, and consequently a potential increase in utility costs.

[23] https://www.selfgenca.com/documents/handbook/2017

The avoided costs are used to value the battery's charge and discharge electricity for the PA, TRC, STRC, and RIM tests. The avoided costs include the value of electricity purchases from central station power plants, emissions, generation capacity, T&D capacity, and ancillary services for every hour of the year. When energy storage systems charge, they increase utility load and therefore increase the utility costs. When energy storage systems discharge, they reduce utility load and therefore result in utility avoided costs. Avoided costs are evaluated in every hour of the year over the life of the storage system. Total avoided costs are the sum of the reduction in costs during discharge minus the sum of the increase in costs during charge.

The avoided costs are derived from the CPUC 2018 electric avoided cost calculator (ACC).[24] The CPUC updated the ACC in 2019 using updated GHG prices and other changes. The timing of this study did not allow us to use the 2019 version of the CPUC ACC. However, we note that the 2018 ACC uses 2017 as the weather year. All the load shapes from this analysis are from calendar year 2017, so there is alignment between the avoided costs used and the modeled load shapes.

The ACC produces an avoided cost shape for each climate zone. We developed a single avoided cost shape for each IOU based on the geographical distribution of the SGIP energy storage population at the end of 2018. The avoided costs for each climate zone were weighted and combined into a single weighted average avoided cost stream for each IOU. Climate zones with a large proportion of the SGIP energy storage population are given a greater weighting compared to climate zones with little or no SGIP energy storage capacity.

To assess the utility value of storage during periods with extreme distribution capacity constraint, we developed extreme distribution avoided costs associated with periods of summer extreme weather. These avoided costs are only used in the distribution upgrade deferral simulation cases. All other simulations rely on the standard avoided costs.

5.2.8 Program Administrator Costs

PAs bear the cost of designing and managing the SGIP. These administrative costs are applied in the PA, RIM, TRC, and STRC tests. We assign them on a $/Wh basis using the installed capacities of the batteries. CPUC decision 17-04-017 assumes that program administration costs equal seven percent of total incentive budget.[25] In our model we set PA administration costs to seven percent of the SGIP incentive amount for each scenario. Administration costs are modeled to increase with inflation at 2.3 percent per year.

24 https://www.cpuc.ca.gov/general.aspx?id=5267

25 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M183/K843/183843620.PDF

5.2.9 Financing, Discount Rates, and Taxes

Below we present several key inputs and global assumptions applicable throughout our modeling:

- The Federal marginal tax rate is 24 percent for residential customers and 21 percent for nonresidential customers
- The California state tax rate is 9.30 percent for residential customers and 8.84 percent for nonresidential customers
- All technologies are financed with debt/equity:
  - Residential customers finance with 40 percent equity and have a debt interest rate of 4.50 percent
  - Nonresidential customers finance with 60 percent equity and have a debt interest rate of 4.52 percent
- The utility discount rate is 5 percent, and the societal discount rate is 4 percent
- The inflation rate 2.3 percent

6 COST-EFFECTIVENESS RESULTS

This section summarizes the results from the cost-effectiveness component of this study. Results are divided into the following subsections:

- Residential energy storage findings and sensitivities
- Nonresidential energy storage findings and sensitivities
- Utility scale in-front of meter (IFOM) energy storage findings

A detailed discussion of the cost-effectiveness methodology and key assumptions was presented in Section 5. The cost-effectiveness results presented in this section represent the findings from over 1,000 distinct residential, nonresidential, and utility scale IFOM simulations based on combinations of customer load shapes, retail rates, and other modifiers such as PV-charging constraints, demand response (DR) programs, and distribution upgrade deferral opportunities. At times throughout this section, we present findings averaged across a group of simulations to present overall cost-effectiveness trends. Other times, we highlight individual simulations results to explore the influence specific cost and benefit components. By selecting individual simulations results, we are not implying that these findings are representative of all other storage systems. Instead, we select specific simulations for in-depth analysis as they allow us to highlight aspects of cost-effectiveness that we deem relevant or important.

Below we summarize the key parameters that make up the simulation results presented in this section. Please refer to Section 5 for additional details on each parameter.

- Two prototypical residential load shapes labeled 'Residential HVAC' and 'Residential No HVAC.' The 'Residential HVAC' load shape has a larger afternoon peak compared to the 'Residential No HVAC' shape.
- Six prototypical nonresidential load shapes labeled 'Elementary School', 'EV Charging Station', 'Food Processing', 'Manufacturing', 'Office', and 'Supermarket.'
  - Nonresidential load shapes are also modified to have the influence of PV generation.
- Residential energy storage dispatch is modeled under "traditional" TOU rates and EV-TOU rates. Traditional TOU rates are defined as the default TOU that are currently available for IOU customers, whereas EV-TOU rates are limited to customers with electric vehicles and often offer wider TOU price differentials.
  - Residential simulations are also modeled with an option to constrain storage charging to PV generation hours.

- Residential simulations are also modeled with an option where the energy storage system provides backup during pre-determined outage events.
- Nonresidential energy storage dispatch is modeled under standard TOU rates with demand charges and dynamic pricing rates (e.g., rates with real-time pricing components).
- Both residential and nonresidential storage dispatch is modeled with the following modifiers:
  - A DR program providing increased participant revenue for discharge during DR events.
  - The opportunity to provide distribution upgrade deferral.
  - Energy storage dispatch that is co-optimized for bill savings and a greenhouse gas (GHG) signal. Two GHG signals are provided, labeled 'GHG – Low' and 'GHG – High.' The 'GHG – High' signal has a higher implied cost of carbon relative to the 'GHG – Low' signal.
- Utility scale storage dispatch that optimizes reduction of utility avoided costs

When interpreting these results, the reader should keep in mind that the findings are based on an ideal dispatch of storage. When optimized exclusively for bill savings, these results represent the best possible financial outcome for customers who install energy storage. In real world conditions, energy storage systems do not have perfect foresight into the next day's load shape and therefore will dispatch less than perfectly.

In this section we focus on the results that we believe are most relevant and illustrative of the impact that various factors can have on energy storage cost-effectiveness under optimal conditions. Appendix C lists the results of all cost-effectiveness tests performed.

6.1 RESIDENTIAL ENERGY STORAGE COST-EFFECTIVENESS

Figure 6-1 on the following page presents results of the participant cost test (PCT) for residential energy storage customers under the base case in 2018. We define the residential base case as all residential simulations based on the two residential load shapes (2x), under the two rates types for each electric IOU (6x), with and without the PV charging constraint (2x), for a total of 24 distinct residential simulations. The results are shown including the effect of the SGIP incentive ($0.35/Wh in 2018).[1] Recall that the PCT represents the cost-effectiveness from the perspective of the storage customer. The average 2018 PCT for residential energy storage performing exclusive bill optimization is 0.59. Base case 2018 PCT values ranged from 0.33 to 0.86. From a participant perspective, the only source of bill savings in the base case is TOU arbitrage, suggesting that the bill savings available from TOU arbitrage combined with state and

[1] $0.35/Wh was selected as a base case incentive level based on conversations with the California Public Utilities Commission and the SGIP Program Administrators.

federal incentives (as applicable, including the SGIP incentive) are not enough to overcome the costs of the energy storage system.

PCT results in Figure 6-1 are color coded by residential rate type – traditional TOU (i.e., default TOU rates available to all residential IOU customers) rates are shown in yellow and EV TOU rates are shown in red. In general, the lowest PCT ratios are for customers on traditional TOU rates. Residential customers performing TOU arbitrage on PG&E's E-TOU B rate have the lowest participant cost test ratios. In contrast, EV TOU rates tend to produce the highest PCT ratios – residential customers on SDG&E's EV-TOU 5 rate have the highest PCT ratio.[2] This is to be expected as EV TOU rates tend to have larger TOU price differentials relative to the traditional TOU rates. Note that EV rates are not always available to energy storage customers who do not also own an EV.

FIGURE 6-1: RESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH SGIP INCENTIVE, 2018

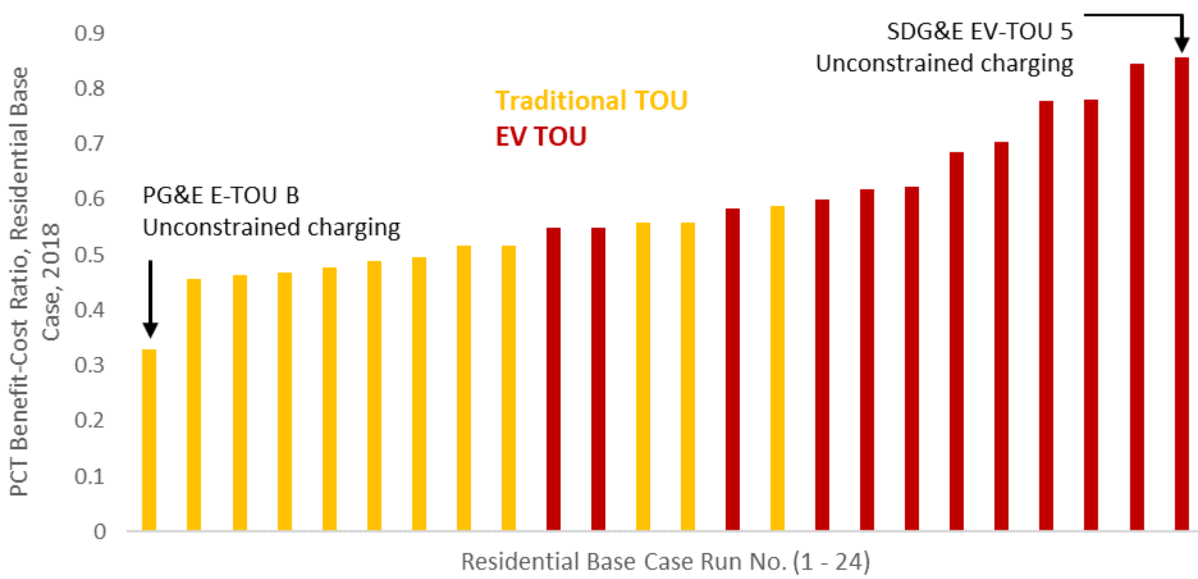


Figure 6-2 and Figure 6-3 on the following page show the average base case residential PCT ratio results by IOU for 2018, 2024, and 2028. Figure 6-2 presents the average PCT ratio for the EV rate while Figure 6-3 illustrates similar results for the TOU rate. Comparing the results in these graphs reinforces the findings in Figure 6-1, the EV rates which provide lower rates at night to encourage customers to delay charging their EV, provides storage customers with better energy arbitrage opportunities. Figure 6-2

[2] SDG&E's EV-TOU 5 rate charges $0.53/kWh during summer on-peak periods, defined as 4:00 pm – 9:00 pm every day. The rate also includes a super off-peak period midnight – 6:00 am on summer Weekdays and midnight – 2:00 pm on Weekends and Holidays. Every other hour, customers on SDG&E's EV-TOU 5 rate are charged $0.29/kWh.
https://www.sdge.com/residential/pricing-plans/about-our-pricing-plans/electric-vehicle-plans

illustrates that when charge and discharge are optimized for the EV rate, the PCT ratio exceeds 1.0 for PG&E and SDG&E in 2024 and is greater than 1.0 for all three utilities in 2028. Figure 6-3 shows that the reduced energy arbitrage opportunities of the TOU rate result in a PCT ratio that is not forecast to exceed 1.0. TOU rates differ during the summer and winter periods with the difference in the peak to off-peak period rates justifying battery use in the summer but the rate differentials typically not being large enough to cover the battery thru-put efficiency during the winter months. For the EV rates, the battery can be operated in both the summer and winter periods to help minimize the customer's utility bill.

FIGURE 6-2: AVERAGE RESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, EV-TOU RATES, BY IOU, 2018, 2024, 2028

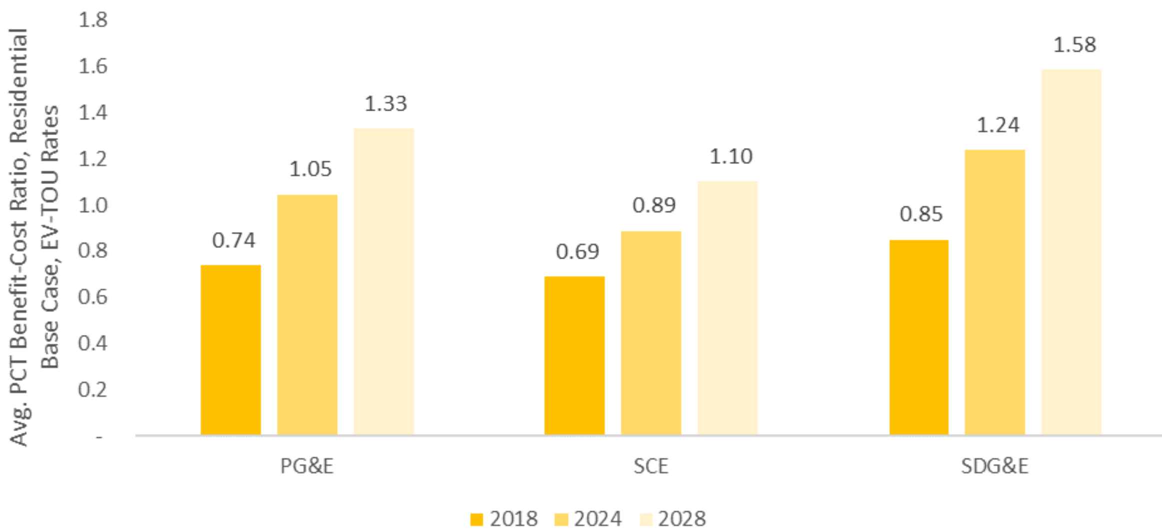


FIGURE 6-3: AVERAGE RESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, TRADITIONAL TOU RATES, BY IOU, 2018, 2024, 2028

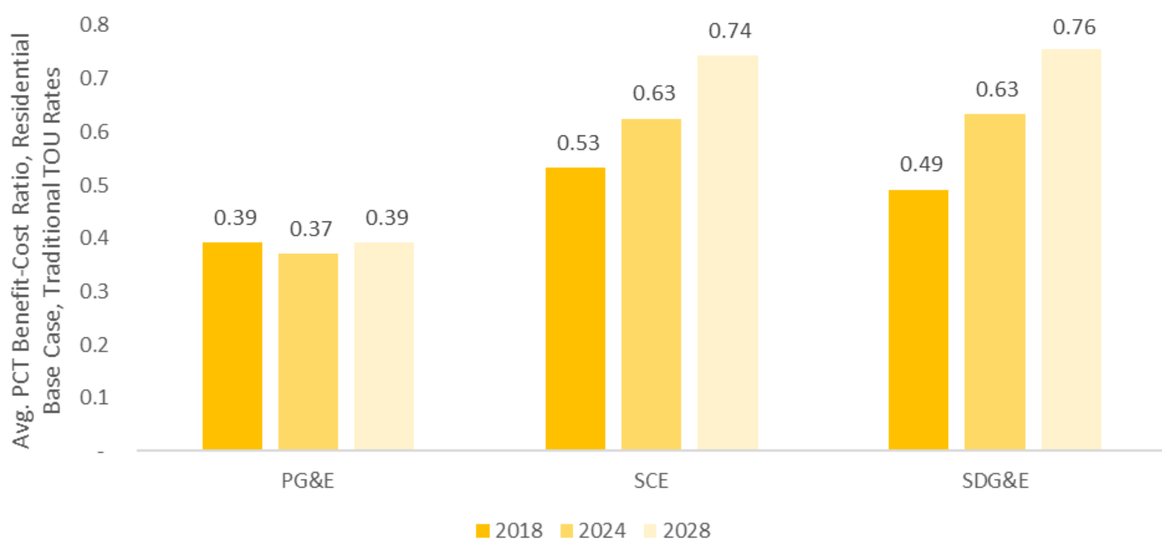
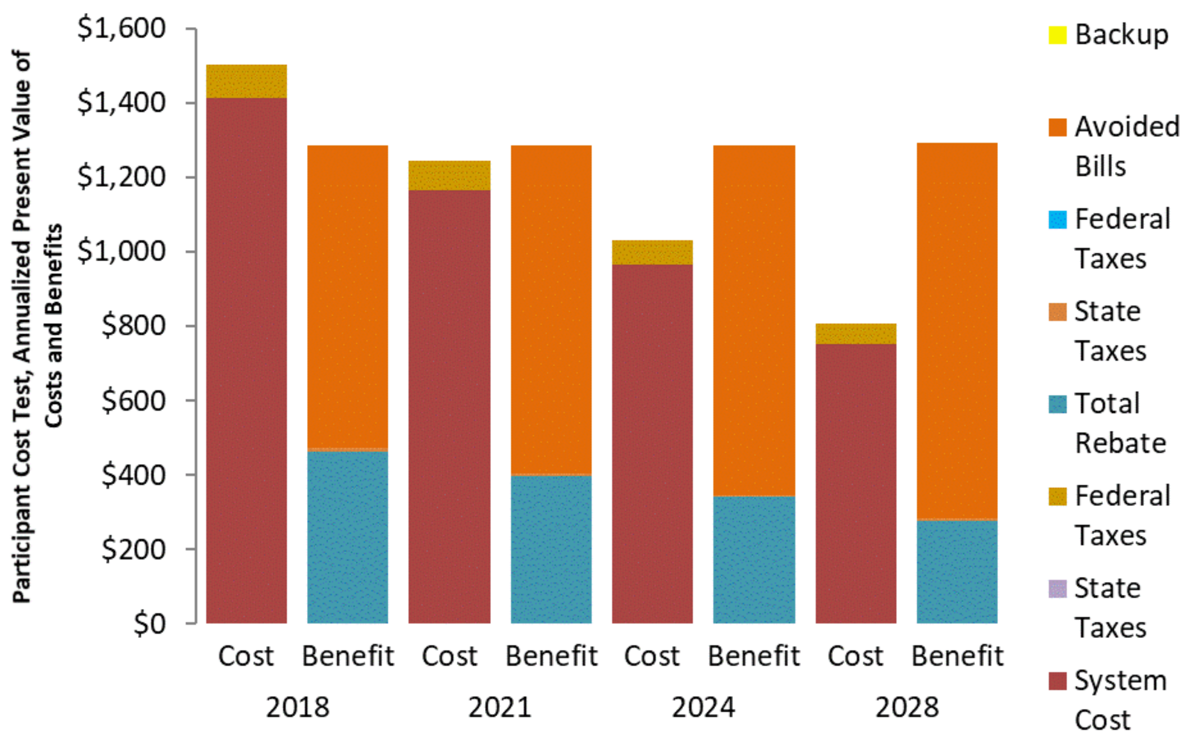


Figure 6-4 shows the various components of the PCT costs and benefits for the Residential HVAC load shape on SDG&E's EV-TOU 5 rate. Results are shown for 2018, 2021, 2024, and 2028. We include this figure as a prototypical example of how the various cost and benefit components evolve over time.[3] This example is not meant to be representative of the cost-effectiveness of all residential energy storage systems.

FIGURE 6-4: RESIDENTIAL HVAC LOAD SHAPE, PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, SDG&E EV TOU-5 RATE, 2018-2028



The PCT ratio in this case starts at 0.86 in 2018, increasing to 1.60 in 2028. The improvement in the PCT ratio is due to several factors. The capital, financing, and insurance costs of the energy storage system are the primary component of the participant's costs. As modeled capital costs decrease, we see the overall participant costs decreasing.[4] On the benefits side, the primary components are the bill reductions from TOU arbitrage and the SGIP incentive. The SGIP incentive is modeled to decline at a rate of five percent per year, resulting in decreased benefits. At the same time, we see increased bill savings due to the modeled increases in retail rates over time. The total benefits remain relatively flat over time, as the

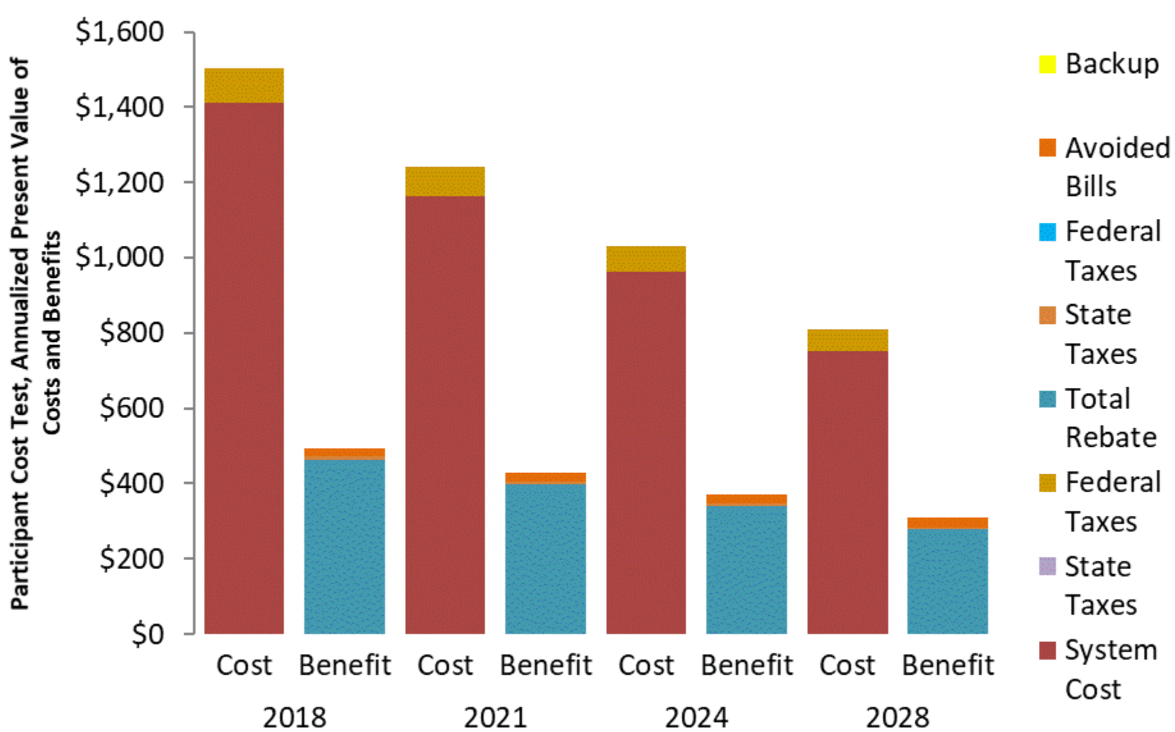
[3] In the graph and in the tests presented throughout this report, the federal and state taxes can be counted as a benefit (e.g., Federal Investment Tax Credit) or a cost depending on their sign.

[4] Technology capital cost assumptions are described in Section 5.

increase in modeled bill savings is balanced with the modeled decline in the SGIP incentive. The modeled decline in storage capital costs are the primary driver of the overall reductions in the PCT benefits ratio.

Figure 6-5 presents the PCT costs and benefits for the Residential No HVAC load shape on PG&E's TOU B rate which results in the lowest PCT ratios. We include this example to illustrate how in certain cases, residential energy storage PCT ratios are not estimated to exceed 1.0 by 2028. In this case we see the same declines in the equipment cost and the SGIP rebate as in the previous example. However, the TOU price differentials and therefore the energy storage bill arbitrage opportunities are much smaller under PG&E's TOU B rate, leading to minimal bill savings and PCT ratios that go from 0.33 in 2018 to 0.38 by 2028.

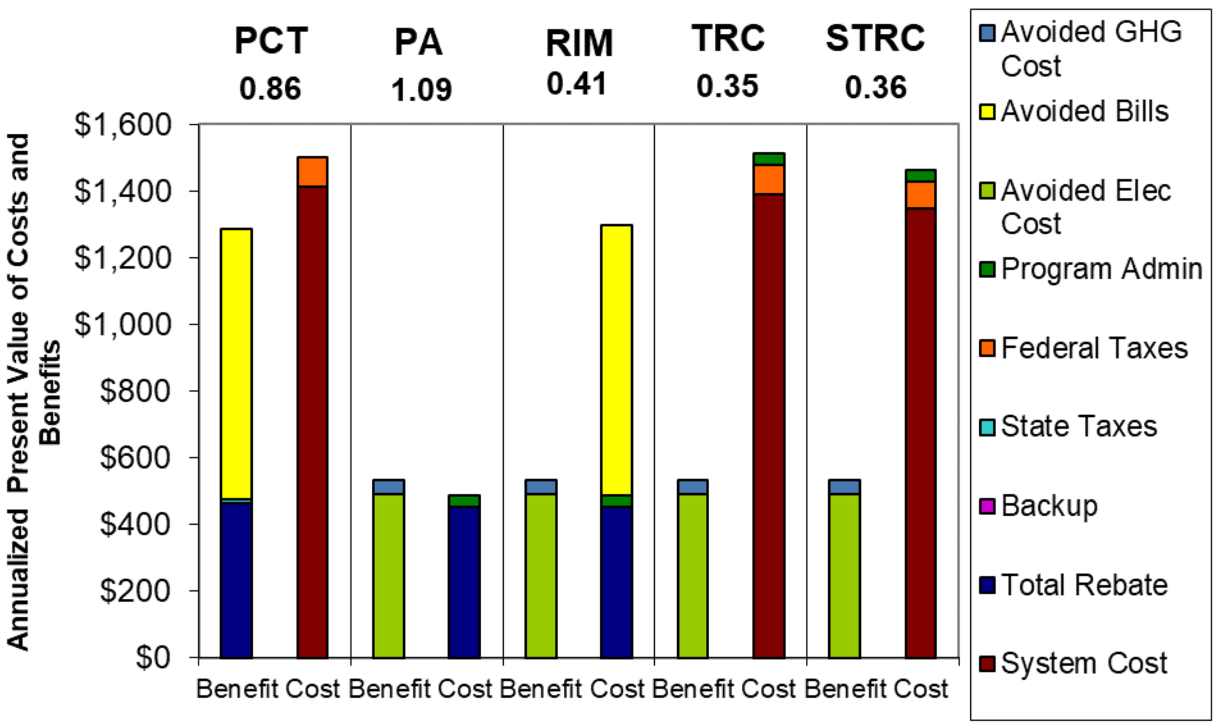
FIGURE 6-5: RESIDENTIAL NO HVAC LOAD SHAPE, PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, PG&E E-TOU-B RATE, 2018-2028



The PCT provides insights into the economics of energy storage from the point of view of the participant. A PCT ratio greater than or equal to 1.0 suggests that the energy storage investment is cost-effective for the participant. However, when evaluating cost-effectiveness, we must consider cost-effectiveness from the perspective of the program administrator (PA), the grid, and nonparticipating ratepayers.

Figure 6-6 presents the results of all cost-effectiveness tests in 2018 for the Residential HVAC Load Shape on SDG&E's EV-TOU-5 rate (including the SGIP incentive). In addition to the PCT, Figure 6-6 shows the program administrator (PA) test, the ratepayer impact measure (RIM) test, the total resource cost (TRC) test, and the societal total resource cost (STRC) test.[5] We include this figure as a prototypical example of the various costs and benefits that are included in each test. However, we urge the reader not to consider the benefit-cost ratios in Figure 6-6 representative of all simulation results. Later in this section we present average benefit-cost ratios for all simulations.

FIGURE 6-6: RESIDENTIAL NO HVAC LOAD SHAPE, ALL TESTS, BASE CASE, WITH INCENTIVE, SDG&E EV-TOU-5 RATE, 2018



The PA ratio in the example above is 1.09, indicating that the benefits to the utility exceed the costs. From the utility perspective, benefits are driven by avoided costs associated with energy storage charge and discharge. In this case, the energy storage system avoided more costs during discharge than it incurred during charging, resulting in a benefit to the utility. These benefits outweighed the costs to the utility, which include the SGIP incentive and the program administration costs. Again, we remind the reader that this is a prototypical example of a single simulation result. Later in this section we discuss average PA test results for all IOUs.

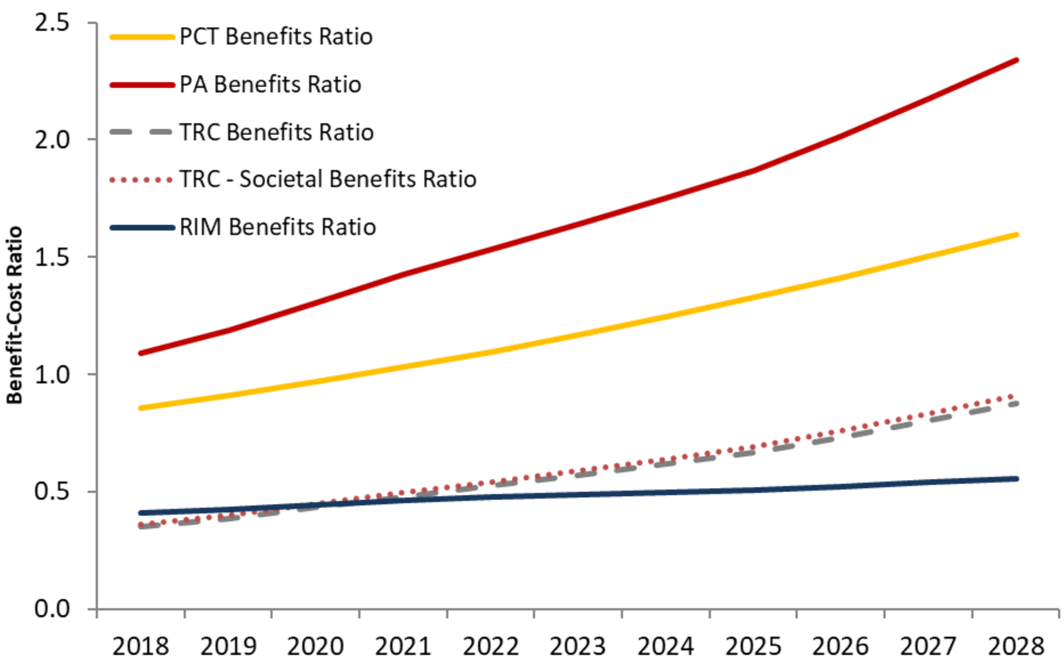
5 Section 5 describes the cost-effectiveness tests in considerable detail.

The RIM test shows the benefits and costs to all ratepayers associated with energy storage charge and discharge. In the RIM test, the benefits to ratepayers are the same as the benefits to the utility in the PA test. Avoided costs result in benefits to ratepayers since a reduction in utility costs results in potential rate reductions. The costs to ratepayers in the RIM test include the SGIP incentive, program administration costs, and the loss of revenue to the utility resulting from bill savings. These components all represent costs to the utility that may translate to increased rates to all ratepayers. In this case, RIM costs exceed the benefits – the reduction in utility costs is less than the SGIP costs and the reduction in utility revenue. All things being equal, the operation of a residential energy storage system under this case will result potential rate increases to nonparticipating ratepayers.

The TRC test considers costs and benefits from a statewide perspective. The benefits are the same as the PA and the RIM test, but the costs are different. SGIP incentive costs are not accounted for in the TRC since they are considered a wealth transfer within the state. The primary cost driver in the TRC is the cost of the energy storage technology, including financing and insurance costs. The TRC is a ratio of the benefits provided to the grid from energy storage relative to its costs. In this case the avoided costs from storage charge/discharge are less than the cost of the technology, resulting in a TRC ratio of 0.35. The STRC benefits ratio for this prototypical example (0.36) is close to the TRC benefits ratio, the primary difference being the discount rate used to calculate the present value of all cash flows.

Figure 6-7 presents the cost benefit ratios for the same prototypical SDG&E EV-TOU-5 case through 2028.

FIGURE 6-7: RESIDENTIAL NO HVAC LOAD SHAPE, ALL TESTS, BASE CASE, WITH INCENTIVE, SDG&E EV-TOU-5 RATE, 2018-2028



As discussed previously, the PCT ratio begins at 0.86 and crosses above 1.0 around 2021. The TRC and STRC ratios are below 50 percent in 2018 and approach 90 percent by 2028. The PA benefits ratio is 1.09 in 2018 and more than doubles by 2028. Subsequent subsections provide IOU-specific average results for all simulations, not just this prototypical example. Figure 6-8 and Figure 6-9 below present the average estimates of the TRC test for the residential base case including SGIP incentives by rate type, electric IOU, and years 2018, 2024, and 2028.

FIGURE 6-8: AVERAGE RESIDENTIAL TOTAL RESOURCE COST TEST, BASE CASE, WITH INCENTIVE, EV-TOU RATES, BY IOU, 2018, 2024, 2028

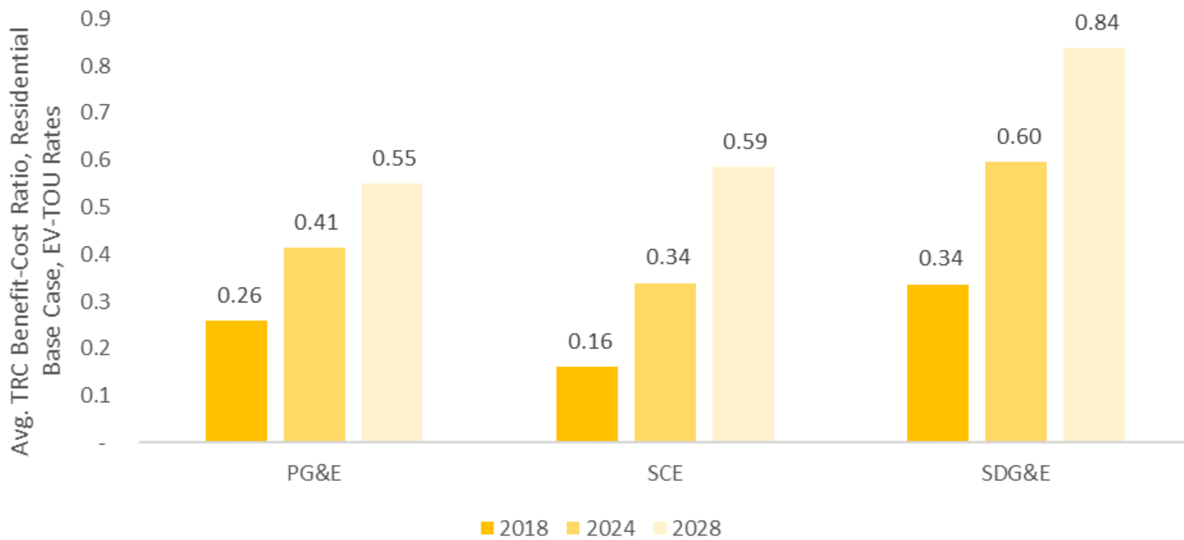


FIGURE 6-9: AVERAGE RESIDENTIAL TOTAL RESOURCE COST TEST, BASE CASE, WITH INCENTIVE, TRADITIONAL TOU RATES, BY IOU, 2018, 2024, 2028

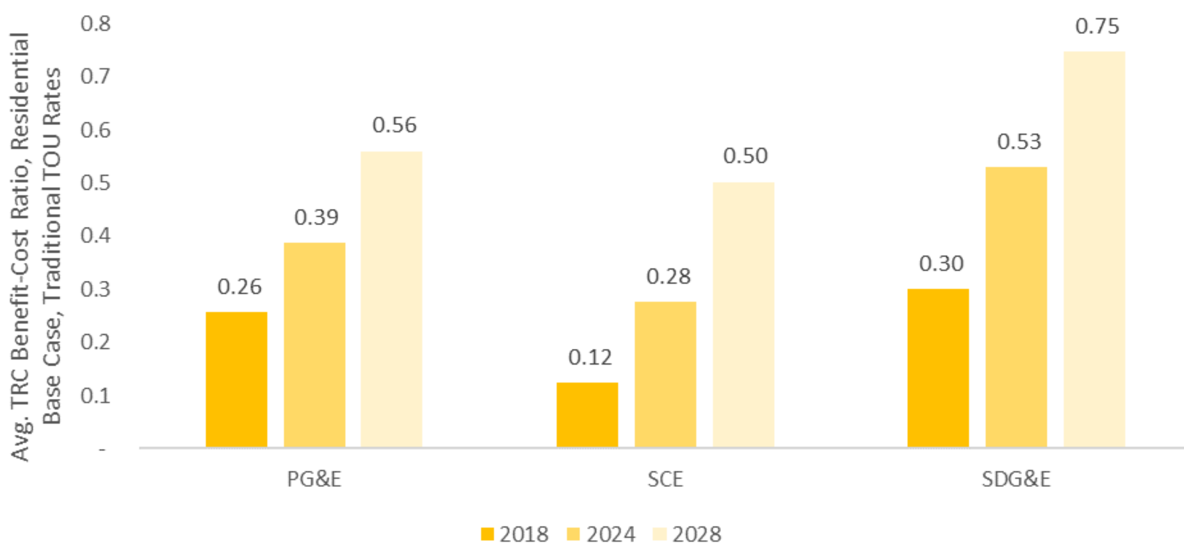


Figure 6-8 and Figure 6-9 illustrate that for the base case, the average TRC ratio is not expected to exceed 1.0 before 2028. The cost of the storage system, in addition to the program non-incentive costs, exceed the value of the avoided cost benefits produced by the energy storage system. The TRC ratios are slightly higher for the EV-TOU rates than the traditional TOU rates, indicating that the EV-TOU rates encourage participants to charge and discharge their batteries during times that are slightly more advantageous to the utility than the traditional TOU rate.

The results forecast that the TRC ratio will approach 1.0 in 2028 for the SDG&E EV rate when used for customer bill minimization. TRC ratio results for alternative use cases (GHG signal, distribution upgrade deferral, demand response, and backup) are presented in subsequent subsections. The distribution deferral and GHG signal cases will illustrate that under our modeling assumptions, residential energy storage systems are estimated to pass the TRC test (i.e., benefit cost ratio greater than 1.0) under specific scenarios.

Figure 6-10 and Figure 6-11 illustrate the average PA cost test ratios for the residential base case including the SGIP incentive for EV-TOU and traditional TOU rates respectively. Figure 6-10 and Figure 6-11 show that the PA test is slightly higher for the EV-TOU rates than the traditional TOU rates. As with the TRC results, the charging and discharging of the customers' energy storage systems is better aligned with utility costs under the EV-TOU rates when compared to the traditional TOU rates. The PA test results are generally higher than the TRC ratios. The costs for the PA test include the program administrative costs and the incentives, which are less than the TRC costs. The TRC costs include the cost of the energy storage system, which is a considerable expense relative to the TRC benefits.

FIGURE 6-10: AVERAGE RESIDENTIAL PROGRAM ADMINISTRATOR COST TEST, BASE CASE, WITH INCENTIVE, EV-TOU RATES, BY IOU, 2018, 2024, 2028

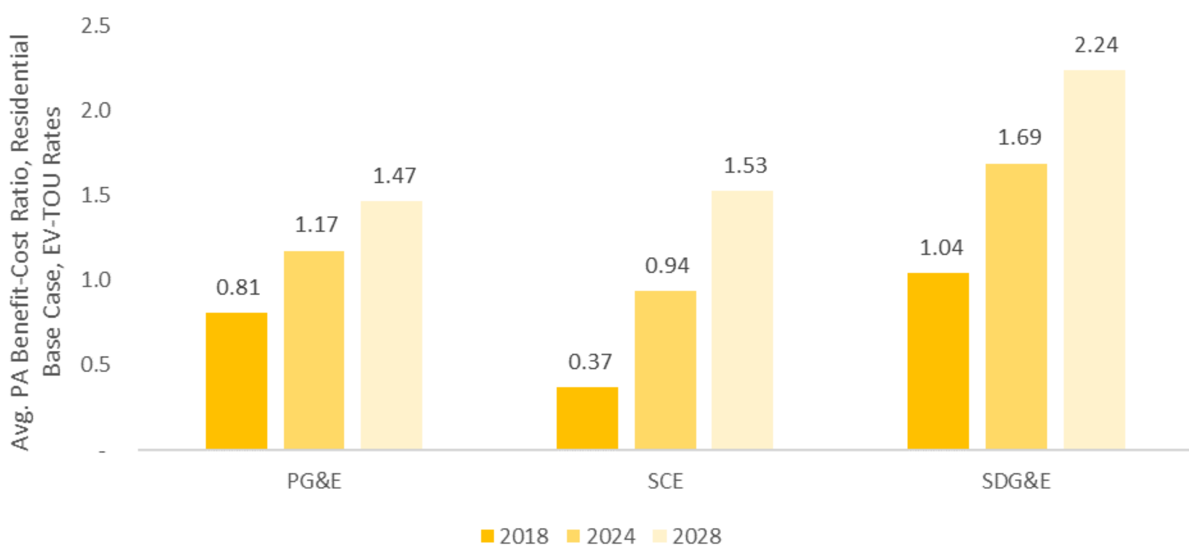


FIGURE 6-11: AVERAGE RESIDENTIAL PROGRAM ADMINISTRATOR COST TEST, BASE CASE, WITH INCENTIVE, TRADITIONAL TOU RATES, BY IOU, 2018, 2024, 2028

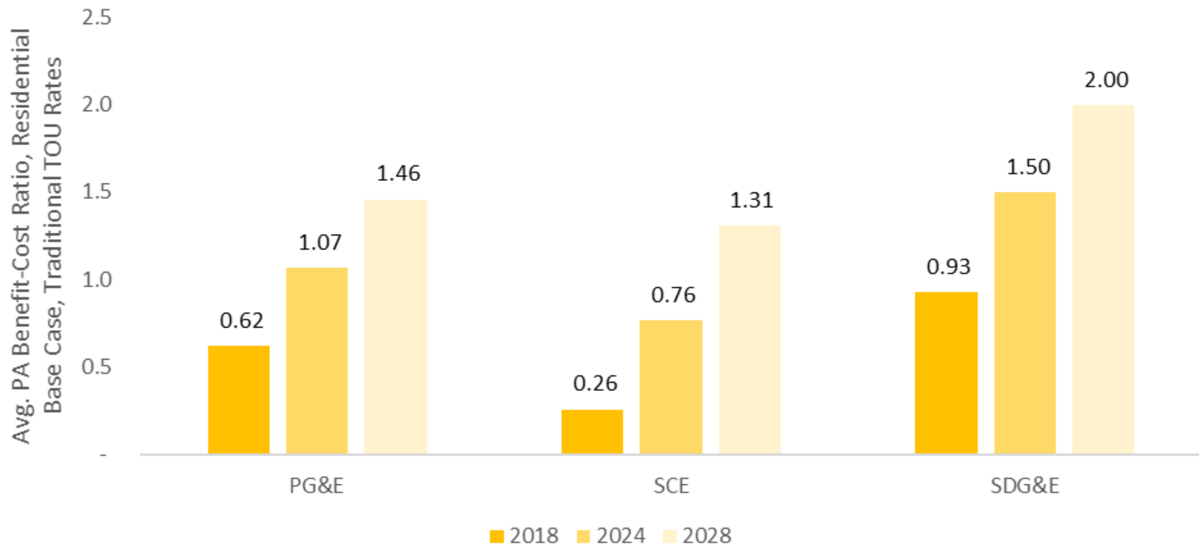


Figure 6-12 and Figure 6-13 show the average RIM ratio for the residential base case with SGIP incentives for the EV-TOU and traditional TOU rates in 2018, 2024, and 2028.

FIGURE 6-12: AVERAGE RESIDENTIAL RATEPAYER IMPACT COST TEST, BASE CASE, WITH INCENTIVE, EV-TOU RATES, BY IOU, 2018, 2024, 2028

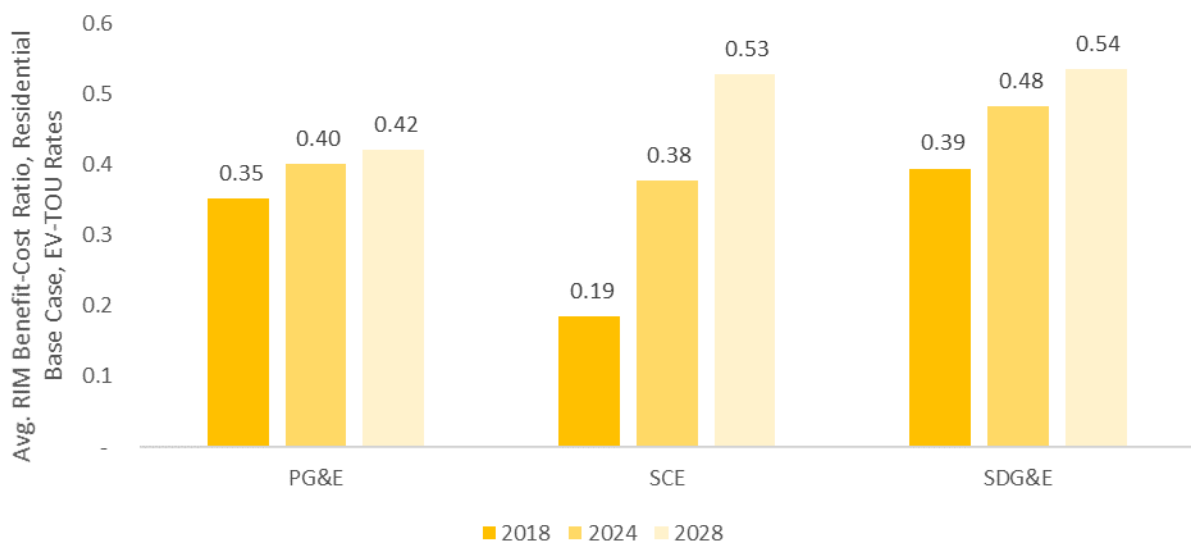
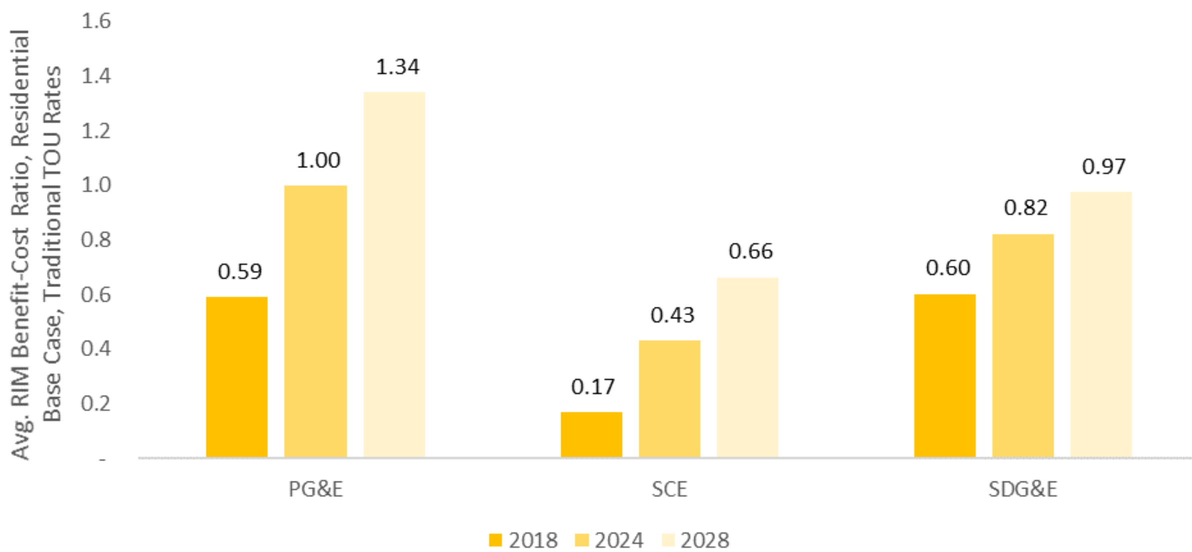


Figure 6-12 and Figure 6-13 show that the average RIM ratio is generally lower for the EV-TOU rates than the traditional TOU rates. Within the RIM test, the customer bill savings are a cost and EV-TOU rates generally provide customers with a larger opportunity for energy arbitrage, larger bill savings, and a higher PCT ratio (see Figure 6-2 and Figure 6-3). The estimates for the PG&E TOU RIM benefits ratio are greater than 1.0 for 2024 and 2028. The avoided cost benefits for the residential base case on the traditional PG&E TOU rate exceed the sum of the program, incentive, and bill impacts. The RIM test results for the traditional PG&E TOU rate benefits from the very low bill saving opportunity on the rate, as evidenced by the low PCT ratio for PG&E in Figure 6-3. Conversely, the EV rate RIM values are generally lower because the EV rate provides the participant with a larger bill savings, which is a cost for the RIM test.

FIGURE 6-13: AVERAGE RESIDENTIAL RATEPAYER IMPACT COST TEST, BASE CASE, WITH INCENTIVE, TRADITIONAL TOU RATES, BY IOU, 2018, 2024, 2028



Modeled Residential Energy Storage Greenhouse Gas Emissions

Greenhouse gas emissions reductions are a key goal of the SGIP. Recent energy storage impact evaluations have found that SGIP residential and nonresidential energy storage systems are increasing GHG emissions, likely due to the misalignment of retail rates and marginal CO_2 emissions rates. This finding led to the creation of the GHG working group and the adoption of new program rules designed to improve the GHG performance of residential and nonresidential energy storage systems.

Figure 6-14 on the following page shows the simulated GHG emissions impact of energy storage systems in the base case under ideal dispatch. Values are shown normalized per energy storage system size (kWh), negative values indicate a GHG emission reduction. In our modeling, 18 out of 24 base case residential energy storage cases achieve GHG emission reductions during their first year of operation. On average, residential energy storage systems in the base case reduce GHG emissions by 3.2 kg CO_2/kWh.

The GHG emissions impact reported in Figure 6-14 is based on ideal dispatch of storage performing residential TOU arbitrage. This finding differs from the observed impacts reported in the SGIP energy storage impact evaluation report, which found that on average, all residential energy storage systems increased GHG emissions. Even under ideal dispatch for bill savings, modeled energy storage systems in the 2017 SGIP impact evaluation report increased GHG emissions. However, one key difference between the 2017 SGIP evaluation results and the results presented in Figure 6-14 are the underlying retail rates which drive energy storage charge and discharge behavior. In the 2017 SGIP impact evaluation report, energy storage systems were largely on tiered volumetric rates with no TOU price differentials. The 2018 SGIP impact evaluation will investigate the GHG impacts of new residential energy storage systems on TOU rates.

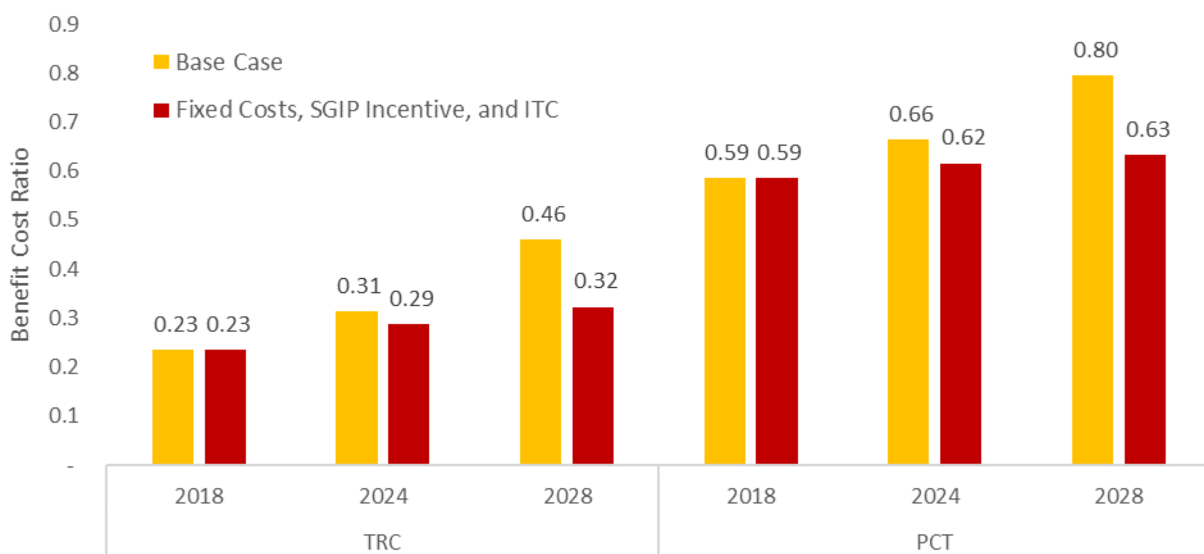
FIGURE 6-14: RESIDENTIAL BASE CASE SIMULATED FIRST YEAR GREENHOUSE GAS IMPACT, 2018

Case Study: No Changes in Technology Cost, SGIP Incentive, and Federal ITC

Our modeling includes many assumptions that change the costs and benefits of energy storage over time. For example, the installed costs of energy storage are projected to decline over time as manufacturing methods improve. Retail rates are projected to increase as the utility's cost to serve load changes. In our modeling we also assume that the SGIP incentive decreases at a rate of five percent per year as a proxy for the program's current step-down incentive mechanism. Finally, we model the Federal Investment Tax Credit (ITC) decreasing from 30 percent to 10 percent after 2021.

The myriad changes in costs and benefits make it difficult to interpret the relative importance of a single factor. Among the parameters we model, the installed costs of the energy storage system are likely a primary driver in changes to the PCT and TRC ratios over time. However, considerable uncertainty surrounds energy storage cost projections – changes in the availability of precious metals, trade disturbances, and supply constraints are some of the factors that could render these cost projections moot. In order to isolate these effects, we consider a set of simulations where the SGIP incentive, the Federal ITC assumptions, and the installed cost of the energy storage system remain fixed over time. In this scenario, the primary drivers of change in the cost-effectiveness tests are the changes in retail rates and the changes to the avoided costs over time. Figure 6-15 summarizes key findings from this case study.

FIGURE 6-15: AVERAGE RESIDENTIAL TOTAL RESOURCE AND PARTICIPANT COST TEST, CASE STUDY BASE CASE VS. FIXED TECHNOLOGY COSTS, SGIP INCENTIVE, AND ITC, ALL IOUS, 2018, 2024, 2028

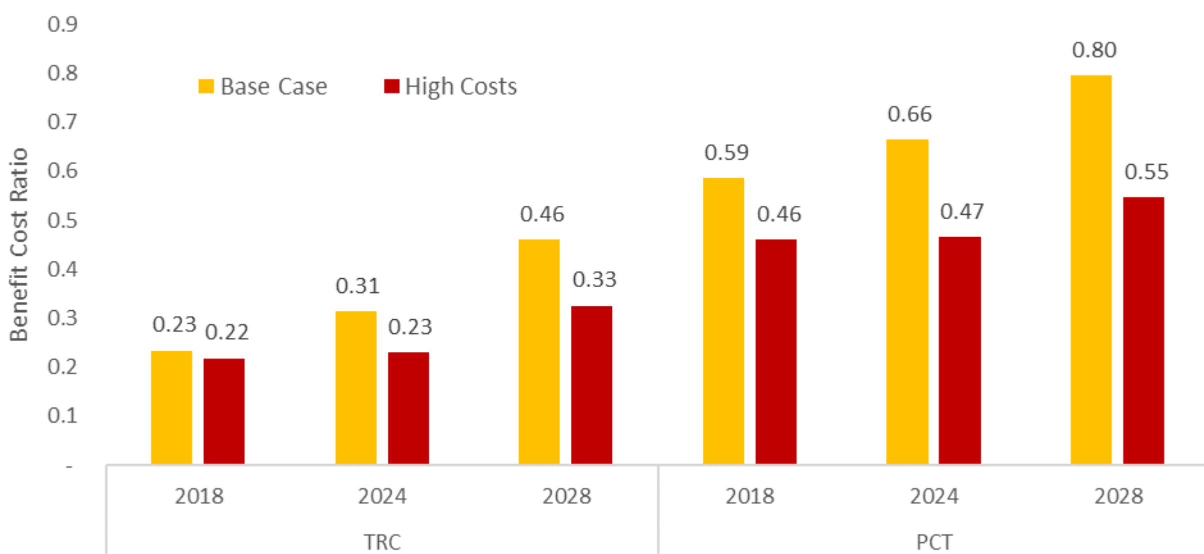


In the residential base case (average of 24 residential simulations across IOUs, rate types, and load shapes), the TRC benefits ratio increases from 0.23 in 2018 to 0.46 in 2028 and the PCT benefits ratio increases from 0.59 in 2018 to 0.80 in 2028. If we assume that installed costs remain static in time, along with the SGIP incentive and the federal ITC, the TRC benefits ratio only increases to 0.32 by 2028, and the PCT benefits ratio increases to 0.63. Without these cost reductions, the 2028 TRC is approximately 30 percent lower and the 2028 PCT is 21 percent lower. In this case study the TRC and PCT still increase over time due to changes in retail rates and utility avoided costs, but the improvements are not as significant without the implied reductions in technology costs.

Case Study: High Capital Costs Scenario

We consider another case study where upfront capital costs are higher than the base case. In this scenario, all modeling assumptions except for the technology upfront costs are consistent with the base case (e.g., the SGIP incentive, the ITC, and the rate of technology cost reductions remain constant). This case study attempts to quantify a scenario where perhaps installation costs are considerably higher than expected, such as when an electrical panel upgrade is required. Alternatively, this scenario is also reflective of an installation by a smaller developer who does not have access to bulk pricing on storage system purchases, or a customer choosing to install a higher-cost technology. The assumptions used to model the base case and high cost scenario were presented in Section 5. Figure 6-16 summarizes findings from this case study.

FIGURE 6-16: AVERAGE RESIDENTIAL TOTAL RESOURCE AND PARTICIPANT COST TEST, CASE STUDY BASE CASE VS. HIGH COST SCENARIO, WITH INCENTIVE, ALL IOUS, 2018, 2024, 2028



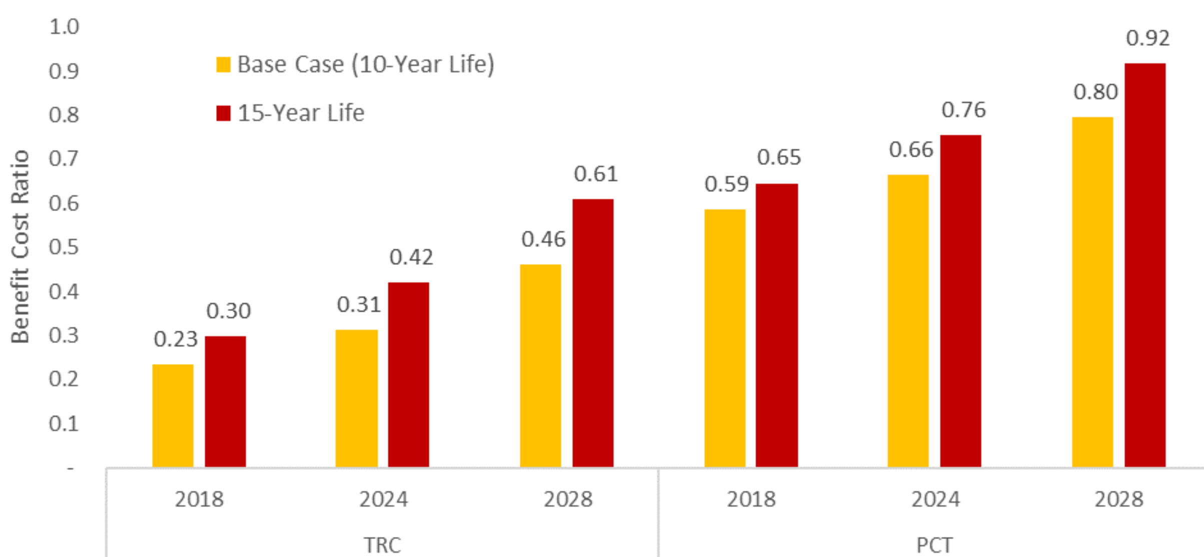
In the high technology cost scenario, the average modeled residential TRC across all IOUs increases from 0.22 in 2018 to 0.33 by 2028, approximately 28 percent lower than the base case projection for 2028. The average 2018 residential PCT is 22 percent lower in the high cost case relative to the base case. By 2028, the simulated average residential PCT is 0.55, 31 percent lower than the average 2028 residential PCT in the base case. Intuitively, the average PCT and TRC benefit ratios are lower in the high cost case relative to the base case. This is expected since the cost of the energy storage system is a key driver of both tests.

Case Study: Fifteen-Year Energy Storage Useful Life

An important assumption in our modeling is the useful life of the energy storage system. Energy storage is a nascent technology and limited information exists on its useful life. In our base case, we assume that energy storage systems operate for ten years. The total benefits and costs associated with an energy storage system – including bill savings, avoided costs, and GHG impacts – accumulate over the life of the measure. This case study changes the modeled useful life of the storage system to 15-years, leading to increased bill impacts and utility avoided costs. Figure 6-17 summarizes findings from this case study.

In general, we find that extending the storage system life from 10 to 15 years increases both the PCT and TRC benefit ratios. During 2018, the average modeled residential TRC benefits ratio increases from 0.23 to 0.30, and the average modeled residential PCT benefits ratio increases from 0.59 to 0.65. By 2028, the average modeled residential TRC benefits ratio with a 15-year life is 0.61, approximately 33 percent higher than the base case. The average 2028 modeled residential TRC benefits ratio in the 15-year life case is 0.92, 15 percent higher than the base case.

FIGURE 6-17: AVERAGE RESIDENTIAL TOTAL RESOURCE COST AND PARTICIPANT TEST, CASE STUDY BASE CASE VS. 15-YEAR LIFE SCENARIO, WITH INCENTIVE, ALL IOUS, 2018, 2024, 2028



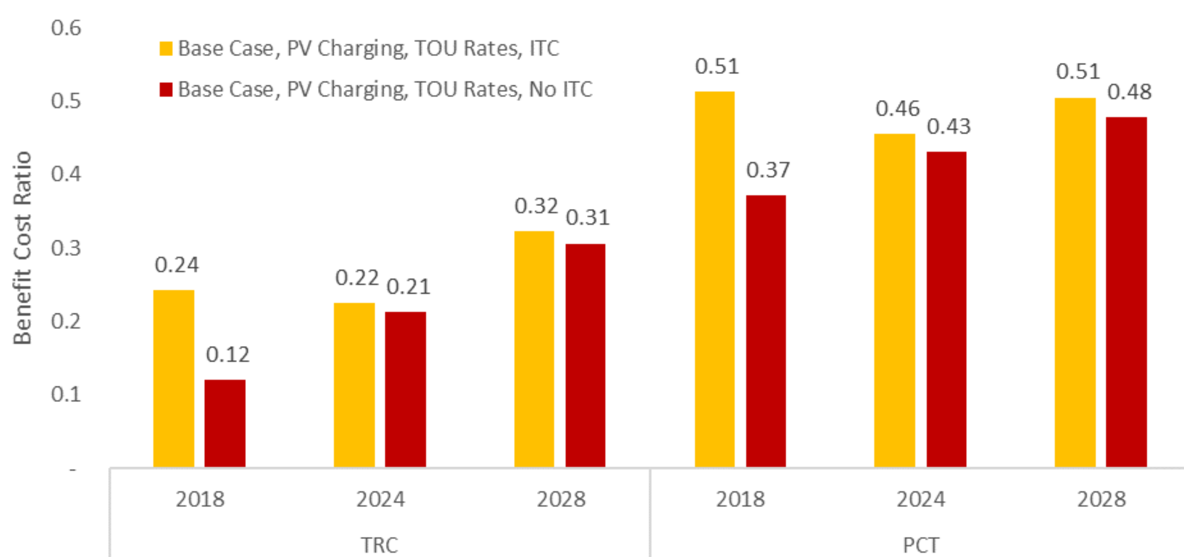
Case Study: No Federal Investment Tax Credit

The Federal Investment Tax Credit provides an additional financial incentive for energy storage systems charging from solar PV. In this case study, we consider a scenario where the Federal ITC is not available. In order to make this comparison useful, we limit the case study to base case residential energy storage systems on TOU rates charging from PV. In our model, customers on EV rates choose to charge overnight when energy rates are lowest and therefore are not eligible for the Federal ITC. Figure 6-18 on the following page summarizes the results of this case study for the six scenarios included in this subset (two load shapes, three IOUs, limited to TOU rates and PV charging).

Eliminating the Federal ITC reduces the average residential participant benefit ratio in all years. In 2018, the average residential benefit ratio without the ITC is 0.37, 28 percent lower than the case with the Federal ITC included. For systems installed in 2024 and 2028 the difference is not as pronounced since our base case model has the ITC dropping to 10 percent in later years. By 2028, we see the average residential participant benefit ratio without the ITC is 0.48, 6 percent lower than the base case with the ITC.

The TRC benefits ratio is also affected by the Federal ITC. The ITC represents a transfer of wealth from the Federal government into California, reducing the cost of the measure and therefore increasing the TRC benefits ratio. In 2018, the average TRC benefits ratio is 0.24 for the base case (TOU rates with PV charging only), and 50 percent lower in the case without the Federal ITC. By 2028 the gap is not as wide, the base case TRC benefits ratio increases to 0.32, and 0.31 in the case without the Federal ITC.

FIGURE 6-18: AVERAGE RESIDENTIAL TOTAL RESOURCE COST AND PARTICIPANT TEST, CASE STUDY BASE CASE VS. NO ITC SCENARIO, WITH INCENTIVE, ALL IOUS, 2018, 2024, 2018



6.1.2 Demand Response Program Influence on Residential Cost-Effectiveness

Participating in demand response programs unlocks a potential revenue stream for energy storage customers. It also ensures that energy storage will discharge during high avoided costs hours which are aligned with the DR signal. Section 5 provides details on the hypothetical DR program modeled for this study. Figure 6-19 summarizes the influence of DR on the residential TRC and PCT. Results are shown for the base case, with the SGIP incentive, averaged across all IOUs, with and without the influence of DR participation. Figure 6-19 shows that, on average, adding DR slightly improves the economics for host customers. DR represents an additional revenue stream which on average increases the modeled 2018

PCT benefits ratio from 0.59 to approximately 0.68. By 2028, the average residential PCT benefits ratio with DR is 1.02, almost 28 percent higher than the 2028 average residential base case PCT benefits ratio.

Averaged across all IOUs we find that the addition of DR leaves the TRC benefits ratio largely unchanged. This potentially counter-intuitive finding is explained by Figure 6-20. Here we show two sets of load and storage charge/discharge shapes for the same customer. In both cases the yellow line is the customer load before storage, the dashed red line is the customer load after storage, and the grey line is the storage charge/discharge shape (charge is positive). The timeseries at the top of Figure 6-20 is the scenario where no DR event is called. The bottom timeseries is the same customer on the same day but in the scenario that includes a one-hour DR event at 4 pm. We can see that in both cases the storage dispatch is very similar. Under residential rates with 4-9 pm on-peak periods, the modeled energy storage system performing TOU arbitrage will begin to discharge at 4 pm. A DR event at 4 pm is coincident with the hours when the storage system is already discharging.

FIGURE 6-19: AVERAGE RESIDENTIAL TOTAL RESOURCE COST AND PARTICIPANT TEST, INFLUENCE OF DEMAND RESPONSE, WITH INCENTIVE, ALL IOUS, 2018, 2024, AND 2028

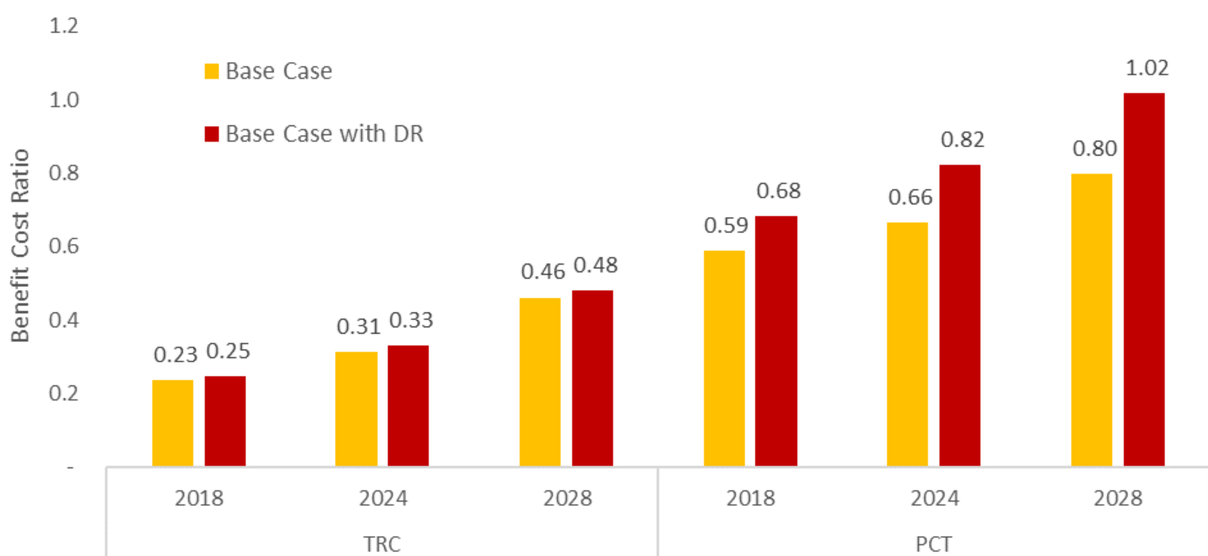
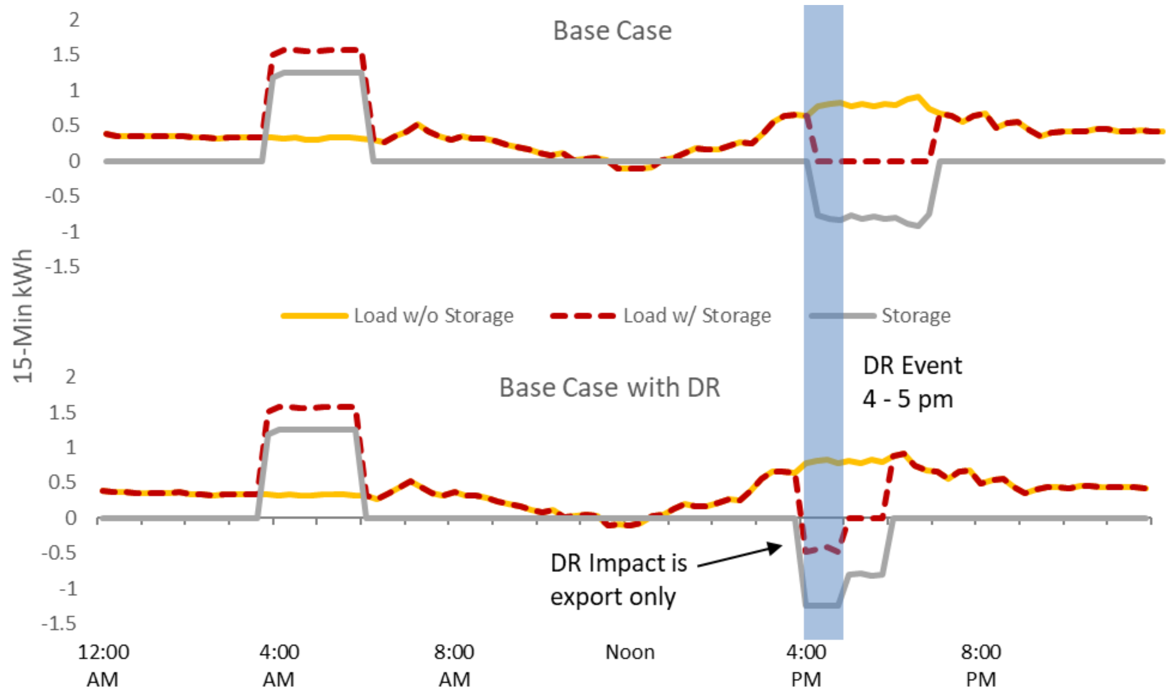


FIGURE 6-20: INFLUENCE OF DEMAND RESPONSE ON STORAGE LOAD SHAPES



In our modeling, residential energy storage is constrained to not export energy back to the grid during discharge. We make an exception for the demand response cases – since the modeled DR program intends to provide system-level benefits, energy storage is allowed to discharge at its rated capacity, even if it results in export. When quantifying the DR benefit for the customer, we consider the marginal benefit provided in the DR scenario beyond the load reduction that the energy storage system was delivering in the same case without DR. In the prototypical example above, the base case energy storage system is export-constrained, meaning that it's not discharging at its full capacity to prevent export. In the DR scenario, the energy storage system discharges at full capacity from 4 – 5 pm, resulting in export during that hour. The net impact of the DR program, and the basis for the DR payment to the participant, is the energy that is exported from 4 – 5 pm.

Current utility interconnection rules and DR program designs may not allow or credit energy storage systems that export during event hours. We chose to allow storage export during DR event hours to illustrate how this program design influences storage cost-effectiveness. In this example, the TRC improves slightly due to increased energy storage discharge during a high avoided cost hour. The PCT also improves because the customer receives a DR payment for the incremental storage discharge beyond their baseline. However, in other cases where the storage system is not export constrained (i.e., the system was already discharging at full capacity during the on-peak TOU period), the DR program would provide no benefit. If the energy storage system is discharging at full capacity in the baseline, no incremental benefit is provided in the DR case.

6.1.3 Greenhouse Gas Signal Influence on Residential Cost-Effectiveness

The CPUC proposed decision approving greenhouse gas emission reduction requirements for the SGIP storage budget calls for the creation of a GHG signal to provide storage developers and customers with storage the information they need to charge storage during low-GHG emission periods and to discharge during high-GHG emission periods. The decision directs the SGIP PAs to create a digitally accessible, real-time, marginal GHG emissions factor in units of kg CO_2/kWh. The GHG signal does not yet exist, but we created two $/kWh price signals using an implied $/MT CO_2 value. For purposes of this analysis, we considered two values for $/MT CO_2:

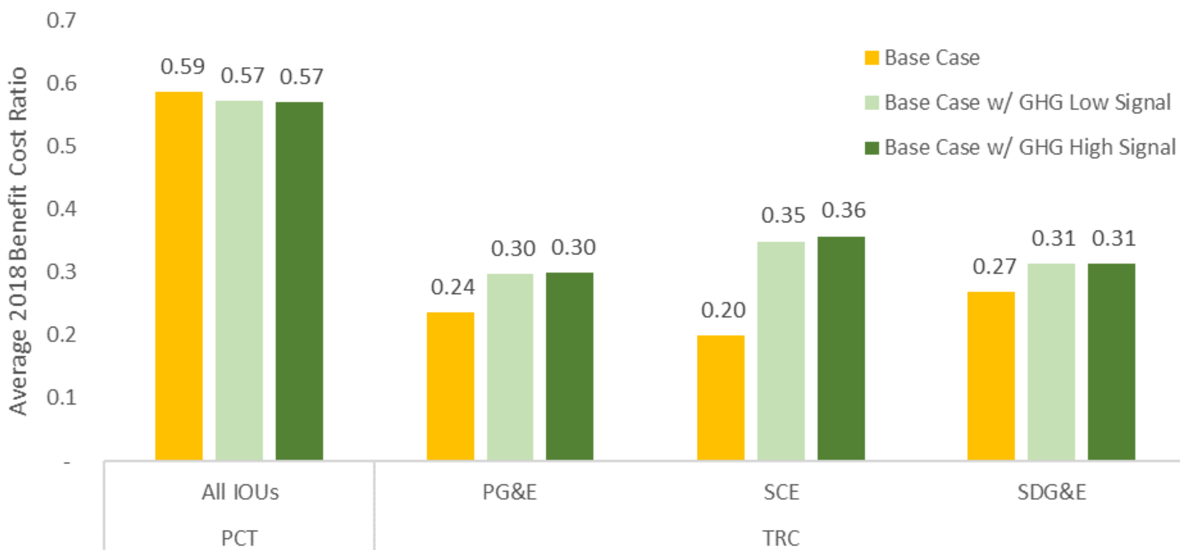
- $15/MT CO_2 (GHG – Low Signal)
- $65/MT CO_2 (GHG – High Signal)

In our modeling, the signals are provided to the storage dispatch algorithm which co-optimizes this value along with the utility retail rate. The signal serves exclusively to influence storage dispatch – the energy storage system will choose to charge when the GHG signal value is low, and discharge when the GHG signal value is high, while also considering the underlying customer retail rate. The value of the signal does not affect the customer's incentive in any way – all modeled residential customers receive the entire SGIP incentive upfront. Storage customers do not earn revenue from the GHG signal in any way. In our modeling, the GHG signal is available to both residential and nonresidential energy storage customers. Lastly, our modeling makes two additional important assumptions:

1. Energy storage systems can respond optimally to the GHG signal, and
2. The GHG signal contains no forecast error (i.e., the signal represents the actual marginal emissions rate)

Both assumptions will result in a best-case scenario for simulated GHG impacts. If actual energy storage charge/discharge does not follow the GHG signal perfectly, the observed GHG impacts will be worse. Furthermore, if the GHG signal contains significant forecast error or otherwise deviates from actual GHG emissions, then the observed GHG impact will be worse. Lastly, we note that the CPUC proposed decision does not require that a GHG signal be provided to residential energy storage systems, the requirement is only for nonresidential systems. However, our modeling considers both residential and nonresidential customers following a GHG signal to illustrate the influence of this signal on storage cost-effectiveness. Figure 6-21 summarizes the influence of the GHG signal on the average participant and TRC benefit ratios for each utility in 2018.

FIGURE 6-21: INFLUENCE OF GHG SIGNAL ON AVERAGE RESIDENTIAL PARTICIPANT AND TOTAL RESOURCE COST TESTS, 2018, WITH INCENTIVE, ALL IOUS



In our modeling, the GHG signal produces a slight reduction in the PCT benefits ratio as it represents a deviation from perfect TOU arbitrage. The presence of a GHG signal might drive an energy storage system to occasionally charge or discharge at times that are not ideal for bill reduction. However, in our modeling across all IOUs, the GHG signal leads to an increase in the average TRC resulting from improved alignment of storage charge/discharge and utility avoided costs. Even though the GHG signal contains no information on avoided costs, the GHG signal is high when energy prices are high. The changes in both the PCT and the TRC benefits ratio are most notable between the base case and the "GHG – Low" case. There is a much smaller difference between the "GHG – Low" and the "GHG – High" cases in both the PCT and the TRC. While our modeling shows the GHG signal improves the TRC under ideal conditions, the improvement is not enough to increase the average 2018 TRC benefits ratio above 1.0 for any IOU.

Figure 6-22 shows the average modeled particiant, TRC, and RIM benefit cost ratios across all IOUs for 2018, 2024, and 2028 with and without responding to the "GHG – High" signal. We see that the participant test does not change considerably between the base case and the case with the GHG signal. By 2028, the average base case participant benefit cost ratio is 0.80 and 0.79 with the GHG signal. The influence of the GHG signal on the TRC is more noticeable, as discussed above. Figure 6-22 shows that the average TRC benefit ratio is 0.69 by 2028, 50 percent higher than the average in the base case. In other words, perfect dispatch and a perfect GHG signal are responsible for lifting the 2028 average TRC benefit ratio by 50 percent relative to the other drivers of improvement in the TRC like a reduction in the installed cost. A similar trend is apparent in the RIM test – the average 2028 residential RIM benefit ratio is 0.93 with the perfect GHG signal, over 50 percent higher than the base case without the GHG signal.

FIGURE 6-22: INFLUENCE OF GHG SIGNAL ON AVERAGE RESIDENTIAL PARTICIPANT, TOTAL RESOURCE, AND RATEPAYER IMPACT COST TEST, WITH INCENTIVE, ALL IOUS, 2018 - 2028

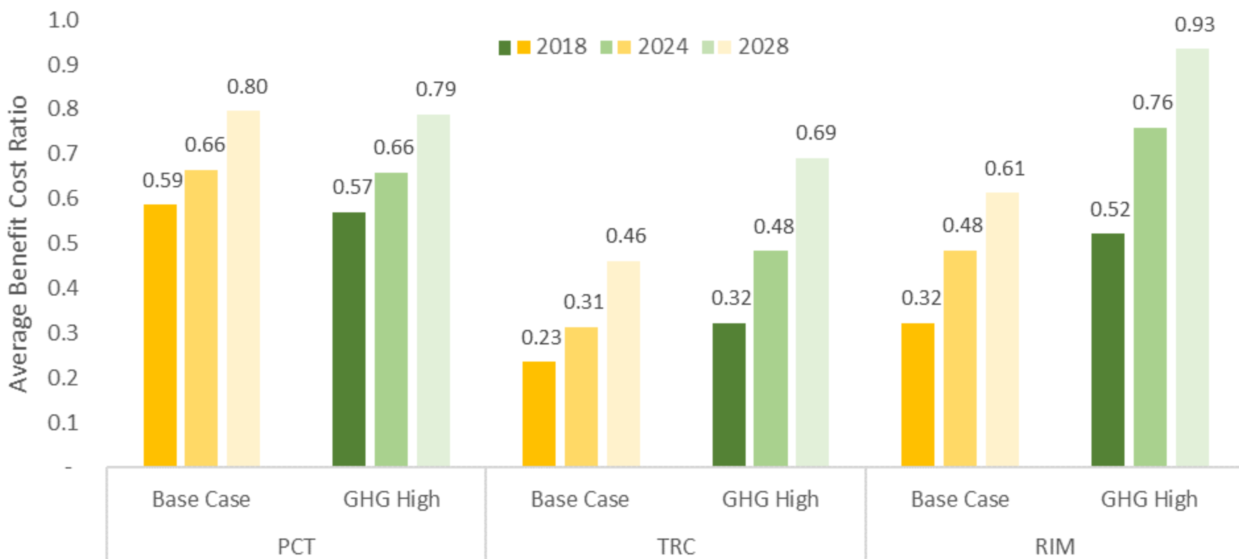
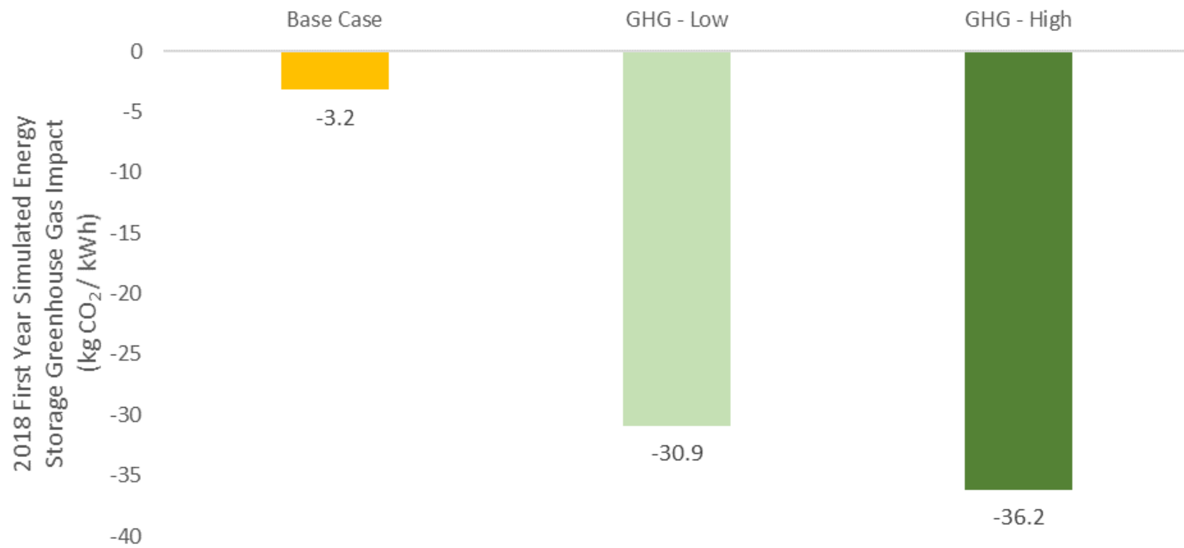


Figure 6-23 on the following page shows the average simulated 2018 first-year greenhouse gas emission impact for the base case and the low/high GHG signal cases. On average, our modeling finds that energy storage systems in the base case working to perfectly arbitrage TOU rates decrease emissions by 3.2 kg of CO_2 per kWh of storage capacity. However, Figure 6-14 above showed that there is considerable variability in this average – one project in the base case was found to decrease 2018 first-year GHG emissions by almost 14 kg CO_2/kWh, whereas another was found to increase first-year emissions by 13 kg CO_2/kWh.

On the other hand, our modeling finds that residential energy storage systems following the GHG signal perfectly always decrease emissions. On average, 2018 cases with the “GHG – Low” signal decrease emissions by 30.9 kg CO_2/kWh during their first year of operation. Cases with the “GHG – High” signal further decrease 2018 first-year emissions by 36.2 kg CO_2/kWh.

FIGURE 6-23: IMPACT OF GREENHOUSE GAS SIGNAL ON AVERAGE FIRST YEAR GREENHOUSE GAS EMISSIONS IMPACT, 2018



As we close this discussion of GHG emissions and the GHG signal, we once again remind the reader of the theoretical nature of this analysis. Our modeling is based on perfect dispatch of energy storage following a GHG signal that perfectly quantifies the grid's marginal CO_2 emissions rate. As such, it represents a theoretical maximum on potential GHG emission reductions from energy storage. Future impact evaluation reports will provide useful insights on the actual performance of energy storage systems under new TOU rates while following a GHG signal.

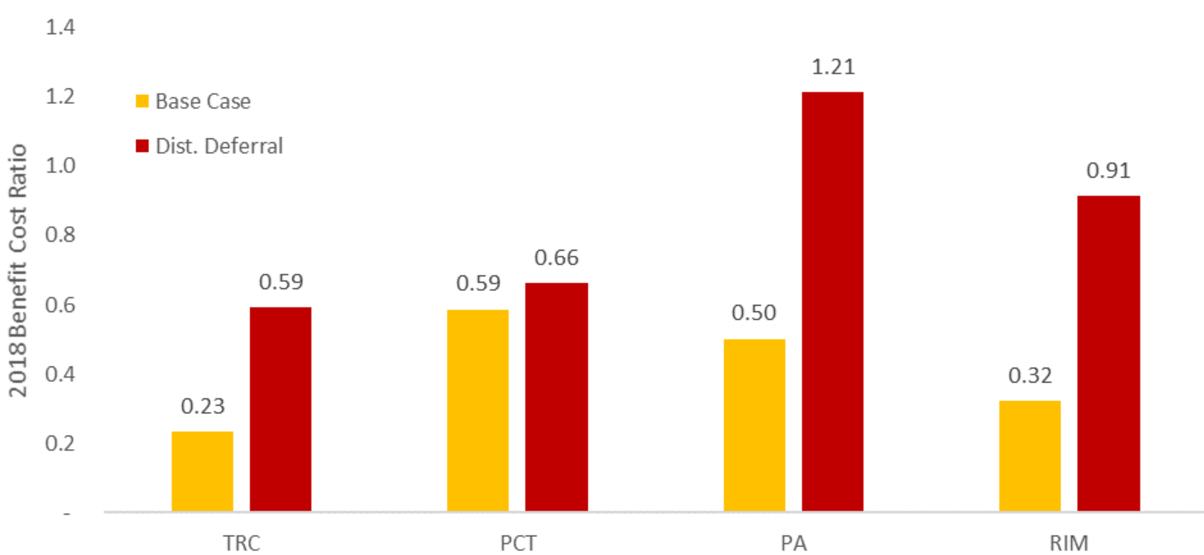
6.1.4 Distribution Upgrade Deferral Influence on Residential Cost-Effectiveness

In this scenario, we consider a case where peak demand on a distribution feeder node is at or near the distribution equipment's load carrying capacity (limit) and a relatively small amount of energy storage capacity located downstream (electrically) from the congested node can serve a portion of peak demand, on the margin, such that an upgrade of the distribution equipment is deferrable. In this case, we assume that the utility has visibility and potentially control of the energy storage system during the hours where the storage is needed for distribution deferral. This case should not be considered a typical or representative example of the potential benefits of BTM energy storage. Rather, it should be viewed as a hypothetical yet plausible scenario where storage is deployed in a carefully targeted pilot program based on areas where the utility identifies opportunities for deferral.

In the distribution upgrade deferral case, the standard distribution avoided costs are replaced with those of a distribution feeder with high avoided costs during limited hours. These avoided costs are representative of a feeder near its maximum loading. Energy storage discharge during these hours of high avoided costs provide greater avoided costs relative to the base case with standard distribution avoided costs. In this scenario we also increase the amount of the SGIP incentive to reflect the increased benefit being delivered to the utility. Specifically, we set the SGIP incentive equal to 50 percent of the cost of the energy storage system. For 2018 residential energy storage systems, this works out to $0.52/Wh, or an additional $0.17/Wh above the base case SGIP incentive in our model. This value was selected to represent a hypothetical co-ownership arrangement of storage where the utility is guaranteed control of the battery on the days with the highest distribution avoided costs. Section 5 provides additional details on the assumptions used in developing the avoided costs for this case.

Figure 6-24 shows the average PCT, TRC, PA, and RIM test results for the base case and the case with distribution deferral in 2018. Because the distribution avoided costs are considerably higher than the base case and the energy storage system is discharging during those high distribution avoided cost hours, the total avoided costs are considerably higher in the distribution deferral case relative to the base case. These high distribution avoided costs translate into increases in the average 2018 TRC, PA, and RIM benefits ratios which all have avoided costs in the numerator. The average 2018 PCT also increases – even though distribution deferral represents a deviation from optimal bill savings, the increased incentive for performing distribution deferral improves the PCT benefits ratio. Adding distribution deferral benefits increases the average 2018 TRC benefits ratio from 0.23 to 0.59. Similarly, the average 2018 PA test benefits ratio increases from 0.50 to 1.21 and the average 2018 RIM test benefits ratio increases from 0.32 to 0.91.

FIGURE 6-24: INFLUENCE OF DISTRIBUTION DEFERRAL ON 2018 AVERAGE TOTAL RESOURCE, PARTICIPANT, PROGRAM ADMINISTRATOR, AND RATEPAYER IMPACT COST TESTS, WITH INCENTIVE, ALL IOUS

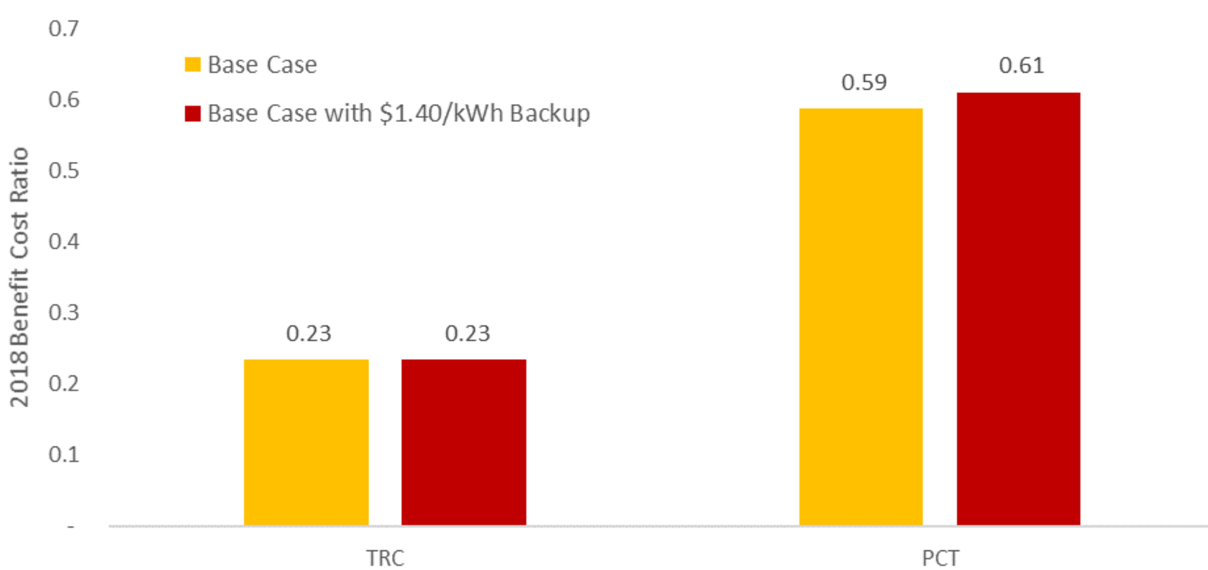


We note that the case with distribution deferral should be considered a hypothetical scenario, not a projection of the benefits we can expect from energy storage in the near future. Utilities currently do not rely on BTM resources for distribution deferral and experiences with utility control of distributed resources are limited to pilot programs. We include this scenario as an example of the potential benefits that can be realized from BTM energy storage if it can be leveraged for local grid needs. For this scenario to materialize utilities need to know that energy storage systems will discharge during the hours of high distribution feeder load. This will require targeted deployment of energy storage and a new program such as joint ownership of energy storage. As Figure 6-24 shows, these types of arrangements offer the potential to dramatically improve the cost-effectiveness of BTM energy storage.

6.1.5 Influence of Backup on Residential Cost-Effectiveness

Energy storage systems that provide backup services can increase the value of energy storage to the participant. The value of lost load (VLL) is a useful metric for quantifying the financial benefit to customers that avoid an interruption in their electricity service. Section 2 provides background on other research performed to quantify a customer's VLL. In our modeling, we assume the energy storage system discharges during three distinct events throughout the year, each lasting four hours. During each event, the customer is "credited" $1.40/kWh of load served during the outage, the inflation-adjusted national average VLL for residential customers facing a four-hour outage. Figure 6-25 shows the average residential PCT and TRC benefit ratios across all IOUs, with and without backup valued at $1.40/kWh, in 2018.

FIGURE 6-25: INFLUENCE OF BACKUP ON 2018 AVERAGE PARTICIPANT AND TOTAL RESOURCE COST TESTS, 2018, WITH INCENTIVE, ALL IOUS



On average, the PCT increases slightly when modeling use cases that include backup. During outage events, the participant receives benefits from avoiding the outage equal to the storage energy delivered multiplied by the VLL ($1.40/kWh). The TRC is not impacted by outage benefits since our modeling does not consider these a benefit to all ratepayers.

We find that, on average, the assumed VLL of $1.40/kWh based on a national average of residential customers does not increase the PCT to at or above 1.0. However, based on the market characterization research described earlier in this report (see Section 4), we know that current SGIP energy storage participants are more affluent than the average California residential customer. It's likely that the VLL for current SGIP participants is higher than the national average. Current SGIP customers likely value uninterrupted energy supply higher than the average California residential customer, perhaps due to a critical medical condition or living in a region subject to increased risk of wildfires.

As the VLL increases, the PCT also increases. Market research findings shown earlier in this report suggest that customers highly value the outage protection benefits that storage provides. Figure 6-26 illustrates the effect of increasing VLL on the PCT ratio for a representative SCE customer. We find that the PCT increases linearly as a function of the VLL. In this case, the breakeven VLL for a specific SCE customer is $22.50/kWh, considerably higher than the national average of $1.40/kWh used earlier. Based on our modeling, this prototypical SCE customer must value their loss of load at this rate for the energy storage system investment to be cost-effective in 2018. This breakeven VLL is at least an order of magnitude above the national average, suggesting that the customer has a very high VLL, or the customer is an early adopter and is not making an economic decision when purchasing storage.

FIGURE 6-26: EFFECT OF VALUE OF LOST LOAD ON PARTICIPANT COST TEST, SCE RESIDENTIAL TOU CUSTOMER, BASE CASE, WITH INCENTIVE, 2018

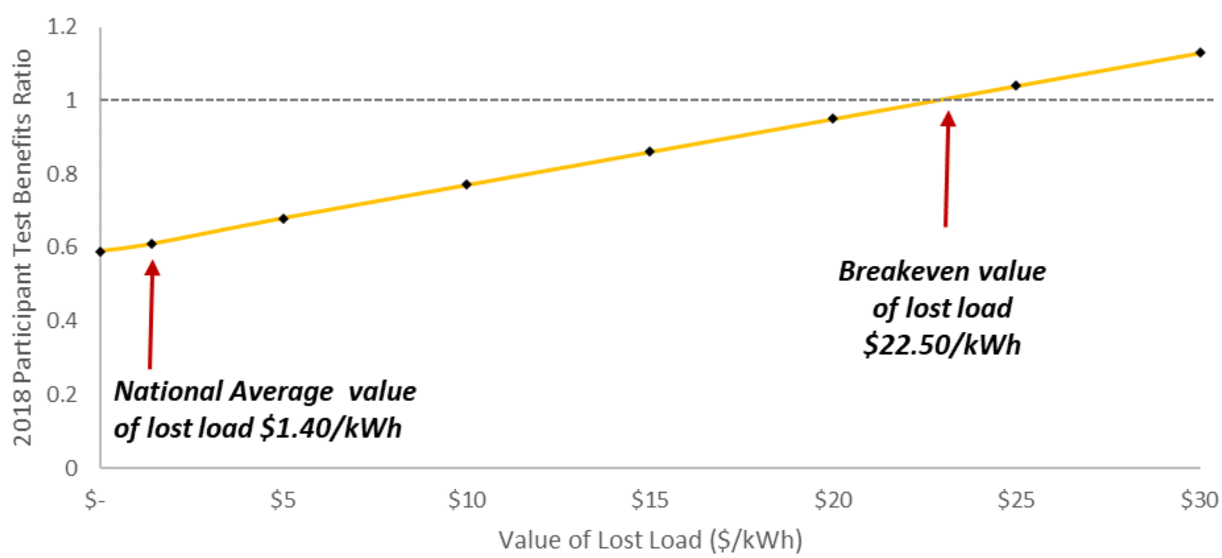
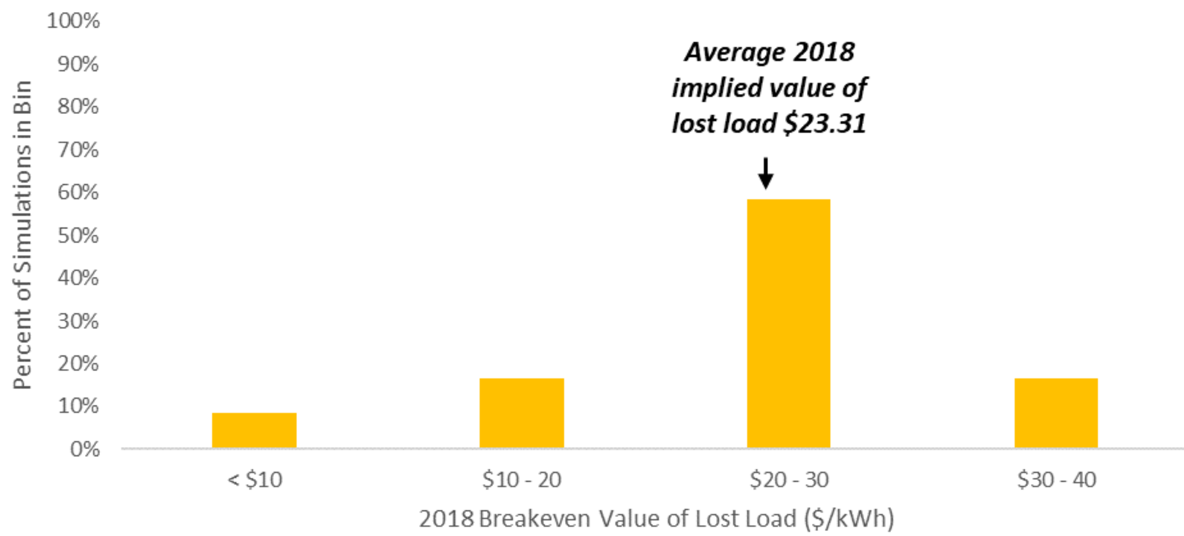


Figure 6-27 expands the breakeven VLL analysis to all base case simulations. For each case, we solve for the VLL that would achieve a PCT of 1.0. The breakeven VLL will be the highest for cases that are least cost-effective without backup, and lowest for the most cost-effective cases. The average breakeven VLL is $23.31/kWh for base case simulations run in 2018. This suggests that for SGIP participants that installed energy storage in 2018, the breakeven value of lost load is almost 17-times greater than the national average of $1.40/kWh.

FIGURE 6-27: BREAKEVEN VALUE OF LOST LOAD FOR PARTICIPANT COST TEST, WITH INCENTIVE, ALL IOUS, 2018



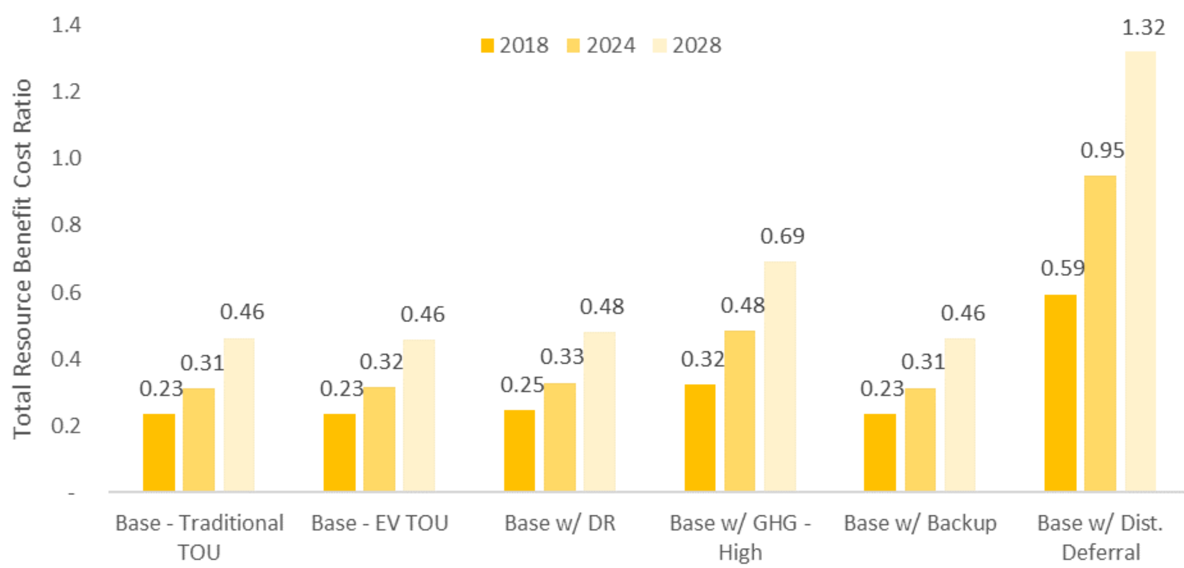
The minimum breakeven 2018 VLL is $8.48/kWh, meaning that for the most cost-effective case, the breakeven VLL is approximately six-times the national average for residential customers. On the other end of the spectrum, the maximum implied 2018 VLL is $39.29/kWh, more than 28-times the national average for residential customers. This maximum value applies to customers on TOU rates with small spreads and limited opportunity for arbitrage. This VLL analysis suggests one of two outcomes: current SGIP energy storage adopters are very affluent and place a considerable premium to uninterrupted energy supply, or they are early adopters that are adopting energy storage for non-economic reasons such as perceived environmental benefits.

6.1.6 Average Residential Total Resource Cost Test Summary

Figure 6-28 summarizes the residential TRC benefit ratios across all IOUs for the residential base case. Results are shown for 2018, 2024, and 2028. In general, all TRC ratios increase over time as the costs of energy storage decrease. In the base case with TOU rates, the TRC increases up to 0.46 by 2028, the final analysis year. The case with "GHG – High" signal increases at a faster rate, up to 0.69 by 2028. The case with distribution deferral shows the most promise, increasing to 0.95 by 2024 and to 1.32 by 2028.

However, this case also represents the greatest departure from status quo: it requires targeted energy storage deployment to locations with distribution feeder constraints and guarantees that energy storage systems will discharge during critical grid hours. Note that these results are averaged across all IOUs and there is considerable variation in the TRC ratios across each utility (see Figure 6-8 and Figure 6-9 for TRC results by IOU and rate type).

FIGURE 6-28: AVERAGE RESIDENTIAL TOTAL RESOURCE COST TEST, WITH INCENTIVE, ALL IOUS, 2018, 2024, 2028

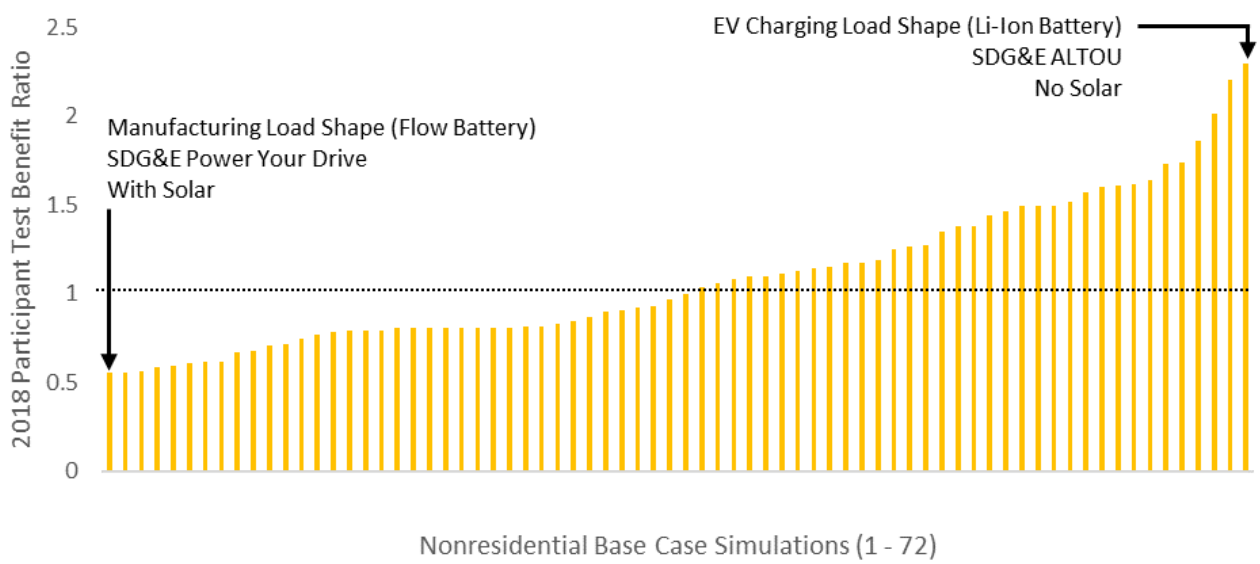


6.2 NONRESIDENTIAL ENERGY STORAGE COST-EFFECTIVENESS

This section presents cost-effectiveness results for nonresidential cases. Here, we focus on the influence of factors that were not explored in the residential section such as the effect of load shape, rate type, and solar generation. Section 5 provides details on the different variables considered in this analysis. We investigate six distinct load shapes in the three IOU service territories. All load shapes are modeled with a two-hour Li-Ion battery except for the 'Manufacturing' load shape which is modeled with a five-hour flow battery. Each simulation also considers the influence of solar as a load modifier – we quantify the benefits of storage being added to a customer load shape with and without solar generation. Finally, each customer is modeled under two rates, a standard TOU rate with demand charges and a "dynamic" rate that varies for each IOU. Customers with PV are modeled on the appropriate rate, which is different from the rate for customers without BTM generation.

For brevity, we do not revisit the effect of factors like DR, the GHG signal, or distribution upgrade deferral. In general, the trends described in the residential section apply to nonresidential cases as well. For example, adding distribution upgrade deferral to a nonresidential simulation with a larger incentive will also increase the participant and TRC benefit ratios. A complete listing of cost-effectiveness results is included in Appendix C. Figure 6-29 on the following page presents the participant benefit ratios for nonresidential base case simulations. Results are shown for all six nonresidential load shapes, three IOUs, two retail rates options (traditional and real-time), and with/without PV generation, for a total of 72 distinct simulations.

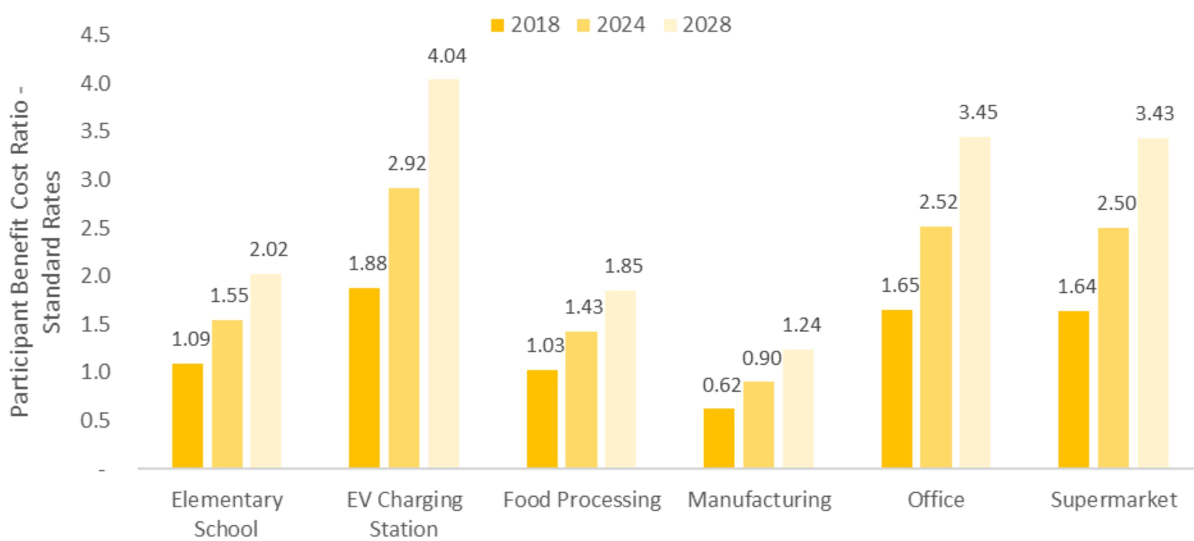
FIGURE 6-29: NONRESIDENTIAL PARTICIPANT TEST BENEFIT RATIO, BASE CASE, 2018, WITH INCENTIVE, ALL IOUS



In general, we find a considerable spread in the 2018 nonresidential participant benefit ratios, ranging from 0.56 on the low end to 2.30 on the high end. The PCT ratios vary considerably as a function of the underlying load shape. Intuitively, load shapes with greater opportunity for demand charge reduction achieve the highest PCT ratios. In the base case, the EV Charging Station load shape on SDG&E's ALTOU rate achieves the highest participant benefit ratio. As shown in Section 5, the EV Charging Station has the highest summer peak load (889 kW) and the lowest load factor (17 percent). Put differently it has a "peaky" load shape with a high summer peak and low overall usage. On the other hand, the manufacturing load shape has the second-highest load factor (64 percent), meaning that the maximum load and average load are closer together. In our simulations, the average nonresidential 2018 participant benefits ratio across all IOUs was 1.09.

Figure 6-30 and Figure 6-31 on the following pages present the average 2018, 2024, and 2028 participant benefits ratio results for the base case with incentives by load shape and rate type. Figure 6-30 shows results for the standard TOU rates with demand charges and Figure 6-31 shows results for the more dynamic rates. These figures show that the participant benefits ratio is highest for the EV Charging Station load shape, followed by the Office and Supermarket load shapes. The average participant benefits ratio is generally higher for the standard rate than the dynamic rates. Storage optimization under the standard rates generally allows for demand charge reduction with energy arbitrage. Demand charge reduction typically provides the highest participant benefits under a standard TOU rate with demand charges. The modeled dynamic rates differ by IOU, with SDG&E's rate having no demand charges while PG&E and SCE's dynamic rates include demand charges. Lower demand charges encourage customers to participate in energy arbitrage that is likely to better align with utility costs but may also provide the customer with lower bill saving benefits. Average participant benefit ratios are lowest for the manufacturing load shape with the flow battery for several reasons: the flow battery is more expensive than the Li-Ion battery in our modeling, it receives a lower incentive per kWh than its two-hour Li-Ion counterparts,[6] and it is installed in a load shape with the second highest load factor providing fewer opportunities for demand charge reduction.

FIGURE 6-30: AVERAGE NONRESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, NO SOLAR, ALL IOUS, STANDARD RATE, BY LOAD SHAPE, 2018, 2024, AND 2028



6 Energy storage systems greater than two-hours in duration receive a decreased incentive rate.

FIGURE 6-31: AVERAGE NONRESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, NO SOLAR, ALL IOUS, DYNAMIC RATE, BY LOAD SHAPE, 2018, 2024, AND 2028

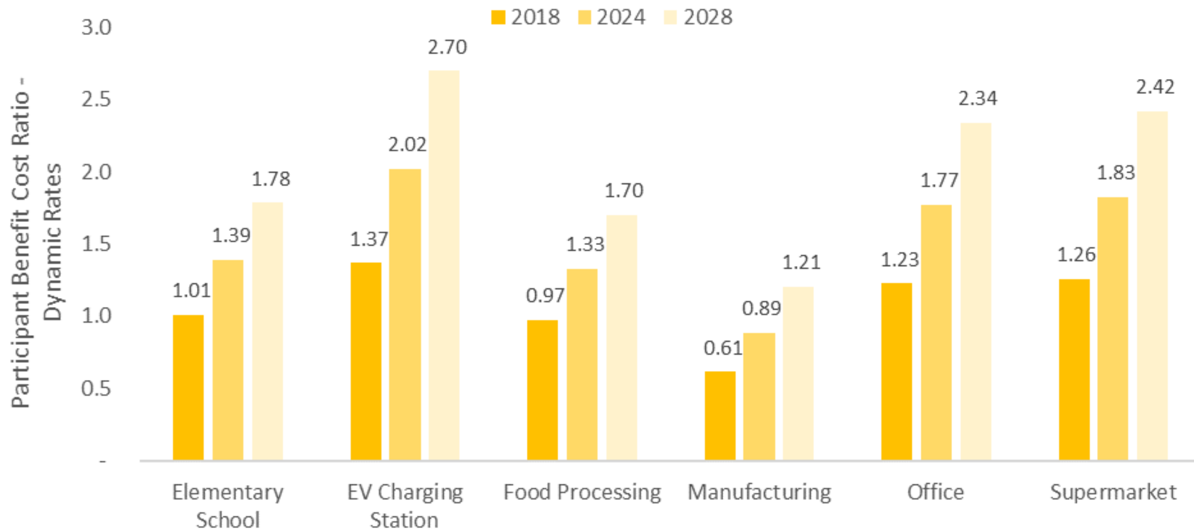
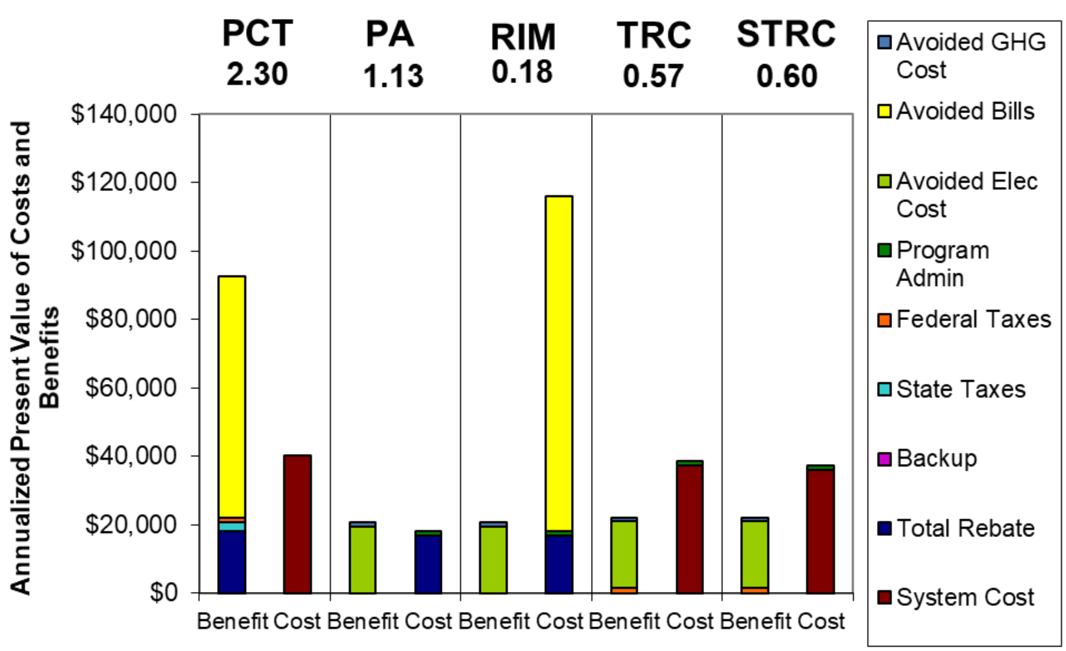


Figure 6-32 presents the cost-effectiveness findings for a prototypical case with the highest 2018 participant benefits ratio, the EV Charging Station load shape under SDG&E's ALTOU rate (no solar). This simulation returns a participant benefit ratio at 2.30. We include this example to allow examination of the various components of costs and benefits that contribute to each cost-effectiveness test.

FIGURE 6-32: EV CHARGING STATION LOAD SHAPE, NO SOLAR, SDG&E ALTOU RATE, BASE CASE, 2018, ALL TESTS



The EV Charging Station load shape has considerable potential for demand charge reduction which is observed in the PCT benefits column. The benefits provided from avoided bills, combined with the system rebate and other tax considerations, greatly outweigh the cost of the system. Similarly, from the PA's perspective, the benefits from avoided costs outweigh the cost of the rebate and program administration. However, the RIM test provides interesting insights into the impact of this scenario on nonparticipating ratepayers. Load shapes with significant opportunity for demand reduction, combined with utility rates with high demand charges, are an excellent opportunity for energy storage to provide demand reductions and bill savings, but these reductions are not always coincident with the hours of high avoided costs. In this case, a RIM test ratio of 0.18 suggests that the bill savings from storage utilization are not proportional to the utility's avoided costs.[7]

Figure 6-33 presents the five cost-effectiveness tests for a storage system installed on the manufacturing load shape on SDG&E's DG-R rate with solar generation (the prototypical case with the lowest participant benefit ratio) in 2018. The manufacturing load shape does not have the same demand charge reduction opportunities as the EV charging station, it does not allow for sufficient demand and energy bill savings for the PCT ratio to be greater than 1.0. Notably, the ratio of avoided costs to SGIP incentives is higher in this case than in the EV charging station, resulting in a PA cost ratio of 1.56. The RIM test remains substantially below 1.0, though the RIM ratio in this example is more than three-times higher than for the previous example.

[7] The bill savings value in the RIM test is larger than in the PCT due to nonresidential tax considerations. The utility sees the total value of the bill reduction in the RIM test, but the nonresidential customer sees the cost reduction in their utility bills diminished by increased taxes associated with a reduction in their costs of doing business.

FIGURE 6-33: MANUFACTURING LOAD SHAPE, WITH SOLAR, SDG&E DG-R RATE, BASE CASE, 2018, ALL TESTS

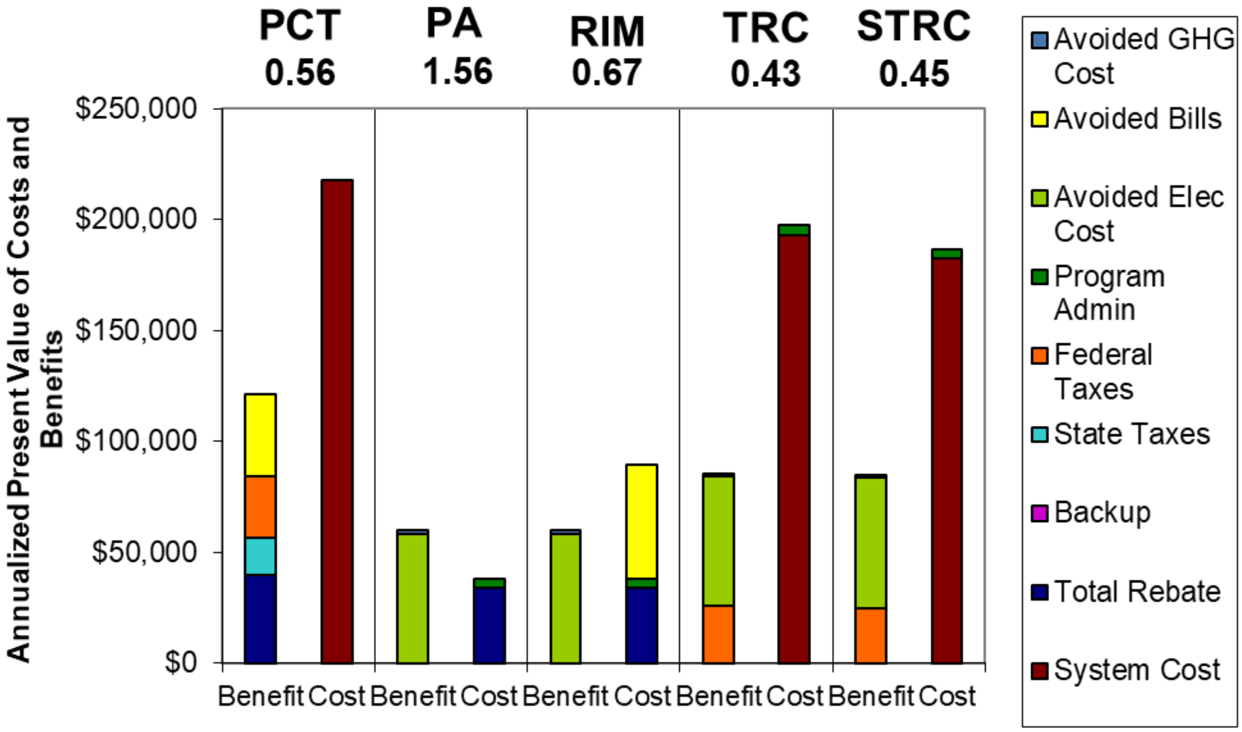


Figure 6-34 on the following page presents the average nonresidential TRC benefits ratios for the base case with incentives, no solar, and standard rates by load shape for 2018, 2024 and 2028. Figure 6-34 shows that the average simulated TRC benefits ratio is not greater than 1.0 for any of the cases in 2018. By 2024, the EV Charging Station and the Office have the highest average TRC benefits ratios at 0.99. For these load shapes, the rising avoided cost values and the declining measure costs lead to simulated TRC ratio estimates approaching cost-effectiveness. All cases except the Manufacturing load shape have average TRC benefit ratios greater than 1.0 by 2028 in our base case with no solar and standard rates. As discussed earlier, the Manufacturing load shape has higher upfront costs relative to other technologies, which lowers the TRC benefits ratio.

FIGURE 6-34: AVERAGE NONRESIDENTIAL TOTAL RESOURCE COST TEST, BASE CASE, WITH INCENTIVE, NO SOLAR, STANDARD RATES, BY LOAD SHAPE, 2018, 2024, AND 2028

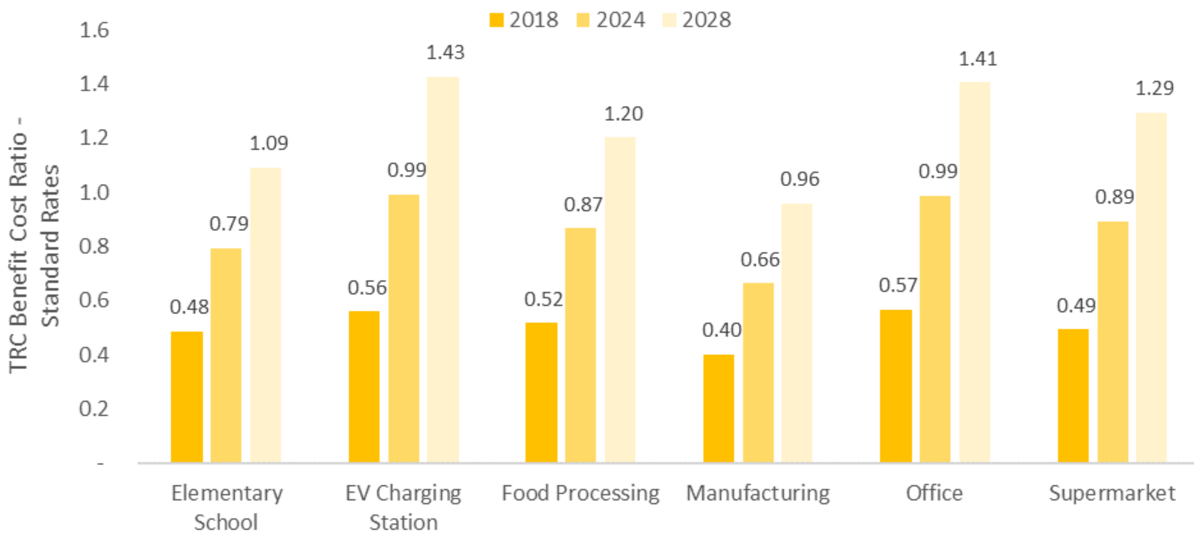


Figure 6-35 presents the average PA benefit test ratios for the base case with incentives and TOU rates by load shape for years 2018, 2024 and 2028. These findings illustrate that the average nonresidential base case simulation without solar is cost-effective or nearly cost-effective for the utilities in 2018 with a standard rate. The cost-effectiveness improves over time. The utility costs include program and incentives costs but do not include the storage measure cost, helping the value of the PA cost test relative to the PCT or the TRC.

FIGURE 6-35: AVERAGE NONRESIDENTIAL PROGRAM ADMINISTRATOR COST TEST, BASE CASE, WITH INCENTIVE, NO SOLAR, STANDARD RATES, BY LOAD SHAPE, 2018, 2024, AND 2028

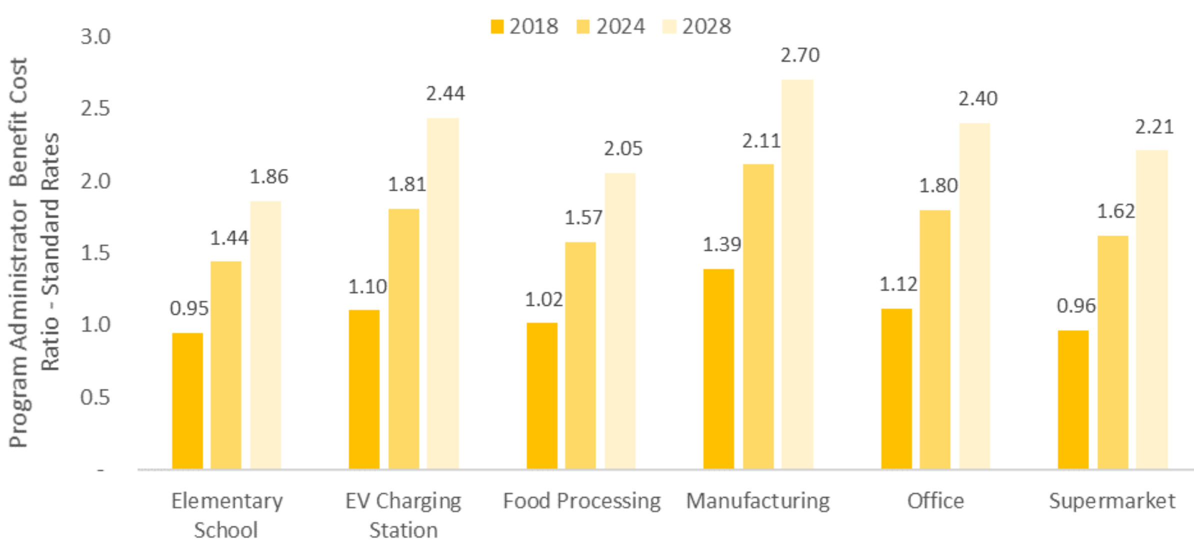
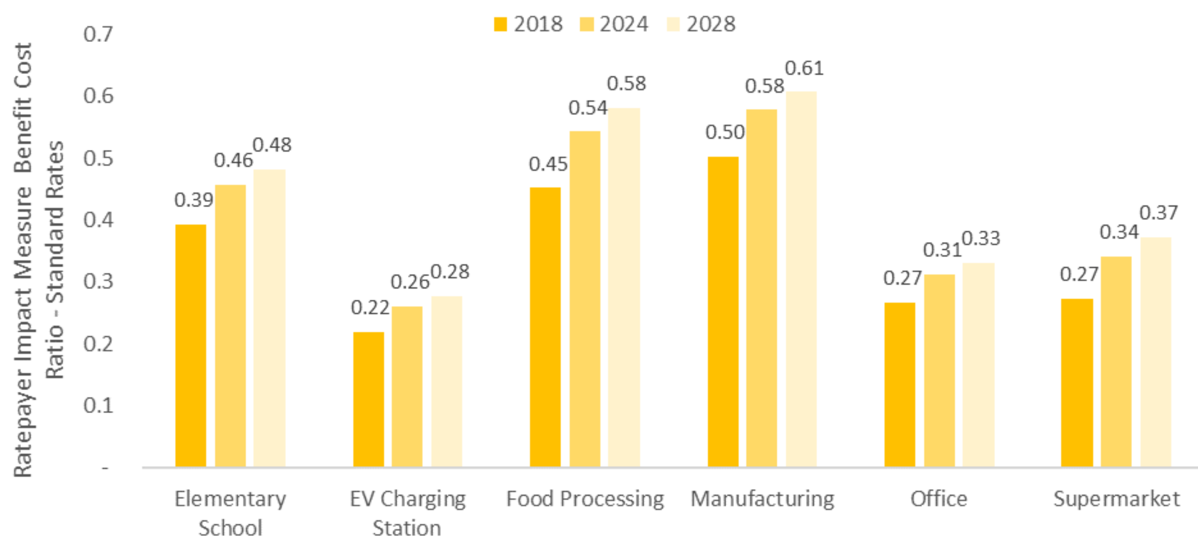


Figure 6-36 shows the average RIM cost test for the base case by load shape for the TOU rate. The average nonresidential RIM test benefits ratio is not estimated to be cost-effective during the simulation period. The substantial demand savings associated with nonresidential energy storage systems are costs for the RIM test. The charging and discharge behavior of energy storage systems under the base case does not sufficiently align with the utility costs to provide benefits large enough to overcome the program, incentive, and bill costs in the ratepayer impact test.

FIGURE 6-36: AVERAGE NONRESIDENTIAL RATEPAYER IMPACT COST TEST, BASE CASE, WITH INCENTIVE, NO SOLAR, STANDARD RATES, BY LOAD SHAPE, 2018, 2024, AND 2028



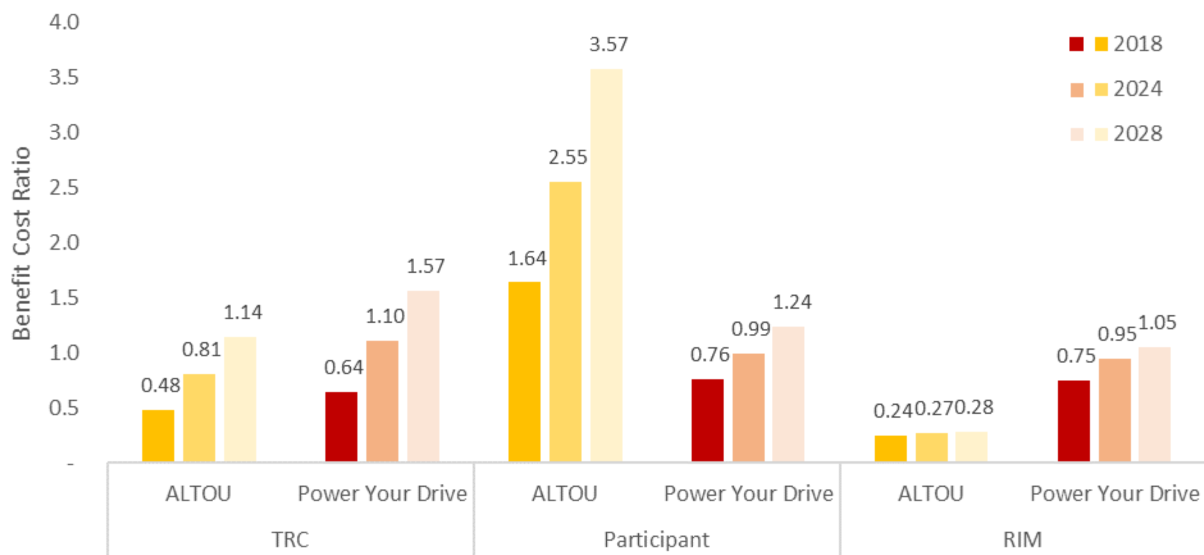
6.2.1 Influence of Dynamic Pricing Rates on Nonresidential Cost-Effectiveness

Real-time-pricing (RTP) rates like SDG&E's Power Your Drive provide hourly price signals to customers who ideally align their consumption with the utility's cost to serve load. SDG&E's Power Your Drive RTP rate is an hourly pricing plan that varies based on the forecasted energy demand. Each day, around 6 pm, the next day's forecasted pricing is posted. Figure 6-37 on the following page shows the influence of switching customers from SDG&E's ALTOU rate to SDG&E's Power Your Drive rate on the average base case 2018 PCT, TRC, and RIM benefits ratios with incentives across all load shapes.

SDG&E's Power Your Drive rate is an energy-only tariff with no demand charges. Demand charges are a significant source of bill savings, and while the Power Your Drive rate provides regular opportunities for energy arbitrage, the bill savings aren't as high and the average 2018 PCT falls from 1.64 to 0.76, approximately 54 percent less. On the other hand, the average 2018 TRC on SDG&E's Power Your Drive rate increases from 0.48 to 0.64, a 33 percent increase. By 2024, the average TRC on SDG&E's Power Your

Drive rate is 1.10, increasing to 1.57 by 2028. Finally, we see considerable improvement in the average RIM test results on SDG&E's Power Your Drive rate. By 2028, the average RIM benefits ratio on SDG&E's Power Your Drive rate is 1.05, almost three-times larger than the RIM benefits ratio on the ALTOU rate during the same year. In general, the increased alignment of the Power Your Drive rate with SDG&E's avoided costs, combined with the lower bill savings relative to the ALTOU rate, together act to increase the RIM benefits ratio.

FIGURE 6-37: INFLUENCE OF REAL TIME PRICING RATES ON PARTICIPANT AND TOTAL RESOURCE COST TESTS, 2018, BASE CASE, WITH INCENTIVE



Section 5 describes the dynamic rates selected from PG&E and SCE. For PG&E nonresidential rates, the modifier is an adder that increases the energy rate by $1.2/kWh. The higher peak-day-pricing (PDP) rates are charged from 5 – 8 pm on the 15 summer days with highest load. SCE's dynamic rate is an hourly rate based on weather at downtown Los Angeles as recorded by the National Weather Service. PG&E's and SCE's RTP rates incorporated both energy and demand charges, hoping to align customer consumption with the value of energy while still encouraging demand reduction. Figure 6-38 on the following page illustrates that the singular focus on energy arbitrage led SDG&E's dynamic rate to better align customer behavior with avoided costs resulting in an average 2018 TRC ratio of 0.64 for SDG&E's RTP rate, 0.60 for PG&E, and 0.37 for SCE. SDG&E's average 2018 standard rate TRC ratio was 0.48 while PG&E's and SCE's standard rate TRCs exceeded their TRCs from their dynamic rates. In our modeling, SDG&E's dynamic rate better aligns customer incentives with utility costs while PG&E and SCE's dynamic rates' demand charges contributed to the storage optimization model seeking the benefits of demand reduction leading to relatively lower avoided cost benefits for the utility.

Figure 6-39 illustrates the influence of the rate type on the participant benefits ratio by IOU. The inclusion of demand charges and the high energy rate differential within the dynamic rates for PG&E and SCE reduces the distinction between the dynamic and standard rates, limiting the difference between the standard and dynamic rate benefits from the customer's viewpoint. For SDG&E, the ALTOU rate enables both TOU energy arbitrage and demand savings while the Power Your Drive rate solely values energy arbitrage leading to a higher PCT ratio for the ALTOU rate. Figure 6-38 and Figure 6-39 illustrate how dynamic rates can help to align customer behavior with utility costs while the inclusion of demand charges lead to a higher storage PCT ratio and a lower TRC ratio.

FIGURE 6-38: INFLUENCE OF DYNAMIC RATES ON TRC BY UTILITY, BASE CASE, NO SOLAR, WITH INCENTIVE, 2018, 2024, 2028

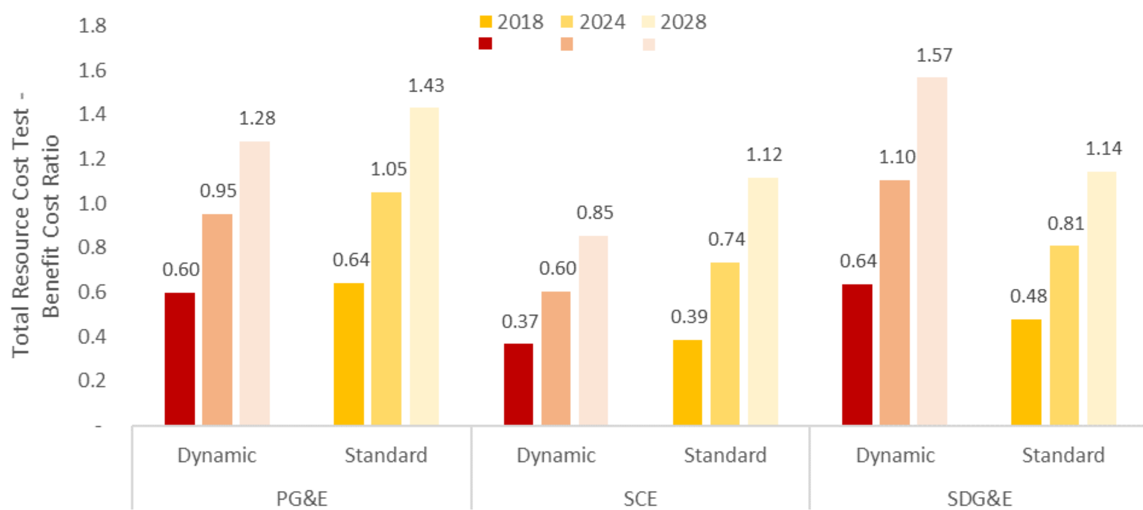
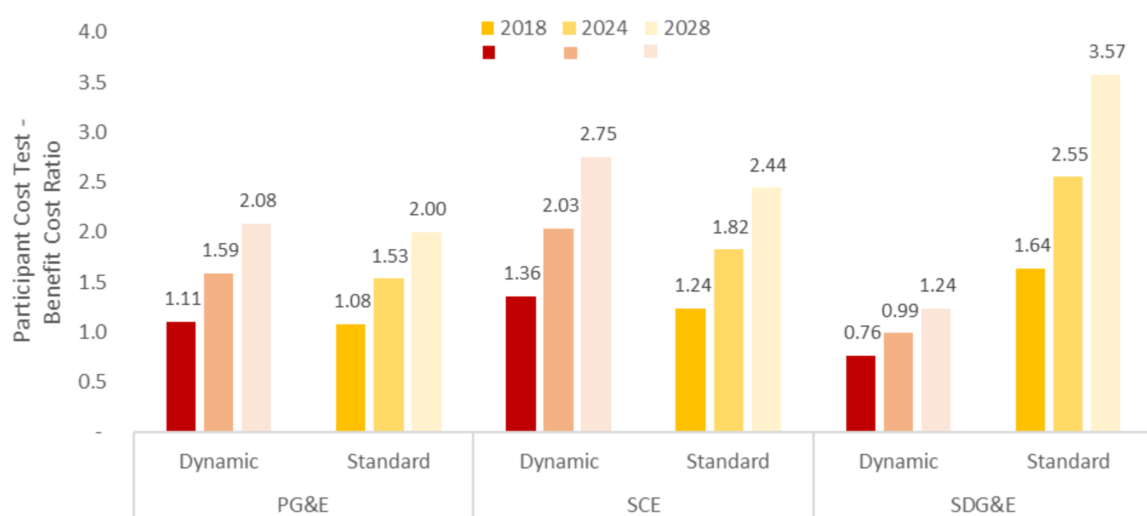


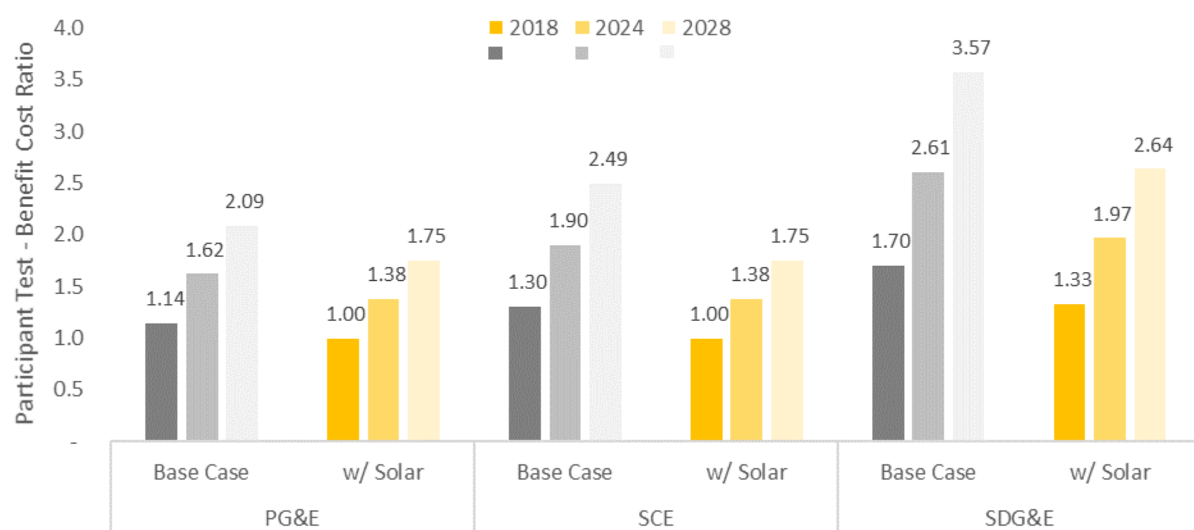
FIGURE 6-39: INFLUENCE OF DYNAMIC RATES ON PCT BY UTILITY, BASE CASE, NO SOLAR, WITH INCENTIVE, 2018, 2024, 2028



6.2.2 Nonresidential Energy Storage and BTM Solar PV Generation

Figure 6-40 shows the average participant benefits ratio for customers on standard nonresidential rates, with and without solar generation. Results are shown for 2018, 2024, and 2028. Figure 6-40 shows that on average, adding energy storage to a nonresidential load shape without pre-existing PV results in a higher participant benefit cost ratio than adding energy storage to a customer with pre-existing PV. Energy storage systems on SDG&E's rates with solar are estimated to have an average PCT of 1.33 in 2018 while energy storage systems installed on customer sites without pre-existing solar have an average 2018 PCT of 1.70. Similar results are observed at PG&E and SCE where energy storage systems installed at sites without solar averaged a PCT of 1.14 and 1.30, respectively while the PCT benefits ratio for energy storage systems installed at sites with pre-existing solar are 1.00 in 2018.

FIGURE 6-40: AVERAGE NONRESIDENTIAL PARTICIPANT COST TEST, BASE CASE, WITH INCENTIVE, STANDARD RATES, BY IOU AND SOLAR GENERATION, 2018, 2024, 2028



The higher average participant benefit ratios for energy storage systems at sites without pre-existing solar generation are a result of differences in the underlying load shape for customers with and without solar and the structure of the utility rates. Adding solar to a load shape reduces demand during the daylight hours, pushing the customer's peak to later in the day. Solar generation load shapes limit the ability of energy storage systems to reduce customer demand charges. Furthermore, the nonresidential rates used to model energy storage cost-effectiveness for customers with BTM solar PV also have a substantially higher energy price differential between on-peak and off-peak periods and lower demand charges than the standard nonresidential rates available for non-solar customers. The rates for nonresidential customers with BTM PV enable batteries to undertake substantial energy arbitrage. These rates, combined with the solar load shape, however, limit the ability of the battery to provide the customer with bill savings associated with demand reduction.

Figure 6-41 shows all base case cost-effectiveness test results for the EV Charging Station load shape without solar on SDG&E's ALTOU rate in 2018. Figure 6-42 on the following page shows a similar set of results for the EV Charging Station load shape with solar on SDG&E's DGR rate. In Figure 6-41 and Figure 6-42, the bill savings associated with the energy storage system have been disaggregated into their energy and demand components for the participant and RIM tests. These graphs clearly show that the PCT is higher in the no solar situation and that the demand savings attributable to the energy storage system account for nearly all the customer bill savings.

Conversely, Figure 6-42 shows that the bill savings from the energy storage system on the EV Charging Station load shape with solar are almost evenly distributed between energy and demand savings. The addition of the solar load shape and the DGR rate with a greater emphasis on TOU prices lead to a better alignment of the battery's charging and discharging with the utility costs and a higher PA, RIM, and TRC relative to the no solar case.

FIGURE 6-41: EV CHARGING STATION LOAD SHAPE, NO SOLAR, SDG&E ALTOU RATE, BASE CASE, 2018, ALL TESTS

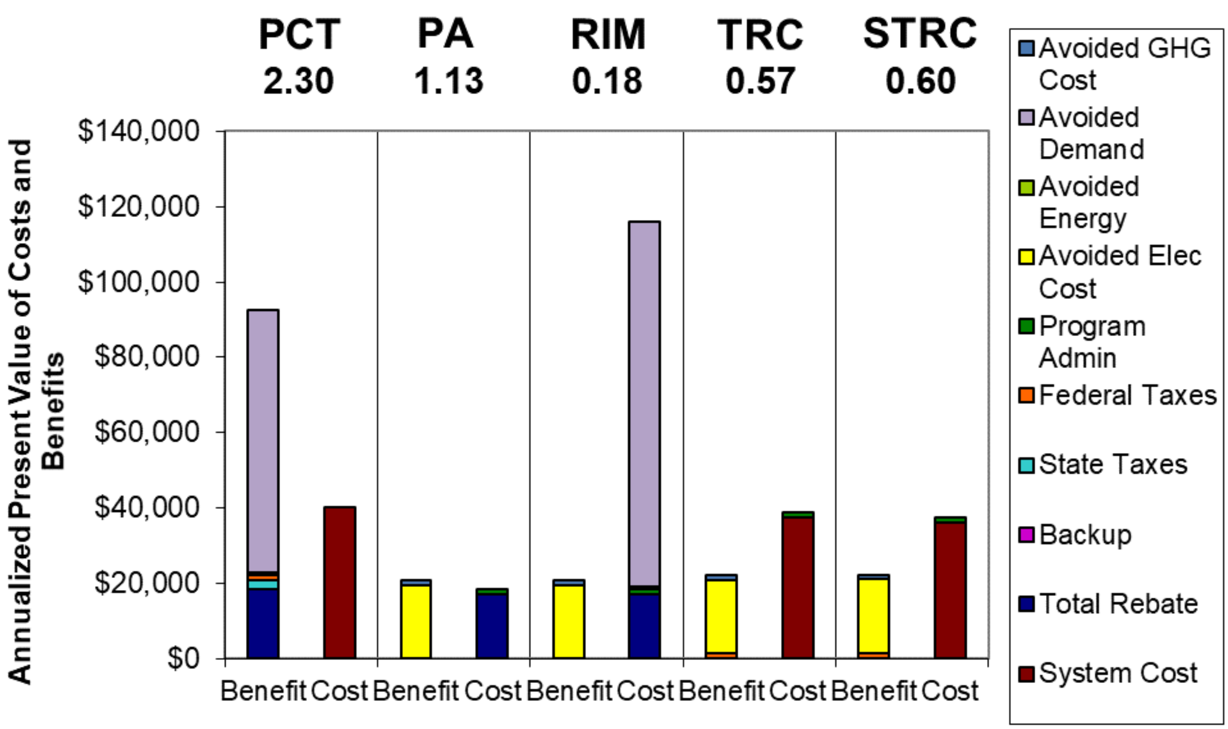


FIGURE 6-42: EV CHARGING STATION LOAD SHAPE, WITH SOLAR GENERATION, SDG&E DGR RATE, BASE CASE, 2018, ALL TESTS

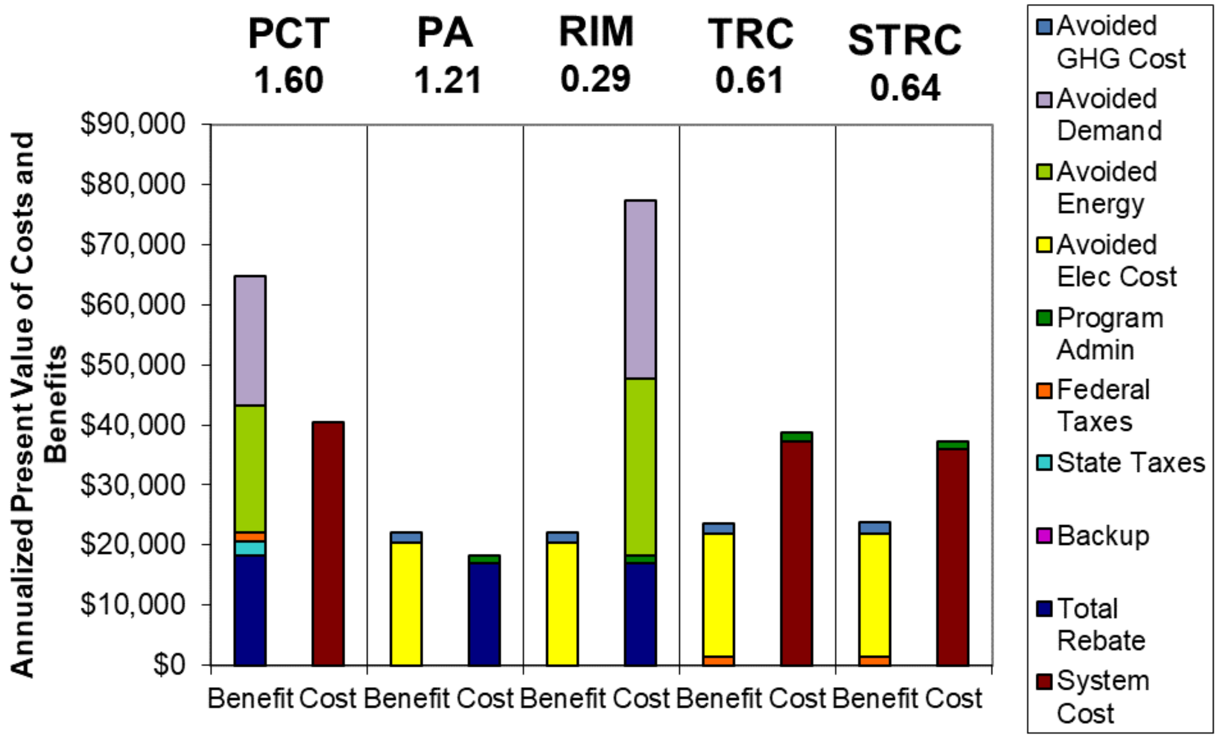
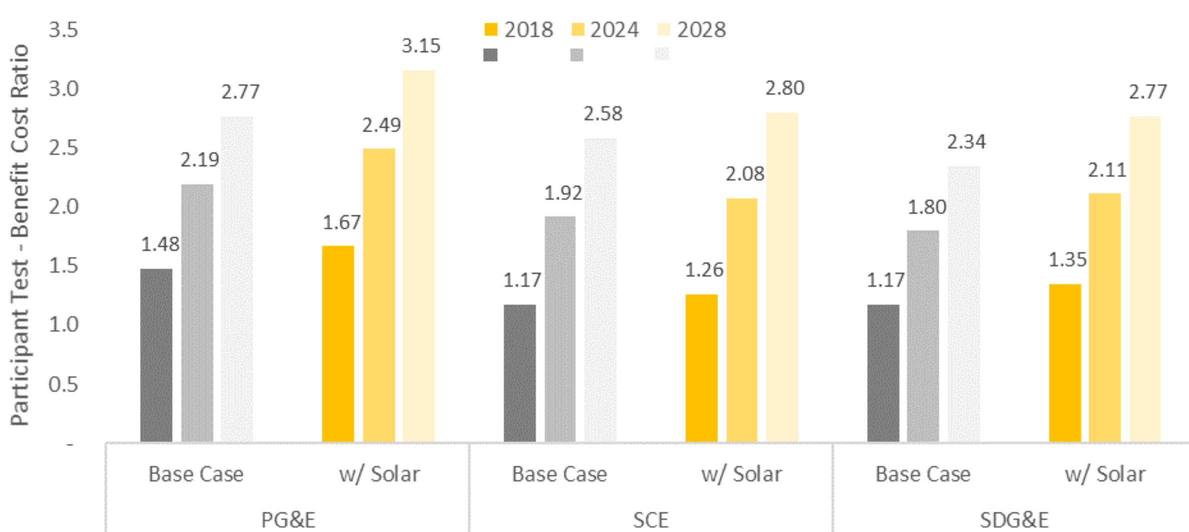


Figure 6-43 shows the PA test benefits ratio by IOU and solar generation for the base case in 2018, 2024 and 2028.

FIGURE 6-43: AVERAGE NONRESIDENTIAL PROGRAM ADMINISTRATOR COST TEST BY IOU, SOLAR GENERATION, BASE CASE, STANDARD RATES, 2018, 2024, 2028

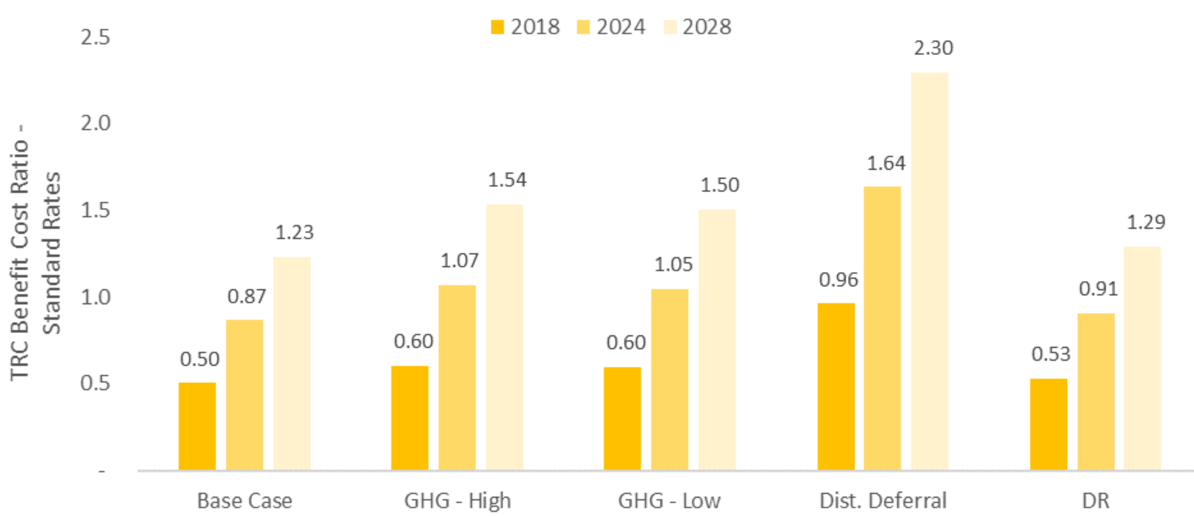


The rates used in the cost-effectiveness evaluation differ for solar and non-solar situations with solar customers receiving the utilities' NEM TOU rate. Figure 6-43 shows that under ideal dispatch, customers with solar PV charge and discharge the battery such that it better aligns with the utilities' costs, leading to systematically higher PA benefit test ratios.

6.2.3 Average Nonresidential Total Resource Cost Summary

Figure 6-44 shows average TRC test ratios across all load shapes and all IOUs with no solar generation under standard rates. Results are shown for 2018, 2024, and 2028. We find that all cases achieve a TRC benefits ratio greater than 1.0 by 2028. The GHG Low, GHG High, and Distribution Deferral cases exceed a TRC benefits ratio of 1.0 by 2024.

FIGURE 6-44: AVERAGE NONRESIDENTIAL TOTAL RESOURCE COST TEST BY STORAGE MODIFIER, ALL IOUS, ALL LOAD SHAPES, STANDARD RATES, 2018, 2024, AND 2028

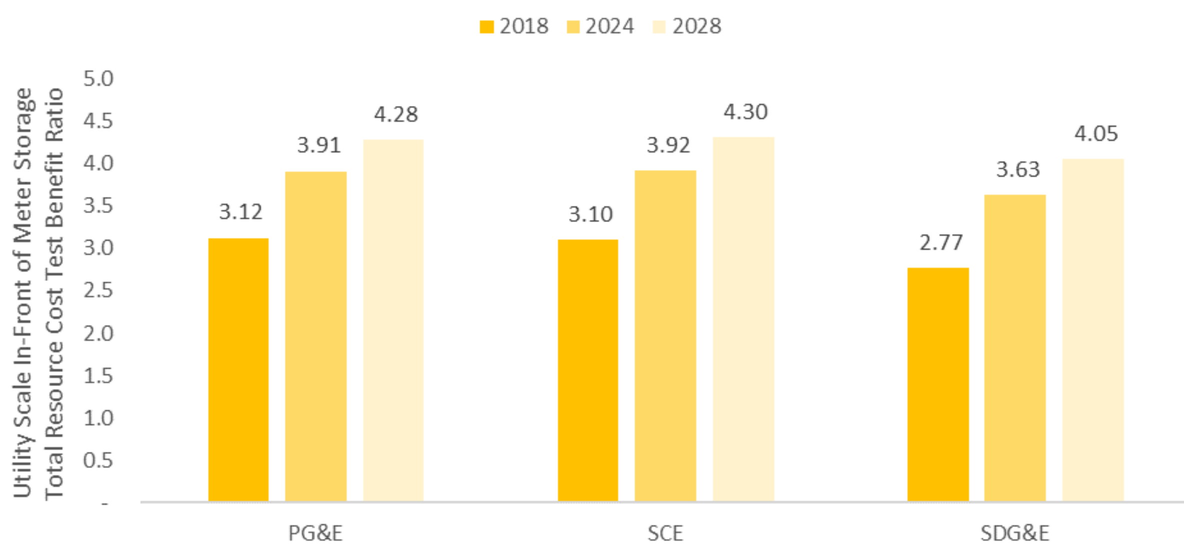


6.3 UTILITY SCALE IN-FRONT OF METER RESULTS

The utility scale simulations consider an energy storage system installed on the distribution system that is arbitraging the utility avoided costs. By being in-front of the meter, utility scale energy storage is not bound by the customer's retail rate or load shape. Instead, the energy storage system is free to maximize benefits to the utility. Effectively, the utility scale results reflect the maximum achievable avoided costs for energy storage. In the utility marginal cost arbitrage case, we simulate a utility-owned energy storage system installed on the distribution system. The storage system has perfect visibility and foresight into the utility marginal costs. When the storage system charges, it increases the utility marginal costs (using the full stack of avoided costs described in Section 5). When the storage system discharges, it reduces the utility avoided costs. Each day the storage system charges and discharges to optimize the utility marginal costs. The costs and benefits to the utility are associated with marginal costs impacts when charging and discharging.

The standard cost-effectiveness tests for evaluating DERs were not designed for evaluation of utility scale in-front of meter resources. However, to create a like-for-like comparison, we leverage the TRC test for use with utility scale storage. Figure 6-45 presents the utility scale TRC benefits ratios by IOU for 2018, 2024, and 2028. In Figure 6-45, the TRC benefits are the total avoided costs delivered from the energy storage system to the utility. The costs are the equipment, financing, and insurance costs associated with the utility scale in-front of meter energy storage system. The Participant, Program Administrator, and RIM tests are not applicable in this case.

FIGURE 6-45: TOTAL RESOURCE COST TEST, UTILITY SCALE IN-FRONT OF METER, BY IOU, 2018, 2024, 2028



Simulated 2018 utility scale in-front of meter TRC ratios are above 2.5 for all IOUs, increasing above 4.0 by 2028. We see multiple reasons for the wide gap between the BTM and utility scale in-front of meter TRC benefit ratios. First, the modeled installed capital costs per kWh of utility scale storage are lower than modeled residential and nonresidential installed costs and equipment costs are the primary driver of overall costs in the TRC (see Section 5 for detailed cost assumptions). Second, the utility scale in-front of meter storage systems are modeled as four-hour batteries, which potentially increases the ability to arbitrage the highest avoided cost hours. Third, as mentioned previously, utility scale in-front of meter energy storage systems are modeled as able to arbitrage the utility's avoided costs perfectly. In doing so, utility scale in-front of meter storage can discharge during the peak hours of each utility's transmission and distribution costs – these costs can reach thousands of dollars per kWh during the hottest summer days. Retail rates currently offer broad TOU periods (e.g., 4-9 pm). While the highest avoided cost hours often land within these peak periods, the battery is not guaranteed to be discharging during the single highest avoided cost hour. Finally, we find that the utilization of utility scale in-front of meter energy storage is considerably higher than the utilization of BTM energy storage. In our modeling, utility scale in-front of meter energy storage is fully dispatched every day of the year. This means that each day, the net benefits of the TRC ratio increase for the entire life of the energy storage system. In contrast, modeled BTM energy storage utilization is considerably lower. Residential energy storage systems in our modeling are often idle for the entirety of winter since TOU rate arbitrage is not economical. Nonresidential storage in our modeling may not operate for days in the winter if the peak-demand for that month has already been avoided.

We make a final note that to date there is very limited experience with utility ownership of energy storage on the distribution system. Our modeling should be considered an example of the best-case scenario as it represents perfect arbitrage of the utility's avoided costs. Primarily, this case serves as a benchmark of the potential benefits that can be attained with perfect dispatch energy storage.

7 STUDY FINDINGS AND IMPLICATIONS

This section summarizes the findings and resulting implications from the combined market research and cost-effectiveness components of this study. It also ties in findings from other studies to create a picture of the past, present, and future of residential and nonresidential BTM energy storage in California.

As noted elsewhere, this study is not an evaluation of storage within the SGIP program (a separate impact evaluation of the 2017 SGIP was completed last year and an impact evaluation of the 2018 SGIP program will be completed later this year). Rather, this study seeks to better understand current market conditions for storage and the key drivers associated with storage cost-effectiveness now and in the future. The cost-effectiveness results presented in this section and Section 6, are based on a set of prototypical end user load shapes combined with a modeling of storage dispatch that is theoretically optimal with respect to rational economic response to a given tariff. These analyses are performed on a 15-minute basis over the lifetime of the equipment for each segment and use case. The load shapes were chosen to capture meaningful variation across utilities and market segments; however, because of the number of simulations required, the set of shapes is limited and not a statistically representative sample of the diverse behavior of populations of end users. Instead, they produce prototypical results for specific cases across a range of scenarios.

This discussion of key findings and implications is divided into the following subsections:

- Introduction
- Assessment of the current storage market
- Assessment of cost-effectiveness results
- Key uncertainties and influences
- Outlook and considerations

7.1 INTRODUCTION

The results of this study are intended to provide data, information, and insights that can be used to help policy makers, program administrators, and stakeholders assess the benefits, costs, and market position of storage from a variety of perspectives. In the case of BTM storage, the results reflect the fact that the technology is still in a very early stage of market development with relatively niche applications in the near term. At the same time, the market and regulatory forces influencing storage are very dynamic and there is the potential for significant shifts if there are major changes in costs, the perceived value of backup, incentives, time-differentiated and GHG price signals, or any of the other factors we have assessed that bear directly on the value and cost-effectiveness of storage from the participant, program administrator, and grid perspectives.

Policy makers in California clearly recognize that storage is an emerging technology with important potential benefits that would support the State's overarching GHG reduction and energy goals. A key challenge with many market transformation initiatives is in forecasting, assessing, and adapting to changes that occur at different stages of a product or service's market development and using that information to inform how and whether those policy interventions should be adjusted. Key questions include whether the interventions are driving the market to develop and change in ways that provide the benefits desired; whether the anticipated market changes are advancing as hoped or expected, or whether they have stalled or reversed; and, related, whether the projected time frame in which the expected net benefits will occur remains within expectations and reason? Until that time as market transformation has occurred, and is clear to most observers, much of the market assessment, cost-effectiveness, and policy analysis remains subject to considerable uncertainty. Given this uncertainty, different stakeholders and analysts may have different assessments of what the market needs, where and when, and whether a sufficient return will be achieved for those investing in the interventions.

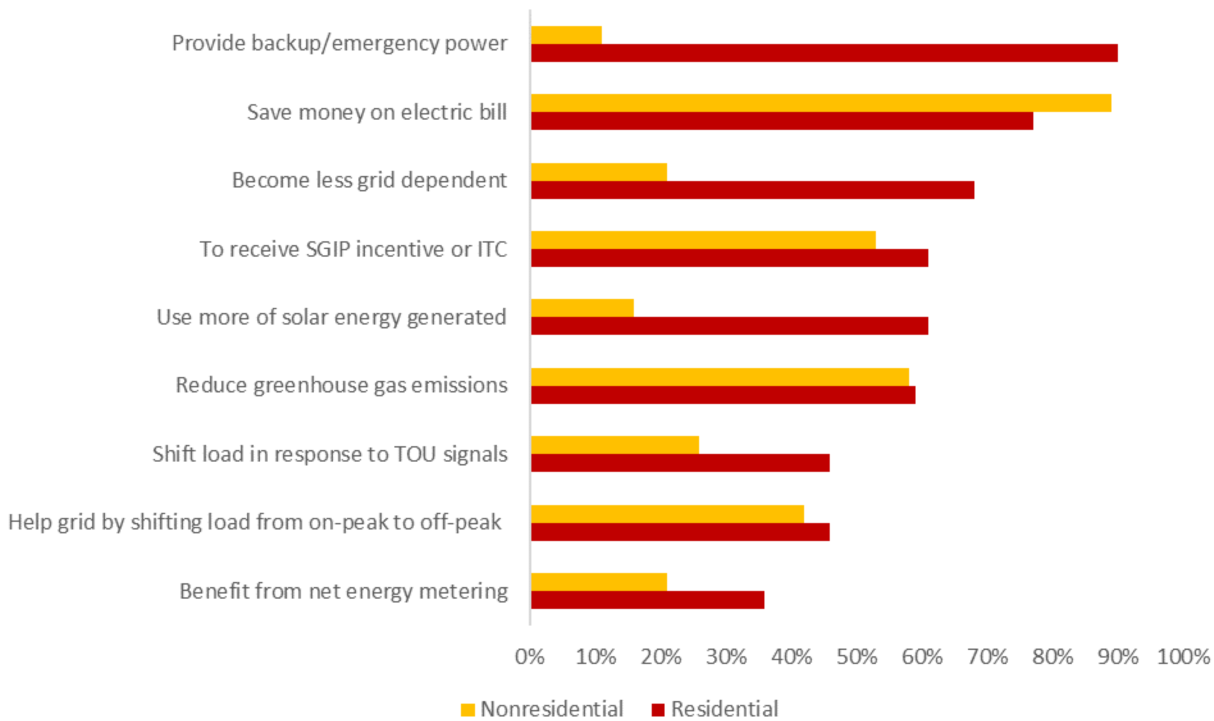
In this context, storage, especially, BTM storage at its current stage of market development, is a classic if not challenging case in point. Some aspects of the results in this study may give indications of ways in which BTM storage can be aided to provide desired net benefits in certain sectors or niche, near-term segments, or to increase the likelihood of achieving broader net benefits in the future. Other aspects of the results may be perceived as indicating the outlook for BTM storage, in the residential sector, is relatively costly and risky as compared to other resource options. Such assessments are best left to the policy making environment. Our goal is to develop, explain, and document the results so that policy makers and stakeholders can utilize them meaningfully within California's broader GHG and energy resource planning and program processes.

7.2 ASSESSMENT OF CURRENT STORAGE MARKET

Since 2017, storage participation in the SGIP has shifted from predominantly nonresidential projects to residential in terms of number of projects; however, nonresidential still accounted for over 80 percent of storage MW in 2018. Program Year 2018 marked the emergence of a residential BTM storage market in the SGIP and California. Even with a very small initial residential storage market, one would expect a shift in number of projects between sectors given the much larger number of residential customers, even when overall market penetration is very low in absolute terms. Although analysts have been predicting for some time that residential BTM storage markets would eventually begin to develop, the timing of that development has been uncertain and sensitive to numerous economic and regulatory factors across states and globally. In California and states like Hawaii and Arizona, some solar developers have begun to offer solar plus storage as an option to their residential customers.

Most residential projects in the SGIP are solar with storage, while nonresidential projects are primarily storage-only**.** Nearly all of the SGIP residential storage projects were paired with solar PV (97 percent based on program tracking data) compared to only 17 percent of the nonresidential storage projects. The very earliest residential adopters are less cost-sensitive and more driven by non-economic factors such as fear of wildfire related outages, the "cool" factor of owning storage, perceived self-consumption of more of their solar generation, the desire for grid independence, and environmental concerns. Figure 7-1 summarizes key motivations for installing energy storage from our market characterization.

FIGURE 7-1: MOTIVATIONS FOR INSTALLING BATTERY STORAGE – SGIP STORAGE PARTICIPANTS



In the wake of the catastrophic fires in Northern California, consumer demand appears to have increased as customers have become interested in backup capability to address perceived increases in preventive outages. Project developers have employed this as a major selling point. In the residential sector, under the Participant Cost Test (PCT) our results indicate that the economics of storage as a bill savings asset are still marginal for most end users, even with SGIP incentives and the ITC, nonetheless, a few segments are showing interest and investing, as evidenced by SGIP participation, despite the costs.

As discussed in Section 6 and below, in the residential sector, storage is generally not cost-effective to end users based on bill savings available from load shifting in response to the electric retail rates we modeled. Residential end users are also motivated, however, by highly individualized assessments of the value of storage for backup power and have widely varying willingness to pay for it. Initial adopters are generally high income, homeowners with solar, and tend to have strong environmental concerns and high levels of education. Some residential adopters are also motivated by the idea of being more energy independent and enabling better use of solar.

In the nonresidential sector, adoption was reported to be more driven by economic factors. Reducing demand charges was the key driver for initial nonresidential storage adopters. Over three-fourths of nonresidential host customers reported having company goals addressing sustainability, climate change, GHG reductions or other environmental objectives. As discussed in Section 6 and below, BTM storage can be cost-effective based on bill savings to some nonresidential customers. Nonetheless, after an initial surge of nonresidential storage projects, the pipeline appears to be stalling based on a significant drop off in SGIP project applications. As found in our interviews with developers and in some parties' comments recently,[1] storage industry developers and trade groups tend to believe the drop off is due to a combination of declining SGIP incentive levels, transitions to new TOU rate structures, uncertainty in program requirements, and perceived delays and hassle costs of program participation.

Findings from the nonresidential host customer surveys regarding the primary drivers for installing storage at their place of business indicate the significance of financial rationales in their decision-making regarding capital investments. The top two reasons reported for installing storage were to save money on their electric bill (84 percent reporting) and to reduce their demand charges (79 percent). Non-financial motivations, such as providing backup/emergency power or reducing GHG emissions, that were key drivers within the residential market, proved significantly less important to businesses. Providing backup/emergency power was a much more significant reason for installing storage for residential customers than for nonresidential customers (88 percent vs. 11 percent, respectively). Similarly, reducing GHG emissions was more important to residential customers (51 percent vs. 26 percent).

Developing dynamic rate structures that optimize across both avoided costs and GHGs was reported by many developers to be important. However, some developers believe strongly that dynamic pricing needs to be optional not mandatory, particularly for residential customers who are less sophisticated and thus, less able to respond on a real-time basis. Some developers would like to see a fully enabled market for aggregating residential BTM to provide T&D and ancillary services but believe such a market is still far off.

[1] Assigned Commissioner's Ruling seeking comment on implementation of Senate Bill 700 and other program modifications, April 15, 2019. See party comments and reply comments.

The nonresidential market appears to be very sensitive to factors that adversely affect the economics or uncertainty of investing in storage. The primary factors identified in this study that may have impacted the recent slowdown in nonresidential battery storage adoption within the SGIP include:

- **Reductions in incentive levels –** while the incentives have declined based on the stepped incentive structure, battery prices reportedly have not come down as fast as some had hoped, resulting in higher prices faced by prospective customers. Manufacturers indicated they do not expect battery prices to drop significantly over the near future beyond what is already projected in industry forecasts such as those used in our cost-effectiveness analysis.
- **Changes in nonresidential utility rate structures –** some developers reported that decreases in demand charges reduced potential bill savings from demand shifting, making storage less financially attractive to nonresidential customers seeking that particular benefit.
- **Perceptions of complex interconnection requirements and SGIP administrative requirements –** developers report that, previously, under higher incentive levels, customers were willing to accept program participation requirements perceived as onerous but are now less inclined to do so under lower incentive levels. The “hassle cost” of participation is strongly correlated with project financials and thus while a project may be cost-effective and lead to financial savings for the customer, they may determine it is not worth the effort to participate in the program.
- **Changes to California Fire Code –** Another non-economic factor fueling reduced nonresidential activity in SGIP, according to one major developer, is last year’s change in the California fire codes which made it, in this respondent’s words, “nearly impossible” to do indoor battery systems. It has reportedly reduced the available market to buildings that have sufficient outdoor space. We have only anecdotal information on this issue at this time, so an assessment of its impact is difficult.
- **Uncertainty regarding the future of SGIP –** Developers indicated concerns over what they perceive as considerable uncertainty around SGIP requirements and incentives. Developers were also nervous about the retroactive elements in some staff proposals during 2018.
- **Risk associated with newer technologies –** While the pace of battery technology development is rapid, battery storage remains a very new product with substantially more risk than other more mature and proven technologies.
- **Size and reaction of early adopter market –** New markets are usually driven by early adopters who have characteristics markedly different from the average customer. These markets are often very small at the outset. Where markets are very dynamic in terms of falling product prices and improving product features, the lag between early adopters and more typical adopters (often referred to as “early majority") can be short; however, in markets with marginal economics or end user value propositions, there can be significant time lapses between the initial early adopters

and broader market adoption. These lags can include gaps in adoption and uneven shifts in the number and type of market actors in each segment as things shake out. It is unclear whether the initial uptick in nonresidential storage projects represented a small segment of early adopters who were willing or curious to investigate the relative costs and benefits of storage or customers whose behavior proves to be more typical and representative of other end users. In addition, if early adopters report to their peer communities that they are dissatisfied with their experience that can also cause slowdowns in market adoption. In the case of storage, initial adopters in our survey reported relatively high satisfaction levels with the technology.

- **Robustness of supplier market –** Initially, markets for new products often have fewer market actors, with more market actors entering as markets expand and fewer market actors often as markets consolidate during the later stages of the product life cycle. A challenge within the current BTM storage market is that it is nascent and very sensitive to the actions of a small number of players. For example, the early nonresidential SGIP storage participation was associated with only a handful of developers; however, we found in our developer interviews that several of these companies had decided to shift their focus from nonresidential to residential or away from direct project development to storage software and control systems. This could indicate that the business model for nonresidential is proving difficult, perhaps with higher transaction costs than developers and investors initially forecasted, with the result being a potentially underserved market in the short term.

That said, the presence of the SGIP program was found to be a major factor influencing the market for behind-the-meter energy storage, to date, in California. The SGIP program is reported to be an extremely important part of project developers' business models in the State**.** Virtually all Low- and Medium-volume firms and over half of High-volume firms reported that 100 percent of their storage installations are in California.[2] On average, California installations are reported by developers we interviewed to account for 100 percent of Small and Medium volume firms' storage sales, and 89 percent of Large volume firms' storage sales. In addition, the vast majority of projects are reported by developers to be incentivized through the SGIP.

The SGIP program and incentives are strongly promoted by developers; however, some customers do decline to go through the program. Reasons for not participating in SGIP include being waitlisted, receiving outside funding such as grants, and avoiding the hassle of applying for incentives. Nonetheless, most developers believe it would be extremely difficult to sell storage projects without the SGIP incentive.

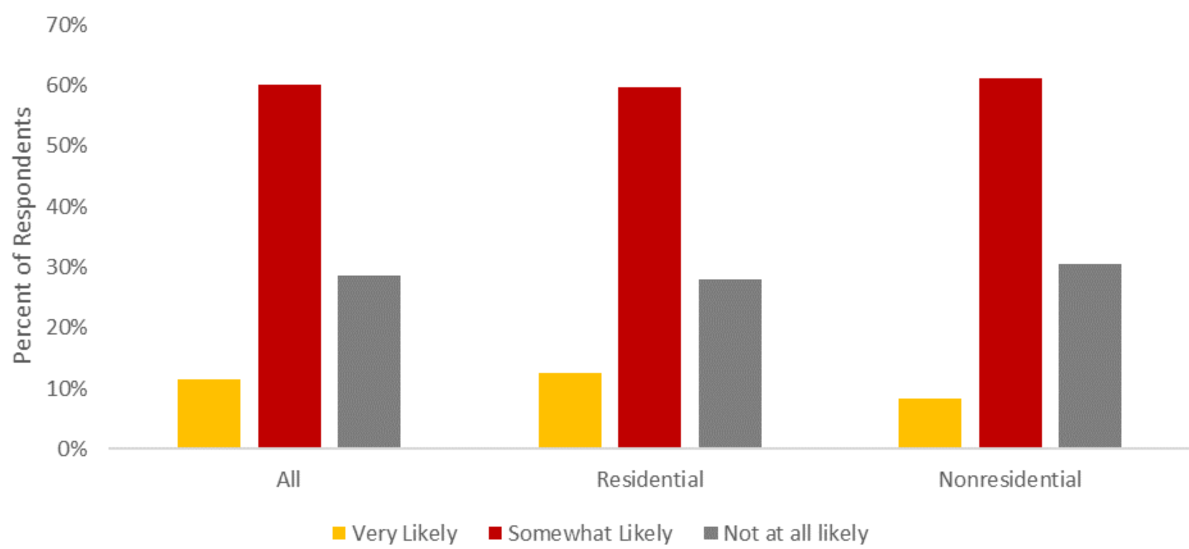
[2] Developers were categorized by size as a function of the number of their SGIP storage projects, as follows: High (>99 projects), Medium (5-99 projects), Small (<5 projects). See Sections 3 and 4 for additional information.

Storage customers also reported that the incentive amount was very important to their decision to purchase storage.

We asked end users that have solar systems a series of questions about their awareness and consideration of storage going forward. The vast majority (roughly 90 percent) of solar adopters are aware of storage. This statistic should not be considered indicative of non-solar end user awareness in the State. The primary perceptions of storage among solar survey respondents was that it was costly, enables use of solar energy or greater grid independence (mostly residential respondents), can be used for backup, and offers potential bill savings (mostly nonresidential respondents).

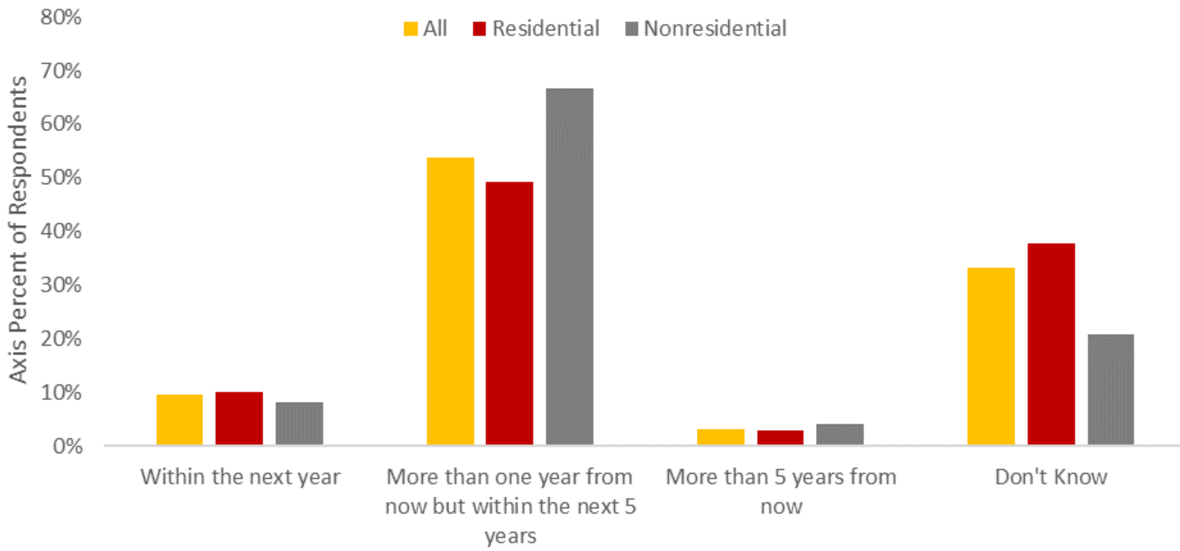
Most respondents indicated they had previously considered installing battery storage (57 percent) and that the perceived high cost of storage was the dominant reason they had not installed it. When asked about their future intentions, somewhat surprisingly, a very high percentage of the solar end users who had heard of storage prior to the survey, 73 percent, reported they were somewhat likely (61 percent) or very likely (12 percent) to install storage in their home or business (residential and nonresidential responses were similar). These results are summarized in Figure 7-2 below.

FIGURE 7-2: LIKELIHOOD OF INSTALLING BATTERY STORAGE "IN THE FUTURE" AMONG END USERS WITH SOLAR (N=140)



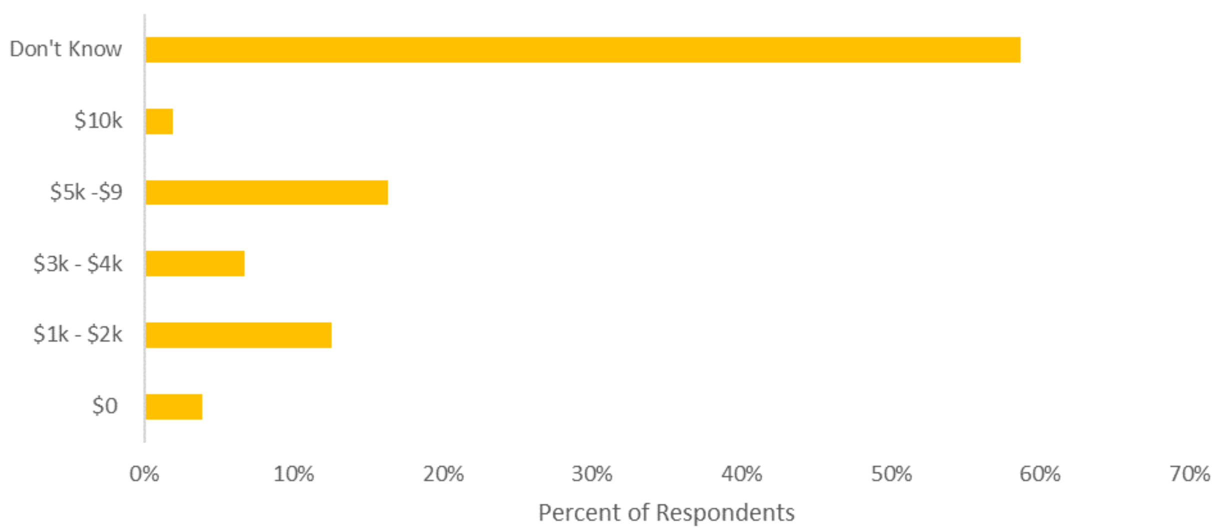
When asked when they anticipated installing storage, most customers indicated within one to five years. Ten percent or less said they planned on installing storage within the next year. Figure 7-3 on the following page summarizes these responses.

FIGURE 7-3: TIMING OF INSTALLATION OF BATTERY STORAGE AMONG END-USERS WITH SOLAR (N=93)



We then asked those end users how much they were willing to pay for storage. Most end users said they didn’t know how much they were willing to pay, only two percent said ten thousand dollars or more, 16 percent indicated five thousand to nine thousand dollars, and 20 percent one thousand to four thousand.

FIGURE 7-4: WILLINGNESS TO PAY FOR STORAGE AMONG RESIDENTIAL END-USERS WITH SOLAR (N=104)



In Table 7-1 below, we present an approximate estimate of residential BTM storage adoptions using the results from our survey of end users with solar. When we combine survey respondents' self-reports of intention to install storage with responses to the willingness to pay and timing of adoption questions, we can arrive at a very approximate estimate of potential future installations. It was not the intention or scope of this study to do a formal adoption analysis, which would require a much larger sample and a much more in-depth set of questions and context framing for respondents. There is significant uncertainty around any stated intention analysis based on customer self-reports, especially for new products with which consumers are unfamiliar. In addition, the majority of end users were not able to answer the willingness to pay question, another indication of end users' unfamiliarity with the product and value proposition. That said, it is interesting to look at how the responses to the questions we included with our broader survey compare with recent program activity. As shown in the table, based on these survey self-reports, there could be demand for as many as 9,000 systems among customers with willingness-to-pay greater than $5,000. This is roughly three times the number of systems in the SGIP in PY2018.

TABLE 7-1: SURVEY-BASED ESTIMATES OF RESIDENTIAL STORAGE ADOPTIONS (PAIRED WITH SOLAR)

Label	Element	Estimate	Source
A	~Number of residential solar systems	800,000	https://www.californiadgstats.ca.gov
B	Factored Adoption Fraction (Willingness-to-Pay >= $5k)	9%	Survey results from existing solar end users
C	Fraction of Adoptions per Year	10%	Survey results
E	Existing Homes Adoptions per Year	6,604	A X B X C
F	New Homes per Year	150,000	CA Dept of Finance[3]
G	Fraction of New Homes with Solar	75%	Estimate
H	New Homeowner Disposition Factor	25%	Estimate*
I	Factored Adoption Fraction	9%	Survey results from existing solar end users
J	New Home Adoptions per Year	2,399	F X G X H X I
K	**Total Forecasted Adoptions Per Year**	**9,004**	E+J

* *This factor is an estimate of the fraction of new home purchasers that are similar, socio-demographically, to existing solar adopters.*

[3] California Department of Finance, *Finance Bulletin*, July 2019. According to this report, new home starts are trending around 100,000 per year, far below Governor Newsom's goal of 500,000 per year. We use an estimate of 150,000 per year for the next five years to reflect some increase from current levels.

7.3 ASSESSMENT OF COST-EFFECTIVENESS RESULTS

In Section 6, we presented the results of this study's cost-effectiveness analysis. As described in detail in that section, we estimated cost-effectiveness using a wide range of tests, input assumptions, market segments, and years. Complete results can be reviewed in Section 6 and in Appendix C. In this section, we focus on representative results and then take a broader consideration of their implications.

When interpreting these results, the reader should keep in mind that, as discussed in Section 6, the cost-effectiveness findings are based on an ideal dispatch of storage. When optimized exclusively for bill savings, these results represent the best possible financial outcome for customers who install energy storage. In the real-world energy storage systems do not have perfect foresight into the next day's load shape and therefore will dispatch less than perfectly.

The results presented below and in Section 6 reflect the present value of the costs and benefits associated with energy storage systems throughout their entire useful life. These ratios reflect the rates, avoided costs, incentives, and technology costs applicable to the technology at the time. As the analysis moves forward in time many of these parameters change. Utility retail rates are forecasted to increase with inflation and the CEC Customer Energy Demand 2017 Baseline Demand Forecast of IOU electricity prices.[4] Utility avoided costs are expected to change to reflect increased penetration of renewables. Technology costs are projected to decrease with learning and economies of scale. Incentive rates are projected to decline and the federal investment tax credit (ITC) to step down.

7.3.1 Cost-Effectiveness Results Summary

The results indicate that the cost-effectiveness of behind the meter storage is highly variable and sensitive to the parameters and use cases tested. This is not surprising given where BTM storage is in its product lifecycle and due to the very nature of the technology. Costs, though declining, are still relatively high for many applications and segments. Market adoption is nascent. Within the context of utility applications, storage is definitionally a *capability* to provide benefit; the realization of this potential benefit depends entirely on how the system is operated.

Another challenge associated with BTM storage is that to achieve utility and social benefits, systems must respond to incentives and price signals designed to induce such benefits, while at the same time try to achieve direct financial benefits for storage owners through end user bill savings. In some of the scenarios

4 https://ww2.energy.ca.gov/2017_energypolicy/documents/2018-02-21_business_meeting/2018-02-21_middemandcase_forecst.php. The analysis uses the mid-level revised electricity price forecast for PG&E, SDG&E, and SCE to estimate forecast growth in utility rates.

we investigated, these twin objective functions can both be achieved, albeit with tradeoffs between one or the other; in other scenarios, incentives and benefit streams do not align well.

Figure 7-5 below and Figure 7-6 on the following page summarize a significant portion of the results from Section 6 to illustrate the range of cost-effectiveness estimated for different cost tests, sectors, market segments, and use cases. These results are discussed in the subsections that follow.

FIGURE 7-5: AVERAGE RESIDENTIAL BTM STORAGE COST-EFFECTIVENESS RESULTS – BY USE CASE

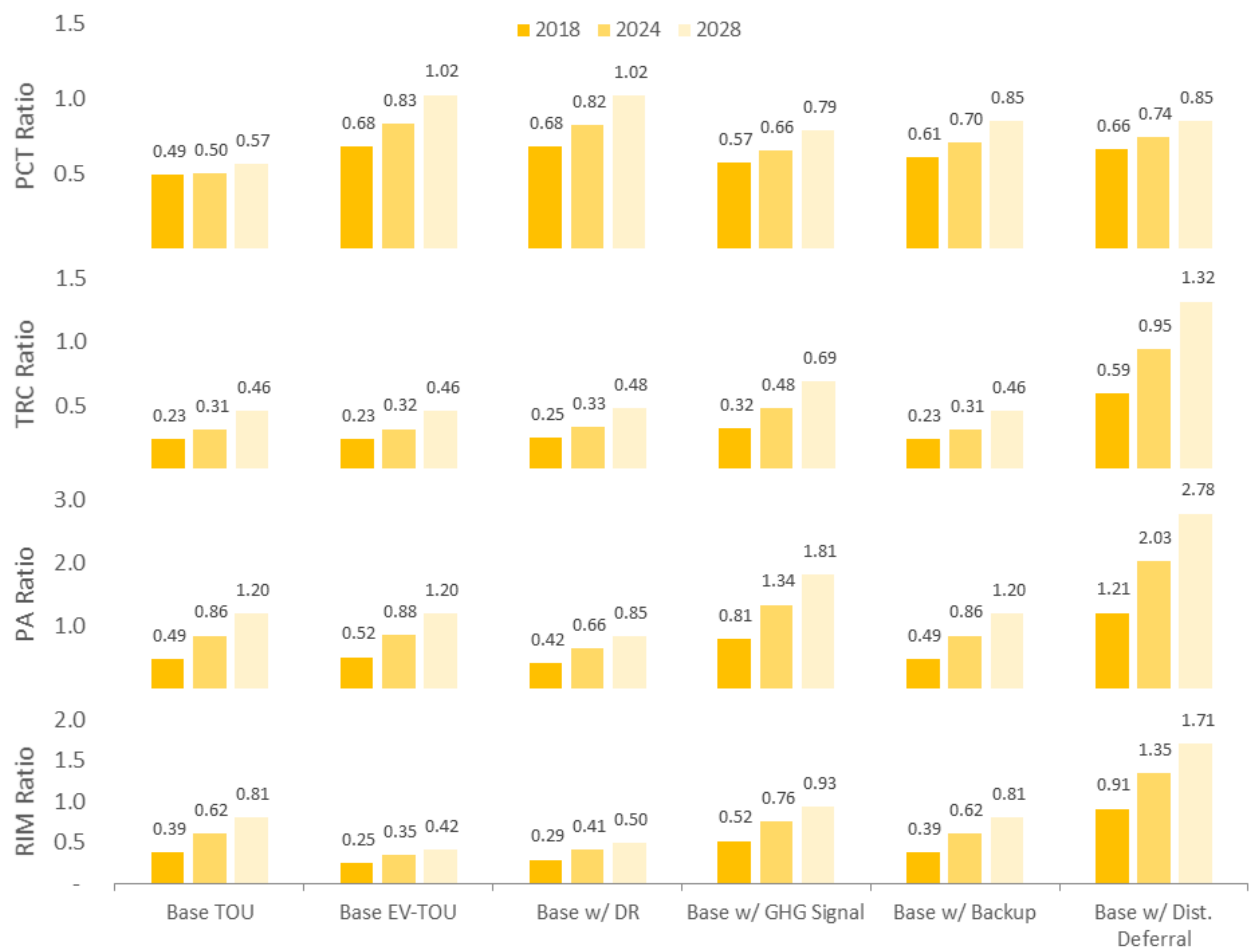
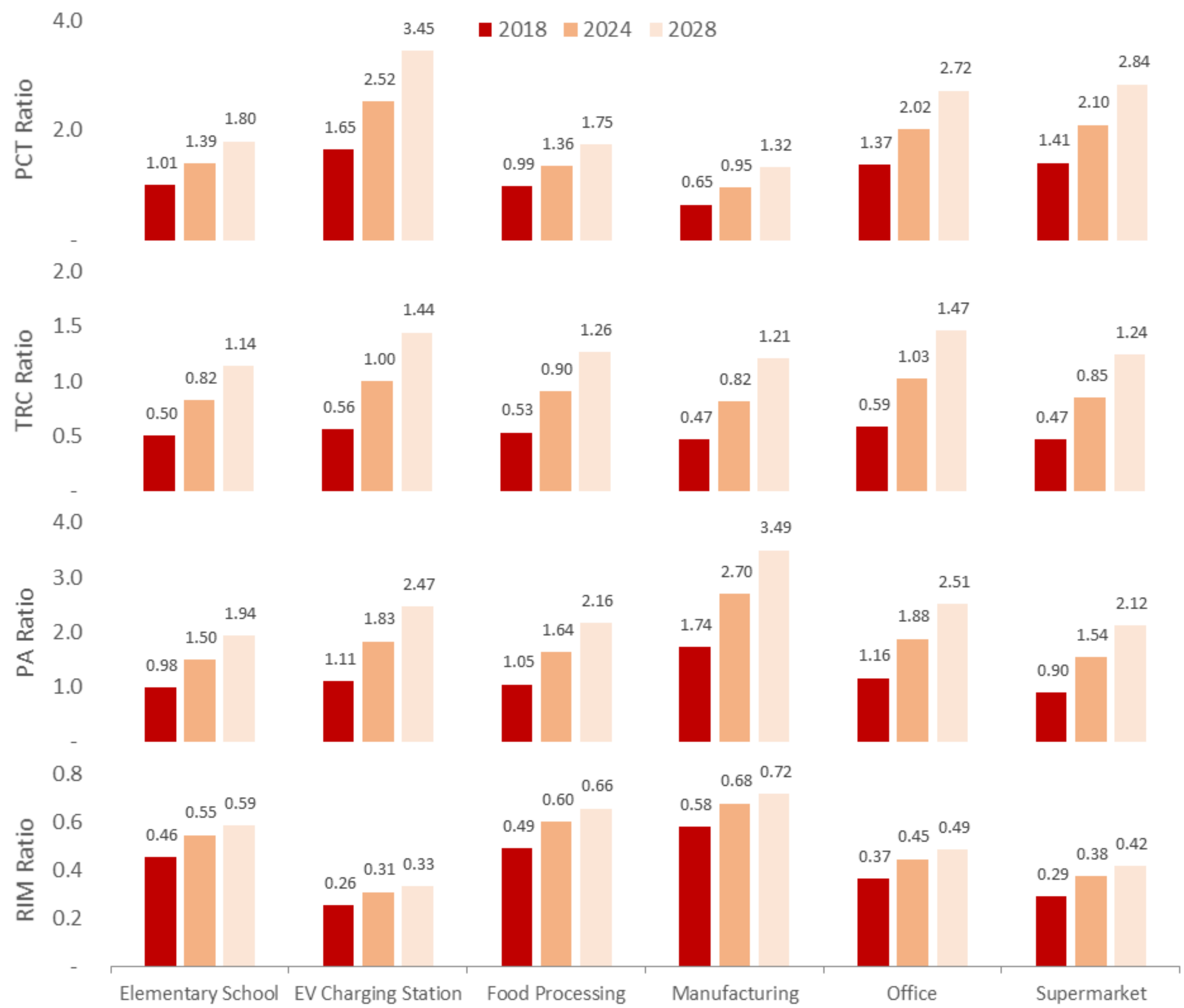


FIGURE 7-6: AVERAGE NONRESIDENTIAL BTM STORAGE COST-EFFECTIVENESS RESULTS – BY LOAD SHAPE



Total Resource Cost Test (TRC) Results

As shown in the summary figures above, under the TRC test (using the *full* cost of the storage system), results for Base Case simulations have TRC ratios ranging from lows near 0.1 for some residential systems in the initial year (2018) to values over 2.0 in the nonresidential sector base case (depending on load shape) by 2028. Nonresidential TRCs generally show that estimated benefits exceed costs (positive TRC with the TRC ratio above 1.0) in the out years and mixed in the mid-years, while residential TRCs are generally not positive (estimated costs exceed benefits) across the entire time frame of the analysis. Nonresidential results vary only slightly by load shape type.

Results vary significantly for both sectors across the alternate use cases. TRCs increase materially under the Distribution Deferral and GHG Signal cases and are largely unchanged under the DR case (see Section 6 for discussion of reasons for use case variation). Nonresidential TRC ratios range from 1.5 to 3.0 for the Distribution Deferral case in 2028 and average approximately 1.7 in 2024. The only Residential cases that have positive TRCs are those associated with the Distribution Deferral and GHG Signal cases in the out years. In 2028, the residential Distribution Deferral TRC ratios range from 1.1 to 1.7 while the GHG Signal case results are the next highest Residential TRC ratio results averaging around 0.75, with a few SCE segments slightly above 1.0. The TRC findings from the cost-effectiveness analysis include the following:

- TRC ratios are higher for non-residential applications than residential applications.
  - Nonresidential applications are modeled to operate year-round while many residential storage scenarios only operate during summer TOU periods.
  - The average size for nonresidential storage is larger than residential storage systems and the cost per kWh is lower for larger storage systems.
- TRC ratios are higher for rates and use cases that encourage charging during periods with low utility costs and discharging when utility costs are high.
  - Residential storage on standard TOU rates have lower TRC ratios than those on EV-TOU rates. The EV rate differential is better aligned with utility costs and is sufficient to encourage battery charging year-round. Modeled traditional TOU rates only encourage storage operation in the summer period.
  - Distribution deferral for residential and non-residential storage better aligns customer behavior with utility benefits leading to higher TRC ratios. The mechanism and market to control and incentivize batteries based on distribution deferral will need to be developed.
- Non-residential storage for customers with solar is associated with higher average TRC ratios.
  - Nonresidential customers with solar are modeled on rates designed for solar PV and their load shapes lead to increased energy arbitrage opportunities, less demand savings, and better alignment with utility costs.
- Non-residential storage modeled with the EV charging station load shape has some of the highest TRC ratios.

Participant Cost Test (PCT) Results

The Participant (PCT) test has important relevance to any analysis of market conditions, end user adoption, program participation, incentive levels, and potential market transformation. Under standard TOU rates, residential PCT ratios ranged from 0.5 to 0.64, increasing over time, under the Base use case. Under the residential EV-TOU rates analyzed, residential PCTs increase significantly relative to standard

TOU rates and estimated end user benefits exceed costs in the mid and later years. Access to a greater price differential of the EV-TOU rates modeled significantly affects the attractiveness of storage from the end user's perspective. Residential PCT ratios are also higher for the backup and demand response use case as these cases provide the customer with additional benefits.

Nonresidential end user's PCT ratios under the Base use case with standard TOU rates are near 1.0 for most of the segments analyzed (including the SGIP incentive) based on the prototypical load shapes chosen for the analysis. These PCTs increase significantly over time and are highest for EV Charging Station load shape. The following bullets highlights the findings for the PCT analysis for the residential and nonresidential storage:

- The PCT is higher in situations where storage owners have multiple benefits.
  - The residential backup and DR use cases provide slightly higher PCT ratios due to their additional benefits. The backup and DR use cases have PCT ratios greater than 1.0 in later years.
  - Nonresidential rates that allow both demand and electricity arbitrage provide additional benefits to customers. PG&E and SCE's modeled dynamic rates have higher PCT ratios than SDG&E's that provides only electricity arbitrage opportunities.
- Residential PCT ratios are higher on rates with larger energy differential between on- and off-peak periods
  - EV-TOU rates facilitate batter usage year-round, existing TOU residential rates do not offer opportunities to cost-effectively charge and discharge batteries during the winter rate period.
  - SDG&E's EV rate provides the largest on- and off-peak differential, leading to the highest PCT by IOU.
- Nonresidential storage PCT ratio estimates are generally greater than 1.0
  - The prototypical load shape used for EV charging stations is associated with the highest average PCTs for a nonresidential segment. This load shape offers significant demand savings potential.
- The presence of pre-existing BTM solar reduces the average PCT ratio of adding storage due to lower demand savings opportunities.

The PCT results for other use cases are not as different from the Base use case as is seen with the TRC results. This is because some of these cases, such as the GHG Signal, did not include a customer benefit in our analyses. For these cases, the PCT results are similar but lower than the Base results indicating that adding the GHG Signal co-optimizations slightly diminished end user benefits (without any corresponding compensation, as modeled).

In its recent IDER Cost-Effectiveness Decision[5] the CPUC reaffirmed the primacy of the TRC for cost-effectiveness analysis. At the same time, the Commission also explicitly stated that it recognizes the importance of the Program Administrator (PA) and Ratepayer Impact Measure (RIM) tests and indicated discussion of those tests should be included in relevant proceedings.

Program Administrator Cost Test (PA) Results

Not surprisingly, PA results are much higher than TRC results. This is often the relationship between the TRC and PA tests (PA significantly higher) since the PA test includes only incentives and administrative costs but does not include the participant's incremental measure costs, as does the TRC. PA ratios for BTM storage are well above one in many of the Residential mid- and out-year cases as well as some of the first-year cases (e.g., the GHG High Signal and Distribution Deferral cases). Nonresidential PA ratios are generally above one in 2018 and average roughly 2.0 in 2024 and 3.0 in 2028. The bullets below present information on the PA cost test results.

- The residential PA ratio is generally greater than 1.0 in 2024 and 2028.
  - Residential rates that are better aligned with utility costs are associated with higher PA ratios.
  - SDG&E's EV-TOU rate is associated with the highest average PA ratios for the base case.
  - EV-TOU rates improve the PA ratio in part because they facilitate the charge/discharge of storage on a year-round basis.
- Distribution deferral and High GHG Signal use cases have the highest PA ratios in the residential and nonresidential sectors.
  - The distribution deferral and High GHG Signal use cases optimize the charge and discharge of the battery to better align with the utilities' high cost periods.
  - The residential distribution deferral average PA ratio is greater than 2.0 for EV-TOU rates and approximately 1.85 for TOU rates in 2018
  - The nonresidential distribution deferral average PA ratio is approximately 2.40 in 2018.
- The nonresidential PA ratios are generally greater than 1.0 in 2018 and increase in 2024 and 2028.
  - As modeled, the manufacturing load shape has the highest PA ratio, averaging 1.9 and 1.63 in 2018. The manufacturing load shape PA ratio is slightly higher than for other load shapes

[5] Decision Adopting Cost-Effectiveness Analysis Framework Policies for All Distributed Energy Resources, Decision 19-05-019, May 16, 2019,

because larger energy storage systems receive a lower SGIP incentive per kWh, reducing the costs in the PA cost test relative to the potential benefits.

- Energy storage systems added to a solar load shape and rate are associated with a slightly higher PA cost test as customers do more energy arbitrage in this situation, which better aligns with utility costs.

Additional Perspectives on the PA Test

While the much higher PA results are expected since the PA test differs from the TRC in that it excludes the participants incremental measure cost (IMC), it is relevant to note and discuss some of the nuances around these results, particularly with respect to the question of incremental measure costs, the TRC test, and participant costs and benefits. Experts have debated the various merits, pros and cons of each the cost-effectiveness tests for many years, one such debate recently centered on the question of incremental measure costs and non-energy impacts. A literature review for the CPUC summarized important aspects of this industry debate.[6] One relevant aspect of this debate is that some analysts believe that, in energy efficiency, there are cases in which there is an asymmetry between costs and benefits in some applications of the TRC test; specifically, when full costs are used in lieu of incremental costs and non-energy impacts are excluded from net benefits. In cases where net non-energy impacts are not included in the TRC, this problem can be mitigated using properly estimated incremental measure costs.[7] The intention of the IMC in the TRC is to isolate only that portion of the costs that is associated with the aspects of the product for which all ratepayer benefits are sought. For example, in the case of energy efficiency, this is the incremental cost of the high efficiency feature of the product, not the full cost of the product.[8]

Returning to the application of these concepts to BTM storage, the discussion above raises the question of how to address the relationship between system costs and benefits given that end users (especially, residential) appear to be adopting storage for multiple reasons including for the purpose of using backup power during power outages. In theory, one could try to estimate the portion of the end user's willingness

6 "Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review", performed by the Regulatory Assistance Project for the California Public Utilities Commission. Attachment A to ALJ's Ruling Providing Revised Literature Review, Rulemaking 14-10-003, 2/23/2017.

7 Rufo, M. (2014). "Perspectives on Program Influence and Cost Effectiveness: Moving Forward from the Recent US Debates." Proceedings of the International Energy Policies and Programmes Evaluation Conference, Berlin, Germany, September 9, 2014.

8 Note, in this example, we are referring to cases of product replacement at natural turnover, as in when an air conditioner has to be replaced and the end user faces the choice of replacing with a standard or energy efficient unit. This cost difference can be estimated very directly using hedonic cost models as well as other techniques to effectively isolated the incremental measure cost associated with only the energy efficiency feature of the product. (In cases of program-induced early replacement, estimation of the cost and benefit stream is more complex.)

to pay that is associated with each of the features of import, for example, the portion associated with the ability of the battery to provide bill savings from load shifting in ways that align with grid needs and requirements (hence, also potentially providing all ratepayer benefits), and the portion associated with the entirely private benefit of having a backup generation source. In practice, disaggregating costs in this way can be difficult if there is no alternate technology that has all of the features except the feature associated with all ratepayer benefits.

Another approach could be to compare battery storage costs to the cost of fossil fuel emergency generators that some customers might otherwise purchase. Even in that case, a straight cost comparison may not isolate incremental costs if, for example, battery backup is perceived to have some additional non-energy benefits such as being quieter, easier to use, cleaner, and safer than fossil fuel generators.

Some analysts have argued that, in cases where no reliable or meaningful estimate of the incremental cost is available, incentives can serve as a proxy for incremental costs. In such cases, they maintain that the PA test becomes a sensitivity case for the TRC (i.e., with the TRC counting the full cost of the measure, while excluding some of the participant-only benefits, and the PA test including only the program administrator costs and also excluding the participant-only benefits).

Another perspective on the PA test is that it is useful for market transformation related programs that have an explicit goal to reduce product costs. The PA test, it is argued, provides a back stop to ensure that ratepayers are getting reasonable value for their funding of incentives. The fact that participants appear to be covering a portion of costs that appears to be uneconomic is attributable to the perspective that they are obtaining additional indirect private benefits. Some analysts argue that the PA test is inferior to the TRC as a primary test for assessing the relative costs and benefits across resources, but that there remain specific market transformation circumstances where passing the PA in the short term provides risk mitigation for the longer-term market transformation objectives (e.g., passing the TRC in the future). Including the full price of the energy storage systems in the TRC is consistent with the distributed generation cost-effectiveness framework.

Ratepayer Impact Measure (RIM) Results

The RIM test is similar in construction to the PA cost test, with the addition of customer bill savings as a cost. The RIM test measures cost-effectiveness from the non-participant or rate payer's point of view. When looking at the RIM results, if a rate, use case, or load shape is associated with increased customer bill savings without comparable increases in utility avoided cost benefits, it is likely that the scenario will be associated with a lower RIM ratio.

High level insights associated with the residential and nonresidential RIM cost tests are presented below.

- The residential and nonresidential RIM cost test ratio is less than the PA cost test ratio due to the inclusion of customer bill savings as a RIM cost.
- The residential RIM cost test ratio is usually larger than the TRC ratio. The nonresidential RIM cost test ratio is usually less than the TRC ratio. Customer bill savings are larger relative to the cost of the measure in the nonresidential sector than the residential sector, leading to the different average RIM and TRC relationships by sector.
- The RIM ratio is higher in situations where the avoided cost impacts are higher and the customer bill savings are relatively lower.
  - In the residential sector, the RIM test is greater than 1.0 for the distribution deferral and GHG Signal use cases in 2024. In both use cases, the battery charge and discharge are co-optimized to the utility's needs.
  - In the residential sector, the RIM test average is slightly higher for the standard TOU rate than the EV-TOU rate.
- The residential analysis included 144 yearly scenarios in which the customer received an incentive (the RIM test is only calculated if there is an incentive). Of the 2028 scenarios, there were seven scenarios where the RIM test was greater than 1.0 and the PCT was greater than 1.0. For each of these scenarios, the TRC and the PA cost test were also greater than 1.0.
  - Residential scenarios passing all four cost-effectiveness tests are limited to the distribution deferral and GHG use cases with an EV rate. The distribution deferral and GHG use cases are associated with high avoided cost benefits (RIM>1). The EV rate is associated with a slightly higher bill savings (PCT>1).
- The nonresidential RIM ratio is generally less than 1.0 due to the large customer bill impacts of storage.
- The nonresidential analysis includes 360 yearly scenarios in which the customer received an incentive. Of the 2024 scenarios, there were 42 where all four cost-effectiveness tests have ratios greater than 1.0. In 2028, there were 82 scenarios passing all four tests.
  - In 2024, all 42 scenarios passing the four cost test ratios are distribution deferral and GHG uses cases.
  - In 2028, 70 of the 82 scenarios passing all four cost-effectiveness tests are distribution deferral and GHG use cases.
  - The base use case passed the four cost-effectiveness tests in 12 scenarios. Of these scenarios, 10 of the 12 were in SDG&E's territory on the Power Your Drive rate. SDG&E's Power Your Drive rate is an energy only rate that aligns with the high avoided cost time periods. The alignment of the Power Your Drive rate with the avoided costs leads to high avoided cost benefits (TRC, PA, and RIM benefits) and high energy benefits for the customer.

7.4 KEY UNCERTAINTIES AND INFLUENCES

As noted previously, there are many uncertainties associated with the emerging BTM storage market in California and elsewhere. Some of these uncertainties are related to the economics of storage and some to characteristics of the marketplace. Some uncertainties are causally related to each other in potentially complex feedback loops as well. A number of key uncertainties are highlighted in Table 7-2 below.

TABLE 7-2: KEY ELEMENTS AND UNCERTAINTIES AFFECTING ENERGY STORAGE COST-EFFECTIVENESS

Element	Uncertainty
Pace, magnitude, timing of cost reductions	Battery costs are expected to decrease over time; however, these decreases, and their timing, may differ significantly from those used as inputs for this study
Maintenance costs	No maintenance costs were assumed for BTM storage for this study
Battery life, battery degradation, safety	Little in situ, cradle to grave data is available for the latest Lithium Ion batteries used for BTM storage
Utility avoided costs	Utility avoided costs are dynamic and will continue to change over time in ways that may be similar to or different from those used as inputs to this study
Utility rate structures	BTM storage end user economics are highly sensitive to tariff structures. Tariffs can provide a performance-based incentive for specific load shifting behaviors. Tariffs may change markedly over time becoming more or less favorable for storage
Presence, amount of ITC over time	The amount and continuance of any ITC are subject to federal policy and could change markedly from the forecast used for this study
Battery end of life value/costs, recycling options/requirements	No costs were assumed for disposing of or recycling batteries at the end of useful life, nor benefits for potential resale/repurposing
Solar marketing, extent of bunding/promotion of PV+storage	In the residential sector, storage adoption may be very sensitive to the extent to which solar providers bundle and promote it to prospective customers; as this is a newly emerging market whose early adopters differ significantly from average end users, there is significant uncertainty with respect to the sustainability and size of this market
Actual performance of control systems compared to modeled optimum	This study modeled dispatch based on load shifting that would optimize tariff benefits to end users ("ideal" dispatch). The most recent SGIP impact evaluation showed behaviors that were often far below these theoretical optima. Real world systems will have to improve significantly to produce the level economic benefits modeled under ideal dispatch.
End user valuation of backup, extent of de-energization events	Residential solar adopters often indicate that backup power during outages is a key driver for adopting or considering adopting storage. In addition, recent fires in California and plans for selective public safety power shut-offs may spur more adoption than would otherwise be the case. The length and frequency of outages over time may affect the development and size of the BTM storage market significantly.
Fire safety restrictions	Recent changes in fire safety requirements were reported to have negatively impacted the nonresidential storage market, particularly with respect to indoor applications. How these requirements play out or evolve and how products, developers, end users, and insurers adapt to them could impact market size.

7.5 FUTURE OUTLOOK AND CONSIDERATIONS

BTM storage is still very early in its market development. BTM storage products, services, and capabilities are relatively new and primarily niche segments of end users are aware and knowledgeable of the technology. While most initial projects within the SGIP program were in the nonresidential sector, there has been a recent surge of residential adopters. Many developers expressed the view that the residential market is or will be of strong interest to them going forward.

Under the TRC cost-effectiveness test, using the full cost of storage, few of the prototypical BTM storage applications analyzed are cost-effective, even in the later years of our 10-year analysis with forecasted cost reductions. Exceptions include later years of several nonresidential segments and limited, targeted cases associated with local distribution constraints and high associated avoided costs.

Although our results indicate that BTM storage also is not cost-effective yet (under the PCT) to residential end users based on load shaping opportunities and the tariffs analyzed, a small group of early adopters indicate that there are additional reasons for choosing storage. These reasons include the desire for backup power during an outage and the perception that storage can be used to self-consume excess mid-day solar output or to provide environmental benefits by shifting the timing of solar contributions to the grid. Such early adopters likely value backup generation at a level much greater than the average customer. Most of these early adopters of residential BTM storage also indicated that the SGIP and ITC were very significant in their decision to install storage and they were unlikely to have done so otherwise.

A significant fraction of residential solar adopters interviewed expressed relatively high interest in acquiring BTM storage in the next five years, although their willingness to pay at current price points was limited. These customers tend to be niche, higher income end users with strong environmental concerns and the desire to be on the cutting edge of new technologies.

Despite positive perceptions among current BTM storage adopters and end users with solar, the most recent impact evaluation of BTM storage within SGIP indicated that residential systems had not yet been operating in ways that produce grid or end user load shaping benefits. This may change due to technology improvements and changes in program and tariff requirements currently under consideration.[9] In the meantime, direct evidence of whether BTM storage can provide load shaping and GHG related benefits in the residential sector remains forthcoming. Even under optimal dispatch as modeled in our cost-effectiveness analysis, residential BTM storage do not achieve positive TRC results (using the full cost of the storage system) for most cases over the time horizon of this study (2018 – 2028).

[9] An impact evaluation of the 2018 SGIP program is currently in progress and will be an important source of in situ data to assess whether storage performance is increasing its alignment with GHG and grid benefits.

In the nonresidential sector, storage adoption was strong in the initial years but there has been a significant slowdown recently within the SGIP program. Developers indicate that some issues with the program may be inhibiting participation. In addition, several developers appear to be shifting away from direct provision of storage to nonresidential end users to storage-related software, or to pursuing residential customers. Although storage appears cost-effective to prototypical nonresidential end users, the value proposition and profitability of delivering storage to such customers remains uncertain as market players adapt going forward. Developers expressed the mixed view that SGIP incentives are beneficial to aiding market development, but that SGIP program requirements and interconnection were also challenging. Another challenge seen in the prior impact evaluation results was that much of the nonresidential end user's financial benefit was associated with demand charge reduction, which was not correlated well with grid and GHG benefits.

The BTM storage market thus presents policy makers, program administrators and market actors with a set of challenging features and characteristics, as well as some opportunities. On the one hand, storage offers the potential to shift some solar or other intermittent renewable generation from periods of excess production to periods of high and steep demand on the grid and associated costly, high GHG, fossil generation. On the other hand, the technology, performance, and markets are emerging and uncertain; economic attractiveness is generally low using standard measures of cost-effectiveness; and benefits are highly sector, tariff, segment, and use case specific, as well as dependent on further cost reductions.

Within this context, policy makers are faced with questions and choices regarding when, how, and to what extent to intervene in the BTM storage market. Based on California's storage-related legislation and CPUC proceedings, interventions could be aimed at supporting several goals, for example:

- Improving actual performance and closing the gap between observed and optimal battery dispatch
- Accelerating cost reductions, driving deeper, more rapid price reductions to increase the range of cost-effective BTM storage applications
- Improving product features, such as maximizing controllability (e.g., GHG signal response time), round trip efficiency, battery life; responsible sourcing; and end-of-life reuse and recycling
- Assuring appropriate levels of equity in funding and access to BTM storage benefits
- Contributing to the State's GHG goals through net positive GHG shifts in storage charging and discharge, increasing the value of solar and other intermittent renewable generation, and reducing reliance on fossil and high GHG generation sources
- Creating a cost-effective, self-sustaining market for grid- and GHG-beneficial BTM storage

Within this context, on August 1, 2019 the CPUC approved changes to SGIP's BTM storage incentives and requirements to better align GHG, grid, and participant benefits. In addition, on April 15, 2019, an ALJ Ruling[10] requested party comments on additional questions regarding SGIP funding allocations and incentive levels.

Below are several considerations based on this study's findings and related sources:

Continue to refine current incentives, program features and tariff requirements to align grid and end user benefits. The CPUC is in the process of proposing and adopting SGIP requirements and program features that address several of this and the 2017 SGIP impact evaluation study's findings that show a need for increased alignment between GHG, grid, and participant benefits.[11] Once these changes have been implemented, further analyses of their effects can be conducted. The operation of storage systems is very sensitive to time-differentiated economic signals and, in practice, the alignment of multiple policy objectives within available tariff options and programmatic requirements is challenging. Continued monitoring of the effects of time differentiated economic signals and refinement of such signals will be a key element of BTM storage value maximization. Since programmatic changes take significant time to develop and vet with stakeholders, it may be most realistic to focus in the near term on the GHG-related program requirements that were recently approved or are currently being considered for approval from the latest CPUC staff proposals and party comments on SB 700 implementation. The performance and market effects from these changes can then be used to consider whether and to what extent further modifications are warranted.

Consider shifting the relative weight of incentives from upfront rebates to tariff/performance-based over time. Because the potential grid benefits of storage require very specific and consistent behavior over many years, performance-based incentives that reward load shifts over time are more likely to result in persistent impacts. At the same time, storage is expensive on a first cost basis and still relatively new and risky from an end user's perspective. Absent significant upfront incentives, this may limit adoption until costs decline more significantly. Paying larger upfront incentives while providing lower bill savings opportunities through tariff differentials may increase adoption in the short term but might produce fewer long-term benefits, which shifts more risk onto ratepayers. On the other hand, providing lower initial incentives and higher bill savings opportunities through favorable tariffs shifts risks to those adopting storage but may not generate the pace and scale of market activity needed for market transformation and the achievement of long-term policy goals. In addition, greater weight on tariff-based incentives may require certain types of tariff guarantees over time, which can be challenging. Shifting

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[10] *Assigned Commissioner's Ruling Seeking Comments on SB 700 and Other Program Modifications*, Rulemaking 12-11-005, April 15, 2019.

[11] *Decision Approving Greenhouse Gas Emission Reduction Requirements for the Self Generation Incentive Program Storage Budget*, Rulemaking 12-11-005, May 31, 2019

over time from a more first-cost weighted to more tariff-focused incentive approach may help to optimally balance these competing pressures and objectives.

Consider adjusting budget allocations between sectors. One of the issues currently facing the CPUC, PAs, and stakeholders is that the residential portion of the SGIP budget is highly subscribed, but the nonresidential portion is underutilized. As we have noted in this study, BTM storage is an emerging market and, as such, is subject to the volatility and uncertainty that often accompanies emerging technologies and services. The relatively fast change from the number of SGIP projects being virtually only nonresidential to being largely residential is one indication of this market volatility. While the share and rate of nonresidential projects could increase again just as quickly, there is no guarantee that nonresidential projects will pick up without changes in project or technology costs, market investment, or adjustments to tariffs and program interventions.

SGIP funding has been purposefully allocated to pre-set shares of the SGIP storage budget for each sector, with the residential sector disproportionately smaller than the nonresidential sector. Having the benefit of time and several phases of changes in market activity to aid in assessing the effects of this allocation, the CPUC requested party comments on the sector allocations in its April 15, 2019 ruling. To the extent that the results of this study can help inform these assessments, we offer a few considerations. On one hand, our cost-effectiveness results indicate that nonresidential applications remain significantly more cost-effective under the TRC (using the *full cost* of BTMS) then the residential sector. From a strictly cost-effectiveness perspective, that could argue for retaining a disproportionately greater share of funding for the nonresidential sector. At the same time, the State and CPUC's BTM storage-related interventions are also focused on market transformation-related goals, which would likely be supported by maintaining consistency in market demand and adjusting to shifts in market activity if such shifts are reasonable within the context of the State's long term BTM storage-related policy objectives. In addition, to achieve market transformation there will have to be a functioning market of BTM storage providers. To the extent that demand shifts from one sector to another and market actors adapt to maintain viability, some portion of program funding may also need to adapt to these shifting market forces to help smooth and stabilize the overall market; if such changes are determined to be reasonably aligned with longer term goals.

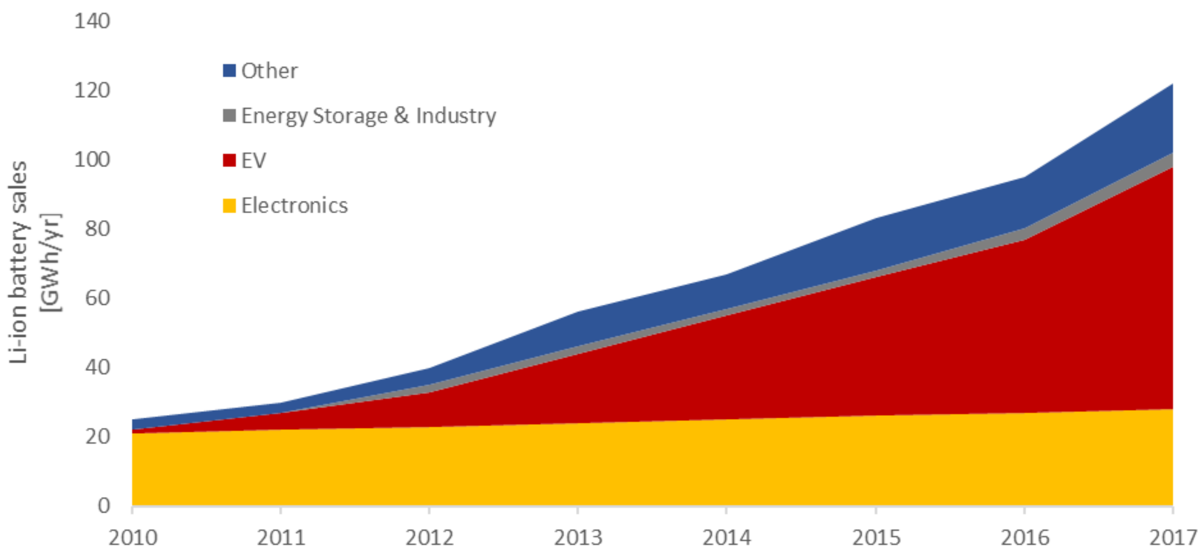
Consider increasing focus on near-term performance demonstration. As noted above, the CPUC has had a strong focus on evaluating the load impacts of energy storage systems and using those to assess and modify the SGIP. For a relatively new technology like BTM storage without an intrinsic operation profile, this focus on timely assessment of load impacts is very important. The CPUC may want to consider a more targeted or explicitly pilot approach to prove out in situ BTM storage performance against policy requirements and load shifting expectations prior to allocation of more extensive funds for widespread deployment.

Under this approach, BTM storage systems might be geographically concentrated to address one or more of the high cost, high need areas of the grid, such as distribution or transmission constrained areas, areas facing energy de-energization, areas with high concentration of renewable resources, or to support SB 1477 related decarbonized buildings (e.g., communities of new homes with PV and all electric end uses). On the performance side, different types of price signals and access to grid markets could be tested with quick response monitoring and evaluation built into the design. Such an approach might accelerate the pace of BTM storage-grid value alignment, albeit with perhaps a smaller total footprint in the short term, with the tradeoff being a potentially larger, more cost-effective market in the long term. In addition, such pilots could perhaps benefit from the short-term application of resources used to ensure that communication and control systems operate as intended to demonstrate flexible and reliable achievement of GHG and grid benefits. This could help to increase the likelihood of beneficial market scaling thereafter.

Market interventions could await further cost reductions and performance improvements or try to shape the market as it is emerging. The BTM storage market is very new, having only come into existence recently, due largely to Li-ion battery price reductions driven by the EV market (and by consumer electronics before that). These EV driven, Li-ion cost reductions enabled the initial foray of developers into the nascent BTM storage market. Most analysts expect Li-ion costs to continue coming down as we have modeled; however, the rate could be faster or slower than most analysts' predictions. Although the stationary storage market's share of the global Li-ion battery market is predicted to increase, it has represented a very small share as compared to EVs (see figure below). The stationary share of the Li-ion market is expected to increase; for example, one study forecasts it will reach roughly 15 percent of combined EV-Stationary demand by 2025.[12] As our results indicate, in the near-term, BTM storage is only cost-effective (from the adopting end user's point of view) for some nonresidential and a very narrow group of residential customers who place a premium value on backup power. Without SGIP incentives and favorable tariff structures, these small, niche markets would be even smaller until global market forces drive additional, significant cost reductions.

[12] Lithium-ion Battery Costs and Market, Bloomberg New Energy Finance, July 2017.

FIGURE 7-7: GLOBAL HISTORICAL GROWTH OF LI-ION BATTERIES BY APPLICATION[13]



These trends and results could be taken to suggest that State-level actions are unlikely to be strong drivers of some goals, such as global Li-ion cost reductions, and that there is time to wait and see how these markets evolve before scaling ratepayer-funded interventions. On the other hand, although the exact timing of cost reductions is highly uncertain, it is likely that niche BTM storage markets will continue to emerge and grow, possibly without interventions, albeit more slowly in the near term. California has an opportunity to direct this evolving market towards more rather than less grid- and GHG-beneficial capability and performance. For BTM storage, this could be particularly important to the development of price- and signal-responsive communication and control systems. In the near term, the combination of the SGIP, storage-related tariffs, and the ITC can have a very significant impact on shaping the development of the emerging BTM storage market.

Continue assessment of the relative benefits, costs, and applications of in-front-of-the-meter (IFOM) storage as compared with BTM storage. IFOM storage and BTM storage share important similarities and differences. Many IFOM storage applications utilize the same Lithium-ion based battery storage technology as BTM storage. However, while underlying cost trends and advances in performance may affect each proportionally, there are areas of material difference as well. IFOM storage is generally of significantly larger scale than individual BTM storage systems. The result is a significantly lower per unit cost due to volume discounts on battery size and economies of scale for balance of system installation

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13 *Li-ion Batteries for mobility and stationary storage applications*, JRC Science for Policy Report, Tsiropoulos I., Tarvydas. D., and Lebedeva N.

costs. Utility scale, IFOM storage may be more likely to have longer storage duration (e.g., 4-hour duration in our analysis rather than the 2-hour duration modeled for BTM storage). In theory, IFOM storage also can be oriented singularly to reducing grid-related costs. Since there are no end user needs to serve, per se, as with BTM storage, nor retail tariff to co-optimize, IFOM storage can be designed to follow near real-time avoided costs and GHG arbitrage objectives.

As shown in Section 6, these differences result in significantly higher cost-effectiveness from a TRC perspective for IFOM storage compared with BTM storage. Although IFOM storage shows better cost-effectiveness from a TRC perspective, this advantage may be reduced under the PA test, depending on incentive levels, since end user adopters carry a portion of the system costs for BTM storage (e.g., to acquire an asset for personal backup power) whereas costs are likely to be spread evenly across all ratepayers for IFOM storage.

In terms of deployment options, each has advantages and disadvantages. Either can be targeted to areas with localized grid constraints, although IFOM storage can likely be deployed more quickly at greater scale for distribution upgrade deferral. Although in theory, either type of storage can be used for near real-time grid services, BTM storage systems face more complex co-optimization challenges than front of the meter systems. There may be a way to increase access to such markets that provide additional revenue opportunities and value for both types of systems. IFOM storage may have an advantage of being semi-moveable and able to shift from one location to another, albeit not often, should localized needs change materially. A potential advantage of BTM storage is that it can be market driven; is often paired with solar, thus impacting NEM load shapes on a customer-by-customer basis; and can be scaled up slowly in very small increments.

As deployments of both systems are still relatively new, analyses of the cost-effectiveness of in situ performance (ex post cost-effectiveness) will be important for both types of storage until a consistent performance record is established.

Continue to assess and align value streams of storage and demand response. While storage can be utilized to contribute to peak demand reduction, compensation for peak load reductions through DR programs must consider concurrent storage load shaping incentives such as TOU rates, as well as associated baselines, in order to avoid unintended double payments and to incent incremental effects.

Assess use of performance incentives and TOU requirements associated with municipal utility storage projects that receive SGIP incentives. While municipal utilities represent only a small portion of SGIP storage projects, CPUC jurisdictional limits restrict the reach of TOU rate requirements for projects funded by IOU gas ratepayers and implemented by municipal electric customers. It is unclear to what extent storage projects funded by gas IOU ratepayers that are installed in municipal electric service territories are required to be on time-differentiated or other performance-based mechanisms to encourage desired dispatch behavior. An analysis of actual electricity tariffs and other requirements and incentives associated with SGIP municipal storage projects should be conducted to inform the CPUC and legislature and to access the value and performance of these projects as compared to the electric IOU storage projects under full CPUC jurisdiction.

Consider complementing comprehensive evaluation and market studies with quarterly or bi-annual quick turnaround assessments. Because the BTM storage market is evolving and the requirements and incentives for SGIP adapt in response to policy and market considerations, quick turnaround impact and market assessments may be useful to help shorten the time lag between program and policy changes and estimation of the resulting impacts and market effects. Possibilities include impact analyses to assess whether changes in participation and load performance are occurring in response to changes in program targets, rules, and requirements; as well as periodic assessments of market trends (e.g., changes in product and installation prices, marketing activities and product offerings, end user awareness, etc.).[14]

Consider further study of future BTM storage adoption. This study focused on solar adopters as the next likely drivers of residential BTM storage; however, a comprehensive analysis of the potential market for BTM storage would consider the entire population of residential and nonresidential end users. In addition, to improve quantification of BTM storage adoption forecasting a more in-depth study of willingness-to-pay would be needed. The results could be used to inform budget setting and incentive levels; BTM storage forecasts for grid planning and IRP; market effects indicators; and customer information needs.

Consider battery reuse, recycling, and sourcing issues and associated end-of-life economic effects. While not in the scope of this study, as the production of lithium-ion batteries for stationary applications adds to the demand from EVs and consumer products, lifecycle environmental and social impacts become increasingly important. Issues such as responsible sourcing, re-use/re-purposing, recycling, and disposal should be addressed proactively to avoid unintended environmental and social impacts. Coordination with the relevant and responsible state agencies is recommended. Information from such analyses can provide additional economic information on potential end-of-life cost or revenue effects for future cost-effectiveness analyses.

[14] See, for example, the Northwest Energy Efficiency Alliance’s use of Market Progress Reports within their market transformation initiatives.

APPENDIX A.1 MANUFACTURER SURVEY

Hello my name is <name>. I'm calling from Itron on behalf of the California Public Utilities Commission as part of an effort to evaluate the Self-Generation Incentive Program, from now on referred to as SGIP. We are interviewing businesses that participated in the SGIP program by selling and/or installing energy storage equipment to residential and nonresidential customers and submitting applications on their behalf to the SGIP. The purpose of our evaluation is to assess the current and future markets for energy storage. This survey provides an important source of information to inform this market assessment. Key areas of focus are your current energy storage system product line, current and future market trends for energy storage systems, and the effect of the SGIP program on your sales of energy storage systems.

Screener

S1. First, I'd like to confirm your company's role(s) in the market for behind-the-meter energy storage systems. According to our records, and other publicly available information, your company serves in the following capacities within the energy storage market, is that correct? [CHECK ALL THAT APPLY]

____Manufacturer
____Distributor
____Reseller
____Installer

Current Product/Market Snapshot

The next several questions concern the behind-the-meter energy storage systems that your company manufactures and sells. [IF APPLICABLE, READ: "I visited your company's website and obtained as much information as I could about your products. I would like to confirm what I found."]

MP1. Please describe your energy storage product line, and specifically the primary features of the units you sell, in terms of the following:

Battery type (e.g. lead acid, lithium ion, sodium Sulphur, nickel cadmium)
Unit sizes offered (kW capacity, cubic feet/footprint)
Useful life
Round trip efficiency

RESPONSE:

Alt. MP1. [IF HAVE WEBSITE INFORMATION:] I visited your company's website and learned the following information about your energy storage product line, which I would like you to confirm.

INSERT MANUFACTURER'S PRODUCT DESCRIPTION HERE

READ description, then ask, "does this sound right?" **RESPONSE:**

MP2. For each behind-the-meter energy storage product that your company makes, please answer the following:

MP2a. Which customer market(s) are these products designed for? **RESPONSE:**

MP2b. What is the total installed cost of the unit? What is its installed cost per kWh? How do the different products that you manufacture compare? **RESPONSE:**

MP2c. What are the barriers to adoption of each product and how can they be addressed? **RESPONSE:**

MP3a. Which product accounts for the largest share of your sales/revenues? **RESPONSE:**

MP3b. Which product accounts for the largest share of the target market? **RESPONSE:**

MP4. Which types of customers do you consider to be your **primary target** when you are manufacturing behind the meter (BTM) Storage systems ? [IF NEEDED: Do you produce systems for nonresidential customers, residential customers or both?] **RESPONSE:**

MP4a. What percentage of your sales does your primary target market account for? **RESPONSE:**

MP4b. Why do you produce systems for these customers in particular? **RESPONSE:**

MP4c. For how long have these customer segments been your primary target? **RESPONSE:**

MP5. How would you describe your company's positioning in the overall BTM storage battery market? (i.e., in terms of markets served and market share) **RESPONSE:**

MP6. We've noted a shift in the types of customers installing SGIP storage systems during late 2018 and afterward. According to SGIP program data, there has been a steep decline in the number and percentage of nonresidential storage applications filed by Nonresidential customers during 2018 and continuing into 2019. Have you observed or experienced any shifts in your sales of Storage systems between different types of customers? What have you experienced and when? What do you think are the key drivers of this? **RESPONSE:**

Drivers and Barriers

The next few questions concern the drivers and barriers that you've observed to your customer targets for storage system manufacturing.

D1. What do you believe are the current and near-term drivers and barriers to customer adoption of storage systems? **RESPONSE:**

D2. And how do you address these concerns/barriers in your business model? **RESPONSE:**

D3. In general, what suggestions do you have for addressing these perceived barriers to adoption? And for addressing concerns about realization of end user and grid benefits? **RESPONSE:**

Future Product/Market Snapshot

F1. Over the next 12 months:

F1a. Where do you see the market(s) for your product line going? **RESPONSE:**
F1b. Which customer markets will be the most important and why? **RESPONSE:**
F1c. Which products will be the most popular and why? **RESPONSE:**
F1d. What evolution/changes in battery technology or features will take place during this period (for example with respect to functionality, controllability or other aspects)? **RESPONSE:**
F1e. What does your company have planned for its next product release, i.e., with respect to new features, functions, controllability or other aspects? **RESPONSE:**
F1f. Is your company exploring alternatives to Lithium Ion batteries, and if so, will they be available during this time frame? **RESPONSE:**

F2. Over the next 3 years:

F2a. Where do you see the market(s) for your product line going? **RESPONSE:**
F2b. Which customer markets will be the most important and why? **RESPONSE:**
F2c. Which products will be the most popular and why? **RESPONSE:**
F2d. What evolution/changes in battery technology or features will take place during this period (for example with respect to functionality, controllability or other aspects)? **RESPONSE:**
F2e. What does your company have planned for its next product release, i.e., with respect to new features, functions, controllability or other aspects? **RESPONSE:**
F2f. Is your company exploring alternatives to Lithium Ion batteries, and if so, will they be available during this time frame? **RESPONSE:**

F3. Over the next 5 years:

F3a. Where do you see the market(s) for your product line going? **RESPONSE:**
F3b. Which customer markets will be the most important and why? **RESPONSE:**

F3c. Which products will be the most popular and why? **RESPONSE:**
F3d. What evolution/changes in battery technology or features will take place during this period (for example with respect to functionality, controllability or other aspects)? **RESPONSE:**
F3e. What does your company have planned for its next product release, i.e., with respect to new features, functions, controllability or other aspects? **RESPONSE:**
F3f. Is your company exploring alternatives to Lithium Ion batteries, and if so, will they be available during this time frame? **RESPONSE:**

F4. What megatrends do you foresee in the markets for behind-the-meter energy storage systems during the next 3 to 5 years? **RESPONSE:**

Effect of SGIP Program

One last area of interest of ours is with respect to the influence of the SGIP program on your sales of storage systems.

P1. What share of your BTM storage equipment sales are in California? What percent receive an incentive through the SGIP program? **RESPONSE:**

P2. How hard would it be to sell energy storage systems without the SGIP incentive? **RESPONSE:**

P3. In general, what effect has the SGIP program had historically on your company's sales of behind-the-meter energy storage systems? What impact will it have in the future and for how long? Please elaborate. **RESPONSE:**

END OF SURVEY. Those are all the questions we have for you. On behalf of the California Public Utilities Commission, thank you very much for your time today.

APPENDIX A.2 DEVELOPER SURVEY

Hello my name is <name>. I'm calling from Itron on behalf of the California Public Utilities Commission as part of an effort to evaluate the Self-Generation Incentive Program, from now on referred to as SGIP. We are interviewing organizations that participated in the SGIP program by selling and/or installing energy storage equipment to residential and/or nonresidential customers. The purpose of the evaluation is to assess the current and future markets for behind-the-meter energy storage. This survey is an important source of information to inform this market assessment. Key areas of focus include: the methods your organization uses to market and sell energy storage systems, current market trends, and the effect the SGIP program has had on the sales of energy storage systems.

Screener/Intro

[ASK OF ALL]
I0. What is your job title? **RESPONSE:**

I1. Are you knowledgeable about your organization's sales and marketing of behind-the-meter storage systems?

1 Yes
2 No

[If I1 = "No" then ask I_Other]
I_Other. Is there someone else at your organization that is more knowledgeable about your organization's sales and marketing of behind-the-meter storage systems?

1 Yes – Record Name and Contact info
2 No – Then Thank and Terminate

[If project_count < 3 then ask I2]
I2. According to our records your organization has been involved with the installation of one or more behind-the-meter storage systems that received an incentive from the SGIP. Is that correct?

1 Yes
2 No

[If I2 = "No"]
I3. Please describe any involvement your organization has had with the SGIP? **RESPONSE:**

If I2 = "No" and Involvement described in I3 is minimal then Thank and Terminate

Thank and Terminate: *"Today we are speaking with project developers who have been involved with the installation of one or more behind-the-meter storage systems that received an incentive from the SGIP. Since you don't fit that description, I have no further questions for you today. Thank you very much for your time."*

I4. Does your organization continue to actively sell/lease behind-the-meter storage systems? **RESPONSE:**

[If I4 = No then Ask I5]
I5. Why not? **RESPONSE:**

I6. Please describe your organizations role in the behind-the-meter energy storage market? (i.e. project developer, storage installer, storage manufacturer, etc.) **RESPONSE:**

I7. What percentage of behind-the-meter storage projects you are involved with are purchased versus leased? [SUM TO 100%]

____ Purchased

____ Leased

_____Other [DESCRIBE]

I8. Does your organization primarily sell/lease standalone solar PV systems, standalone behind-the-meter storage systems, or combined solar PV and behind-the-meter storage systems? [**If Dev_type = BOTH**] Does this vary by market segment (res/non-res)? **RESPONSE:**

I8_res. Approximately what percentage of your solar PV and behind-the-meter storage sales/leases in the residential market are: [SUM TO 100%]

____ Standalone solar PV systems

____ Standalone behind-the-meter storage systems

____ Combined Solar PV and Storage systems

I8_nonres. Approximately what percentage of your solar PV and behind-the-meter storage sales in the non-residential market are: [SUM TO 100%]

____ Standalone solar PV systems

____ Standalone behind-the-meter storage systems

____ Combined Solar PV and Storage systems

Current Product/Market Snapshot

I'd like to find out about the customer markets your organization serves and the specific energy storage products you offer for sale/lease.

P1. Which types of customers do you consider to be your primary target for behind-the-meter storage systems? **[If more than one target market]** What percentage of your business do these markets represent? **RESPONSE:**

P1a. Why do you target these markets in particular? **RESPONSE:**

P1b. For how long have these customer segments been your primary target? **RESPONSE:**

P2. Please describe your behind-the-meter storage product line. [**DO NOT READ:** Looking for info on the size, features, and capabilities of the storage system – i.e. an X kW system with a Y duration with XYZ capabilities demand charge reduction, bidding into markets, etc.] **RESPONSE:**

P2a. [If multiple product lines reported in P2] Which behind-the-meter storage products account for the primary share of your behind-the-meter storage revenue? **[If more than one target market]** How does it vary by market segment? **RESPONSE:**

P2b. What are typical end use customer costs to purchase and install the behind-the-meter storage systems sold by your organization? **RESPONSE:**

P2c. What are other typical behind-the-meter storage costs for end users on top of purchase and installation (such as interconnection costs or maintenance costs)? **RESPONSE:**

P3. During the past 18 months, has your organization shifted the types of customers to which you market/sell BTM storage products? **[If yes,** probe for details on what type of shift and what the shift is attributable to?] **RESPONSE:**

Sales Strategies

Next, I'd like to ask you a few questions about the marketing methods your organization uses when selling/leasing BTM storage systems.

S1. Please describe the strategies or approaches your organization uses to promote the purchase/lease of energy storage systems. [**IF NEEDED:** By strategies we mean things like cold calling, door-to-door marketing, website marketing, referrals/word of mouth, mass market advertising, direct mail, etc.) **[If Dev_type = BOTH**] Does this vary by market segment? **RESPONSE:**

S2. Do you use proactive methods, where you reach out to potential customers to generate leads for BTM Storage projects? **RESPONSE:**

S2a. If so, what do these methods consist of? Do they vary by customer size or type? [*e.g. simple emails for small customers, formal offer for larger ones*] **RESPONSE:**

S2b. How often do customers approach you regarding the purchase or lease of energy storage systems? What are the typical circumstances around such contact? **RESPONSE:**

S3. How successful have your methods been in general? For example, what percentage of units have you sold/leased using these approaches? What percent of leads result in a sale/lease? How long does a typical cycle take from first contact to deal being completed? **RESPONSE:**

Marketing Messages

I'd also like to learn more about the specific messages and information your organization provides to customers when reaching out to sell/lease BTM storage systems.

M1. What benefits do you emphasize in your marketing of behind-the-meter storage to customers? How are these communicated to them? (eg. Verbally, in a sales quote, etc.) **RESPONSE:**

M2. On a scale of 1 to 5 where 1 is not at all important and 5 if extremely important, how important are the following items in your behind-the-meter storage sales messaging?

1. Energy Bill Savings
2. **[If sell NonRes customers]** Reduction in Demand Charges
3. Improving the reliability of the customer's electric supply
4. Provision of backup power during an outage
5. Participation in Demand Response programs
6. Ability to use more of the solar the customer generates
7. The Investment tax credit
8. The SGIP
9. Other benefits **RESPONSE:**

M2a. [If 1-Energy Bill Savings scored 2-5] How much, as a percentage of their annual bill, do you say the customer may be able to save? **RESPONSE:**

M2b. [If 2-Reduced Demand Charges scored 2-5] How much do you say they may be able to save? **RESPONSE:**

M2c. [If 3-Improve Reliability or 4 Backup Power scored 2-5] What percentage of customer's load during an outage do you typically estimate will be served? Over how many hours? **RESPONSE:**

M2d. [If 6-The Investment tax credit scored 2-5] How does the federal investment tax credit factor into your decision to promote solar PV paired with behind-the-meter storage? **RESPONSE:**

M2e. **[If 7-SGIP scored 2-5]** What features of the SGIP do you promote? **RESPONSE:**

M3. Do you address whether solar PV systems with behind-the-meter storage are preferable or required compared with Solar PV without storage? If so, what additional benefits or requirements do you indicate for solar PV systems with storage as compared to solar PV systems without storage? **RESPONSE:**

M4. Do you provide them with information on the economics of the investment (in terms of the payback period and/or rate of return) for storage-only versus storage and solar PV together? **RESPONSE:**

M5. Do you mention anything about Net Energy Metering? If so, what do you tell them? **RESPONSE:**

M6. Do you provide information about the impact of changing Time-of-Use rates on the economics of behind-the-meter storage systems? What information do you provide? **RESPONSE:**

Drivers and Barriers

The next few questions concern the drivers and barriers that you've observed to your customers' adoption of behind-the-meter storage systems.

D1. What do you believe are the current and near-term drivers to customer adoption of storage systems? How do these vary by size/type of customer? **RESPONSE:**

D2. Is there a relationship between purchase of solar PV and purchase of behind-the-meter storage? Does either technology drive sales of the other? Please explain. **RESPONSE:**

D2_both. [If selling combined solar/storage > 0] Do you find customer's decisions to install solar PV or the amount of the solar PV they install is influenced by their decision to install behind the meter storage? What percentage of the time do you find each of the following? [SUM TO 100%]

1 Typically, a customer's decision to install storage influences their decision to install solar PV [RECORD PERCENTAGE]

2 Typically, a customer's decision to install storage influences the amount of solar PV they install [RECORD PERCENTAGE]

3 Typically, a customer's decision to purchase solar PV influences their decision to install storage [RECORD PERCENTAGE]

4 Typically, customers make a joint decision to purchase solar PV and storage [RECORD PERCENTAGE]

B1. What do you believe are current and near-term barriers adoption of behind-the-meter storage systems? How do these vary by size/type of customer? **RESPONSE:**

B2. How do you address these perceived barriers in order to make the sale? What messaging and other strategies do you use? **RESPONSE:**

B3. In general, what suggestions do you have for utilities/regulators/state agencies to address barriers to increased adoption of behind-the-meter storage systems? **RESPONSE:**

B4. What do you estimate is the typical payback period or internal rate of return for BTM storage systems? Please estimate by residential/non-residential segments, if possible.

Residential
____ Payback (Years)
____ IRR (%)

Non-Residential
____ Payback (Years)
____ IRR (%)

B5. What percentage, roughly, of a customer's BTM storage system costs do you estimate are offset by the SGIP incentive? Please estimate by residential/non-residential segments, if possible.

____ Residential (%)
____ Non-Residential (%)

Market Segments/Trends

We've noted a shift in the types of customers installing SGIP storage systems.

T1. [If they sell to Nonres customers read: According to SGIP program data, there has been a steep decline in the number and percentage of nonresidential storage applications during 2018 and continuing into 2019. Have you observed or experienced any shifts in your sales of Storage systems between different types of customers? What have you experienced and when? What do you think are the key drivers of this shift? **RESPONSE:**

Effect of SGIP Program

One last area of interest is the influence of the SGIP on your customers' adoption of behind-the-meter storage systems.

P1. What share of your organizations behind-the-meter storage sales are in California vs. the rest of the U.S. and outside the U.S.? [ANSWERS SUM TO 100%]

____ California
____ U.S.
____ Outside U.S.

P2. What percent of your organizations behind-the-meter storage sales are incentivized through the SGIP? **RESPONSE:**

P3. How hard would it be to sell/lease behind-the-meter storage systems without the SGIP incentive? **RESPONSE:**

P4. In general, what effect has the SGIP had on your company's sales/leases of behind-the-meter energy storage systems? What impact do you expect it will it have in the future and for how long? Please elaborate. **RESPONSE:**

END OF SURVEY. Those are all the questions we have for you today. On behalf of the California Public Utilities Commission, thank you very much for your time.

APPENDIX A.3 WEB SURVEY FOR HOST CUSTOMERS

TABLE A.3-1: SURVEY INPUT VARIABLES

Variable	Description
Host_contact	Customer Name
Host_email	Customer email address
HouseFlag	Flag indicating whether host customer is a residential or non-residential location. 1= Residential, 0 = Non-Residential
Project_Developer	Project Developer from Sample, can't be equal to host customer
NAICS_Descrption	Business type description
Solar	Equals 1 if solar generation is installed, 0 if no solar
Multiple_systems	Flag indicating If host customer installed multiple storage systems. 1 = Multiple storage systems, 0 = Single storage system.

Thank you for agreeing to complete this survey. We will be asking a few questions regarding your experience with the **[IF HouseFlag = 1 then insert "residential"]** energy storage system installed **[IF HouseFlag = 0 then insert "by your organization"]** with support from California's Self-Generation Incentive Program (SGIP).

[If Multiple_Systems = 1 show:

If you installed an energy storage system at more than one location with support from the SGIP, please base your responses to the following questions on the "typical" installation.]

A.3.1 Background

[IF HouseFlag = 1 THEN ASK A1]

A1. Our records show that an energy storage system was installed at your home, is this correct?

- **1** Yes, an energy storage system was installed at my home
- 2 No, the energy storage system was installed at another individuals home
- 3 No, the energy storage system was installed at a non-residential location
- 4 No, I am not aware of an energy storage system being installed in any location
- 99 Don't Know

[IF HouseFlag = 0 THEN ASK A2]

A2. Our records show that an energy storage system(s) was installed at your organization's facility, is this correct?

- 1 Yes, an energy storage system was installed at my organization's facility
- 2 No, the energy storage system was installed at my residence
- 3 No, the energy storage system was installed at a residence that is not mine

4 No, I am not aware of an energy storage system being installed in any location
99 Don’t Know

[IF HouseFlag = 0 and A2 = 1, THEN ASK A2a]
A2a. According to our records this location is <NAICS_DESCRIPTION>. Is that correct?
1 Yes
2 No
99 Don’t Know

[IF (HouseFlag = 1 and A1 = 3) OR A2a = 2, THEN ASK A2b]
A2b. [IF A2a = 3 then display “Please describe the primary business activity performed at the location where the storage was installed?” **[IF HouseFlag = 1 and A1 = 3 then display** “Please describe the primary business activity performed at this non-residential location where the storage was installed”]?
1 [RECORD]
99 Don’t Know

[UPDATE HouseFlag for the remainder of the survey:
IF A1 in (2, 4 or 99) or A2 in (3, 4 or 99) THEN GO TO “Thank and Terminate”
IF A1 = 3 THEN HouseFlag = 0 (switch to nonres host customer)
IF A2 = 2 THEN HouseFlag = 1 (switch to res host customer)]

[ASK OF ALL]
A3. How knowledgeable are you about how the energy storage system has operated since it was installed?
1 Very knowledgeable
2 Somewhat knowledgeable
3 Not at all knowledgeable
99 Don’t Know

A5. How did you first learn about energy storage systems?
1 Through < Project_Developer >
2 Online research
3 Through my utility
4 Through SGIP materials
5 Word of mouth
6 Other [RECORD]
99 Don’t Know

A6. Our records indicate that you [if Solar = 1 then display “have”, if Solar = 0 then display “do not have”] a solar PV generation system installed at your [IF HouseFlag = 1 THEN display “home” ELSE display “facility”], is that correct?

1 Yes
2 No
99 Don't Know

[FIX SOLAR FLAG BASED ON RESPONSE TO A6:

IF A6 = 2 and Solar = 1 then Solar = 0

IF A6 = 2 and Solar = 0 then Solar = 1]

[Create flag to indicate Storage and Solar or just Storage:

IF Solar = 1 then STORAGE_SOLAR = 1

ELSE STORAGE_SOLAR = 0]

[If Solar = 1 THEN ASK SOLAR_SIZE]

Solar_Size. Approximately what is the size in kW of your solar PV system?

1 [RECORD ANSWER] kW
99 Don't Know

[IF Solar = 1 THEN ASK A7]

A7. When was the solar PV system purchased?

1 At the same time as the storage system
2 Before the storage system
3 After the storage system
4 Some solar PV was purchased before installing storage and additional solar PV was added at the same time or after installing storage
99 Don't know

A.3.2 Reasons for Installation

[IF STORAGE_SOLAR=0, THEN ASK I1a and I1a1]

I1a. What was the primary reason you decided to install a storage system [IF HouseFlag = 1 THEN display "in your home" ELSE display "at your facility]?

1 [RECORD ANSWER]
0 I do not recall (CHECK BOX)

I1a1. [IF I1a = 1 display "Please select any additional factors that were", IF I1a = 0 display "Were any of these factors"] important in your decision to install storage? Please select all that apply.

1 To save money on electric bill
2 **[IF HouseFlag = 0]** To reduce demand charges
3 To receive an incentive through the SGIP

4 To shift load in response to time-of-use price signals
5 To help the grid by shifting load from on-peak to off-peak times
6 **[IF HouseFlag = 0]** To satisfy corporate goals or initiatives
7 To provide backup/emergency power
8 Other [RECORD]
99 Don't Know

[IF STORAGE_SOLAR=1, THEN ASK I1b and I1b1]
I1b. What was the primary reason you decided to install both a solar PV and a storage system [IF HouseFlag = 1 THEN display "in your home" ELSE display "at your facility]?

1 [RECORD ANSWER]
0 I do not recall (CHECK BOX)

I1b1. [IF I1b = 1 display "Please select any additional factors that were", IF I1b = 0 display "Were any of these factors"] important in your decision to install storage?

1 To save money on electric bill
2 **[IF HouseFlag = 0]** To reduce demand charges
3 To receive an incentive through the SGIP
4 To shift load in response to time-of-use price signals
5 To help the grid by shifting load from on-peak to off-peak times
6 **[IF HouseFlag = 0]** To satisfy corporate goals or initiatives
7 To provide backup/emergency power
8 To benefit from net energy metering
9 To become less grid dependent
10 To use more of the solar energy we generate
11 To receive the federal investment tax credit
12 To reduce greenhouse gas emissions
13 I thought it was required
14 It was highly recommended to me to combine with solar PV
15 Other [RECORD]
99 Don't Know

[IF A7 = 3 THEN ASK A8a]
A8a. Did your storage system influence your decision to install solar PV or the amount of solar PV that was installed?
1 Yes
2 No
99 Don't Know

[IF A8a = 1 THEN ASK A9a]

A9a. How did it influence it?

1 I would not have purchased a solar PV system without the storage
2 I would have purchased a smaller solar PV system without the storage
3 I would have purchased a larger solar PV system without the storage
4 Other [RECORD]
99 Don't Know

[IF A9a = 2 or 3 THEN ASK A10a]

A10a. By approximately what percentage did you [IF A9a = 2 then display "decrease", IF A9a = 3 then display "increase"] your solar PV system as a result of your storage purchase?

1 ______ Percent [RECORD ANSWER]
99 Don't Know

[IF A7 = 2 THEN ASK A8b]

A8b. Did your solar PV system influence your decision to install storage?

1 Yes
2 No
99 Don't Know

[IF A8b = 1 THEN ASK A9b]

A9b. How did it influence it?

1 I would not have purchased storage without the solar PV system installed
2 I get more value from the solar PV energy produced with a storage system
3 Other [RECORD]
99 Don't Know

[IF A7 = 1, 4 or 99 THEN ASK A8c]

A8c. Did your decision to purchase storage influence your decision to install [IF A7 = 4 THEN DISPLAY "more"] solar PV or the amount of solar PV installed? Or did your decision to install solar PV influence your decision to install storage?

1 My decision to install storage influenced my decision to install solar PV
2 My decision to install storage influenced the amount of solar PV installed
3 My decision to purchase solar PV influenced my decision to install storage
4 It was a joint decision to purchase solar PV and storage
5 Other [RECORD]
99 Don't Know

[IF A8c = 1,2 THEN ASK A9c1]

A9c1. How did it influence it?

1 I would not have purchased a solar PV system without the storage

2 I would have purchased a smaller solar PV system without the storage
3 I would have purchased a larger solar PV system without the storage
4 Other [RECORD]
99 Don't Know

[IF A9c1 = 2,3 THEN ASK A10c1]

A10c1. On a percentage basis, approximately how much [IF A9c1 = 2 then display "smaller", IF A9c1 = 3 then display "bigger"] would your solar PV system have been without your storage purchase?

1 ______ Percent [RECORD ANSWER]
99 Don't Know

[IF A8c = 3 THEN ASK A9c2]

A9c2. How did it influence it?

1 I would not have purchased storage without the solar PV system
2 I get more value from the solar PV energy produced with a storage system
3 Other [RECORD]
99 Don't Know

[IF A8c = 4, 5, 99 THEN ASK A9c3]

A9c3. Please describe why you decided to install both a solar PV system and a storage system rather than just one or the other?

NOTE: If one technology influenced the purchase of the other please describe that influence.

1 [RECORD]
99 Don't Know

2 Storage Only Battery

[IF STORAGE_SOLAR=0 AND A3 = 1 or 2 THEN ASK I2a, IF STORAGE_SOLAR=0 AND A3 = 3 or 99 THEN SKIP to I2h, IF STORAGE_SOLAR=1 THEN SKIP TO I3a]

I2a. Are you getting the benefits you expected from the storage system? Please describe.

1 [RECORD ANSWER]
99 Don't Know

[IF HouseFlag = 0 ASK I2b]

I2b. Have you been able to successfully reduce your demand charges?

1 Yes
2 No
3 Have not tried to reduce demand charges
4 Am not on a rate with demand charges
99 Don't Know

[ASK OF ALL]
I2c. Are you currently on a time-of-use rate?

1 Yes
2 No
99 Don't Know

[IF I2c=1, THEN ASK I2c1]
I2c1. Have you been able to successfully shift your load from on-peak to off-peak periods?

1 Yes
2 No
3 Have not tried to shift load from on-peak to off-peak
99 Don't Know

[ASK OF ALL]
I2d. What fraction and types of loads, if any, are tied to your storage system?
For example, is it [IF HouseFlag = 1 then display "your whole home or just select loads within your home? If only select loads, which ones?", IF HouseFlag = 0 then display "your whole building, multiple buildings, or just select loads within a single building? If only select loads, which ones?"]

1 [RECORD ANSWER]
99 Don't Know

I2e. Since installing storage, have you experienced any power outages?

1 Yes
2 No
99 Don't Know

[IF I2e=1, THEN ASK I2e1]
I2e1. How did the storage system perform during the outage(s)?

1 [RECORD ANSWER]
99 Don't Know

[IF I2e=1, THEN ASK I2e2]
I2e2. For how long did it provide backup power and for which load(s)?

1 [RECORD ANSWER]
99 Don't Know

I2f1. Does the level of controllability meet your [IF HouseFlag = 0 then display "organization's"] expectations?

1 Yes
2 No

99 Don’t Know

I2g. Please rate your [IF HouseFlag = 0 then display “organization’s”] satisfaction with the operation of your storage system on a scale of 1 to 5, where 1 is not at all satisfied and 5 is extremely satisfied.

[RECORD 1 TO 5 RATING]
Add checkbox for unable to rate

[IF I2g=1 or 2, THEN ASK 12g1]
I2g1. Why [IF HouseFlag = 1 then display “are you”, If HouseFlag =0 then display “is your organization”] not satisfied with the storage system?

1 [RECORD ANSWER]

I2h. Please rate your satisfaction with the storage system as installed (i.e. the aesthetics/size/location of the system) on a scale of 1 to 5 scale, where 1 is not at all satisfied and 5 is extremely satisfied.

1 [RECORD 1 TO 5 RATING]
Add checkbox for unable to rate

[IF I2h=1 or 2, THEN ASK 12h1]
I2h1. Why aren’t you satisfied?

1 [RECORD ANSWER]

I2i. How important were economic factors (such as cost, incentives, payback period) in your decision to install storage? Please use a 1 to 5 scale of importance, where 1 is not at all important and 5 is extremely important.

1 [RECORD 1 TO 5 RATING]
Add checkbox for unable to rate

I2j. Did you buy the equipment or are you leasing it?

1 Bought it
2 Leasing it
99 Don’t Know

[IF I2j=1, THEN ASK I2l]
I2l. Approximately how much did it cost to purchase and install the storage equipment?

1 [RECORD ANSWER]
0 I do not know (CHECK BOX)

[IF I2j=2, THEN ASK I2l2]
I2l2. Approximately how much are the monthly lease payments for your storage equipment?

1 [RECORD ANSWER] per month
0 I do not know (CHECK BOX)

[ASK I2m of All]

I2m. Do you consider the cost of the storage system to be reasonable?

1 Yes
2 No
99 Don't Know

[IF I2m=1, 2, THEN ASK I2m1]

I2m1. Why do you say that?

1 [RECORD ANSWER]

I2n. Did you, or the company that sold or leased you the storage system, calculate the payback period or rate of return for the energy storage system? The payback period is the number of years it takes to repay your upfront costs for the system through electricity bill savings. (Select all that apply)

1 Yes, calculated payback back period
2 Yes, calculated rate of return
3 No
99 Don't Know

[IF I2n=1, THEN ASK I2n1]

I2n1. What was the estimated payback period, in years, for the storage system including tax credits or incentives received?

1 [RECORD ANSWER] Years
0 I do not recall (CHECK BOX)

[IF I2n=2, THEN ASK I2n2]

I2n2. What was the estimated rate of return, for the investment value of the storage system, including any tax credits or incentives?

1 [RECORD ANSWER] Percent
0 I do not recall (CHECK BOX)

[IF I2j=2, THEN ASK I2p and 12q]

I2p. How long is the lease period for the storage system?

1 _____ years [RECORD ANSWER]
0 I do not know (CHECK BOX)

I2q. What happens to the storage equipment at the end of the lease period?

1 We have the option to purchase the storage equipment
2 The storage equipment is returned to leasing company
3 Other [RECORD]
0 I do not know (CHECK BOX)

[ASK OF ALL]

I2r. What is the expected lifetime of your storage system in years?

1 _____ years [RECORD ANSWER]
0 I do not know (CHECK BOX)

I2s. Did you consider other alternatives to energy storage?

1 Yes
2 No
99 Don't Know

[IF HouseFlag = 0 and I2s=1, THEN ASK I2s1]
I2s1. What alternatives did you consider?

1 Backup generator
2 [If Solar = 0] Solar PV
3 Wind turbine
4 Distributed Generation
5 Combined Heat and Power (CHP)
6 Fuel Cell
7 Participation in a Demand Response Program
8 Installation of Energy Efficient Equipment
9 Other [RECORD]
10 None
99 Don't Know

[IF HouseFlag = 0 and I2s1 in (1-9), THEN ASK I2s2]
I2s2. Why did you choose storage over these alternatives?

1 [RECORD ANSWER]

[IF HouseFlag = 1 THEN ASK I2t]
I2t. Did you consider installing an emergency backup generator?

1 Yes
2 No
99 Don't Know

[IF I2t=1, THEN ASK I2t1]
I2t1. Why did you choose storage instead?

1 [RECORD ANSWER]

3 Storage Plus Solar Battery

[IF STORAGE_SOLAR=1 AND A3 = 1 or 2 THEN ASK I3a, IF STORAGE_SOLAR=1 AND A3 = 3 or 99 THEN SKIP to I3h, IF STORAGE_SOLAR=0 THEN SKIP TO I4a]

I3a. Are you getting the benefits you expected from your solar PV and storage systems? Please describe.

1 [RECORD ANSWER]
99 Don't Know

[IF HouseFlag = 0 ASK I3b]
I3b. Have you been able to successfully reduce your demand charges?

1 Yes
2 No
3 Have not tried to reduce demand charges
4 Am not on a rate with demand charges
99 Don't Know

[ASK OF ALL]
I3c. Are you currently on a time-of-use rate?

1 Yes
2 No
99 Don't Know

[IF I3c=1, THEN ASK I3c1]
I3c1. Have you been able to successfully shift your load from on-peak to off-peak periods?

1 Yes
2 No
3 Have not tried to shift load from on-peak to off-peak
99 Don't Know

I3c2. Have you used your storage system to use more of your solar generated energy?

1 Yes
2 No
99 Don't Know

I3d. What fraction and types of loads, if any, are tied to your storage system?

For example, is it [IF HouseFlag = 1 then display "your whole home or just select loads within your home? If only select loads, which ones?", IF HouseFlag = 0 then display "your whole building, multiple buildings, or just select loads within a single building? If only select loads, which ones?"]

1 [RECORD ANSWER]
99 Don't Know

I3e. Since having the solar and storage systems installed, have you experienced any power outages?

1 Yes
2 No
99 Don't Know

[IF I3e=1, THEN ASK I3e1]
I3e1. How did the storage system perform during the outage(s)?
1 [RECORD ANSWER]
99 Don't Know

[IF I3e=1, THEN ASK I3e2]
I3e2. For how long did it provide backup power and for which load(s)?
1 [RECORD ANSWER]
99 Don't Know

[IF I3f=1, THEN ASK 13f1]
I3f1. Does the level of controllability meet your [IF HouseFlag = 0 then display "organization's"] expectations?
1 Yes
2 No
99 Don't Know

I3g. Please rate your [IF HouseFlag =0 then display "is your organization"] satisfaction with the operation of your storage system on a scale of 1 to 5, where 1 is not at all satisfied and 5 is extremely satisfied.

1 [RECORD 1 to 5 RATING]
Add checkbox for unable to rate

[IF I3g=1 or 2, THEN ASK 13g1]
I3g1. Why [IF HouseFlag = 1 then display "are you", If HouseFlag =0 then display "is your organization"] not satisfied with the storage system?
1 [RECORD ANSWER]

I3h. Please rate your satisfaction with the storage system as installed (i.e. the aesthetics/size/location of the system) using the same 1 to 5 scale, where 1 is not at all satisfied and 5 is extremely satisfied.

1 [RECORD 1 to 5 RATING]
Add checkbox for unable to rate

[IF I3h=1 or 2, THEN ASK 13h1]
I3h1. Why aren't you satisfied?
1 [RECORD ANSWER]

I3i. How important were economic factors (such as cost, incentives, payback period) in your decision to install [If A7 = 1 or 99 then display "a solar PV system and a storage system together", IF A7 = 2 "storage considering you already had solar PV installed", IF A7 = 3 "solar PV considering you already had storage installed")? Please use a 1 to 5 scale of importance, where 1 is not at all important and 5 is extremely important.

1 [RECORD 1 to 5 RATING]
Add checkbox for unable to rate

I3j. Did you buy the storage [If A7 = 1 then display "and solar PV"] equipment or are you leasing it?

1 Bought it
2 Leasing it
99 Don't Know

[IF I3j=1, THEN ASK I3l]
I3l. Approximately how much did it cost to purchase and install the storage [IF A7 = 1 then display "and solar PV"] equipment?

1 [RECORD ANSWER]
0 I do not know (CHECK BOX)

[IF I3j=2, THEN ASK I3l2]
I3l2. Approximately how much are the monthly lease payments for your storage [IF A7 = 1 then display "and solar PV"] equipment?

1 [RECORD ANSWER] per month
0 I do not know (CHECK BOX)

[ASK I3m of All]
I3m. Do you consider the cost of the [IF A7 = 1 then display "solar PV and"] storage system to be reasonable?

1 Yes
2 No
99 Don't Know

[IF I3m=1, 2, THEN ASK I3m1]
I3m1. Why do you say that?

1 [RECORD ANSWER]

I3n. Did you, or the company that sold or leased you the [IF A7 = 1 then display "solar PV and"] storage system, calculate the payback period or rate of return for the system? The payback period is the number of years it takes to repay your upfront costs for the system through electricity bill savings. (Select all that apply)

1 Yes, calculated payback back period

2 Yes, calculated rate of return
3 No
99 Don't Know

[IF I3n=1, THEN ASK I3n1]
I3n1. What was the estimated payback period, in years, for the [IF A7 = 1 then display "solar PV and"] storage system including any tax credits or incentives received?

1 [RECORD ANSWER] Years
0 I do not know (CHECK BOX)

[IF I3n=2, THEN ASK I3n2]
I3n2. What was the estimated rate of return, for the investment value of the [IF A7 = 1 then display "solar PV and"] storage system, including any tax credits or incentives?

1 [RECORD ANSWER] Percent
0 I do not know (CHECK BOX)

[IF I3j=2, THEN ASK I3p and I3q]
I3p. How long is the lease period for the [IF A7 = 1 then display "solar PV and"] storage system?

1 _____ years [RECORD ANSWER]
0 I do not know (CHECK BOX)

I3q. What happens to the [IF A7 = 1 then display "solar PV and"] storage equipment at the end of the lease period?

1 We have the option to purchase the equipment
2 The equipment is returned to leasing company
3 Other [RECORD]
0 I do not know (CHECK BOX)

[ASK OF ALL]
I3r. What is the expected lifetime of your storage system in years?

1 ______ years [RECORD ANSWER]
0 I do not know (CHECK BOX)

I3s. Did you consider alternatives to energy storage?

1 Yes
2 No
99 Don't Know

[IF HouseFlag = 0 and I3s=1, THEN ASK I3s1]
I3s1. What alternatives did you consider?

1 Backup Generator
2 Wind Turbine

3 Distributed Generation
4 [If Solar = 0] Solar PV
5 Combined Heat and Power (CHP)
6 Fuel Cell
7 Participation in a Demand Response Program
8 Installation of Energy Efficient Equipment
9 Other [RECORD]
10 None
99 Don't Know

[IF HouseFlag = 0 and I3s1 in (1-9), THEN ASK I3s2]
I3s2. Why did you choose storage over these alternatives?
1 [RECORD ANSWER]

[IF HouseFlag = 1 THEN ASK I3t]
I3t. Did you consider installing an emergency backup generator?

1 Yes
2 No
99 Don't Know

[IF I3t=1, THEN ASK I3t1]
I3t1. Why did you choose storage instead?
1 [RECORD ANSWER]

A.3.3 Vendor Messaging

I4a. Which of the following benefits of storage were described to you by the storage equipment vendor when you were researching/purchasing your storage system? (Select all that apply)

1 Energy Bill Savings
2 **[If HouseFlag = 0]** Reduced Demand Charges
3 Improving the reliability of your electric supply
4 Participation in a Demand Response program
5 **[If** STORAGE_SOLAR = 1**]** Ability to use more of your own solar
6 Investment tax credit
7 Environmental benefits such as a reduction in GHG emissions
8 Other benefits [RECORD ANSWER]
9 Vendor did not describe any benefits
99 I do not recall benefits described

[IF I4a=1, THEN ASK I4a1]

I4a1. Approximately how much did they say you would be able to save on your energy bills?

1 [RECORD ANSWER] percent
0 I do not recall

I4b. Which of the following costs of storage were described to you by the storage equipment vendor when you were researching/purchasing your storage system? (Select all that apply)

1 Cost of storage system
2 Cost of installation
3 Interconnection costs
4 Maintenance costs
5 Other costs [RECORD ANSWER]
6 Vendor did not describe any costs
99 I do not recall costs described

[IF STORAGE_SOLAR=1 THEN ASK I4c]

I4c. Did the equipment vendor indicate that storage was required with solar PV systems?

1 Yes
2 No
99 Don't Know

[IF I4c=1, THEN ASK I4c1]

I4c1. Please provide details on an additional benefits or requirements for installing a solar PV system with storage versus solar PV on its own that were described to you by the equipment vendor?

1 [RECORD ANSWER] percent
0 I do not recall

I4d. Did the equipment vendor discuss with you the economics of the following alternative system configurations?

1 [If STORAGE_SOLAR =1] Storage Only
2 Solar PV only
3 [If STORAGE_SOLAR =0] Storage and Solar PV combined
4 Equipment vendor did not provide the economics of any alterative system configurations besides the one installed
99 Don't Know

I4e. Did the equipment vendor mention anything about Net Energy Metering?

1 Yes
2 No
99 Don't Know

[IF I4e=1, THEN ASK I4e1]

I4e1. What did they tell you about Net Energy Metering?

1 [RECORD ANSWER]

I4f. Finally, did the person who sold you your storage system make any comments or provide any information about the impact of the new time-of-use rates on the economics of your storage system?

1 Yes
2 No
99 Don't Know

[IF I4f=1, THEN ASK I4f1]

I4f1. What did they tell you about time-of-use rates?

1 [RECORD ANSWER]

A.3.4 Satisfaction with the SGIP

I5. Using a 1 to 5 scale, where 1 is not at all satisfied and 5 is extremely satisfied, please rate your satisfaction with the following SGIP elements:

I5a. Overall SGIP Application Process [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
I5b. SGIP Incentive amount [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
I5c. How long it took to receive the SGIP incentive [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
I5d. SGIP requirements [such as providing performance data or installing metering equipment] [RECORD 1 TO 5 RATING, or checkbox for "N/A"]

I5a. Based on your experience, how likely are you to recommend installing a storage system to others?

1 Very Likely
2 Somewhat Likely
3 Not at all Likely
99 Don't Know

I5b. Based on your experience, how likely are you to recommend the SGIP to others?

1 Very Likely
2 Somewhat Likely
3 Not at all Likely
99 Don't Know

A.3.5 Decision Influences

I6. Using a 1 to 5 scale, where 1 is not at all important and 5 is extremely important, please rate how important each of the following items were to [If HouseFlag = 0 display "your organization", If HouseFlag

= 1 display "you"] when deciding to purchase storage [IF STORAGE_SOLAR =1 then display " and solar PV"] technology. [Rotate question order, Add checkbox for N/A]

- **I6a.** Upfront Cost [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6b.** Incentive amount [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6c.** Tax benefits [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6d.** Reliability of electric energy supply [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6e.** Operation and Maintenance costs [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6f.** Electric rate structures/TOU rates [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6g.** [**IF I2n in 1 or 2 or I3n = 1 or 2]** Payback period or Rate of Return [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6h.** [**IF I2j = 2 or I3j=2]** Leasing terms [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6i.** Environmental benefits of storage technology. [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6j**. [IF STORAGE_SOLAR = 1] Environmental benefits of solar PV technology. [RECORD 1 TO 5 RATING, or checkbox for "N/A"]
- **I6k**. Other influences [RECORD ANSWER] [RECORD 1 TO 5 RATING, or checkbox for "N/A"]

A.3.6 Customer Demographics/Firmographics

[If HouseFlag = 1 ASK Res1-Res9]

Res1. How long have you owned your home?

1	Less than 5 years
2	5 to 9 years
3	10 to 14 years
4	15 to 19 years
5	20 to 24 years
6	25 or more years
99	Don't know

Res2. Which of the following dwelling types best describes your home?

1	Single Family house
2	Townhouse, duplex or row house
3	Apartment or Condominium with 2-4 units
4	Apartment or Condominium with 5+ units
5	Mobile Home
6	Other [Record]
99	Don't know

Res3. How many people of the following age groups live in your home year-round? [record # or if left blank = 0]

1 Less than 18 years old
2 18-24 years old
3 25-34 years old
4 35-44 years old
5 45-54 years old
6 55-64 years old
7 65+ years old
99 Don't know

Res4. Which of the following best represents your annual household income from all sources before taxes?

1 Less than $50,000
2 $50,000 or more but less than $75,000
3 $75,000 or more but less than $100,000
4 $100,000 or more
99 Don't know

Res5. What is the highest level of education attained by the head of household?

1 Some high school
2 High school graduate
3 Trade or technical school
4 Some college
5 College graduate
6 Some graduate school
7 Post-graduate degree
8 Other [RECORD]
99 Don't know

Res6. How would you classify the location where the storage was installed?

1 Urban
2 Suburban
3 Rural
99 Don't know

Res7. Compared to others, which description best describes you or your household?

1 Usually the last to try a new product

2 Usually among the last to try a new product
3 Usually in the middle when it comes to trying a new product
4 Usually among the first to try a new product
5 Usually the first to try a new product
99 Don't know

Res8. Which of the following best describes where you reside with respect to wildfire risk.

1 I reside in an area with high wildfire risk
2 I reside in an area with moderate wildfire risk
3 I reside in an area with low wildfire risk
99 Don't know

[IF Res8 in 1 or 2 ASK Res9]
Res9. Has your home ever been affected by your utility using preventative fire outages on days with high fire risk?

1 Yes, I have lost power at my home due to my utility using preventative fire outages.
2 No, I have not lost power at my home due to my utility using preventative fire outages.
99 Don't know

[If HouseFlag = 0 ASK NonRes1-NonRes4a]

NonRes1. Does your organization own or lease the facility where this storage system was installed?

1 Own
2 Lease
3 [If Multiple_systems = 1] Storage was installed at both owned and leased locations
4 Other [RECORD]
99 Don't know

NonRes2. Does your organization …

1 Occupy the entire building where the storage system was installed,
2 Occupy a portion of the building where the storage system was installed,
3 Lease the building where the storage system was installed to a tenant.
4 Other [RECORD]
99 Don't know

NonRes3. What is the approximate number of full-time equivalent workers of all types employed by your organization at the facility where the storage was installed?

1 1 to 10

2	11 to 50
3	51 to 100
4	101 to 250
5	251 to 500
6	501 to 1,000
7	More than 1,000
99	Don't know

NonRes4. Does your organization have any company goals regarding sustainability, GHG reductions, or climate change? (Select all that apply)

1	Yes – we have sustainability goals
2	Yes – we have GHG reduction goals
3	Yes – we have climate change goals
4	Yes – we have other environmental goals
5	No
99	Don't know

[If NonRes4 = 4 then ask NonRes4a]
NonRes4a. Please describe your organizations other environmental goals.

1	[RECORD]

END OF SURVEY. Those are all the questions we have for you. On behalf of the California Public Utilities Commission, thank you very much for your time today.

THANK AND TERMINATE: This surveying effort is directed individuals who had a storage system installed in their home and so that is all of the questions we have for you. Thank you very much for your time and willingness to participate in this important study.

APPENDIX A.4 WEB SURVEY FOR SOLAR NON-STORAGE PARTICIPANTS

TABLE A.4-1: SURVEY INPUT VARIABLES

Variable	Description
NP_contact	Customer Name
NP_email	Customer email address
HouseFlag	Flag indicating whether host customer is a residential or non-residential location. 1= Residential, 0 = Non-Residential
Solar	1 = if in CSI Participant database, 0 = if not in CSI Participant database

Thank you for agreeing to complete this survey. We have a few questions for you on your awareness and attitudes regarding Solar PV and battery storage systems.

A.4-1 Background

[IF HouseFlag = 1 and Solar = 1 THEN ASK A1]

A1. Our records show that Solar PV was installed at your home, is this correct?

1 Yes, I installed Solar PV at my current home

2 Yes, I installed Solar PV at a previous home

3 No, I did not install Solar PV at my home

99 Don't Know

[IF HouseFlag = 0 and Solar = 1 THEN ASK A2]

A2. Our records show that Solar PV was installed at your organization's facility, is this correct?

1 Yes, Solar PV was installed at my place of business

2 No, Solar PV was not installed at my place of business

99 Don't Know

[IF A1 = 3,99 or A2 = 2,99 then SOLAR =0]

A3. Have you ever heard of battery storage that can be installed in your home or business (e.g. Tesla Powerwall)? **[Answers 1 and 2 can be selected together – all else single answers]**

1 Yes, I have heard of battery storage and have it installed in my home

2 Yes, I have heard of battery storage and have it installed in my business

3 Yes, I have heard of battery storage but do not have any installed in my home or business

4 No, I have not heard of battery storage

99 Don't Know

[Drop customers who already have Storage installed:

IF A3 = 1,2 THEN GO TO "Thank and Terminate"]

[IF A3 = 3 THEN ASK A3b ELSE SKIP TO C3]

A3b. What have you heard about battery storage technology?

1 [RECORD ANSWER]

99 Don't Know

A4. How familiar would you say you are with battery storage technology?

1 Very familiar

2 Somewhat familiar

3 Not very familiar

4 Not at all familiar

A5. When did you first become aware of battery storage technology?

1 Within the last year

2 More than 1 year ago but less than 5 years ago

3 More than 5 years ago

99 Don't Know

A6. Have you ever heard of the Self Generation Incentive Program, which is administered by California's investor-owned utilities, and pays customers a significant rebate to offset a portion of the cost of an energy storage system?

1 Yes, I have heard of the Self Generation Incentive Program

2 No, I have not heard of the Self Generation Incentive Program

99 Don't Know

A7. How did you first become aware of battery storage? [Rotate Answers]

1 **[IF A6 = 1]** Through the Self Generation Incentive Program

2 Through a Solar or Storage Company or contractor

3 Through online research

4 Through my utility

5 Word of mouth

6 Other [RECORD]

99 Don't Know

A.4-2 Considered Storage Purchase/Lease and Barriers

C1. Have you ever considered installing battery storage in your **[IF HouseFlag = 1 display** “home?”, **IF HouseFlag = 0 display** “place of business?”]

1	**[IF SOLAR =1]** Yes, considered installing battery storage at the time Solar PV was installed
2	Yes, considered installing batter storage **[IF SOLAR = 1 display** “at another time”]
3	No, have not considered installing battery storage
99	Don’t Know

C2. What is the main reason you have not **[IF C1 = 1,2 display** “installed”, **IF CI1 = 3 display** “considered installing”] battery storage?

1	Lack of awareness / Had not heard of it
2	Too expensive
3	Didn’t need it
4	Energy bill savings not sufficient
5	Other Reason [RECORD ANSWER]
99	Don’t Know

C3. [If A3 = 4, 99 display “Battery storage consists of a large scale battery that can be installed in your home or business and can be charged using solar or grid electricity.”] Battery storage may provide a number of benefits to home or business locations. Please select up to 3 benefits from the list below that would be the primary drivers for you to consider installing battery storage in your **[IF HouseFlag = 1 display** “home?”, **IF HouseFlag = 0 display** “place of business?”] [SELECT UP TO 3 ANSWERS]

1	To save money on electric bill
2	**[IF HouseFlag = 0]** To reduce demand charges
3	To receive an incentive through the Self Generation Incentive Program (SGIP)
4	To shift load in response to time-of-use price signals
5	To help the grid by shifting load from on-peak to off-peak times
6	**[IF HouseFlag = 0]** To satisfy corporate goals or initiatives
7	To provide backup/emergency power
8	To benefit from net energy metering
9	To become less grid dependent
10	**[IF SOLAR = 1]** To use more of the solar energy we generate
11	To receive the federal investment tax credit
12	To reduce greenhouse gas emissions
13	Other [RECORD]
99	Don’t Know

[If HouseFlag = 1 ASK C4]

C4. Are you aware that battery storage can be used to power your home for up to a week depending on your home's energy use and solar availability?

1 Yes
2 No
99 Don't Know

[If HouseFlag = 1 ASK C4b]

C4b. What is the maximum amount you would you be willing to pay for a battery storage system that provides your power needs for several days or more during a power outage?

1 [Record Answer in thousands of dollars]
99 Don't Know

C5. Have you ever considered installing an emergency backup generator in your **[IF HouseFlag = 1 display** "home?", **IF HouseFlag = 0 display** "place of business?"]

1 Yes
2 No
99 Don't Know

A.4-3 Likelihood of Storage Installation in Home or Work Location

L1. How likely are you to [**If A3 = 4 or 99** then display "consider installing", **else If A3 = 3** display "install"] battery storage in your **[IF HouseFlag = 1 display** "home", **IF HouseFlag = 0 display** "place of business"] in the future?

1 Very Likely
2 Somewhat Likely
3 Not at all likely

[IF L1 = 1,2 and A3 = 3 then ASK L2]

L2. When do you anticipate you would install battery storage in your **[IF HouseFlag = 1 display** "home?", **IF HouseFlag = 0 display** "place of business?"]

1 Within the next year
2 More than one year from now but within the next 5 years
3 More than 5 years from now
99 Don't Know

[IF L1 = 3 then ASK L3]

L3. What are the main reasons you are unlikely to install battery storage in your **[IF HouseFlag = 1 display** "home?", **IF HouseFlag = 0 display** "place of business?"]

1 [Record Answer]
99 Don't Know

[IF L1 = 3 then ASK L4]

L4. Please rate on a scale of 1 to 5, where 5 is very significant and 1 is not at all significant, how significant the following reasons are in your decision to not install storage? [ROTATE LIST AND ALSO INCLUDE a "Unsure" answer]

1	Cost
2	Safety concerns
3	Energy Reliability
4	How the battery storage looks
5	Space the battery storage takes up

A.4-4 Customer Demographics/Firmographics

[If HouseFlag = 1 ASK Res1-Res9]

Res1. How long have you owned your home?

1	Less than 5 years
2	5 to 9 years
3	10 to 14 years
4	15 to 19 years
5	20 to 24 years
6	25 or more years
99	Don't know

Res2. Which of the following dwelling types best describes your home?

1	Single Family house
2	Townhouse, duplex or row house
3	Apartment or Condominium with 2-4 units
4	Apartment or Condominium with 5+ units
5	Mobile Home
6	Other [Record]
99	Don't know

Res3. How many people of the following age groups live in your home year-round? [record # or if left blank = 0]

1	Less than 18 years old
2	18-24 years old
3	25-34 years old

4 35-44 years old
5 45-54 years old
6 55-64 years old
7 65+ years old
99 Don't know

Res4. Which of the following best represents your annual household income from all sources before taxes?

1 Less than $50,000
2 $50,000 or more but less than $75,000
3 $75,000 or more but less than $100,000
4 $100,000 or more
99 Don't know

Res5. What is the highest level of education attained by the head of household?

1 Some high school
2 High school graduate
3 Trade or technical school
4 Some college
5 College graduate
6 Some graduate school
7 Post-graduate degree
8 Other [RECORD]
99 Don't know

Res6. How would you classify the location where you live?

1 Urban
2 Suburban
3 Rural
99 Don't know

Res7. Compared to others, which description best describes you or your household?

1 Usually the last to try a new product
2 Usually among the last to try a new product
3 Usually in the middle when it comes to trying a new product
4 Usually among the first to try a new product
5 Usually the first to try a new product
99 Don't know

Res8. Which of the following best describes where you reside with respect to wildfire risk.

1	I reside in an area with high wildfire risk
2	I reside in an area with moderate wildfire risk
3	I reside in an area with low wildfire risk
99	Don't know

[IF Res8 in 1 or 2 ASK Res9]
Res9. Has your home ever been affected by your utility using preventative fire outages on days with high fire risk?

1	Yes, I have lost power at my home due to my utility using preventative fire outages.
2	No, I have not lost power at my home due to my utility using preventative fire outages.
99	Don't know

[If HouseFlag = 0 ASK NonRes1-NonRes4a]

NonRes1. Does your organization own or lease the facility where you work?

1	Own
2	Lease
3	Other [RECORD]
99	Don't know

A2a. Please describe the primary business activity performed at your business location?

1	[RECORD]
99	Don't Know

NonRes3. What is the approximate number of full-time equivalent workers of all types employed by your organization at the facility where you work?

1	1 to 10
2	11 to 50
3	51 to 100
4	101 to 250
5	251 to 500
6	501 to 1,000
7	More than 1,000
99	Don't know

NonRes4. Does your organization have any company goals regarding sustainability, GHG reductions, or climate change? (Select all that apply)

1 Yes – we have sustainability goals
2 Yes – we have GHG reduction goals
3 Yes – we have climate change goals
4 Yes – we have other environmental goals
5 No
99 Don't know

[If NonRes4 = 4 then ask NonRes4a]
NonRes4a. Please describe your organizations other environmental goals.

1 [RECORD]

END OF SURVEY. Those are all the questions we have for you. On behalf of the California Public Utilities Commission, thank you very much for your time today.

THANK AND TERMINATE:

Unfortunately, you do not qualify for this survey.

This surveying effort is directed towards individuals who do not have a storage system installed in their home or work location and so that is all of the questions we have for you. Thank you very much for your time and willingness to participate in this important study.

Appendix B.1: Host Customer Survey Banner Tables

<STORAGE_SOLAR> Generated Storage_Solar Flag

STORAGE_SOLAR	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Not Solar	3.2	2.2	42.1	0.0	100.0
Solar	96.8	97.8	57.9	100.0	0.0
n	784	765	19	759	25

<A1> Our records show that an energy storage system was installed at your home, is this correct?

A1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes, an energy storage system was installed at my home	99.7	99.7	0.0	100.0	100.0
No, the energy storage system was installed at another individuals home	0.1	0.1	0.0	0.0	0.0
No, I am not aware of an energy storage system being installed in any location	0.1	0.1	0.0	0.0	0.0
n	767	767	0	748	17

<A2> Our records show that an energy storage system(s) was installed at your organization's facility, is this correct?

A2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes, an energy storage system was installed at my organization's facility	100.0	0.0	100.0	100.0	100.0
n	19	0	19	11	8

<A2A> According to our records this location is (NAICS_DESCRIPTION). Is that correct?

A2A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	89.5	0.0	89.5	81.8	100.0
No	10.5	0.0	10.5	18.2	0.0
n	19	0	19	11	8

<A2B_CAT> Please describe the primary business activity performed at the location where the storage was installed?

A2B_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Freight Forwarding	50.0	0.0	50.0	50.0	0.0
My home	50.0	0.0	50.0	50.0	0.0
n	2	0	2	2	0

<A3> How knowledgeable are you about how the energy storage system has operated since it was installed?

A3	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Very knowledgeable	50.8	50.5	63.2	51.1	44.0
Somewhat knowledgeable	44.4	44.6	36.8	44.1	56.0
Not at all knowledgeable	4.5	4.6	0.0	4.6	0.0
Don't Know	0.3	0.3	0.0	0.3	0.0
n	783	764	19	758	25

<A5> How did you first learn about energy storage systems?

A5	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Through project developer	57.7	57.6	63.2	57.3	72.0
Online research	31.2	31.8	5.3	31.9	8.0
Through my utility	0.1	0.1	0.0	0.0	4.0
Through SGIP materials	0.8	0.8	0.0	0.8	0.0
Word of mouth	5.9	5.6	15.8	6.1	0.0
Other	0.1	0.1	0.0	0.1	0.0
News article	1.0	1.0	0.0	1.1	0.0
Professional experience	1.5	1.3	10.5	1.3	8.0
Podcast	0.1	0.1	0.0	0.1	0.0
Advertisement	0.5	0.5	0.0	0.5	0.0
Don't Know	1.0	0.9	5.3	0.8	8.0
n	783	764	19	758	25

<A6> Our records indicate that you had a solar PV generation system installed at your home/facility, is that correct?

A6	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	94.6	95.0	77.8	94.4	100.0
No	2.8	2.4	22.2	2.9	0.0
Don't Know	2.6	2.6	0.0	2.7	0.0
n	779	761	18	754	25

<SOLAR_SIZE_CAT> Approximately what is the size, in kW, of your solar PV system?

SOLAR_SIZE_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
< 5 kW	15.3	15.5	0.0	15.3	0.0
5-6.9 kW	21.8	22.1	0.0	21.8	0.0
7-9.9 kW	17.3	17.4	9.1	17.3	0.0
10-20 kW	10.9	10.8	18.2	10.9	0.0
>20 kW	6.1	5.3	63.6	6.1	0.0
Don't know	28.6	28.9	9.1	28.6	0.0
n	752	741	11	752	0

<A7> When was the solar PV system purchased?

A7	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
At the same time as the storage system	48.1	48.0	54.5	48.1	0.0
Before the storage system	44.1	44.1	45.5	44.1	0.0
After the storage system	3.2	3.2	0.0	3.2	0.0
Some solar PV was purchased before installing storage and and additional solar PV was added a the same time or after installing storage	4.1	4.2	0.0	4.1	0.0
Don't know	0.4	0.4	0.0	0.4	0.0
n	750	739	11	750	0

<I1AB> What was the primary reason you decided to install a storage system/both a solar PV and a storage system?

I1AB	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
To save money on electric bill	31.3	30.8	52.6	31.5	28.0
Energy Savings / Efficiency	8.7	8.5	15.8	8.4	16.0
To provide backup/emergency power	43.8	44.7	5.3	43.9	44.0
To respond to time-of-use price signals	9.7	9.6	10.5	9.5	16.0
Clean Energy / Enviromental / Green reasons	18.7	18.8	15.8	19.2	4.0
To become less grid dependant	17.0	17.3	5.3	17.5	4.0
To receive incentive	3.6	3.7	0.0	3.7	0.0
Electric Vehicle	4.1	4.2	0.0	4.2	0.0
Latest Tecnology / 1st Adopter	1.0	1.0	0.0	1.1	0.0
To use more of the solar we generate	9.5	9.6	5.3	9.9	0.0
Other	2.5	2.6	0.0	2.4	8.0
To reduce demand charges	1.1	0.4	31.6	0.8	12.0
To shift load from on-peak to off-peak times	2.7	2.3	15.8	1.7	32.0
To benefit from net energy metering	0.3	0.3	0.0	0.3	0.0
Highly recommended to combine with solar	1.1	1.2	0.0	1.2	0.0
n	786.0	767.0	19.0	759.0	25.0

<I1AB1> What were the other reasons you decided to install a storage system/both a solar PV and a storage system in your home/at your facility?

I1AB1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
To save money on electric bill	72.4	72.2	84.2	72.3	76.0
To reduce demand charges	1.9	0.0	78.9	0.9	32.0
To receive an incentive through the SGIP	54.7	54.8	52.6	54.9	48.0
To shift load in response to time-of-use price signals	43.6	44.2	21.1	43.3	52.0
To help the grid by shifting load from on-peak to off-peak times	45.3	45.5	36.8	45.1	52.0
To satisfy corporate goals or initiatives	1.1	0.0	47.4	0.8	12.0
To provide backup/emergency power	86.4	88.2	10.5	87.4	56.0
To benefit from net energy metering	35.8	36.2	21.1	37.0	0.0
To become less grid dependent	65.4	66.7	15.8	67.6	0.0
To use more of the solar energy we generate	57.5	58.7	10.5	59.4	0.0
To receive the federal investment tax credit	42.0	43.0	0.0	43.3	0.0
To reduce greenhouse gas emissions	50.3	50.9	26.3	51.9	0.0
I thought it was required	0.6	0.7	0.0	0.7	0.0
It was highly recommended to me to combine with solar PV	6.6	6.5	10.5	6.9	0.0
Other	2.6	2.6	0.0	2.5	4.0
Electric Vehicle Charging	0.3	0.3	0.0	0.3	0.0
n	784	765	19	759	25

<A8A> Did your storage system influence your decision to install solar PV or the amount of solar PV that was installed?

A8A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	21.7	21.7	0.0	21.7	0.0
No	69.6	69.6	0.0	69.6	0.0
Don't Know	8.7	8.7	0.0	8.7	0.0
n	23	23	0	23	0

<A9A> How did it influence it?

A9A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I would not have purchased a solar PV system without the storage	60.0	60.0	0.0	60.0	0.0
I would have purchased a smaller solar PV system without the storage	20.0	20.0	0.0	20.0	0.0
I would have purchased a larger solar PV system without the storage	20.0	20.0	0.0	20.0	0.0
n	5	5	0	5	0

<A10A> By approximately what percentage did you increase/decrease your solar PV system as a result of your storage purchase?

A10A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Don't know	100.0	100.0	0.0	100.0	0.0
n	2	2	0	2	0

<A8B> Did your solar PV system influence your decision to install storage?

A8B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	82.1	83.0	20.0	82.1	0.0
No	16.7	16.0	60.0	16.7	0.0
Don't Know	1.2	0.9	20.0	1.2	0.0
n	329	324	5	329	0

<A9B> How did it influence it?

A9B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I would not have purchased storage without the solar PV system installed	51.5	51.3	100.0	51.5	0.0
I get more value from the solar PV energy produced with a storage system	46.7	46.8	0.0	46.7	0.0
Other	0.7	0.7	0.0	0.7	0.0
Don't Know	1.1	1.1	0.0	1.1	0.0
n	270	269	1	270	0

<A8C> Did your decision to purchase storage influence your decision to install (more) solar PV or the amount of solar PV installed? Or did your decision to install solar PV influence your decision to install storage?

A8C	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
My decision to install storage influenced my decision to install solar PV	6.9	7.1	0.0	6.9	0.0
My decision to install storage influenced the amount of solar PV installed	3.6	3.7	0.0	3.6	0.0
My decision to purchase solar PV influenced my decision to install storage	29.0	28.5	66.7	29.0	0.0
It was a joint decision to purchase solar PV and storage	57.1	57.4	33.3	57.1	0.0
Other	0.3	0.3	0.0	0.3	0.0
Don't Know	3.1	3.1	0.0	3.1	0.0
n	389	383	6	389	0

<A9C1> How did it influence it?

A9C1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I would not have purchased a solar PV system without the storage	43.9	43.9	0.0	43.9	0.0
I would have purchased a smaller solar PV system without the storage	22.0	22.0	0.0	22.0	0.0
I would have purchased a larger solar PV system without the storage	22.0	22.0	0.0	22.0	0.0
Don't Know	12.2	12.2	0.0	12.2	0.0
n	41	41	0	41	0

<A10C1> On a percentage basis, approximately how much smaller/bigger would your solar PV system have been without your storage purchase?

A10C1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
15	5.6	5.6	0.0	5.6	0.0
20	5.6	5.6	0.0	5.6	0.0
25	22.2	22.2	0.0	22.2	0.0
30	11.1	11.1	0.0	11.1	0.0
33	5.6	5.6	0.0	5.6	0.0
50	11.1	11.1	0.0	11.1	0.0
100	5.6	5.6	0.0	5.6	0.0
Don't know	33.3	33.3	0.0	33.3	0.0
n	18	18	0	18	0

<A9C2> How did it influence it?

A9C2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I would not have purchased storage without the solar PV system	53.1	53.2	50.0	53.1	0.0
I get more value from the solar PV energy produced with a storage system	43.4	44.0	25.0	43.4	0.0
I assumed the battery would be used daily	0.9	0.9	0.0	0.9	0.0
I would not have installed a solar PV system without a storage system	0.9	0.9	0.0	0.9	0.0
To power critical equipment during outages	0.9	0.0	25.0	0.9	0.0
Don't Know	0.9	0.9	0.0	0.9	0.0
n	113	109	4	113	0

<A9C3> Please describe why you decided to install both a solar PV system and a storage system rather than just one or the other?

A9C3	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
To save money on electric bill	12.8	12.4	50.0	12.8	0.0
Energy Savings / Efficiency	6.2	6.2	0.0	6.2	0.0
To provide backup/emergency power	28.4	28.7	0.0	28.4	0.0
To respond to time-of-use price signals	4.3	4.3	0.0	4.3	0.0
Clean Energy / Enviromental / Green reasons	3.8	3.8	0.0	3.8	0.0
To become less grid dependant	11.4	11.5	0.0	11.4	0.0
To receive incentive	7.6	7.7	0.0	7.6	0.0
Electric Vehicle	2.4	2.4	0.0	2.4	0.0
Latest Tecnology / 1st Adopter	0.9	1.0	0.0	0.9	0.0
To use more of the solar we generate	14.2	14.4	0.0	14.2	0.0
Packaged Deal / Bundled Installation from Dealer	2.4	2.4	0.0	2.4	0.0
Complimentary Technology	16.1	16.3	0.0	16.1	0.0
It was recommended to me	0.9	1.0	0.0	0.9	0.0
it made sense to me	9.5	9.6	0.0	9.5	0.0
Other	2.8	2.9	0.0	2.8	0.0
n	211	209	2	211	0

<I23A> Are you getting the benefits you expected from the storage system? Please describe.

I23A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	81.6	81.8	73.7	81.9	72.7
No	4.2	4.0	10.5	4.0	9.1
Using more of solar that is generated	4.8	4.9	0.0	4.9	0.0
Backup Ability	24.2	24.8	5.3	24.3	22.7
Saving Energy	4.9	4.9	5.3	4.8	9.1
Saving Money	16.7	16.8	15.8	17.2	4.5
Rebates / Incentives	0.9	0.8	5.3	0.8	4.5
Positive impact on Load Shifting / Time of Use	11.1	11.2	5.3	11.3	4.5
Clean Energy / Enviromental	2.7	2.6	5.3	2.8	0.0
Energy Independence / Reduced Grid Dependence	8.1	8.3	0.0	8.3	0.0
Technical Features	2.2	2.3	0.0	2.3	0.0
Return On Investment / Payback	0.7	0.6	5.3	0.6	4.5
Not seeing expected financial savings	4.2	4.2	5.3	4.2	4.5
Negative effect of Time of Use	1.2	1.2	0.0	1.2	0.0
Unsure of benefits / Don't Know	5.2	5.2	5.3	5.3	4.5
Would like more control over own system / indepence from grid	2.5	2.6	0.0	2.6	0.0
Would like more storage / larger system.	3.6	3.7	0.0	3.7	0.0
Electric Vehicle Charging	2.5	2.6	0.0	2.6	0.0
Somewhat/Almost/Partial/Mostly	6.1	6.3	0.0	5.9	13.6
Reduced demand charge	0.6	0.0	21.1	0.3	9.1
n	669	650	19	647	22

<I23B> Have you been able to successfully reduce your demand charges?

I23B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	89.5	0.0	89.5	90.9	87.5
No	5.3	0.0	5.3	0.0	12.5
Am not on a rate with demand charges	5.3	0.0	5.3	9.1	0.0
n	19	0	19	11	8

<I23C> Are you currently on a time-of-use rate?

I23C	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	59.7	59.5	68.4	59.3	72.0
No	16.5	16.5	15.8	16.8	8.0
Don't Know	23.8	24.0	15.8	24.0	20.0
n	764	745	19	739	25

<I23C1> Have you been able to successfully shift your load from on-peak to off-peak periods?

I23C1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	75.7	77.7	7.7	76.3	61.1
No	3.7	3.2	23.1	3.2	16.7
Have not tried to shift load from on-peak to off-peak	13.4	11.7	69.2	13.2	16.7
Don't Know	7.2	7.4	0.0	7.3	5.6
n	456.0	443.0	13.0	438.0	18.0

<I3C2> Have you used your storage system to use more of your solar generated energy?

I3C2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	76.2	76.6	45.5	76.2	0.0
No	11.1	10.7	36.4	11.1	0.0
Don't Know	12.7	12.6	18.2	12.7	0.0
n	739	728	11	739	0

<I23D> What fraction and types of loads, if any, are tied to your storage system?

I23D	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Whole home / building	41.1	40.4	63.2	41.0	45.5
Whole home, except car charger	2.7	2.8	0.0	2.5	9.1
Whole home, except one outlet/circuit	2.8	2.9	0.0	2.5	13.6
All but AC	5.5	5.7	0.0	5.6	4.5
25%-49%	0.7	0.7	0.0	0.7	0.0
50%-74%	1.1	1.0	5.3	1.2	0.0
75%-89%	0.7	0.7	0.0	0.7	0.0
90%+ / most	3.1	3.2	0.0	3.1	4.5
nighttime load	0.1	0.1	0.0	0.1	0.0
Other	1.4	1.5	0.0	1.5	0.0
daytime load	0.1	0.1	0.0	0.1	0.0
Not AC	8.0	8.2	0.0	7.9	9.1
Not EV (car charger)	3.8	3.9	0.0	4.0	0.0
Not pool pump	2.3	2.3	0.0	2.1	9.1
less than 25%	0.4	0.3	5.3	0.3	4.5
Essesntial loads/Refrigeration	6.4	6.4	5.3	6.6	0.0
Just select loads	21.0	21.5	5.3	21.8	0.0
n	704	685	19	680	22

<I23E> Since installing storage, have you experienced any power outages?

I23E	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	66.1	66.0	68.4	65.4	84.0
No	31.2	31.3	26.3	31.8	12.0
Don't Know	2.8	2.7	5.3	2.7	4.0
n	760	741	19	735	25

<I23E1_CAT> How did the storage system perform during the outage(s)?

I23E1_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
As expected/excelled/perfect	82.1	83.2	38.5	82.3	76.2
Didn't work	6.6	6.1	23.1	6.4	9.5
Mostly great	7.0	7.0	7.7	7.3	0.0
Neutral/NA	2.0	1.4	23.1	1.9	4.8
Negative	0.6	0.6	0.0	0.6	0.0
Other	0.4	0.4	0.0	0.4	0.0
99	1.4	1.2	7.7	1.0	9.5
n	502	489	13	481	21

<I23E2_CAT> For how long did it provide backup power and for which load(s)?

I23E2_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Less than hour	28.1	28.8	0.0	28.1	28.6
1-6 hours	33.1	33.7	7.7	34.3	4.8
> 6-12 hours	8.4	8.6	0.0	7.9	19.0
> 12-24 hours	3.8	3.9	0.0	3.7	4.8
> 1 day	3.6	3.7	0.0	3.5	4.8
Not for backup	1.0	0.0	38.5	0.6	9.5
Entire outage	8.0	8.2	0.0	7.9	9.5
Didn't work	2.6	2.7	0.0	2.7	0.0
N/A	4.2	3.5	30.8	4.2	4.8
Don't know	7.4	7.0	23.1	7.1	14.3
n	502	489	13	481	21

<I23F1> Does the level of controllability meet your expectations?

I23F1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	71.5	71.6	68.4	71.5	72.0
No	15.5	15.5	15.8	15.8	8.0
Don't Know	12.9	12.8	15.8	12.7	20.0
n	759	740	19	734	25

<I23G> Please rate your satisfaction with the operation of your storage system

I23G	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Not at all Satisfied	1.3	1.4	0.0	1.4	0.0
2	1.9	1.9	0.0	1.8	4.2
3	4.5	4.3	10.5	4.5	4.2
4	25.7	25.0	52.6	25.8	20.8
Extremely Satisfied	63.4	64.2	31.6	63.3	66.7
Unable To Rate	3.3	3.3	5.3	3.3	4.2
n	756	737	19	732	24

<I23G1> Why are you not satisfied with the storage system?

I23G1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Does not work as expected	56.5	56.5	0.0	54.5	100.0
Not seeing expected financial savings	8.7	8.7	0.0	9.1	0.0
Time of Use issues	8.7	8.7	0.0	9.1	0.0
Would like more control over own system / indepence from grid	34.8	34.8	0.0	36.4	0.0
Dealer Misrepresentation	17.4	17.4	0.0	18.2	0.0
Other	13.0	13.0	0.0	13.6	0.0
n	23	23	0	22	1

<I23H> Please rate your satisfaction with the storage system as installed (i.e. the aesthetics/size/location of the system)

I23H	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Not at all Satisfied	1.2	1.2	0.0	1.2	0.0
2	1.9	1.9	0.0	1.8	4.2
3	4.2	4.2	5.3	4.0	12.5
4	19.7	19.3	36.8	19.8	16.7
Extremely Satisfied	72.1	72.5	57.9	72.3	66.7
Unable To Rate	0.9	1.0	0.0	1.0	0.0
n	756	737	19	732	24

<I23H1> Why aren't you satisfied?

I23H1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Does not work as expected	18.2	18.2	0.0	14.3	100.0
Not seeing expected financial savings	13.6	13.6	0.0	14.3	0.0
Time of Use issues	4.5	4.5	0.0	4.8	0.0
Would like more control over own system / indepence from grid	9.1	9.1	0.0	9.5	0.0
Dealer Misrepresentation	9.1	9.1	0.0	9.5	0.0
Aesthetically Unappealing / Overly Bulky	50.0	50.0	0.0	52.4	0.0
n	22	22	0	21	1

<I23I> How important were economic factors (such as cost, incentives, payback period) in your decision to install storage?

I23I	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Not at all Important	1.3	1.4	0.0	1.2	4.2
2	2.1	2.2	0.0	2.2	0.0
3	13.5	13.6	10.5	13.3	20.8
4	24.0	24.4	10.5	24.4	12.5
Extremely Important	58.4	58.0	73.7	58.2	62.5
Unable To Rate	0.7	0.5	5.3	0.7	0.0
n	754	735	19	730	24

<I23J> Did you buy the equipment or are you leasing it?

I23J	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Bought it	90.8	92.2	36.8	91.5	70.8
Leasing it	8.4	7.2	52.6	7.9	20.8
Don't Know	0.8	0.5	10.5	0.5	8.3
n	754	735	19	730	24

<I23L_CAT> Approximately how much did it cost to purchase and install the storage equipment?

I23L_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
<10000	21.3	21.3	14.3	20.9	35.3
10001-15000	15.7	15.9	0.0	15.3	29.4
15001-25000	19.8	20.0	0.0	19.9	17.6
25001-40000	21.6	21.8	0.0	22.1	0.0
>40000	21.7	21.0	85.7	21.8	17.6
n	682	675	7	665	17

<I23L2_CAT> Approximately how much are the monthly lease payments for your storage equipment?

I23L2_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	7.9	9.4	0.0	8.6	0.0
1-100	23.8	28.3	0.0	25.9	0.0
101-150	17.5	20.8	0.0	19.0	0.0
>150	50.8	41.5	100.0	46.6	100.0
n	63	53	10	58	5

<I23M> Do you consider the cost of the storage system to be reasonable?

I23M	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	71.3	71.2	73.7	71.0	79.2
No	16.6	16.9	5.3	17.0	4.2
Don't Know	12.1	11.9	21.1	12.0	16.7
n	752.0	733.0	19.0	728.0	24.0

<I23N> Did you, or the company that sold or leased you the storage system, calculate the payback period or rate of return for the energy storage system? (Select all that apply)

I23N	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes, calculated payback back period	44.4	44.3	47.4	45.5	12.0
Yes, calculated rate of return	14.3	14.0	26.3	14.1	20.0
No	33.3	33.6	21.1	32.8	48.0
n	784	765	19	759	25

<I23N1_CAT> *What was the estimated payback period, in years, for the storage system including tax credits or incentives received?*

I23N1_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
< 5	9.5	9.5	11.1	9.6	0.0
5-5.9	10.1	10.1	11.1	10.2	0.0
6-6.9	9.2	9.5	0.0	9.0	33.3
7-7.9	15.0	15.1	11.1	15.2	0.0
8-8.9	5.5	5.6	0.0	5.5	0.0
9-9.9	2.6	2.7	0.0	2.6	0.0
10-14.9	16.5	16.0	33.3	16.6	0.0
> 15	8.7	8.9	0.0	8.7	0.0
Don't know	22.8	22.6	33.3	22.4	66.7
n	346	337	9	343	3

<I23N2> *What was the estimated rate of return, for the investment value of the storage system, including any tax credits or incentives?*

I23N2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Don't know	75.7	76.4	60.0	75.5	80.0
1	1.8	1.9	0.0	1.9	0.0
4	0.9	0.9	0.0	0.9	0.0
7	1.8	1.9	0.0	1.9	0.0
8	1.8	1.9	0.0	1.9	0.0
10	3.6	3.8	0.0	3.8	0.0
14	1.8	0.9	20.0	1.9	0.0
15	0.9	0.9	0.0	0.9	0.0
15	0.9	0.9	0.0	0.9	0.0
20	2.7	2.8	0.0	2.8	0.0
40	3.6	3.8	0.0	3.8	0.0
45	0.9	0.9	0.0	0.9	0.0
50	2.7	1.9	20.0	1.9	20.0
100	0.9	0.9	0.0	0.9	0.0
n	111	106	5	106	5

<I23P> How long is the lease period for the storage system?

I23P	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Don't know	22.2	24.5	10.0	24.1	0.0
3	1.6	0.0	10.0	0.0	20.0
4	1.6	0.0	10.0	0.0	20.0
5	3.2	0.0	20.0	0.0	40.0
10	15.9	17.0	10.0	17.2	0.0
15	1.6	1.9	0.0	1.7	0.0
17	1.6	1.9	0.0	1.7	0.0
20	49.2	52.8	30.0	51.7	20.0
25	3.2	1.9	10.0	3.4	0.0
n	63	53	10	58	5

<I23Q> What happens to the storage equipment at the end of the lease period?

I23Q	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I do not know	30.2	32.1	20.0	31.0	20.0
We have the option to purchase the storage equipment	39.7	39.6	40.0	41.4	20.0
The storage equipment is returned to leasing company	20.6	17.0	40.0	17.2	60.0
Return, continue lease, or purchase	3.2	3.8	0.0	3.4	0.0
We get to keep the equipment at no cost	3.2	3.8	0.0	3.4	0.0
Option to renew	1.6	1.9	0.0	1.7	0.0
It is a demonstration project; We will deal with that issue when it arises	1.6	1.9	0.0	1.7	0.0
n	63	53	10	58	5

<I23R> What is the expected lifetime of your storage system in years?

I23R	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Don't know	40.8	40.8	42.1	40.5	50.0
1	0.1	0.1	0.0	0.1	0.0
5	0.3	0.3	0.0	0.3	0.0
6	0.1	0.1	0.0	0.1	0.0
7	0.3	0.3	0.0	0.3	0.0
8	0.3	0.3	0.0	0.3	0.0
9	0.3	0.3	0.0	0.3	0.0
10	21.0	20.9	26.3	20.6	33.3
12	0.4	0.4	0.0	0.4	0.0
15	5.5	5.7	0.0	5.7	0.0
20	16.4	16.5	15.8	16.6	12.5
25	9.7	9.8	5.3	9.9	4.2
30	3.9	3.7	10.5	4.0	0.0
32	0.1	0.1	0.0	0.1	0.0
40	0.4	0.4	0.0	0.4	0.0
50	0.3	0.3	0.0	0.3	0.0
n	742	723	19	718	24

<I23S> Did you consider other alternatives to energy storage?

I23S	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	19.7	19.6	21.1	19.4	29.2
No	78.7	78.8	73.7	79.1	66.7
Don't Know	1.6	1.5	5.3	1.5	4.2
n	742	723	19	718	24

<I23S1> What alternatives did you consider? (Select all that apply)

I23S1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Backup generator	50.0	0.0	50.0	100.0	33.3
Solar PV	75.0	0.0	75.0	0.0	100.0
Wind turbine	0.0	0.0	0.0	0.0	0.0
Distributed Generation	0.0	0.0	0.0	0.0	0.0
Combined Heat and Power (CHP)	0.0	0.0	0.0	0.0	0.0
Fuel Cell	50.0	0.0	50.0	0.0	66.7
Participation in a Demand Response Program	25.0	0.0	25.0	0.0	33.3
Installation of Energy Efficient Equipment	50.0	0.0	50.0	0.0	66.7
Other	0.0	0.0	0.0	0.0	0.0
None	0.0	0.0	0.0	0.0	0.0
n	4	0	4	1	3

<I23T> Did you consider installing an emergency backup generator?

I23T	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	35.0	35.0	0.0	34.9	37.5
No	63.3	63.3	0.0	63.4	62.5
Don't Know	1.7	1.7	0.0	1.7	0.0
n	723	723	0	707	16

<I23T1> Why did you choose storage instead?

I23T1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Cost	13.8	13.8	0.0	13.1	50.0
Convenience / Ease of Use	13.8	13.8	0.0	13.6	25.0
Environment / Clean Energy / Green	26.7	26.7	0.0	26.3	50.0
Fuel requirement	23.3	23.3	0.0	23.7	0.0
Complete System / Works with PV	14.2	14.2	0.0	14.4	0.0
Instant Start	2.9	2.9	0.0	3.0	0.0
Noise	13.3	13.3	0.0	13.6	0.0
Aesthetics / Apperance / Size	4.2	4.2	0.0	4.2	0.0
Maintenance	11.3	11.3	0.0	11.4	0.0
Reliability	2.9	2.9	0.0	3.0	0.0
Safety	2.1	2.1	0.0	2.1	0.0
Emergency Backaup	8.8	8.8	0.0	8.9	0.0
Rebates / Incentives	2.5	2.5	0.0	2.5	0.0
Have / plan to get generator.	8.3	8.3	0.0	8.5	0.0
Other	9.2	9.2	0.0	9.3	0.0
n	240	240	0	236	4

<I4A> Which of the following benefits of storage were described to you by the storage equipment vendor when you were researching/purchasing your storage system? (Select all that apply)

I4A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Energy Bill Savings	63.6	63.1	84.2	63.5	72.0
Reduced Demand Charges	2.5	0.4	89.5	1.6	32.0
Improving the reliability of your electric supply	62.5	63.1	36.8	63.5	36.0
Participation in a Demand Response program	16.4	15.9	36.8	16.6	12.0
Ability to use more of your own solar	62.0	63.0	21.1	63.0	36.0
Investment tax credit	49.0	49.5	26.3	50.3	12.0
Environmental benefits such as a reduction in GHG emissions	38.2	37.8	52.6	38.5	32.0
Other benefits	0.1	0.1	0.0	0.1	0.0
Vendor did not describe any benefits	3.6	3.7	0.0	3.6	4.0
Rebates / Incentives	0.4	0.4	0.0	0.4	0.0
n	786	767	19	759	25

<I4A1> Approximately how much did they say you would be able to save on your energy bills?

I4A1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Don't know	72.2	72.3	68.8	71.8	83.3
1	0.6	0.6	0.0	0.6	0.0
5	0.2	0.2	0.0	0.2	0.0
10	0.2	0.2	0.0	0.2	0.0
15	0.2	0.2	0.0	0.2	0.0
20	0.4	0.4	0.0	0.4	0.0
25	1.0	0.4	18.8	0.8	5.6
30	0.4	0.2	6.3	0.4	0.0
35	0.8	0.8	0.0	0.8	0.0
40	0.6	0.6	0.0	0.6	0.0
45	0.2	0.2	0.0	0.2	0.0
50	2.4	2.3	6.3	2.1	11.1
60	1.0	1.0	0.0	1.0	0.0
62	0.2	0.2	0.0	0.2	0.0
66	0.2	0.2	0.0	0.2	0.0
70	1.6	1.7	0.0	1.7	0.0
75	1.4	1.5	0.0	1.5	0.0
80	1.6	1.7	0.0	1.7	0.0
85	1.0	1.0	0.0	1.0	0.0
90	5.6	5.8	0.0	5.8	0.0
93	0.2	0.2	0.0	0.2	0.0
95	1.8	1.9	0.0	1.9	0.0
97	0.2	0.2	0.0	0.2	0.0
98	0.4	0.4	0.0	0.4	0.0
100	5.0	5.2	0.0	5.2	0.0
140	0.2	0.2	0.0	0.2	0.0
400	0.2	0.2	0.0	0.2	0.0
n	497	481	16	479	18

<I4B> ***Which of the following costs of storage were described to you by the storage equipment vendor when you were researching/purchasing your storage system? (Select all that apply)***

I4B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Cost of storage system	73.9	73.9	73.7	73.9	80.0
Cost of installation	67.7	67.5	73.7	67.6	76.0
Interconnection costs	32.4	31.7	63.2	31.9	52.0
Maintenance costs	17.8	16.4	73.7	17.3	36.0
Other costs	0.3	0.1	5.3	0.1	4.0
Vendor did not describe any costs	3.7	3.4	15.8	3.8	0.0
Lease Costs / Payments	0.4	0.4	0.0	0.4	0.0
Permits	0.4	0.4	0.0	0.4	0.0
n	786	767	19	759	25

<I4C> ***Did the equipment vendor indicate that storage was required with solar PV systems?***

I4C	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	5.4	5.5	0.0	5.4	0.0
No	87.3	87.3	90.0	87.3	0.0
Don't Know	7.3	7.2	10.0	7.3	0.0
n	701	691	10	701	0

<I4C1> ***Please provide details on additional benefits or requirements for installing a solar PV system with storage versus solar PV on its own that were described to you by the equipment vendor?***

I4C1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Cost Savings	5.6	5.6	0.0	5.6	0.0
Backup	11.1	11.1	0.0	11.1	0.0
Time of Use	2.8	2.8	0.0	2.8	0.0
Complete Systyem	8.3	8.3	0.0	8.3	0.0
Ability to use more of solar produced	2.8	2.8	0.0	2.8	0.0
Other	2.8	2.8	0.0	2.8	0.0
n	36	36	0	36	0

<I4D> ***Did the equipment vendor discuss with you the economics of the following alternative system configurations?***

I4D	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Storage Only	2.8	2.8	0.0	2.9	0.0
Solar PV only	21.5	21.7	16.7	22.3	0.0
Storage and Solar PV combined	0.8	0.9	0.0	0.0	25.0
Equipment vendor did not provide the economics of any alterative system configurations beside: the one installed	51.2	51.0	61.1	50.9	62.5
Don't Know	23.6	23.7	22.2	24.0	12.5
n	724	706	18	700	24

<I4E> ***Did the equipment vendor mention anything about Net Energy Metering?***

I4E	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes	56.9	57.3	42.1	58.5	8.3
No	19.0	18.7	31.6	17.9	50.0
Don't Know	24.1	24.0	26.3	23.5	41.7
n	726	707	19	702	24

<I4E1> ***What did they tell you about Net Energy Metering?***

I4E1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
What Net metering is / How Net metering works	12.5	12.5	12.5	12.5	0.0
Ability to sell back / return energy to utility grid	12.7	13.0	0.0	12.8	0.0
Demand Shifting / Time of Use	6.7	6.4	25.0	6.8	0.0
Changes in billing / rates	4.2	4.3	0.0	4.3	0.0
Annual reconciliation of net electric costs	7.7	7.6	12.5	7.8	0.0
Net Energy Metering is required for solar customers	2.7	2.8	0.0	2.8	0.0
Saves Money	5.5	5.3	12.5	5.5	0.0
Credits on bills	8.5	7.9	37.5	8.5	0.0
Tracks usage / production	3.5	3.6	0.0	3.5	0.0
Good / recommended	1.5	1.3	12.5	1.5	0.0
Allows meter to "run backwards"	2.0	2.0	0.0	2.0	0.0
Will be placed on NEM 2.0	1.5	1.5	0.0	1.5	0.0
Already aware or enrolled, or had previous experience with Net Energy Metering	11.7	12.0	0.0	11.8	0.0
Other	12.2	12.5	0.0	12.0	50.0
n	401	393	8	399	2

<I4F> ***Finally, did the person who sold you your storage system make any comments or provide any information about the impact of the new time-of-use rates on the economics of your storage system?***

I4F	ALL	Residential	Nonresidential	Storage+Solar	Storage Only

Yes	39.6	39.9	31.6	40.0	29.2
No	35.5	35.7	26.3	35.6	33.3
Don't Know	24.9	24.4	42.1	24.4	37.5
n	724	705	19	700	24

<I5_A> Overall SGIP Application Process

I5_A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	2.4	2.5	0.0	2.5	0.0
Not at all Satisfied	7.7	7.8	5.3	7.7	9.1
2	8.6	8.8	0.0	8.6	9.1
3	21.9	22.0	21.1	22.2	13.6
4	27.3	26.6	52.6	26.7	45.5
Extremely Satisfied	32.1	32.4	21.1	32.4	22.7
n	711	692	19	689	22

<I5_B> SGIP Incentive amount

I5_B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	5.1	4.9	10.5	5.2	0.0
Not at all Satisfied	2.3	2.3	0.0	2.3	0.0
2	2.4	2.5	0.0	2.5	0.0
3	13.1	13.4	0.0	13.4	4.5
4	28.7	28.2	47.4	28.6	31.8
Extremely Satisfied	48.5	48.7	42.1	48.0	63.6
n	711	692	19	689	22

<I5_C> How long it took to receive the SGIP incentive

I5_C	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	5.5	5.3	10.5	5.7	0.0
Not at all Satisfied	14.9	15.2	5.3	15.1	9.1
2	16.2	16.5	5.3	16.3	13.6
3	20.8	20.5	31.6	20.5	31.8
4	23.1	22.8	31.6	22.9	27.3
Extremely Satisfied	19.6	19.7	15.8	19.6	18.2
n	711	692	19	689	22

<I5_D> SGIP requirements

I5_D	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	10.5	10.7	5.3	10.5	13.6
Not at all Satisfied	5.8	5.8	5.3	6.0	0.0
2	6.5	6.6	0.0	6.7	0.0
3	26.7	26.6	31.6	26.6	31.8
4	25.7	25.6	31.6	25.5	31.8
Extremely Satisfied	24.8	24.7	26.3	24.8	22.7
n	711	692	19	689	22

<I5A> Based on your experience, how likely are you to recommend installing a storage system to others?

I5A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Very Likely	75.8	76.2	63.2	76.3	59.1
Somewhat Likely	19.7	19.2	36.8	19.2	36.4
Not at all Likely	2.8	2.9	0.0	2.9	0.0
Don't Know	1.7	1.7	0.0	1.6	4.5
n	711	692	19	689	22

<I5B> Based on your experience, how likely are you to recommend the SGIP to others?

I5B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Very Likely	71.5	71.6	68.4	71.9	59.1
Somewhat Likely	19.3	19.0	31.6	19.0	27.3
Not at all Likely	4.4	4.5	0.0	4.2	9.1
Don't Know	4.8	4.9	0.0	4.8	4.5
n	710	691	19	688	22

<I6A> Please rate how important the upfront cost was when deciding to purchase storage (and solar PV) technology.

I6A	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	2.3	2.2	5.3	2.4	0.0
Not at all Satisfied	2.7	2.6	5.3	2.7	4.5
2	4.9	5.0	0.0	5.0	0.0
3	24.5	24.9	10.5	24.4	27.3
4	28.1	28.4	15.8	28.1	27.3
Extremely Satisfied	37.5	36.8	63.2	37.4	40.9
n	701	682	19	679	22

<I6B> Please rate how important the incentive amount was when deciding to purchase storage (and solar PV) technology.

I6B	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	3.7	3.8	0.0	3.7	4.5
Not at all Satisfied	2.6	2.6	0.0	2.5	4.5
2	2.7	2.6	5.3	2.8	0.0
3	14.3	14.5	5.3	14.6	4.5
4	28.1	27.9	36.8	27.8	36.4
Extremely Satisfied	48.6	48.5	52.6	48.6	50.0
n	701	682	19	679	22

<I6C> Please rate how important the tax benefit was when deciding to purchase storage (and solar PV) technology.

I6C	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	4.3	4.0	15.8	3.7	22.7
Not at all Satisfied	3.9	3.5	15.8	3.5	13.6
2	2.7	2.6	5.3	2.7	4.5
3	18.3	18.5	10.5	18.6	9.1
4	26.5	26.8	15.8	26.5	27.3
Extremely Satisfied	44.4	44.6	36.8	45.1	22.7
n	701	682	19	679	22

<I6D> Please rate how important the reliability of electric energy supply was when deciding to purchase storage (and solar PV) technology.

I6D	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	1.6	0.9	26.3	1.3	9.1
Not at all Satisfied	0.7	0.7	0.0	0.7	0.0
2	3.4	3.2	10.5	3.4	4.5
3	10.0	9.8	15.8	9.6	22.7
4	19.0	19.2	10.5	19.6	0.0
Extremely Satisfied	65.3	66.1	36.8	65.4	63.6
n	701	682	19	679	22

<I6E> Please rate how important the operation and maintenance cost was when deciding to purchase storage (and solar PV) technology.

I6E	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	3.7	3.5	10.5	3.7	4.5
Not at all Satisfied	2.7	2.6	5.3	2.8	0.0
2	5.7	5.9	0.0	5.7	4.5
3	21.0	21.3	10.5	21.2	13.6
4	28.1	28.2	26.3	27.8	36.4
Extremely Satisfied	38.8	38.6	47.4	38.7	40.9
n	701	682	19	679	22

<I6F> Please rate how important the electric rate structure/TOU rate was when deciding to purchase storage (and solar PV) technology.

I6F	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	4.0	4.1	0.0	4.1	0.0
Not at all Satisfied	4.3	4.4	0.0	4.3	4.5
2	6.1	6.3	0.0	6.3	0.0
3	20.1	19.9	26.3	20.3	13.6
4	28.8	28.7	31.6	28.7	31.8
Extremely Satisfied	36.7	36.5	42.1	36.2	50.0
n	701	682	19	679	22

<I6G> Please rate how important the payback period or Rate of Return was when deciding to purchase storage (and solar PV) technology.

I6G	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	2.2	2.0	7.7	2.2	0.0
Not at all Satisfied	0.8	0.8	0.0	0.8	0.0
2	4.9	5.0	0.0	4.9	0.0
3	27.5	27.7	23.1	27.4	33.3
4	31.5	32.1	15.4	31.8	16.7
Extremely Satisfied	33.2	32.4	53.8	32.9	50.0
n	371	358	13	365	6

<I6H> Please rate how important the leasing terms were when deciding to purchase storage (and solar PV) technology.

I6H	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	20.0	23.2	0.0	21.3	0.0
Not at all Satisfied	11.3	11.6	9.1	12.0	0.0
2	2.5	2.9	0.0	2.7	0.0
3	15.0	15.9	9.1	16.0	0.0
4	13.8	11.6	27.3	13.3	20.0
Extremely Satisfied	37.5	34.8	54.5	34.7	80.0
n	80	69	11	75	5

<I6I> Please rate how important the environmental benefits of storage technology was when deciding to purchase storage (and solar PV) technology.

I6I	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	1.3	1.2	5.3	1.2	4.5
Not at all Satisfied	4.7	4.8	0.0	4.9	0.0
2	3.9	3.8	5.3	4.0	0.0
3	16.4	16.0	31.6	16.1	27.3
4	23.1	23.0	26.3	22.8	31.8
Extremely Satisfied	50.6	51.2	31.6	51.1	36.4
n	701	682	19	679	22

<I6J> Please rate how important the environmental benefits of solar PV technology was when deciding to purchase storage (and solar PV) technology.

I6J	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	2.0	1.3	26.3	1.0	31.8
Not at all Satisfied	3.9	4.0	0.0	4.0	0.0
2	3.0	2.8	10.5	3.1	0.0
3	12.7	12.6	15.8	12.7	13.6
4	22.0	22.1	15.8	21.6	31.8
Extremely Satisfied	56.5	57.2	31.6	57.6	22.7
n	701	682	19	679	22

<I6K> Please rate how important the other influences were when deciding to purchase storage (and solar PV) technology.

I6K	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
N/A	55.6	55.0	78.9	55.1	72.7
Not at all Satisfied	12.4	12.6	5.3	12.5	9.1
2	2.9	2.9	0.0	2.9	0.0
3	13.6	13.6	10.5	13.7	9.1
4	7.4	7.5	5.3	7.7	0.0
Extremely Satisfied	8.1	8.4	0.0	8.1	9.1
n	701	682	19	679	22

<I6> Please specify the other influences.

I6	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
None / Don't Know / NA	65.8	66.1	52.6	66.8	40.9
Backup power	6.5	6.7	0.0	6.5	9.1
EV charging	1.4	1.5	0.0	1.5	0.0
Cost / Bill Savings	4.5	4.7	0.0	4.6	4.5
Energy Savings / Efficiency	1.0	1.0	0.0	1.0	0.0
Peak Load shaving / Demand reduction / Time of Use/ Net Metering	0.6	0.6	0.0	0.6	0.0
Clean Energy / Enviromental / Green reasons	4.0	4.1	0.0	4.1	0.0
Energy Independence / Reduce Grid Dependence	2.8	2.9	0.0	2.9	0.0
Rebates / Incentives	1.0	1.0	0.0	1.0	0.0
Latest Tecnology / 1st Adopter	2.8	2.9	0.0	2.8	4.5
Ability to use more of solar that is generated	0.7	0.7	0.0	0.7	0.0
Aesthetics / Apperance	1.7	1.8	0.0	1.6	4.5
Technical features	2.1	2.0	5.3	2.1	4.5
Brand Name	1.6	1.6	0.0	1.5	4.5
Increased Home Resale Value	0.9	0.9	0.0	0.9	0.0
Other	6.7	6.4	15.8	6.8	4.5
n	704	685	19	680	22

<RES1> How long have you owned your home?

RES1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Less than 5 years	21.3	21.3	0.0	21.5	14.3
5 to 9 years	18.7	18.7	0.0	18.5	28.6
10 to 14 years	9.9	9.9	0.0	10.2	0.0
15 to 19 years	15.5	15.5	0.0	15.2	28.6
20 to 24 years	9.5	9.5	0.0	9.6	7.1
25 or more years	23.8	23.8	0.0	23.9	21.4
Don't Know	1.3	1.3	0.0	1.0	0.0
n	685	685	0	669	14

<RES2> Which of the following dwelling types best describes your home?

RES2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Single Family house	95.2	95.2	0.0	95.7	85.7
Townhouse, duplex or row house	2.2	2.2	0.0	1.9	14.3
Apartment or Condominium with 2-4 units	0.1	0.1	0.0	0.1	0.0
Apartment or Condominium with 5+ units	0.3	0.3	0.0	0.3	0.0
Mobile Home	0.3	0.3	0.0	0.3	0.0
Farm/Ranch	0.4	0.4	0.0	0.4	0.0
Don't Know	1.5	1.5	0.0	1.2	0.0
n	685	685	0	669	14

<RES3_1> Less than 18 years old

RES3_1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	67.2	67.2	0.0	67.1	71.4
1	12.5	12.5	0.0	12.3	21.4
2	15.9	15.9	0.0	16.1	7.1
3	3.1	3.1	0.0	3.2	0.0
4	0.7	0.7	0.0	0.8	0.0
6	0.1	0.1	0.0	0.2	0.0
10	0.4	0.4	0.0	0.5	0.0
n	673	673	0	659	14

<RES3_2> 18-24 years old

RES3_2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	89.2	89.2	0.0	89.4	78.6
1	7.9	7.9	0.0	7.7	14.3
2	2.1	2.1	0.0	2.0	7.1
3	0.3	0.3	0.0	0.3	0.0
5	0.1	0.1	0.0	0.2	0.0
10	0.4	0.4	0.0	0.5	0.0
n	673	673	0	659	14

<RES3_3> 25-34 years old

RES3_3	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	88.3	88.3	0.0	88.3	85.7
1	6.5	6.5	0.0	6.5	7.1
2	4.3	4.3	0.0	4.2	7.1
3	0.3	0.3	0.0	0.3	0.0
4	0.1	0.1	0.0	0.2	0.0
10	0.4	0.4	0.0	0.5	0.0
n	673	673	0	659	14

<RES3_4> 35-44 years old

RES3_4	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	78.5	78.5	0.0	78.5	78.6
1	7.9	7.9	0.0	7.7	14.3
2	13.1	13.1	0.0	13.2	7.1
3	0.1	0.1	0.0	0.2	0.0
10	0.4	0.4	0.0	0.5	0.0
n	673	673	0	659	14

<RES3_5> 45-54 years old

RES3_5	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	72.7	72.7	0.0	72.8	64.3
1	11.9	11.9	0.0	11.7	21.4
2	14.9	14.9	0.0	14.9	14.3
3	0.1	0.1	0.0	0.2	0.0
4	0.1	0.1	0.0	0.2	0.0
10	0.3	0.3	0.0	0.3	0.0
n	673	673	0	659	14

<RES3_6> 55-64 years old

RES3_6	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	63.7	63.7	0.0	63.4	78.6
1	17.7	17.7	0.0	18.1	0.0
2	18.3	18.3	0.0	18.2	21.4
10	0.3	0.3	0.0	0.3	0.0
n	673	673	0	659	14

<RES3_7> 65+ years old

RES3_7	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
0	62.0	62.0	0.0	62.1	57.1
1	16.0	16.0	0.0	16.2	7.1
2	21.1	21.1	0.0	20.8	35.7
3	0.3	0.3	0.0	0.3	0.0
5	0.1	0.1	0.0	0.2	0.0
10	0.4	0.4	0.0	0.5	0.0
n	673	673	0	659	14

<RES4> Which of the following best represents your annual household income from all sources before taxes?

RES4	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Less than $50,000	1.8	1.8	0.0	1.8	0.0
$50,000 or more but less than $75,000	5.5	5.5	0.0	5.5	7.1
$75,000 or more but less than $100,000	9.8	9.8	0.0	10.0	0.0
$100,000 or more	65.4	65.4	0.0	65.2	85.7
Don't Know	17.5	17.5	0.0	17.5	7.1
n	685	685	0	669	14

<RES5> What is the highest level of education attained by the head of household?

RES5	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Some high school	0.4	0.4	0.0	0.4	0.0
High school graduate	2.3	2.3	0.0	2.4	0.0
Trade or technical school	1.8	1.8	0.0	1.8	0.0
Some college	12.1	12.1	0.0	12.1	14.3
College graduate	28.5	28.5	0.0	29.0	7.1
Some graduate school	5.5	5.5	0.0	5.2	21.4
Post-graduate degree	43.2	43.2	0.0	43.0	57.1
Don't Know	6.1	6.1	0.0	6.0	0.0
n	685	685	0	669	14

<RES6> How would you classify the location where the storage was installed?

RES6	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Urban	22.3	22.3	0.0	22.4	21.4
Suburban	59.1	59.1	0.0	59.2	64.3
Rural	13.7	13.7	0.0	13.8	14.3
Don't Know	4.8	4.8	0.0	4.6	0.0
n	685	685	0	669	14

<RES7> Compared to others, which description best describes you or your household?

RES7	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Usually the last to try a new product	0.4	0.4	0.0	0.4	0.0
Usually among the last to try a new product	1.6	1.6	0.0	1.6	0.0
Usually in the middle when it comes to trying a new product	39.3	39.3	0.0	39.8	21.4
Usually among the first to try a new product	39.0	39.0	0.0	38.7	57.1
Usually the first to try a new product	12.7	12.7	0.0	12.6	21.4
Don't Know	7.0	7.0	0.0	6.9	0.0
n	685	685	0	669	14

<RES8> Which of the following best describes where you reside with respect to wildfire risk.

RES8	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
I reside in an area with high wildfire risk	19.0	19.0	0.0	18.7	35.7
I reside in an area with moderate wildfire risk	29.8	29.8	0.0	30.0	21.4
I reside in an area with low wildfire risk	46.0	46.0	0.0	46.2	42.9
Don't know	5.3	5.3	0.0	5.1	0.0
n	685	685	0	669	14

<RES9> Has your home ever been affected by your utility using preventative fire outages on days with high fire risk?

RES9	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes, I have lost power at my home due to my utility using preventative fire outages	10.8	10.8	0.0	10.8	14.3
No, I have not lost power at my home due to my utility using preventative fire outages	31.5	31.5	0.0	31.4	42.9
Don't Know	57.7	57.7	0.0	57.8	42.9
n	685	685	0	669	14

<NONRES1> Does your organization own or lease the facility where this storage system was installed?

NONRES1	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Own	73.7	0.0	73.7	90.9	50.0
Lease	21.1	0.0	21.1	9.1	37.5
Don't Know	5.3	0.0	5.3	0.0	12.5
n	19	0	19	11	8

<NONRES2> Does your organization ...

NONRES2	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Occupy the entire building where the storage system was installed	68.4	0.0	68.4	81.8	50.0
Occupy a portion of the building where the storage system was installed	26.3	0.0	26.3	18.2	37.5
Lease the building where the storage system was installed to a tenant	5.3	0.0	5.3	0.0	12.5
n	19	0	19	11	8

<NONRES3> What is the approximate number of full-time equivalent workers of all types employed by your organization at the facility where the storage was installed?

NONRES3	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
1 to 10	15.8	0.0	15.8	18.2	12.5
11 to 50	15.8	0.0	15.8	18.2	12.5
51 to 100	15.8	0.0	15.8	9.1	25.0
101 to 250	15.8	0.0	15.8	18.2	12.5
251 to 500	15.8	0.0	15.8	18.2	12.5
501 to 1,000	5.3	0.0	5.3	9.1	0.0
More than 1,000	15.8	0.0	15.8	9.1	25.0
n	19	0	19	11	8

<NONRES4> Does your organization have any company goals regarding sustainability, GHG reductions, or climate change? (Select all that apply)

NONRES4	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
Yes – we have sustainability goals	57.9	0.0	57.9	54.5	62.5
Yes – we have GHG reduction goals	26.3	0.0	26.3	18.2	37.5
Yes – we have climate change goals	15.8	0.0	15.8	9.1	25.0
Yes – we have other environmental goals	36.8	0.0	36.8	27.3	50.0
No	36.8	0.0	36.8	36.4	37.5
n	19	0	19	11	8

<NONRES4A_CAT> Please describe your organizations other environmental goals.

NONRES4A_CAT	ALL	Residential	Nonresidential	Storage+Solar	Storage Only
- Powered by 100% renewable energy - 100% carbon neutral - Reduce carbon content of actua energy used 24/7	14.3	0.0	14.3	0.0	25.0
Our usage of material to produce our product are subject to sustainablity. Our food services are committed to bio-degradable packaging.	14.3	0.0	14.3	0.0	25.0
We establish ESG on a property basis for energy, water, waste.	14.3	0.0	14.3	0.0	25.0
We operate an Energy conservation program that establishes and helps drive the district toward cost avoidance goals, GHG reduction goals, and reviews/monitors energy consumption at all of our properties.	14.3	0.0	14.3	33.3	0.0
We strive to reduce our environmental footprint to net zero 'if possible'.	14.3	0.0	14.3	33.3	0.0
Extensive plastic scrap recycling program specific to our industry.	14.3	0.0	14.3	33.3	0.0
iso 14K program	14.3	0.0	14.3	0.0	25.0
n	7	0	7	3	4

** Values are shown as percent of survey participants.*

** n is the number of respondents.*

Appendix B.2: Solar Non-Storage Survey Banner Tables

<A1> Our records show that Solar PV was installed at your home, is this correct?

A1	ALL	Residential	Nonresidential
Yes, I installed Solar PV at my current home	93.043	93.043	0
Yes, I installed Solar PV at a previous home	2.609	2.609	0
No, I did not install Solar PV at my home	2.609	2.609	0
Don't Know	1.739	1.739	0
n	115	115	0

<A2> Our records show that Solar PV was installed at your organization's facility, is this correct?

A2	ALL	Residential	Nonresidential
Yes, Solar PV was installed at my place of business	90.4762	0	90.4762
No, Solar PV was not installed at my place of business	7.1429	0	7.1429
Don't Know	2.381	0	2.381
n	42	0	42

<A3> Have you ever heard of battery storage that can be installed in your home or business?

A3	ALL	Residential	Nonresidential
Yes, I have heard of battery storage and have it installed in my home	1.274	0.87	2.381
Yes, I have heard of battery storage and have it installed in my business	1.911	0	7.1429
Yes, I have heard of battery storage but do not have any installed in my home or business	88.535	90.435	83.3333
No, I have not heard of battery storage	7.006	7.826	4.7619
n	157	115	42

<A3B> ***What have you heard about battery storage technology?***

A3B	ALL	Residential	Nonresidential
Cost / Bill Savings	3.597	3.846	2.8571
Energy Savings / Efficiency	0	0	0
Backup for Emergencies / Outages	15.108	14.423	17.1429
Peak Load shaving / Demand reduction / Time of Use/ Net Metering	9.353	4.808	22.8571
Clean Energy / Enviromental / Green reasons	1.439	1.923	0
Energy Independence / Reduce Grid Dependence	6.475	7.692	2.8571
Is available / Exists	6.475	6.731	5.7143
Electric Vehicle	1.439	1.923	0
Latest Tecnology	1.439	1.923	0
Ability to use more of solar that is generated / store for "cloudy" days	17.266	21.154	5.7143
Expensive to install	25.18	24.038	28.5714
Large spave requirement	1.439	1.923	0
Other	7.194	6.731	8.5714
n	139	104	35

<A4> ***How familiar would you say you are with battery storage technology?***

A4	ALL	Residential	Nonresidential
Very familiar	7.353	6.931	8.5714
Somewhat familiar	47.794	48.515	45.7143
Not very familiar	36.029	36.634	34.2857
Not at all familiar	8.824	7.921	11.4286
n	136	101	35

<A5> ***When did you first become aware of battery storage technology?***

A5	ALL	Residential	Nonresidential
Within the last year	7.407	7	8.5714
More than 1 year ago but less than 5 years ago	57.037	57	57.1429
More than 5 years ago	34.074	34	34.2857
Don't Know	1.481	2	0
n	135	100	35

<A6> ***Have you ever heard of the Self Generation Incentive Program?***

A6	ALL	Residential	Nonresidential
Yes, I have heard of the Self Generation Incentive Program	10.448	9.0909	14.2857
No, I have not heard of the Self Generation Incentive Program	88.06	89.899	82.8571
Don't Know	1.493	1.0101	2.8571
n	134	99	35

<A7> How did you first become aware of battery storage?

A7	ALL	Residential	Nonresidential
Through the Self Generation Incentive Program	0.758	1.0309	0
Through a Solar or Storage Company or contractor	21.97	20.6186	25.7143
Through online research	22.727	27.8351	8.5714
Through my utility	2.273	0	8.5714
Word of mouth	30.303	28.866	34.2857
Other Specify:	21.97	21.6495	22.8571
n	132	97	35

<C1> Have you ever considered installing battery storage in your home/business?

C1	ALL	Residential	Nonresidential
Yes, considered installing battery storage at the time Solar PV was installed	7.576	10.3093	0
Yes, considered installing battery storage (at another time)	49.242	52.5773	40
No, have not considered installing battery storage	42.424	36.0825	60
Don't Know	0.758	1.0309	0
n	132	97	35

<C2> What is the main reason you have not installed/considered installing battery storage?

C2	ALL	Residential	Nonresidential
Lack of awareness / Had not heard of it	3.817	5.2083	0
Too expensive	47.328	45.8333	51.4286
Didn't need it	9.924	9.375	11.4286
Energy bill savings not sufficient	11.45	10.4167	14.2857
Other Specify:	21.374	21.875	20
Don't Know	6.107	7.2917	2.8571
n	131	96	35

<C3> Primary drivers for you to consider installing battery storage in your home/business

C3	ALL	Residential	Nonresidential
To save money on electric bill	48.408	46.957	52.381
To reduce demand charges	7.006	0	26.1905
To receive an incentive through the Self Generation Incentive Program (SGIP)	19.108	18.261	21.4286
To shift load in response to time-of-use price signals	22.293	22.609	21.4286
To help the grid by shifting load from on-peak to off-peak times	13.376	13.043	14.2857
To satisfy corporate goals or initiatives	0.637	0	2.381
To provide backup/emergency power	58.599	63.478	45.2381
To benefit from net energy metering	5.096	3.478	9.5238
To become less grid dependent	24.204	26.957	16.6667
To use more of the solar energy we generate	25.478	30.435	11.9048
To receive the federal investment tax credit	7.006	6.957	7.1429
To reduce greenhouse gas emissions	11.465	13.913	4.7619
Other	1.911	2.609	0
n	157	115	42

<C4> Are you aware that battery storage can be used to power your home for up to a week depending on your home's energy use and solar availability?

C4	ALL	Residential	Nonresidential
Yes	32.381	32.381	0
No	59.048	59.048	0
Don't Know	8.571	8.571	0
n	105	105	0

<C4B> What is the maximum amount you would you be willing to pay for a battery storage system that provides your power needs for several days or more during a power outage?

C4B	ALL	Residential	Nonresidential
0	3.846	3.846	0
1	7.692	7.692	0
2	4.808	4.808	0
3	6.731	6.731	0
4	0.962	0.962	0
5	11.538	11.538	0
6	2.885	2.885	0
8	0.962	0.962	0
10	1.923	1.923	0
Don't know	58.654	58.654	0
n	104	104	0

<C5> Have you ever considered installing an emergency backup generator in your home/business?

C5	ALL	Residential	Nonresidential
Yes	45.714	49.038	36.1111
No	52.857	50.962	58.3333
Don't Know	1.429	0	5.5556
n	140	104	36

<L1> How likely are you to install/consider installing battery storage in your home/business in the future?

L1	ALL	Residential	Nonresidential
Very Likely	11.429	12.5	8.3333
Somewhat Likely	60	59.615	61.1111
Not at all likely	28.571	27.885	30.5556
n	140	104	36

<L2> When do you anticipate you would install battery storage in your home/business?

L2	ALL	Residential	Nonresidential
Within the next year	9.6774	10.1449	8.3333
More than one year from now but within the next 5 years	53.7634	49.2754	66.6667
More than 5 years from now	3.2258	2.8986	4.1667
Don't Know	33.3333	37.6812	20.8333
n	93	69	24

<L4A> Please rate how significant COST is in your decision to not install storage

L4A	ALL	Residential	Nonresidential
1 Not at all Significant	7.6923	10.7143	0
3	7.6923	7.1429	9.0909
4	5.1282	3.5714	9.0909
5 Very Significant	74.359	71.4286	81.8182
Unsure	5.1282	7.1429	0
n	39	28	11

<L4B> Please rate how significant SAFETY CONCERNS are in your decision to not install storage

L4B	ALL	Residential	Nonresidential
1 Not at all Significant	38.4615	32.1429	54.5455
2	12.8205	14.2857	9.0909
3	12.8205	10.7143	18.1818
4	2.5641	3.5714	0
5 Very Significant	20.5128	21.4286	18.1818
Unsure	12.8205	17.8571	0
n	39	28	11

<L4C> Please rate how significant ENERGY RELIABILITY is in your decision to not install storage

L4C	ALL	Residential	Nonresidential
1 Not at all Significant	23.0769	25	18.1818
2	12.8205	10.7143	18.1818
3	28.2051	21.4286	45.4545
4	7.6923	7.1429	9.0909
5 Very Significant	15.3846	17.8571	9.0909
Unsure	12.8205	17.8571	0
n	39	28	11

<L4D> Please rate how significant HOW THE BATTERY STORAGE LOOKS is in your decision to not install storage

L4D	ALL	Residential	Nonresidential
1 Not at all Significant	51.2821	50	54.5455
2	10.2564	10.7143	9.0909
3	12.8205	10.7143	18.1818
4	5.1282	3.5714	9.0909
5 Very Significant	15.3846	17.8571	9.0909
Unsure	5.1282	7.1429	0
n	39	28	11

<L4E> Please rate how significant SPACE THE BATTERY STORAGE TAKES UP is in your decision to not install storage

L4E	ALL	Residential	Nonresidential
1 Not at all Significant	35.8974	28.5714	54.5455
2	7.6923	10.7143	0
3	12.8205	7.1429	27.2727
4	15.3846	17.8571	9.0909
5 Very Significant	17.9487	21.4286	9.0909
Unsure	10.2564	14.2857	0
n	39	28	11

<RES1> How long have you owned your home?

RES1	ALL	Residential	Nonresidential
Less than 5 years	5.825	5.825	0
5 to 9 years	12.621	12.621	0
10 to 14 years	21.359	21.359	0
15 to 19 years	12.621	12.621	0
20 to 24 years	13.592	13.592	0
25 or more years	33.981	33.981	0
n	103	103	0

<RES2> Which of the following dwelling types best describes your home?

RES2	ALL	Residential	Nonresidential
Single Family house	98.058	98.058	0
Townhouse, duplex or row house	0.971	0.971	0
Co-op	0.971	0.971	0
n	103	103	0

<RES3_1> Less than 18 years old

RES3_1	ALL	Residential	Nonresidential
1	31.25	31.25	0
2	37.5	37.5	0
3	25	25	0
4	6.25	6.25	0
n	16	16	0

<RES3_2> 18-24 years old

RES3_2	ALL	Residential	Nonresidential
1	33.3333	33.3333	0
2	66.6667	66.6667	0
n	9	9	0

<RES3_3> 25-34 years old

RES3_3	ALL	Residential	Nonresidential
1	77.7778	77.7778	0
2	22.2222	22.2222	0
n	9	9	0

<RES3_4> 35-44 years old

RES3_4	ALL	Residential	Nonresidential
1	46.1538	46.1538	0
2	53.8462	53.8462	0
n	13	13	0

<RES3_5> 45-54 years old

RES3_5	ALL	Residential	Nonresidential
1	40	40	0
2	60	60	0
n	20	20	0

<RES3_6> *55-64 years old*

RES3_6	ALL	Residential	Nonresidential
1	41.0256	41.0256	0
2	56.4103	56.4103	0
4	2.5641	2.5641	0
n	39	39	0

<RES3_7> *65+ years old*

RES3_7	ALL	Residential	Nonresidential
1	22.6415	22.6415	0
2	75.4717	75.4717	0
3	1.8868	1.8868	0
n	53	53	0

<RES4> *Which of the following best represents your annual household income from all sources before taxes?*

RES4	ALL	Residential	Nonresidential
Less than $50,000	2.941	2.941	0
$50,000 or more but less than $75,000	8.824	8.824	0
$75,000 or more but less than $100,000	14.706	14.706	0
$100,000 or more	55.882	55.882	0
Don't know	17.647	17.647	0
n	102	102	0

<RES5> *What is the highest level of education attained by the head of household?*

RES5	ALL	Residential	Nonresidential
High school graduate	0.98	0.98	0
Trade or technical school	1.961	1.961	0
Some college	9.804	9.804	0
College graduate	28.431	28.431	0
Some graduate school	10.784	10.784	0
Post-graduate degree	45.098	45.098	0
Don't Know	2.941	2.941	0
n	102	102	0

<RES6> *How would you classify the location where you live?*

RES6	ALL	Residential	Nonresidential
Urban	20.588	20.588	0
Suburban	59.804	59.804	0
Rural	18.627	18.627	0
Don't know	0.98	0.98	0
n	102	102	0

<RES7> Compared to others, which description best describes you or your household?

RES7	ALL	Residential	Nonresidential
Usually among the last to try a new product	1.961	1.961	0
Usually in the middle when it comes to trying a new product	48.039	48.039	0
Usually among the first to try a new product	33.333	33.333	0
Usually the first to try a new product	6.863	6.863	0
Don't know	9.804	9.804	0
n	102	102	0

<RES8> Which of the following best describes where you reside with respect to wildfire risk.

RES8	ALL	Residential	Nonresidential
I reside in an area with high wildfire risk	13.725	13.725	0
I reside in an area with moderate wildfire risk	34.314	34.314	0
I reside in an area with low wildfire risk	48.039	48.039	0
Don't know	3.922	3.922	0
n	102	102	0

<RES9> Has your home ever been affected by your utility using preventative fire outages on days with high fire risk?

RES9	ALL	Residential	Nonresidential
Yes, I have lost power at my home due to my utility using preventative fire outages	6.1224	6.1224	0
No, I have not lost power at my home due to my utility using preventative fire outages	85.7143	85.7143	0
Don't know	8.1633	8.1633	0
n	49	49	0

<NONRES1> Does your organization own or lease the facility where you work?

NONRES1	ALL	Residential	Nonresidential
Own	94.2857	0	94.2857
Own and Lease to a tenant	2.8571	0	2.8571
Don't Know	2.8571	0	2.8571
n	35	0	35

<NONRES3> ***What is the approximate number of full-time equivalent workers of all types employed by your organization at the facility where you work?***

NONRES3	ALL	Residential	Nonresidential
1 to 10	41.1765	0	41.1765
11 to 50	32.3529	0	32.3529
51 to 100	8.8235	0	8.8235
101 to 250	2.9412	0	2.9412
251 to 500	2.9412	0	2.9412
501 to 1,000	2.9412	0	2.9412
More than 1,000	2.9412	0	2.9412
Don't Know	5.8824	0	5.8824
n	34	0	34

<NONRES4> ***Does your organization have any company goals regarding sustainability, GHG reductions, or climate change? (Select all that apply)***

NONRES4	ALL	Residential	Nonresidential
Yes - we have sustainability goals	21.2121	0	21.2121
Yes - we have GHG reduction goals	6.0606	0	6.0606
Yes - we have climate change goals	3.0303	0	3.0303
Yes - we have other environmental goals	12.1212	0	12.1212
No	51.5152	0	51.5152
Don't Know	6.0606	0	6.0606
n	33	0	33

<NONRES4> ***Does your organization have any company goals regarding sustainability, GHG reductions, or climate change? (Select all that apply)***

NONRES4A	ALL	Residential	Nonresidential
Efficient rice varieties and production methods for our grower owners	25	0	25
Proprietary	25	0	25
Sustainability	25	0	25
Blank	25	0	25
n	4	0	4

** Values are shown as percent of survey participants.*

** n is the number of respondents.*

APPENDIX C SUMMARY OF COST-EFFECTIVENESS RESULTS

This appendix includes tables with benefit-cost ratios for each simulation run for this analysis. Each table includes the benefit ratio for the Participant Cost Test (PCT), Total Resource Cost Test (TRC), Ratepayer Impact Measure Test (RIM), and the Program Administrator Test (PA). Results are listed for 2018, 2024, and 2028. Note that the PA and RIM test results are not presented for cases without an SGIP incentive.

TABLE C-1: RESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE, 2018, 2024, AND 2028

						2018				2024				2028			
Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.53	0.00	0.27	0.00	0.87	0.00	0.41	0.00	1.19	0.00	0.54	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.78	0.29	0.23	0.72	1.11	0.33	0.36	1.03	1.42	0.34	0.48	1.29
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.62	0.00	0.39	0.00	0.73	0.00	0.50	0.00	0.97	0.00	0.80	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.78	0.23	0.23	0.46	0.96	0.42	0.40	1.09	1.20	0.57	0.68	1.75
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.61	0.00	0.40	0.00	1.01	0.00	0.69	0.00	1.38	0.00	0.96	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.86	0.41	0.35	1.09	1.25	0.50	0.62	1.75	1.60	0.56	0.88	2.34
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.30	0.00	0.50	0.00	0.14	0.00	0.52	0.00	0.15	0.00	0.71	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.46	0.64	0.33	0.66	0.38	1.04	0.41	1.11	0.40	1.38	0.59	1.50
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.42	0.00	0.35	0.00	0.41	0.00	0.42	0.00	0.52	0.00	0.68	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.59	0.23	0.19	0.34	0.64	0.50	0.32	0.88	0.76	0.74	0.57	1.47
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.23	0.00	0.35	0.00	0.36	0.00	0.60	0.00	0.48	0.00	0.84	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.50	0.62	0.31	0.96	0.64	0.83	0.54	1.53	0.76	0.99	0.76	2.04
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.45	0.00	0.33	0.00	0.73	0.00	0.52	0.00	1.00	0.00	0.68	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.70	0.41	0.29	0.90	0.98	0.47	0.46	1.32	1.25	0.50	0.62	1.64
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.34	0.00	0.12	0.00	0.55	0.00	0.32	0.00	0.75	0.00	0.54	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.60	0.15	0.09	0.27	0.82	0.34	0.28	0.78	1.01	0.48	0.49	1.30
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.60	0.00	0.37	0.00	1.00	0.00	0.63	0.00	1.36	0.00	0.88	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.85	0.38	0.32	1.00	1.23	0.47	0.57	1.62	1.57	0.51	0.80	2.13
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.05	0.00	0.22	0.00	0.06	0.00	0.41	0.00	0.07	0.00	0.59	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.55	0.18	0.57	0.36	0.96	0.36	1.03	0.38	1.30	0.53	1.42
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.20	0.00	0.08	0.00	0.33	0.00	0.27	0.00	0.44	0.00	0.49	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.12	0.06	0.17	0.61	0.37	0.23	0.65	0.72	0.59	0.43	1.15
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.22	0.00	0.33	0.00	0.35	0.00	0.58	0.00	0.46	0.00	0.81	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.49	0.59	0.29	0.90	0.63	0.81	0.52	1.47	0.75	0.96	0.73	1.95
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.35	0.00	0.41	0.00	0.20	0.00	0.52	0.00	0.21	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.11	0.17	0.17	0.63	0.13	0.09	0.23	0.75	0.13	0.10	0.25
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.54	0.00	0.49	0.00	0.52	0.00	0.48	0.00	0.67	0.00	0.65	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.68	0.34	0.31	0.57	0.74	0.48	0.36	0.97	0.90	0.58	0.53	1.34
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.44	0.00	0.41	0.00	0.39	0.00	0.51	0.00	0.53	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.29	0.26	0.42	0.63	0.43	0.27	0.74	0.75	0.54	0.41	1.04
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.48	0.00	0.15	0.00	0.41	0.00	0.16	0.00	0.51	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.52	0.30	0.54	0.38	0.75	0.30	0.79	0.40	0.94	0.40	1.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.47	0.00	0.31	0.00	0.45	0.00	0.37	0.00	0.61	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.41	0.30	0.54	0.53	0.62	0.34	0.91	0.61	0.79	0.49	1.25
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.42	0.00	0.30	0.00	0.35	0.00	0.37	0.00	0.48	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.28	0.24	0.37	0.53	0.44	0.24	0.64	0.61	0.58	0.36	0.91
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.33	0.00	0.29	0.00	0.18	0.00	0.35	0.00	0.19	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.10	0.16	0.13	0.51	0.12	0.07	0.18	0.59	0.13	0.08	0.20
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.38	0.00	0.35	0.00	0.28	0.00	0.43	0.00	0.35	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.20	0.21	0.27	0.57	0.28	0.17	0.45	0.67	0.35	0.24	0.61
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.36	0.00	0.29	0.00	0.24	0.00	0.35	0.00	0.30	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.16	0.18	0.20	0.52	0.24	0.13	0.34	0.59	0.32	0.19	0.49

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.40	0.00	0.14	0.00	0.29	0.00	0.15	0.00	0.35	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.46	0.30	0.22	0.31	0.37	0.45	0.17	0.47	0.39	0.58	0.24	0.61
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.39	0.00	0.23	0.00	0.29	0.00	0.27	0.00	0.37	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.24	0.21	0.29	0.46	0.37	0.18	0.47	0.51	0.48	0.26	0.65
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.36	0.00	0.23	0.00	0.24	0.00	0.27	0.00	0.30	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.17	0.18	0.20	0.46	0.27	0.13	0.34	0.51	0.35	0.19	0.47

TABLE C-2: RESIDENTIAL COST-EFFECTIVENESS RESULTS, WITH BACKUP, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018 PCT Ratio	2018 RIM Ratio	2018 TRC Ratio	2018 PA Ratio	2024 PCT Ratio	2024 RIM Ratio	2024 TRC Ratio	2024 PA Ratio	2028 PCT Ratio	2028 RIM Ratio	2028 TRC Ratio	2028 PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.55	0.00	0.27	0.00	0.91	0.00	0.42	0.00	1.25	0.00	0.55	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.80	0.30	0.23	0.72	1.15	0.33	0.37	1.04	1.48	0.35	0.49	1.31
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.64	0.00	0.40	0.00	0.78	0.00	0.51	0.00	1.03	0.00	0.81	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.80	0.23	0.24	0.48	1.00	0.43	0.41	1.12	1.26	0.58	0.70	1.79
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.64	0.00	0.40	0.00	1.06	0.00	0.68	0.00	1.44	0.00	0.96	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.88	0.41	0.35	1.09	1.29	0.50	0.62	1.75	1.65	0.55	0.87	2.33
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.33	0.00	0.49	0.00	0.18	0.00	0.51	0.00	0.21	0.00	0.69	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.48	0.63	0.32	0.65	0.42	1.02	0.40	1.09	0.46	1.36	0.58	1.47
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.45	0.00	0.35	0.00	0.45	0.00	0.43	0.00	0.58	0.00	0.69	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.61	0.24	0.20	0.36	0.68	0.51	0.33	0.91	0.82	0.76	0.59	1.50
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.25	0.00	0.35	0.00	0.40	0.00	0.60	0.00	0.54	0.00	0.84	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.52	0.61	0.31	0.95	0.68	0.83	0.54	1.52	0.82	0.98	0.76	2.03
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.47	0.00	0.33	0.00	0.77	0.00	0.51	0.00	1.06	0.00	0.67	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.73	0.40	0.29	0.89	1.02	0.46	0.46	1.30	1.30	0.49	0.61	1.62
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.36	0.00	0.12	0.00	0.59	0.00	0.32	0.00	0.80	0.00	0.54	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.62	0.15	0.09	0.28	0.85	0.34	0.28	0.79	1.06	0.48	0.49	1.30
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.63	0.00	0.36	0.00	1.04	0.00	0.63	0.00	1.42	0.00	0.87	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.87	0.38	0.32	0.99	1.27	0.46	0.57	1.60	1.63	0.51	0.79	2.11
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.07	0.00	0.21	0.00	0.10	0.00	0.40	0.00	0.13	0.00	0.58	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.35	0.53	0.18	0.56	0.40	0.94	0.35	1.00	0.44	1.28	0.52	1.38
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.23	0.00	0.08	0.00	0.37	0.00	0.27	0.00	0.49	0.00	0.48	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.50	0.12	0.06	0.18	0.65	0.37	0.23	0.65	0.77	0.59	0.43	1.15
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.24	0.00	0.33	0.00	0.39	0.00	0.57	0.00	0.52	0.00	0.80	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.51	0.59	0.29	0.89	0.66	0.81	0.51	1.46	0.80	0.96	0.72	1.93
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.50	0.00	0.36	0.00	0.45	0.00	0.21	0.00	0.58	0.00	0.22	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.65	0.13	0.18	0.19	0.68	0.15	0.10	0.26	0.81	0.15	0.11	0.28
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.57	0.00	0.48	0.00	0.56	0.00	0.47	0.00	0.73	0.00	0.64	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.71	0.33	0.30	0.55	0.78	0.47	0.35	0.94	0.96	0.57	0.52	1.31
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.50	0.00	0.44	0.00	0.45	0.00	0.39	0.00	0.57	0.00	0.53	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.64	0.28	0.26	0.42	0.67	0.43	0.27	0.73	0.80	0.54	0.41	1.04
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.35	0.00	0.49	0.00	0.19	0.00	0.43	0.00	0.21	0.00	0.54	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.49	0.55	0.31	0.57	0.42	0.81	0.32	0.85	0.45	1.01	0.42	1.07
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.47	0.00	0.35	0.00	0.44	0.00	0.43	0.00	0.59	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.39	0.29	0.51	0.57	0.60	0.32	0.87	0.67	0.76	0.48	1.20

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.43	0.00	0.34	0.00	0.37	0.00	0.43	0.00	0.50	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.30	0.25	0.39	0.57	0.47	0.25	0.68	0.66	0.62	0.38	0.97
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.43	0.00	0.34	0.00	0.33	0.00	0.18	0.00	0.41	0.00	0.19	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.57	0.11	0.16	0.14	0.55	0.13	0.07	0.19	0.64	0.14	0.08	0.21
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.46	0.00	0.40	0.00	0.39	0.00	0.32	0.00	0.49	0.00	0.41	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.61	0.24	0.23	0.33	0.61	0.35	0.20	0.55	0.72	0.44	0.30	0.75
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.43	0.00	0.37	0.00	0.33	0.00	0.27	0.00	0.41	0.00	0.34	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.57	0.19	0.20	0.24	0.56	0.29	0.15	0.41	0.64	0.38	0.23	0.58
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.34	0.00	0.41	0.00	0.18	0.00	0.32	0.00	0.20	0.00	0.40	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.49	0.35	0.24	0.36	0.41	0.53	0.21	0.55	0.45	0.69	0.28	0.72

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.40	0.00	0.27	0.00	0.31	0.00	0.33	0.00	0.40	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.54	0.27	0.22	0.32	0.50	0.42	0.20	0.53	0.57	0.54	0.29	0.72
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.37	0.00	0.27	0.00	0.26	0.00	0.33	0.00	0.33	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.54	0.19	0.19	0.23	0.50	0.31	0.14	0.39	0.57	0.40	0.21	0.54

TABLE C-3: RESIDENTIAL COST-EFFECTIVENESS RESULTS, WITH GHG SIGNAL (LOW), 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.53	0.00	0.40	0.00	0.87	0.00	0.63	0.00	1.20	0.00	0.85	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.78	0.45	0.35	1.10	1.11	0.51	0.57	1.62	1.42	0.55	0.77	2.05
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.40	0.00	0.50	0.00	0.66	0.00	0.91	0.00	0.90	0.00	1.32	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.66	0.67	0.45	1.38	0.92	0.90	0.83	2.35	1.15	1.06	1.21	3.24
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.61	0.00	0.43	0.00	1.02	0.00	0.76	0.00	1.39	0.00	1.08	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.86	0.45	0.38	1.19	1.25	0.55	0.69	1.95	1.60	0.62	0.98	2.62
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.05	0.00	0.31	0.00	0.06	0.00	0.51	0.00	0.07	0.00	0.70	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.79	0.27	0.82	0.36	1.21	0.46	1.29	0.38	1.55	0.63	1.68
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.21	0.00	0.44	0.00	0.33	0.00	0.82	0.00	0.45	0.00	1.21	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.81	0.39	1.22	0.62	1.19	0.75	2.11	0.73	1.48	1.10	2.94
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.23	0.00	0.37	0.00	0.36	0.00	0.64	0.00	0.48	0.00	0.90	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.50	0.65	0.32	1.01	0.64	0.89	0.58	1.64	0.76	1.06	0.82	2.19
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.45	0.00	0.41	0.00	0.73	0.00	0.67	0.00	1.01	0.00	0.90	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.70	0.52	0.37	1.14	0.98	0.61	0.60	1.71	1.25	0.65	0.81	2.17
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.34	0.00	0.40	0.00	0.55	0.00	0.74	0.00	0.75	0.00	1.06	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.60	0.59	0.36	1.10	0.82	0.81	0.67	1.89	1.01	0.96	0.97	2.58
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.60	0.00	0.37	0.00	1.00	0.00	0.65	0.00	1.36	0.00	0.92	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.85	0.38	0.33	1.01	1.23	0.48	0.59	1.66	1.58	0.54	0.83	2.23
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.05	0.00	0.27	0.00	0.06	0.00	0.46	0.00	0.07	0.00	0.63	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.68	0.23	0.71	0.36	1.08	0.41	1.15	0.38	1.39	0.57	1.51
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.20	0.00	0.36	0.00	0.33	0.00	0.69	0.00	0.44	0.00	1.01	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.66	0.32	0.99	0.61	1.01	0.62	1.76	0.72	1.26	0.92	2.46
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.22	0.00	0.32	0.00	0.35	0.00	0.56	0.00	0.46	0.00	0.79	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.49	0.57	0.28	0.87	0.63	0.79	0.50	1.43	0.75	0.94	0.72	1.91
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.48	0.00	0.41	0.00	0.45	0.00	0.52	0.00	0.58	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.38	0.31	0.56	0.63	0.52	0.33	0.90	0.75	0.60	0.46	1.17
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.54	0.00	0.55	0.00	0.52	0.00	0.61	0.00	0.67	0.00	0.84	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.68	0.45	0.37	0.75	0.74	0.66	0.49	1.32	0.90	0.80	0.72	1.83
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.52	0.00	0.41	0.00	0.55	0.00	0.51	0.00	0.76	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.45	0.34	0.66	0.63	0.68	0.43	1.16	0.75	0.84	0.64	1.62
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.50	0.00	0.15	0.00	0.47	0.00	0.16	0.00	0.61	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.58	0.32	0.60	0.38	0.90	0.35	0.95	0.40	1.15	0.49	1.23
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.52	0.00	0.31	0.00	0.56	0.00	0.37	0.00	0.77	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.52	0.35	0.68	0.53	0.81	0.44	1.19	0.61	1.03	0.65	1.65

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.50	0.00	0.30	0.00	0.51	0.00	0.37	0.00	0.70	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.46	0.32	0.60	0.53	0.73	0.40	1.06	0.61	0.93	0.58	1.47
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.44	0.00	0.29	0.00	0.37	0.00	0.35	0.00	0.46	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.34	0.26	0.43	0.51	0.48	0.25	0.68	0.59	0.57	0.35	0.88
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.46	0.00	0.35	0.00	0.43	0.00	0.43	0.00	0.57	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.35	0.28	0.48	0.57	0.53	0.31	0.84	0.67	0.66	0.45	1.14
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.45	0.00	0.29	0.00	0.41	0.00	0.35	0.00	0.54	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.35	0.27	0.45	0.52	0.56	0.29	0.79	0.59	0.71	0.43	1.08
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.44	0.00	0.14	0.00	0.38	0.00	0.15	0.00	0.49	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.46	0.43	0.26	0.44	0.37	0.69	0.27	0.71	0.39	0.90	0.37	0.94

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.45	0.00	0.23	0.00	0.42	0.00	0.27	0.00	0.56	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.40	0.28	0.47	0.46	0.64	0.30	0.82	0.51	0.82	0.44	1.11
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.44	0.00	0.23	0.00	0.39	0.00	0.27	0.00	0.52	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.36	0.26	0.43	0.46	0.58	0.28	0.74	0.51	0.75	0.40	1.01

TABLE C-4: RESIDENTIAL COST-EFFECTIVENESS RESULTS, WITH GHG SIGNAL (HIGH), 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.53	0.00	0.40	0.00	0.87	0.00	0.64	0.00	1.19	0.00	0.86	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.78	0.45	0.36	1.10	1.11	0.52	0.58	1.63	1.42	0.55	0.78	2.07
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.40	0.00	0.51	0.00	0.65	0.00	0.93	0.00	0.89	0.00	1.35	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.66	0.69	0.45	1.41	0.91	0.93	0.85	2.40	1.14	1.09	1.24	3.31
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.61	0.00	0.43	0.00	1.01	0.00	0.75	0.00	1.38	0.00	1.06	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.85	0.44	0.38	1.17	1.24	0.54	0.67	1.91	1.60	0.61	0.96	2.57
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.04	0.00	0.31	0.00	0.05	0.00	0.53	0.00	0.06	0.00	0.73	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.82	0.27	0.85	0.35	1.28	0.48	1.35	0.37	1.66	0.66	1.77
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.21	0.00	0.49	0.00	0.33	0.00	0.90	0.00	0.44	0.00	1.32	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.90	0.44	1.35	0.61	1.32	0.82	2.33	0.73	1.63	1.21	3.22
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.22	0.00	0.38	0.00	0.35	0.00	0.65	0.00	0.47	0.00	0.92	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.49	0.67	0.33	1.03	0.63	0.92	0.59	1.67	0.75	1.10	0.84	2.24
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.45	0.00	0.42	0.00	0.73	0.00	0.67	0.00	1.00	0.00	0.90	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.70	0.52	0.37	1.14	0.98	0.62	0.61	1.72	1.24	0.66	0.82	2.19
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.33	0.00	0.41	0.00	0.54	0.00	0.76	0.00	0.73	0.00	1.10	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.59	0.61	0.37	1.14	0.80	0.85	0.69	1.95	0.99	1.01	1.00	2.68
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.60	0.00	0.37	0.00	1.00	0.00	0.64	0.00	1.36	0.00	0.91	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.85	0.38	0.32	1.00	1.23	0.47	0.58	1.64	1.57	0.53	0.82	2.20
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.05	0.00	0.28	0.00	0.05	0.00	0.48	0.00	0.06	0.00	0.66	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.71	0.24	0.74	0.36	1.14	0.42	1.20	0.38	1.49	0.60	1.60
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.20	0.00	0.40	0.00	0.32	0.00	0.75	0.00	0.43	0.00	1.10	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.47	0.73	0.35	1.09	0.60	1.11	0.68	1.93	0.72	1.38	1.01	2.68
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.21	0.00	0.33	0.00	0.34	0.00	0.57	0.00	0.46	0.00	0.80	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.48	0.58	0.28	0.88	0.62	0.81	0.51	1.45	0.74	0.97	0.73	1.94
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.48	0.00	0.41	0.00	0.45	0.00	0.52	0.00	0.58	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.38	0.31	0.56	0.63	0.51	0.33	0.89	0.75	0.60	0.46	1.16
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.54	0.00	0.54	0.00	0.52	0.00	0.60	0.00	0.67	0.00	0.83	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.68	0.44	0.36	0.73	0.74	0.64	0.48	1.29	0.90	0.78	0.71	1.79
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.48	0.00	0.51	0.00	0.41	0.00	0.55	0.00	0.51	0.00	0.76	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.44	0.34	0.65	0.63	0.67	0.43	1.16	0.74	0.84	0.64	1.61
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.50	0.00	0.14	0.00	0.48	0.00	0.15	0.00	0.62	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.46	0.59	0.32	0.61	0.37	0.93	0.36	0.97	0.39	1.20	0.50	1.27
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.51	0.00	0.30	0.00	0.54	0.00	0.37	0.00	0.75	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.49	0.33	0.64	0.53	0.79	0.43	1.15	0.61	1.01	0.63	1.60

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.49	0.00	0.30	0.00	0.51	0.00	0.36	0.00	0.70	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.46	0.32	0.59	0.53	0.73	0.39	1.05	0.60	0.94	0.58	1.47
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.44	0.00	0.29	0.00	0.37	0.00	0.35	0.00	0.47	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.34	0.27	0.44	0.51	0.49	0.26	0.69	0.59	0.59	0.36	0.90
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.45	0.00	0.35	0.00	0.42	0.00	0.43	0.00	0.57	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.35	0.28	0.48	0.57	0.53	0.31	0.83	0.67	0.66	0.45	1.14
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.44	0.00	0.29	0.00	0.40	0.00	0.35	0.00	0.54	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.35	0.27	0.44	0.51	0.55	0.29	0.77	0.59	0.69	0.42	1.06
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.43	0.00	0.14	0.00	0.37	0.00	0.14	0.00	0.48	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.46	0.41	0.26	0.42	0.37	0.67	0.26	0.69	0.39	0.88	0.36	0.92

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.45	0.00	0.23	0.00	0.41	0.00	0.27	0.00	0.54	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.38	0.27	0.45	0.46	0.62	0.29	0.79	0.51	0.80	0.42	1.08
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.44	0.00	0.23	0.00	0.39	0.00	0.27	0.00	0.52	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.51	0.36	0.26	0.43	0.46	0.59	0.28	0.75	0.51	0.77	0.41	1.03

TABLE C-5: RESIDENTIAL COST-EFFECTIVENESS RESULTS, WITH DEMAND RESPONSE, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.66	0.00	0.28	0.00	1.09	0.00	0.42	0.00	1.51	0.00	0.55	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.90	0.26	0.24	0.53	1.32	0.28	0.37	0.67	1.71	0.29	0.49	0.75
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.67	0.00	0.39	0.00	0.82	0.00	0.50	0.00	1.09	0.00	0.79	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.83	0.21	0.23	0.40	1.04	0.38	0.40	0.89	1.31	0.52	0.68	1.36
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.66	0.00	0.39	0.00	1.10	0.00	0.67	0.00	1.50	0.00	0.95	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.90	0.38	0.35	0.94	1.32	0.46	0.61	1.42	1.70	0.51	0.86	1.80
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.36	0.00	0.50	0.00	0.23	0.00	0.53	0.00	0.28	0.00	0.71	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.51	0.56	0.33	0.58	0.47	0.86	0.41	0.91	0.53	1.09	0.60	1.16
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.46	0.00	0.34	0.00	0.47	0.00	0.42	0.00	0.61	0.00	0.67	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.63	0.21	0.19	0.30	0.71	0.45	0.32	0.74	0.85	0.66	0.57	1.19
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.29	0.00	0.34	0.00	0.47	0.00	0.59	0.00	0.64	0.00	0.83	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.56	0.53	0.30	0.78	0.75	0.70	0.53	1.15	0.91	0.81	0.75	1.44
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.55	0.00	0.32	0.00	0.89	0.00	0.49	0.00	1.23	0.00	0.65	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.79	0.34	0.28	0.67	1.13	0.39	0.44	0.88	1.46	0.41	0.59	1.01
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.43	0.00	0.14	0.00	0.71	0.00	0.35	0.00	0.97	0.00	0.59	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.69	0.16	0.11	0.27	0.96	0.32	0.31	0.62	1.21	0.44	0.53	0.93
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.72	0.00	0.37	0.00	1.19	0.00	0.63	0.00	1.64	0.00	0.87	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.96	0.34	0.32	0.75	1.41	0.40	0.57	1.06	1.83	0.44	0.79	1.27
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.15	0.00	0.23	0.00	0.23	0.00	0.42	0.00	0.31	0.00	0.60	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.42	0.45	0.20	0.47	0.52	0.70	0.37	0.73	0.60	0.87	0.54	0.92
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.30	0.00	0.11	0.00	0.48	0.00	0.30	0.00	0.66	0.00	0.53	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.56	0.14	0.08	0.19	0.75	0.34	0.26	0.53	0.92	0.51	0.48	0.84
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.34	0.00	0.33	0.00	0.55	0.00	0.57	0.00	0.75	0.00	0.80	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.60	0.48	0.29	0.67	0.81	0.63	0.51	0.96	1.01	0.72	0.72	1.16
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.67	0.00	0.40	0.00	0.73	0.00	0.27	0.00	0.97	0.00	0.30	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.81	0.15	0.22	0.20	0.95	0.16	0.16	0.23	1.19	0.16	0.19	0.23
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.62	0.00	0.49	0.00	0.65	0.00	0.48	0.00	0.85	0.00	0.66	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.76	0.31	0.31	0.48	0.87	0.42	0.37	0.74	1.07	0.50	0.54	0.96
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.58	0.00	0.44	0.00	0.57	0.00	0.39	0.00	0.75	0.00	0.53	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.72	0.24	0.26	0.33	0.79	0.34	0.28	0.52	0.97	0.42	0.41	0.67
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.41	0.00	0.48	0.00	0.29	0.00	0.42	0.00	0.36	0.00	0.53	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.43	0.31	0.44	0.52	0.58	0.30	0.60	0.59	0.67	0.41	0.70
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.49	0.00	0.48	0.00	0.43	0.00	0.46	0.00	0.55	0.00	0.62	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.63	0.36	0.30	0.45	0.66	0.52	0.34	0.70	0.79	0.63	0.50	0.89
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.52	0.00	0.42	0.00	0.47	0.00	0.36	0.00	0.60	0.00	0.48	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.66	0.24	0.24	0.29	0.69	0.34	0.24	0.46	0.84	0.43	0.36	0.59
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.60	0.00	0.38	0.00	0.61	0.00	0.24	0.00	0.80	0.00	0.28	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.74	0.14	0.20	0.17	0.83	0.16	0.13	0.20	1.03	0.16	0.16	0.20
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/	No	0.53	0.00	0.42	0.00	0.50	0.00	0.34	0.00	0.64	0.00	0.43	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
				PV Charging													
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.23	0.24	0.30	0.72	0.31	0.22	0.43	0.87	0.36	0.32	0.54
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.53	0.00	0.38	0.00	0.50	0.00	0.27	0.00	0.64	0.00	0.34	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.16	0.20	0.19	0.72	0.21	0.16	0.28	0.87	0.26	0.23	0.35
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.42	0.00	0.30	0.00	0.32	0.00	0.37	0.00	0.40	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.29	0.24	0.30	0.53	0.38	0.21	0.40	0.61	0.45	0.28	0.47
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.46	0.00	0.42	0.00	0.38	0.00	0.33	0.00	0.48	0.00	0.43	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.60	0.26	0.24	0.29	0.61	0.36	0.22	0.43	0.72	0.44	0.32	0.54
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.49	0.00	0.38	0.00	0.44	0.00	0.27	0.00	0.56	0.00	0.34	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.64	0.16	0.20	0.19	0.66	0.23	0.15	0.27	0.79	0.28	0.22	0.34

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TABLE C-6: RESIDENTIAL COST-EFFECTIVENESS RESULTS, WITH DISTRIBUTION DEFERRAL, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.88	0.73	0.64	1.43	1.18	0.89	1.05	2.30	1.47	0.99	1.43	3.09
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.85	0.74	0.63	1.27	1.03	1.04	1.07	2.28	1.25	1.26	1.56	3.26
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.95	0.70	0.67	1.48	1.30	0.86	1.11	2.43	1.62	0.95	1.52	3.27
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.51	1.18	0.61	1.20	0.47	1.98	0.96	2.03	0.48	2.71	1.35	2.81
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.66	0.87	0.58	1.17	0.73	1.35	0.99	2.10	0.83	1.74	1.45	3.03
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.61	1.03	0.63	1.41	0.72	1.43	1.05	2.29	0.83	1.71	1.43	3.08
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.81	0.87	0.71	1.58	1.06	1.09	1.16	2.54	1.30	1.22	1.58	3.41
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.71	0.77	0.55	1.23	0.90	1.11	1.01	2.20	1.07	1.36	1.46	3.14
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.94	0.71	0.67	1.48	1.29	0.87	1.12	2.45	1.60	0.97	1.53	3.30
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.45	1.15	0.52	1.17	0.46	1.96	0.92	2.01	0.46	2.70	1.30	2.80
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.59	0.85	0.51	1.13	0.70	1.34	0.94	2.07	0.79	1.73	1.39	2.98
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.60	1.06	0.65	1.44	0.71	1.50	1.08	2.37	0.82	1.80	1.48	3.19
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.80	0.55	1.04	0.70	1.13	0.80	1.68	0.80	1.36	1.10	2.26
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.73	0.85	0.62	1.20	0.79	1.20	0.95	2.01	0.92	1.45	1.34	2.76
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.89	0.60	1.15	0.70	1.28	0.90	1.89	0.78	1.57	1.25	2.58
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.53	1.19	0.62	1.20	0.47	1.91	0.92	1.94	0.47	2.58	1.27	2.63

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.61	1.00	0.61	1.18	0.61	1.52	0.93	1.96	0.66	1.94	1.31	2.71
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.61	0.96	0.59	1.13	0.61	1.43	0.89	1.86	0.66	1.81	1.22	2.53
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.60	0.84	0.51	0.98	0.59	1.25	0.75	1.59	0.64	1.58	1.04	2.14
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.63	0.88	0.56	1.07	0.64	1.31	0.84	1.77	0.70	1.64	1.17	2.43
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.60	0.88	0.54	1.02	0.59	1.33	0.80	1.67	0.64	1.69	1.10	2.28
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	1.08	0.57	1.09	0.47	1.77	0.85	1.78	0.47	2.40	1.17	2.43
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.57	0.97	0.56	1.07	0.54	1.52	0.84	1.76	0.57	1.98	1.17	2.41
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.57	0.92	0.53	1.02	0.54	1.42	0.79	1.66	0.57	1.85	1.09	2.25

TABLE C-7: RESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH 15-YEAR LIFE, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.69	0.00	0.35	0.00	1.12	0.00	0.53	0.00	1.54	0.00	0.71	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.92	0.32	0.30	0.93	1.34	0.35	0.47	1.34	1.73	0.37	0.63	1.70
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.74	0.00	0.48	0.00	0.92	0.00	0.68	0.00	1.22	0.00	1.04	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.89	0.30	0.33	0.73	1.13	0.50	0.57	1.56	1.43	0.65	0.92	2.38
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.80	0.00	0.53	0.00	1.30	0.00	0.91	0.00	1.76	0.00	1.27	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	1.02	0.46	0.47	1.46	1.50	0.55	0.82	2.34	1.94	0.60	1.16	3.10
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.32	0.00	0.58	0.00	0.16	0.00	0.66	0.00	0.18	0.00	0.89	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.46	0.85	0.41	0.91	0.39	1.35	0.54	1.47	0.41	1.77	0.77	1.97
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.49	0.00	0.43	0.00	0.50	0.00	0.58	0.00	0.65	0.00	0.90	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.64	0.33	0.27	0.56	0.73	0.64	0.47	1.28	0.88	0.88	0.78	2.01
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.30	0.00	0.47	0.00	0.46	0.00	0.79	0.00	0.62	0.00	1.10	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.55	0.74	0.41	1.28	0.72	0.97	0.71	2.03	0.88	1.13	1.00	2.69
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.58	0.00	0.43	0.00	0.94	0.00	0.67	0.00	1.30	0.00	0.88	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.82	0.45	0.37	1.17	1.17	0.51	0.60	1.71	1.51	0.53	0.80	2.15
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.44	0.00	0.19	0.00	0.71	0.00	0.45	0.00	0.96	0.00	0.73	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.69	0.22	0.15	0.47	0.95	0.41	0.40	1.13	1.19	0.55	0.65	1.75
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.78	0.00	0.49	0.00	1.28	0.00	0.83	0.00	1.73	0.00	1.15	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	1.01	0.42	0.43	1.34	1.48	0.51	0.75	2.15	1.91	0.55	1.05	2.81
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.06	0.00	0.30	0.00	0.08	0.00	0.54	0.00	0.09	0.00	0.77	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.34	0.76	0.26	0.80	0.37	1.26	0.48	1.37	0.39	1.67	0.69	1.86
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.27	0.00	0.15	0.00	0.42	0.00	0.39	0.00	0.56	0.00	0.66	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.53	0.21	0.11	0.34	0.69	0.49	0.34	0.97	0.83	0.70	0.59	1.58
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.29	0.00	0.44	0.00	0.45	0.00	0.76	0.00	0.59	0.00	1.05	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.54	0.71	0.39	1.21	0.71	0.95	0.68	1.95	0.86	1.10	0.95	2.56
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.54	0.00	0.37	0.00	0.50	0.00	0.23	0.00	0.65	0.00	0.25	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.13	0.19	0.21	0.72	0.15	0.11	0.29	0.87	0.15	0.13	0.33
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.62	0.00	0.56	0.00	0.64	0.00	0.61	0.00	0.83	0.00	0.83	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.76	0.41	0.38	0.78	0.85	0.57	0.49	1.31	1.05	0.67	0.70	1.80
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.54	0.00	0.50	0.00	0.50	0.00	0.49	0.00	0.63	0.00	0.67	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.67	0.36	0.32	0.58	0.71	0.52	0.37	1.01	0.85	0.64	0.55	1.40
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.34	0.00	0.54	0.00	0.16	0.00	0.51	0.00	0.18	0.00	0.64	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.67	0.36	0.70	0.38	0.97	0.38	1.04	0.41	1.21	0.52	1.32
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.46	0.00	0.54	0.00	0.37	0.00	0.58	0.00	0.45	0.00	0.78	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.59	0.52	0.37	0.73	0.58	0.77	0.45	1.23	0.68	0.95	0.66	1.68

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.46	0.00	0.47	0.00	0.36	0.00	0.45	0.00	0.45	0.00	0.60	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.59	0.36	0.29	0.51	0.58	0.55	0.32	0.88	0.67	0.70	0.48	1.22
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.35	0.00	0.34	0.00	0.20	0.00	0.43	0.00	0.22	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.12	0.17	0.16	0.56	0.14	0.08	0.22	0.65	0.16	0.10	0.27
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.49	0.00	0.42	0.00	0.42	0.00	0.34	0.00	0.53	0.00	0.44	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.63	0.24	0.24	0.36	0.64	0.35	0.22	0.61	0.75	0.42	0.32	0.82
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.44	0.00	0.39	0.00	0.34	0.00	0.29	0.00	0.42	0.00	0.38	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.20	0.21	0.28	0.56	0.31	0.17	0.47	0.65	0.39	0.26	0.66
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.33	0.00	0.43	0.00	0.16	0.00	0.35	0.00	0.16	0.00	0.44	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.39	0.26	0.41	0.38	0.59	0.23	0.62	0.40	0.76	0.32	0.81

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.43	0.00	0.27	0.00	0.36	0.00	0.33	0.00	0.46	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.54	0.31	0.25	0.39	0.49	0.47	0.24	0.64	0.55	0.60	0.34	0.87
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.39	0.00	0.27	0.00	0.29	0.00	0.32	0.00	0.37	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.54	0.22	0.21	0.27	0.49	0.34	0.17	0.46	0.55	0.44	0.25	0.64

TABLE C-8: RESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH FIXED STORAGE COSTS AND INCENTIVES, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.78	0.29	0.23	0.72	0.85	0.30	0.25	0.78	0.89	0.30	0.27	0.82
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.78	0.23	0.23	0.46	0.84	0.37	0.36	0.83	0.87	0.48	0.46	1.11
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.86	0.41	0.35	1.09	0.94	0.46	0.43	1.33	0.99	0.49	0.48	1.48
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.46	0.64	0.33	0.66	0.46	0.80	0.39	0.84	0.46	0.90	0.43	0.95
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.59	0.23	0.19	0.34	0.62	0.42	0.30	0.66	0.63	0.57	0.40	0.93
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.50	0.62	0.31	0.96	0.52	0.71	0.37	1.15	0.54	0.77	0.42	1.29
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.70	0.41	0.29	0.90	0.76	0.42	0.32	0.99	0.80	0.42	0.34	1.04
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.60	0.15	0.09	0.27	0.64	0.30	0.19	0.59	0.67	0.40	0.27	0.82
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.85	0.38	0.32	1.00	0.93	0.43	0.40	1.22	0.97	0.45	0.44	1.35
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.33	0.55	0.18	0.57	0.33	0.74	0.25	0.78	0.33	0.85	0.29	0.90
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.12	0.06	0.17	0.50	0.31	0.16	0.49	0.52	0.45	0.24	0.73
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.49	0.59	0.29	0.90	0.51	0.69	0.36	1.11	0.53	0.75	0.40	1.24
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.11	0.17	0.17	0.65	0.11	0.18	0.18	0.66	0.10	0.17	0.16
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.68	0.34	0.31	0.57	0.72	0.42	0.37	0.73	0.74	0.47	0.41	0.85
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.62	0.29	0.26	0.42	0.64	0.36	0.31	0.56	0.66	0.42	0.34	0.66
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.52	0.30	0.54	0.47	0.58	0.32	0.60	0.47	0.61	0.34	0.64

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.41	0.30	0.54	0.58	0.51	0.35	0.69	0.58	0.58	0.39	0.79
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.28	0.24	0.37	0.57	0.36	0.28	0.48	0.58	0.42	0.32	0.58
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.10	0.16	0.13	0.56	0.10	0.16	0.13	0.57	0.09	0.16	0.13
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.58	0.20	0.21	0.27	0.60	0.24	0.23	0.34	0.62	0.27	0.25	0.39
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.55	0.16	0.18	0.20	0.56	0.20	0.20	0.26	0.57	0.23	0.22	0.31
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.46	0.30	0.22	0.31	0.46	0.34	0.24	0.35	0.47	0.37	0.25	0.39
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.24	0.21	0.29	0.53	0.30	0.24	0.36	0.53	0.34	0.26	0.41
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.17	0.18	0.20	0.53	0.21	0.20	0.26	0.53	0.25	0.22	0.30

TABLE C-9: RESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH NO ITC (PV CHARGING ONLY), 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.33	0.52	0.17	0.54	0.36	0.75	0.28	0.79	0.38	0.94	0.38	1.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.41	0.41	0.17	0.54	0.50	0.62	0.32	0.91	0.58	0.79	0.47	1.25
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.41	0.28	0.12	0.37	0.50	0.44	0.23	0.64	0.58	0.58	0.34	0.91
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.32	0.30	0.10	0.31	0.35	0.45	0.17	0.47	0.37	0.58	0.23	0.61
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.37	0.24	0.09	0.29	0.44	0.37	0.17	0.47	0.49	0.48	0.24	0.65
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.37	0.17	0.06	0.20	0.43	0.27	0.12	0.34	0.48	0.35	0.18	0.47

TABLE C-10: RESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH HIGH STORAGE COSTS, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.36	0.00	0.19	0.00	0.58	0.00	0.28	0.00	0.78	0.00	0.36	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.54	0.29	0.16	0.72	0.75	0.33	0.25	1.03	0.95	0.34	0.33	1.29
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.49	0.00	0.34	0.00	0.51	0.00	0.36	0.00	0.66	0.00	0.55	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.60	0.23	0.23	0.46	0.66	0.42	0.29	1.09	0.81	0.57	0.47	1.75
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.42	0.00	0.27	0.00	0.67	0.00	0.46	0.00	0.90	0.00	0.64	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.59	0.41	0.24	1.09	0.84	0.50	0.42	1.75	1.06	0.56	0.59	2.34
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.30	0.00	0.43	0.00	0.14	0.00	0.38	0.00	0.14	0.00	0.50	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.40	0.64	0.31	0.66	0.28	1.04	0.30	1.11	0.29	1.38	0.42	1.50
Res HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.37	0.00	0.31	0.00	0.30	0.00	0.31	0.00	0.37	0.00	0.48	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.48	0.23	0.21	0.34	0.45	0.50	0.23	0.88	0.52	0.74	0.40	1.47
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.16	0.00	0.24	0.00	0.25	0.00	0.40	0.00	0.32	0.00	0.56	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.34	0.62	0.21	0.96	0.43	0.83	0.37	1.53	0.51	0.99	0.52	2.04
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	No	0.31	0.00	0.23	0.00	0.49	0.00	0.35	0.00	0.66	0.00	0.46	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings	Yes	0.49	0.41	0.20	0.90	0.66	0.47	0.32	1.32	0.83	0.50	0.42	1.64
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	No	0.24	0.00	0.09	0.00	0.37	0.00	0.22	0.00	0.49	0.00	0.36	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings	Yes	0.42	0.15	0.06	0.27	0.55	0.34	0.19	0.78	0.67	0.48	0.33	1.30
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	No	0.41	0.00	0.25	0.00	0.66	0.00	0.43	0.00	0.88	0.00	0.58	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings	Yes	0.58	0.38	0.22	1.00	0.83	0.47	0.39	1.62	1.05	0.51	0.54	2.13
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	No	0.04	0.00	0.15	0.00	0.05	0.00	0.28	0.00	0.06	0.00	0.40	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings	Yes	0.23	0.55	0.13	0.57	0.25	0.96	0.25	1.03	0.26	1.30	0.36	1.42
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	No	0.15	0.00	0.06	0.00	0.22	0.00	0.18	0.00	0.29	0.00	0.33	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings	Yes	0.33	0.12	0.04	0.17	0.41	0.37	0.16	0.65	0.48	0.59	0.29	1.15
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	No	0.16	0.00	0.23	0.00	0.24	0.00	0.39	0.00	0.31	0.00	0.54	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.34	0.59	0.20	0.90	0.43	0.81	0.35	1.47	0.50	0.96	0.49	1.95
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.33	0.00	0.31	0.00	0.17	0.00	0.38	0.00	0.18	0.00
Res HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.11	0.21	0.17	0.45	0.13	0.09	0.23	0.53	0.13	0.10	0.25
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.46	0.00	0.42	0.00	0.38	0.00	0.35	0.00	0.47	0.00	0.46	0.00
Res HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.56	0.34	0.31	0.57	0.53	0.48	0.27	0.97	0.62	0.58	0.38	1.34
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.42	0.00	0.39	0.00	0.31	0.00	0.30	0.00	0.37	0.00	0.38	0.00
Res HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.52	0.29	0.27	0.42	0.45	0.43	0.21	0.74	0.52	0.54	0.30	1.04
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.42	0.00	0.14	0.00	0.31	0.00	0.14	0.00	0.38	0.00
Res HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.42	0.52	0.30	0.54	0.28	0.75	0.23	0.79	0.29	0.94	0.29	1.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.38	0.00	0.42	0.00	0.24	0.00	0.34	0.00	0.28	0.00	0.44	0.00
Res HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.48	0.41	0.30	0.54	0.39	0.62	0.26	0.91	0.43	0.79	0.36	1.25

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.38	0.00	0.38	0.00	0.24	0.00	0.27	0.00	0.28	0.00	0.35	0.00
Res HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.48	0.28	0.26	0.37	0.39	0.44	0.19	0.64	0.43	0.58	0.27	0.91
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.32	0.00	0.23	0.00	0.15	0.00	0.27	0.00	0.16	0.00
Res. No HVAC	PG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.10	0.20	0.13	0.37	0.12	0.07	0.18	0.42	0.13	0.08	0.20
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.40	0.00	0.35	0.00	0.27	0.00	0.22	0.00	0.32	0.00	0.27	0.00
Res. No HVAC	SCE	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.49	0.20	0.24	0.27	0.41	0.28	0.14	0.45	0.47	0.35	0.19	0.61
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	No	0.37	0.00	0.34	0.00	0.23	0.00	0.20	0.00	0.27	0.00	0.24	0.00
Res. No HVAC	SDG&E	Yes	EV-TOU	Bill Savings w/ PV Charging	Yes	0.47	0.16	0.22	0.20	0.38	0.24	0.12	0.34	0.42	0.32	0.16	0.49
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.32	0.00	0.36	0.00	0.14	0.00	0.23	0.00	0.14	0.00	0.27	0.00
Res. No HVAC	PG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.41	0.30	0.25	0.31	0.28	0.45	0.15	0.47	0.29	0.58	0.19	0.61

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.35	0.00	0.36	0.00	0.19	0.00	0.23	0.00	0.22	0.00	0.28	0.00
Res. No HVAC	SCE	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.45	0.24	0.24	0.29	0.34	0.37	0.15	0.47	0.37	0.48	0.20	0.65
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	No	0.35	0.00	0.34	0.00	0.19	0.00	0.20	0.00	0.22	0.00	0.24	0.00
Res. No HVAC	SDG&E	Yes	E-TOU	Bill Savings w/ PV Charging	Yes	0.45	0.17	0.22	0.20	0.34	0.27	0.12	0.34	0.37	0.35	0.15	0.47

TABLE C-11: NONRESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE, 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	PG&E	Yes	E-TOU	Bill Savings	Yes	0.96	0.61	0.70	1.40	1.31	0.74	1.18	2.16	1.65	0.80	1.63	2.79
Supermarket	PG&E	Yes	E-TOU	Bill Savings	No	0.67	0.00	0.83	0.00	0.99	0.00	1.33	0.00	1.31	0.00	1.78	0.00
Supermarket	PG&E	Yes	RTP	Bill Savings	Yes	1.00	0.51	0.61	1.21	1.37	0.60	1.00	1.83	1.75	0.63	1.37	2.34
Supermarket	PG&E	Yes	RTP	Bill Savings	No	0.71	0.00	0.74	0.00	1.05	0.00	1.15	0.00	1.41	0.00	1.52	0.00
Supermarket	PG&E	No	E-TOU	Bill Savings	Yes	1.10	0.54	0.73	1.46	1.54	0.67	1.29	2.36	1.99	0.72	1.82	3.11
Supermarket	PG&E	No	E-TOU	Bill Savings	No	0.81	0.00	0.86	0.00	1.22	0.00	1.43	0.00	1.66	0.00	1.97	0.00
Supermarket	PG&E	No	RTP	Bill Savings	Yes	1.13	0.46	0.64	1.26	1.59	0.55	1.09	2.00	2.06	0.59	1.53	2.62
Supermarket	PG&E	No	RTP	Bill Savings	No	0.84	0.00	0.77	0.00	1.27	0.00	1.24	0.00	1.72	0.00	1.68	0.00
Supermarket	SCE	Yes	E-TOU	Bill Savings	Yes	1.11	0.08	0.14	0.22	1.57	0.20	0.40	0.71	2.04	0.28	0.72	1.23
Supermarket	SCE	Yes	E-TOU	Bill Savings	No	0.82	0.00	0.28	0.00	1.25	0.00	0.55	0.00	1.71	0.00	0.88	0.00
Supermarket	SCE	Yes	RTP	Bill Savings	Yes	1.15	0.08	0.14	0.22	1.63	0.19	0.40	0.71	2.14	0.26	0.72	1.23
Supermarket	SCE	Yes	RTP	Bill Savings	No	0.86	0.00	0.28	0.00	1.31	0.00	0.55	0.00	1.81	0.00	0.88	0.00
Supermarket	SCE	No	E-TOU	Bill Savings	Yes	1.61	0.14	0.33	0.61	2.45	0.21	0.67	1.22	3.34	0.24	1.06	1.81
Supermarket	SCE	No	E-TOU	Bill Savings	No	1.33	0.00	0.46	0.00	2.14	0.00	0.82	0.00	3.02	0.00	1.22	0.00
Supermarket	SCE	No	RTP	Bill Savings	Yes	1.86	0.12	0.33	0.61	2.88	0.17	0.67	1.22	3.96	0.20	1.06	1.81
Supermarket	SCE	No	RTP	Bill Savings	No	1.57	0.00	0.46	0.00	2.57	0.00	0.82	0.00	3.64	0.00	1.22	0.00
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.46	0.24	0.47	0.92	2.20	0.29	0.84	1.52	3.02	0.31	1.20	2.05
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	No	1.17	0.00	0.60	0.00	1.89	0.00	0.98	0.00	2.69	0.00	1.36	0.00
Supermarket	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.74	0.65	1.30	1.01	0.97	1.14	2.08	1.25	1.09	1.62	2.77
Supermarket	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.79	0.00	0.69	0.00	1.29	0.00	0.90	0.00	1.77	0.00
Supermarket	SDG&E	No	E-TOU	Bill Savings	Yes	2.20	0.14	0.42	0.82	3.51	0.15	0.71	1.29	4.97	0.15	1.00	1.71
Supermarket	SDG&E	No	E-TOU	Bill Savings	No	1.92	0.00	0.56	0.00	3.21	0.00	0.86	0.00	4.67	0.00	1.15	0.00
Supermarket	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.74	0.65	1.30	1.01	0.97	1.14	2.08	1.25	1.09	1.62	2.77

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.79	0.00	0.69	0.00	1.29	0.00	0.90	0.00	1.77	0.00
Office	PG&E	Yes	E-TOU	Bill Savings	Yes	1.08	0.55	0.72	1.44	1.51	0.65	1.22	2.23	1.95	0.69	1.70	2.90
Office	PG&E	Yes	E-TOU	Bill Savings	No	0.79	0.00	0.85	0.00	1.19	0.00	1.37	0.00	1.61	0.00	1.85	0.00
Office	PG&E	Yes	RTP	Bill Savings	Yes	1.10	0.47	0.64	1.27	1.54	0.55	1.06	1.95	1.99	0.58	1.47	2.51
Office	PG&E	Yes	RTP	Bill Savings	No	0.81	0.00	0.77	0.00	1.22	0.00	1.21	0.00	1.66	0.00	1.62	0.00
Office	PG&E	No	E-TOU	Bill Savings	Yes	1.49	0.35	0.68	1.36	2.23	0.40	1.16	2.12	2.99	0.41	1.61	2.75
Office	PG&E	No	E-TOU	Bill Savings	No	1.21	0.00	0.82	0.00	1.92	0.00	1.31	0.00	2.66	0.00	1.76	0.00
Office	PG&E	No	RTP	Bill Savings	Yes	1.49	0.31	0.61	1.21	2.23	0.35	1.02	1.86	2.98	0.36	1.40	2.40
Office	PG&E	No	RTP	Bill Savings	No	1.21	0.00	0.74	0.00	1.92	0.00	1.17	0.00	2.66	0.00	1.56	0.00
Office	SCE	Yes	E-TOU	Bill Savings	Yes	0.93	0.52	0.57	1.12	1.25	0.70	1.06	1.93	1.58	0.81	1.57	2.68
Office	SCE	Yes	E-TOU	Bill Savings	No	0.63	0.00	0.70	0.00	0.92	0.00	1.20	0.00	1.23	0.00	1.72	0.00
Office	SCE	Yes	RTP	Bill Savings	Yes	1.06	0.34	0.45	0.88	1.48	0.36	0.68	1.22	1.91	0.38	0.91	1.54
Office	SCE	Yes	RTP	Bill Savings	No	0.77	0.00	0.59	0.00	1.16	0.00	0.82	0.00	1.57	0.00	1.06	0.00
Office	SCE	No	E-TOU	Bill Savings	Yes	1.44	0.27	0.52	1.02	2.15	0.34	0.97	1.76	2.89	0.39	1.45	2.48
Office	SCE	No	E-TOU	Bill Savings	No	1.15	0.00	0.65	0.00	1.84	0.00	1.11	0.00	2.57	0.00	1.61	0.00
Office	SCE	No	RTP	Bill Savings	Yes	1.38	0.23	0.43	0.83	2.04	0.23	0.63	1.13	2.74	0.23	0.83	1.41
Office	SCE	No	RTP	Bill Savings	No	1.09	0.00	0.56	0.00	1.73	0.00	0.78	0.00	2.41	0.00	0.98	0.00
Office	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.25	0.34	0.54	1.06	1.83	0.40	0.93	1.70	2.46	0.42	1.32	2.26
Office	SDG&E	Yes	E-TOU	Bill Savings	No	0.96	0.00	0.67	0.00	1.51	0.00	1.08	0.00	2.13	0.00	1.48	0.00
Office	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Office	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
Office	SDG&E	No	E-TOU	Bill Savings	Yes	2.01	0.18	0.50	0.97	3.17	0.19	0.83	1.51	4.47	0.19	1.16	1.97
Office	SDG&E	No	E-TOU	Bill Savings	No	1.73	0.00	0.63	0.00	2.87	0.00	0.98	0.00	4.16	0.00	1.31	0.00
Office	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Office	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	Yes	1.49	0.44	0.85	1.71	2.23	0.49	1.41	2.60	2.98	0.50	1.93	3.31
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	No	1.21	0.00	0.98	0.00	1.91	0.00	1.56	0.00	2.66	0.00	2.09	0.00
EV Charging Station	PG&E	Yes	RTP	Bill Savings	Yes	1.63	0.33	0.71	1.42	2.47	0.36	1.16	2.13	3.34	0.36	1.57	2.69
EV Charging Station	PG&E	Yes	RTP	Bill Savings	No	1.35	0.00	0.85	0.00	2.16	0.00	1.31	0.00	3.02	0.00	1.73	0.00
EV Charging Station	PG&E	No	E-TOU	Bill Savings	Yes	1.73	0.37	0.85	1.71	2.64	0.40	1.41	2.59	3.58	0.41	1.92	3.29
EV Charging Station	PG&E	No	E-TOU	Bill Savings	No	1.45	0.00	0.98	0.00	2.33	0.00	1.56	0.00	3.26	0.00	2.08	0.00
EV Charging Station	PG&E	No	RTP	Bill Savings	Yes	1.74	0.31	0.72	1.44	2.65	0.33	1.17	2.15	3.59	0.34	1.59	2.71
EV Charging Station	PG&E	No	RTP	Bill Savings	No	1.45	0.00	0.85	0.00	2.34	0.00	1.32	0.00	3.28	0.00	1.74	0.00
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	Yes	1.17	0.15	0.25	0.44	1.68	0.27	0.58	1.05	2.21	0.34	0.97	1.66
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	No	0.89	0.00	0.38	0.00	1.36	0.00	0.73	0.00	1.88	0.00	1.13	0.00
EV Charging Station	SCE	Yes	RTP	Bill Savings	Yes	1.51	0.19	0.40	0.76	2.28	0.19	0.58	1.03	3.08	0.19	0.76	1.30
EV Charging Station	SCE	Yes	RTP	Bill Savings	No	1.23	0.00	0.53	0.00	1.96	0.00	0.72	0.00	2.76	0.00	0.92	0.00
EV Charging Station	SCE	No	E-TOU	Bill Savings	Yes	1.60	0.11	0.26	0.46	2.43	0.18	0.60	1.08	3.31	0.23	0.99	1.69
EV Charging Station	SCE	No	E-TOU	Bill Savings	No	1.32	0.00	0.39	0.00	2.12	0.00	0.74	0.00	2.99	0.00	1.14	0.00
EV Charging Station	SCE	No	RTP	Bill Savings	Yes	1.57	0.18	0.39	0.74	2.37	0.18	0.56	1.00	3.21	0.17	0.74	1.25

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	SCE	No	RTP	Bill Savings	No	1.28	0.00	0.52	0.00	2.06	0.00	0.70	0.00	2.89	0.00	0.89	0.00
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.60	0.29	0.61	1.21	2.45	0.32	1.05	1.91	3.40	0.33	1.48	2.54
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	No	1.32	0.00	0.75	0.00	2.15	0.00	1.19	0.00	3.08	0.00	1.64	0.00
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	Yes	2.30	0.18	0.57	1.13	3.68	0.19	0.97	1.76	5.23	0.19	1.37	2.33
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	No	2.02	0.00	0.71	0.00	3.39	0.00	1.11	0.00	4.93	0.00	1.52	0.00
EV Charging Station	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
EV Charging Station	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
Food Processing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.75	0.80	0.65	1.30	0.93	0.98	1.03	1.88	1.11	1.05	1.35	2.30
Food Processing	PG&E	Yes	E-TOU	Bill Savings	No	0.45	0.00	0.78	0.00	0.60	0.00	1.17	0.00	0.76	0.00	1.50	0.00
Food Processing	PG&E	Yes	RTP	Bill Savings	Yes	0.82	0.70	0.64	1.28	1.05	0.80	0.98	1.78	1.28	0.82	1.25	2.14
Food Processing	PG&E	Yes	RTP	Bill Savings	No	0.52	0.00	0.78	0.00	0.72	0.00	1.12	0.00	0.94	0.00	1.40	0.00
Food Processing	PG&E	No	E-TOU	Bill Savings	Yes	0.78	0.72	0.63	1.25	0.99	0.83	0.95	1.74	1.20	0.87	1.22	2.08
Food Processing	PG&E	No	E-TOU	Bill Savings	No	0.49	0.00	0.76	0.00	0.67	0.00	1.10	0.00	0.85	0.00	1.37	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	PG&E	No	RTP	Bill Savings	Yes	0.84	0.63	0.61	1.20	1.10	0.69	0.89	1.63	1.35	0.70	1.13	1.93
Food Processing	PG&E	No	RTP	Bill Savings	No	0.55	0.00	0.74	0.00	0.77	0.00	1.04	0.00	1.01	0.00	1.28	0.00
Food Processing	SCE	Yes	E-TOU	Bill Savings	Yes	0.90	0.44	0.47	0.91	1.20	0.61	0.88	1.60	1.51	0.71	1.31	2.23
Food Processing	SCE	Yes	E-TOU	Bill Savings	No	0.61	0.00	0.60	0.00	0.88	0.00	1.03	0.00	1.17	0.00	1.46	0.00
Food Processing	SCE	Yes	RTP	Bill Savings	Yes	0.92	0.42	0.47	0.91	1.24	0.59	0.88	1.60	1.57	0.68	1.31	2.23
Food Processing	SCE	Yes	RTP	Bill Savings	No	0.63	0.00	0.60	0.00	0.92	0.00	1.03	0.00	1.22	0.00	1.46	0.00
Food Processing	SCE	No	E-TOU	Bill Savings	Yes	1.04	0.32	0.42	0.80	1.44	0.43	0.78	1.41	1.86	0.49	1.15	1.95
Food Processing	SCE	No	E-TOU	Bill Savings	No	0.74	0.00	0.55	0.00	1.12	0.00	0.92	0.00	1.52	0.00	1.30	0.00
Food Processing	SCE	No	RTP	Bill Savings	Yes	1.27	0.25	0.42	0.80	1.86	0.32	0.78	1.41	2.47	0.36	1.15	1.95
Food Processing	SCE	No	RTP	Bill Savings	No	0.99	0.00	0.55	0.00	1.54	0.00	0.92	0.00	2.14	0.00	1.30	0.00
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.19	0.34	0.52	1.02	1.72	0.42	0.91	1.66	2.30	0.45	1.32	2.26
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	No	0.90	0.00	0.65	0.00	1.40	0.00	1.06	0.00	1.97	0.00	1.48	0.00
Food Processing	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Food Processing	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
Food Processing	SDG&E	No	E-TOU	Bill Savings	Yes	1.27	0.31	0.51	1.00	1.86	0.36	0.87	1.58	2.51	0.39	1.24	2.12

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	SDG&E	No	E-TOU	Bill Savings	No	0.98	0.00	0.64	0.00	1.54	0.00	1.02	0.00	2.18	0.00	1.40	0.00
Food Processing	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Food Processing	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.62	0.92	0.64	2.62	0.89	1.04	1.12	3.88	1.20	1.08	1.65	4.87
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	No	0.50	0.00	0.69	0.00	0.74	0.00	1.19	0.00	1.03	0.00	1.73	0.00
Manufacturing	PG&E	Yes	RTP	Bill Savings	Yes	0.61	0.79	0.56	2.22	0.88	0.87	0.94	3.18	1.19	0.88	1.35	3.92
Manufacturing	PG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.61	0.00	0.73	0.00	1.01	0.00	1.02	0.00	1.43	0.00
Manufacturing	PG&E	No	E-TOU	Bill Savings	Yes	0.57	0.64	0.43	1.55	0.78	0.71	0.69	2.23	1.03	0.74	0.97	2.75
Manufacturing	PG&E	No	E-TOU	Bill Savings	No	0.45	0.00	0.49	0.00	0.64	0.00	0.76	0.00	0.86	0.00	1.05	0.00
Manufacturing	PG&E	No	RTP	Bill Savings	Yes	0.61	0.74	0.53	2.05	0.88	0.78	0.85	2.84	1.18	0.78	1.19	3.44
Manufacturing	PG&E	No	RTP	Bill Savings	No	0.50	0.00	0.58	0.00	0.73	0.00	0.92	0.00	1.01	0.00	1.27	0.00
Manufacturing	SCE	Yes	E-TOU	Bill Savings	Yes	0.59	0.57	0.42	1.48	0.83	0.72	0.75	2.44	1.11	0.79	1.13	3.24
Manufacturing	SCE	Yes	E-TOU	Bill Savings	No	0.47	0.00	0.47	0.00	0.68	0.00	0.82	0.00	0.94	0.00	1.21	0.00
Manufacturing	SCE	Yes	RTP	Bill Savings	Yes	0.67	0.21	0.26	0.69	0.99	0.20	0.34	0.87	1.37	0.20	0.43	1.03
Manufacturing	SCE	Yes	RTP	Bill Savings	No	0.55	0.00	0.32	0.00	0.84	0.00	0.41	0.00	1.20	0.00	0.51	0.00
Manufacturing	SCE	No	E-TOU	Bill Savings	Yes	0.59	0.49	0.38	1.29	0.84	0.60	0.64	2.04	1.12	0.64	0.94	2.66
Manufacturing	SCE	No	E-TOU	Bill Savings	No	0.47	0.00	0.43	0.00	0.69	0.00	0.71	0.00	0.95	0.00	1.02	0.00
Manufacturing	SCE	No	RTP	Bill Savings	Yes	0.68	0.14	0.22	0.45	1.01	0.10	0.23	0.45	1.40	0.08	0.24	0.45
Manufacturing	SCE	No	RTP	Bill Savings	No	0.56	0.00	0.27	0.00	0.87	0.00	0.30	0.00	1.24	0.00	0.32	0.00
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.81	0.49	0.55	2.15	1.30	0.58	1.04	3.56	1.91	0.60	1.61	4.74
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	No	0.70	0.00	0.60	0.00	1.16	0.00	1.11	0.00	1.75	0.00	1.69	0.00
Manufacturing	SDG&E	Yes	RTP	Bill Savings	Yes	0.56	0.67	0.43	1.56	0.77	0.71	0.68	2.18	1.03	0.72	0.95	2.69
Manufacturing	SDG&E	Yes	RTP	Bill Savings	No	0.44	0.00	0.49	0.00	0.62	0.00	0.75	0.00	0.86	0.00	1.03	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Manufacturing	SDG&E	No	E-TOU	Bill Savings	Yes	0.71	0.37	0.39	1.33	1.09	0.42	0.65	2.08	1.55	0.44	0.96	2.70
Manufacturing	SDG&E	No	E-TOU	Bill Savings	No	0.59	0.00	0.44	0.00	0.94	0.00	0.72	0.00	1.38	0.00	1.04	0.00
Manufacturing	SDG&E	No	RTP	Bill Savings	Yes	0.56	0.67	0.43	1.56	0.77	0.71	0.68	2.18	1.03	0.72	0.95	2.69
Manufacturing	SDG&E	No	RTP	Bill Savings	No	0.44	0.00	0.49	0.00	0.62	0.00	0.75	0.00	0.86	0.00	1.03	0.00
Elementary School	PG&E	Yes	E-TOU	Bill Savings	Yes	0.71	0.74	0.56	1.11	0.87	0.88	0.85	1.55	1.02	0.94	1.10	1.87
Elementary School	PG&E	Yes	E-TOU	Bill Savings	No	0.42	0.00	0.70	0.00	0.54	0.00	1.00	0.00	0.67	0.00	1.25	0.00
Elementary School	PG&E	Yes	RTP	Bill Savings	Yes	0.77	0.58	0.50	0.98	0.97	0.65	0.72	1.30	1.16	0.65	0.89	1.52
Elementary School	PG&E	Yes	RTP	Bill Savings	No	0.47	0.00	0.64	0.00	0.64	0.00	0.87	0.00	0.82	0.00	1.05	0.00
Elementary School	PG&E	No	E-TOU	Bill Savings	Yes	0.79	0.62	0.55	1.08	1.01	0.70	0.82	1.48	1.22	0.72	1.04	1.77
Elementary School	PG&E	No	E-TOU	Bill Savings	No	0.50	0.00	0.68	0.00	0.68	0.00	0.96	0.00	0.88	0.00	1.19	0.00
Elementary School	PG&E	No	RTP	Bill Savings	Yes	0.83	0.51	0.49	0.96	1.08	0.54	0.69	1.25	1.32	0.53	0.84	1.43
Elementary School	PG&E	No	RTP	Bill Savings	No	0.54	0.00	0.62	0.00	0.75	0.00	0.84	0.00	0.98	0.00	1.00	0.00
Elementary School	SCE	Yes	E-TOU	Bill Savings	Yes	0.87	0.49	0.50	0.98	1.15	0.65	0.89	1.61	1.43	0.74	1.28	2.19
Elementary School	SCE	Yes	E-TOU	Bill Savings	No	0.58	0.00	0.64	0.00	0.82	0.00	1.03	0.00	1.09	0.00	1.44	0.00
Elementary School	SCE	Yes	RTP	Bill Savings	Yes	0.90	0.47	0.50	0.98	1.20	0.62	0.89	1.61	1.50	0.70	1.28	2.19
Elementary School	SCE	Yes	RTP	Bill Savings	No	0.61	0.00	0.64	0.00	0.87	0.00	1.03	0.00	1.16	0.00	1.44	0.00
Elementary School	SCE	No	E-TOU	Bill Savings	Yes	1.14	0.29	0.42	0.81	1.62	0.37	0.76	1.37	2.13	0.41	1.11	1.89

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Elementary School	SCE	No	E-TOU	Bill Savings	No	0.85	0.00	0.55	0.00	1.30	0.00	0.90	0.00	1.79	0.00	1.26	0.00
Elementary School	SCE	No	RTP	Bill Savings	Yes	1.38	0.23	0.42	0.81	2.05	0.28	0.76	1.37	2.74	0.31	1.11	1.89
Elementary School	SCE	No	RTP	Bill Savings	No	1.09	0.00	0.55	0.00	1.73	0.00	0.90	0.00	2.42	0.00	1.26	0.00
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.17	0.32	0.49	0.95	1.70	0.38	0.82	1.48	2.27	0.40	1.16	1.98
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	No	0.89	0.00	0.62	0.00	1.38	0.00	0.96	0.00	1.93	0.00	1.31	0.00
Elementary School	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Elementary School	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00
Elementary School	SDG&E	No	E-TOU	Bill Savings	Yes	1.35	0.28	0.49	0.95	2.00	0.31	0.81	1.47	2.72	0.32	1.14	1.94
Elementary School	SDG&E	No	E-TOU	Bill Savings	No	1.06	0.00	0.62	0.00	1.69	0.00	0.96	0.00	2.40	0.00	1.29	0.00
Elementary School	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.77	0.69	1.37	1.04	1.00	1.20	2.20	1.29	1.12	1.71	2.92
Elementary School	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.82	0.00	0.71	0.00	1.35	0.00	0.94	0.00	1.86	0.00

TABLE C-12: NONRESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH GHG SIGNAL (LOW), 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	PG&E	Yes	E-TOU	Bill Savings	Yes	0.96	0.69	0.78	1.58	1.31	0.87	1.38	2.53	1.65	0.96	1.95	3.34
Supermarket	PG&E	Yes	E-TOU	Bill Savings	No	0.67	0.00	0.92	0.00	0.99	0.00	1.53	0.00	1.31	0.00	2.10	0.00
Supermarket	PG&E	Yes	RTP	Bill Savings	Yes	1.00	0.66	0.79	1.59	1.38	0.81	1.37	2.52	1.76	0.88	1.92	3.29
Supermarket	PG&E	Yes	RTP	Bill Savings	No	0.71	0.00	0.92	0.00	1.06	0.00	1.52	0.00	1.42	0.00	2.07	0.00
Supermarket	PG&E	No	E-TOU	Bill Savings	Yes	1.10	0.56	0.75	1.50	1.54	0.68	1.31	2.41	1.99	0.74	1.86	3.18
Supermarket	PG&E	No	E-TOU	Bill Savings	No	0.81	0.00	0.88	0.00	1.22	0.00	1.46	0.00	1.66	0.00	2.01	0.00
Supermarket	PG&E	No	RTP	Bill Savings	Yes	1.13	0.53	0.73	1.47	1.59	0.63	1.26	2.31	2.07	0.68	1.76	3.02
Supermarket	PG&E	No	RTP	Bill Savings	No	0.84	0.00	0.87	0.00	1.27	0.00	1.41	0.00	1.73	0.00	1.92	0.00
Supermarket	SCE	Yes	E-TOU	Bill Savings	Yes	1.11	0.51	0.70	1.40	1.57	0.67	1.32	2.42	2.05	0.76	1.95	3.34
Supermarket	SCE	Yes	E-TOU	Bill Savings	No	0.82	0.00	0.83	0.00	1.25	0.00	1.47	0.00	1.71	0.00	2.11	0.00
Supermarket	SCE	Yes	RTP	Bill Savings	Yes	1.15	0.49	0.69	1.39	1.64	0.63	1.31	2.40	2.14	0.71	1.93	3.30
Supermarket	SCE	Yes	RTP	Bill Savings	No	0.86	0.00	0.83	0.00	1.32	0.00	1.45	0.00	1.81	0.00	2.08	0.00
Supermarket	SCE	No	E-TOU	Bill Savings	Yes	1.61	0.28	0.61	1.20	2.44	0.36	1.15	2.11	3.32	0.40	1.72	2.95
Supermarket	SCE	No	E-TOU	Bill Savings	No	1.32	0.00	0.74	0.00	2.13	0.00	1.30	0.00	3.00	0.00	1.88	0.00
Supermarket	SCE	No	RTP	Bill Savings	Yes	1.85	0.23	0.57	1.13	2.86	0.28	1.08	1.98	3.93	0.31	1.62	2.77
Supermarket	SCE	No	RTP	Bill Savings	No	1.56	0.00	0.71	0.00	2.56	0.00	1.23	0.00	3.62	0.00	1.77	0.00
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.48	0.30	0.59	1.17	2.23	0.36	1.06	1.93	3.06	0.38	1.53	2.62
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	No	1.19	0.00	0.72	0.00	1.92	0.00	1.20	0.00	2.74	0.00	1.68	0.00
Supermarket	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.76	0.67	1.33	1.01	1.01	1.17	2.15	1.25	1.13	1.67	2.86
Supermarket	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.80	0.00	0.69	0.00	1.32	0.00	0.90	0.00	1.83	0.00
Supermarket	SDG&E	No	E-TOU	Bill Savings	Yes	2.19	0.15	0.48	0.93	3.49	0.17	0.82	1.50	4.94	0.18	1.18	2.02
Supermarket	SDG&E	No	E-TOU	Bill Savings	No	1.91	0.00	0.61	0.00	3.19	0.00	0.97	0.00	4.64	0.00	1.34	0.00
Supermarket	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.76	0.67	1.33	1.01	1.01	1.17	2.15	1.25	1.13	1.67	2.86

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.80	0.00	0.69	0.00	1.32	0.00	0.90	0.00	1.83	0.00
Office	PG&E	Yes	E-TOU	Bill Savings	Yes	1.03	0.61	0.75	1.52	1.43	0.74	1.29	2.37	1.83	0.79	1.81	3.10
Office	PG&E	Yes	E-TOU	Bill Savings	No	0.74	0.00	0.89	0.00	1.11	0.00	1.44	0.00	1.49	0.00	1.96	0.00
Office	PG&E	Yes	RTP	Bill Savings	Yes	1.05	0.61	0.76	1.54	1.45	0.72	1.29	2.36	1.86	0.77	1.78	3.05
Office	PG&E	Yes	RTP	Bill Savings	No	0.76	0.00	0.90	0.00	1.13	0.00	1.44	0.00	1.52	0.00	1.94	0.00
Office	PG&E	No	E-TOU	Bill Savings	Yes	1.49	0.38	0.74	1.48	2.23	0.43	1.25	2.30	2.99	0.45	1.74	2.98
Office	PG&E	No	E-TOU	Bill Savings	No	1.21	0.00	0.87	0.00	1.92	0.00	1.40	0.00	2.66	0.00	1.90	0.00
Office	PG&E	No	RTP	Bill Savings	Yes	1.49	0.39	0.75	1.50	2.23	0.43	1.26	2.31	2.98	0.45	1.74	2.99
Office	PG&E	No	RTP	Bill Savings	No	1.21	0.00	0.88	0.00	1.92	0.00	1.41	0.00	2.66	0.00	1.90	0.00
Office	SCE	Yes	E-TOU	Bill Savings	Yes	0.91	0.68	0.71	1.43	1.22	0.90	1.31	2.40	1.53	1.03	1.92	3.30
Office	SCE	Yes	E-TOU	Bill Savings	No	0.62	0.00	0.85	0.00	0.89	0.00	1.46	0.00	1.19	0.00	2.08	0.00
Office	SCE	Yes	RTP	Bill Savings	Yes	1.06	0.36	0.47	0.91	1.48	0.38	0.71	1.28	1.91	0.40	0.96	1.63
Office	SCE	Yes	RTP	Bill Savings	No	0.77	0.00	0.60	0.00	1.15	0.00	0.86	0.00	1.57	0.00	1.11	0.00
Office	SCE	No	E-TOU	Bill Savings	Yes	1.44	0.37	0.69	1.38	2.15	0.46	1.28	2.34	2.89	0.50	1.88	3.23
Office	SCE	No	E-TOU	Bill Savings	No	1.15	0.00	0.82	0.00	1.84	0.00	1.42	0.00	2.57	0.00	2.04	0.00
Office	SCE	No	RTP	Bill Savings	Yes	1.38	0.24	0.44	0.86	2.04	0.25	0.66	1.19	2.74	0.25	0.88	1.49
Office	SCE	No	RTP	Bill Savings	No	1.09	0.00	0.58	0.00	1.73	0.00	0.81	0.00	2.41	0.00	1.03	0.00
Office	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.26	0.37	0.60	1.19	1.85	0.44	1.04	1.90	2.49	0.47	1.50	2.56
Office	SDG&E	Yes	E-TOU	Bill Savings	No	0.97	0.00	0.73	0.00	1.53	0.00	1.19	0.00	2.16	0.00	1.65	0.00
Office	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Office	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
Office	SDG&E	No	E-TOU	Bill Savings	Yes	2.01	0.20	0.56	1.11	3.17	0.23	0.98	1.79	4.47	0.24	1.41	2.41
Office	SDG&E	No	E-TOU	Bill Savings	No	1.73	0.00	0.70	0.00	2.87	0.00	1.13	0.00	4.16	0.00	1.56	0.00
Office	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Office	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	Yes	1.49	0.44	0.86	1.73	2.23	0.52	1.51	2.77	2.99	0.55	2.12	3.64
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	No	1.21	0.00	0.99	0.00	1.92	0.00	1.66	0.00	2.66	0.00	2.28	0.00
EV Charging Station	PG&E	Yes	RTP	Bill Savings	Yes	1.64	0.39	0.85	1.71	2.49	0.45	1.46	2.69	3.36	0.46	2.04	3.49
EV Charging Station	PG&E	Yes	RTP	Bill Savings	No	1.36	0.00	0.98	0.00	2.18	0.00	1.61	0.00	3.04	0.00	2.19	0.00
EV Charging Station	PG&E	No	E-TOU	Bill Savings	Yes	1.73	0.37	0.85	1.73	2.64	0.43	1.50	2.76	3.58	0.45	2.11	3.62
EV Charging Station	PG&E	No	E-TOU	Bill Savings	No	1.45	0.00	0.99	0.00	2.33	0.00	1.65	0.00	3.26	0.00	2.27	0.00
EV Charging Station	PG&E	No	RTP	Bill Savings	Yes	1.74	0.37	0.84	1.70	2.66	0.41	1.45	2.67	3.60	0.43	2.02	3.47
EV Charging Station	PG&E	No	RTP	Bill Savings	No	1.46	0.00	0.98	0.00	2.35	0.00	1.60	0.00	3.29	0.00	2.18	0.00
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	Yes	1.18	0.52	0.75	1.51	1.69	0.67	1.42	2.61	2.22	0.75	2.10	3.61
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	No	0.89	0.00	0.89	0.00	1.37	0.00	1.57	0.00	1.89	0.00	2.26	0.00
EV Charging Station	SCE	Yes	RTP	Bill Savings	Yes	1.51	0.20	0.41	0.78	2.27	0.20	0.60	1.09	3.08	0.20	0.81	1.37
EV Charging Station	SCE	Yes	RTP	Bill Savings	No	1.23	0.00	0.54	0.00	1.96	0.00	0.75	0.00	2.75	0.00	0.96	0.00
EV Charging Station	SCE	No	E-TOU	Bill Savings	Yes	1.60	0.35	0.74	1.49	2.43	0.44	1.40	2.57	3.31	0.48	2.07	3.55
EV Charging Station	SCE	No	E-TOU	Bill Savings	No	1.32	0.00	0.87	0.00	2.12	0.00	1.55	0.00	2.99	0.00	2.23	0.00
EV Charging Station	SCE	No	RTP	Bill Savings	Yes	1.57	0.19	0.40	0.77	2.37	0.19	0.59	1.06	3.21	0.19	0.78	1.33

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	SCE	No	RTP	Bill Savings	No	1.28	0.00	0.53	0.00	2.06	0.00	0.73	0.00	2.89	0.00	0.94	0.00
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.61	0.30	0.63	1.25	2.46	0.35	1.13	2.06	3.40	0.37	1.64	2.80
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	No	1.32	0.00	0.76	0.00	2.15	0.00	1.28	0.00	3.08	0.00	1.79	0.00
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	Yes	2.30	0.19	0.62	1.23	3.68	0.22	1.11	2.03	5.23	0.23	1.61	2.75
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	No	2.02	0.00	0.76	0.00	3.39	0.00	1.26	0.00	4.93	0.00	1.76	0.00
EV Charging Station	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
EV Charging Station	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
Food Processing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.75	0.83	0.67	1.33	0.93	1.06	1.11	2.03	1.11	1.17	1.51	2.58
Food Processing	PG&E	Yes	E-TOU	Bill Savings	No	0.45	0.00	0.80	0.00	0.60	0.00	1.26	0.00	0.76	0.00	1.66	0.00
Food Processing	PG&E	Yes	RTP	Bill Savings	Yes	0.82	0.85	0.78	1.56	1.05	1.05	1.28	2.35	1.29	1.14	1.74	2.97
Food Processing	PG&E	Yes	RTP	Bill Savings	No	0.52	0.00	0.91	0.00	0.73	0.00	1.43	0.00	0.94	0.00	1.89	0.00
Food Processing	PG&E	No	E-TOU	Bill Savings	Yes	0.78	0.75	0.65	1.30	0.99	0.93	1.06	1.93	1.20	1.01	1.42	2.43
Food Processing	PG&E	No	E-TOU	Bill Savings	No	0.49	0.00	0.78	0.00	0.66	0.00	1.20	0.00	0.85	0.00	1.58	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	PG&E	No	RTP	Bill Savings	Yes	0.85	0.78	0.75	1.50	1.10	0.93	1.21	2.22	1.36	1.00	1.62	2.77
Food Processing	PG&E	No	RTP	Bill Savings	No	0.55	0.00	0.88	0.00	0.78	0.00	1.36	0.00	1.01	0.00	1.78	0.00
Food Processing	SCE	Yes	E-TOU	Bill Savings	Yes	0.90	0.58	0.61	1.22	1.20	0.79	1.14	2.09	1.51	0.91	1.68	2.87
Food Processing	SCE	Yes	E-TOU	Bill Savings	No	0.61	0.00	0.75	0.00	0.88	0.00	1.29	0.00	1.17	0.00	1.83	0.00
Food Processing	SCE	Yes	RTP	Bill Savings	Yes	0.92	0.61	0.66	1.31	1.23	0.82	1.22	2.23	1.56	0.93	1.78	3.05
Food Processing	SCE	Yes	RTP	Bill Savings	No	0.63	0.00	0.79	0.00	0.91	0.00	1.36	0.00	1.22	0.00	1.93	0.00
Food Processing	SCE	No	E-TOU	Bill Savings	Yes	1.04	0.42	0.54	1.06	1.44	0.56	1.00	1.82	1.86	0.63	1.46	2.50
Food Processing	SCE	No	E-TOU	Bill Savings	No	0.74	0.00	0.67	0.00	1.12	0.00	1.14	0.00	1.52	0.00	1.61	0.00
Food Processing	SCE	No	RTP	Bill Savings	Yes	1.27	0.37	0.60	1.20	1.85	0.47	1.11	2.03	2.46	0.51	1.63	2.78
Food Processing	SCE	No	RTP	Bill Savings	No	0.98	0.00	0.74	0.00	1.54	0.00	1.26	0.00	2.13	0.00	1.78	0.00
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.19	0.40	0.59	1.18	1.72	0.49	1.07	1.96	2.30	0.53	1.56	2.66
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	No	0.90	0.00	0.73	0.00	1.40	0.00	1.22	0.00	1.97	0.00	1.71	0.00
Food Processing	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Food Processing	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
Food Processing	SDG&E	No	E-TOU	Bill Savings	Yes	1.27	0.33	0.54	1.06	1.86	0.40	0.95	1.73	2.51	0.42	1.36	2.33

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	SDG&E	No	E-TOU	Bill Savings	No	0.98	0.00	0.67	0.00	1.54	0.00	1.09	0.00	2.18	0.00	1.52	0.00
Food Processing	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Food Processing	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.62	0.94	0.65	2.68	0.89	1.07	1.15	3.99	1.20	1.12	1.70	5.04
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	No	0.50	0.00	0.70	0.00	0.74	0.00	1.22	0.00	1.03	0.00	1.79	0.00
Manufacturing	PG&E	Yes	RTP	Bill Savings	Yes	0.61	0.85	0.59	2.37	0.88	0.94	1.01	3.45	1.19	0.97	1.46	4.29
Manufacturing	PG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.64	0.00	0.73	0.00	1.08	0.00	1.02	0.00	1.55	0.00
Manufacturing	PG&E	No	E-TOU	Bill Savings	Yes	0.57	0.67	0.45	1.63	0.78	0.76	0.73	2.36	1.03	0.79	1.03	2.94
Manufacturing	PG&E	No	E-TOU	Bill Savings	No	0.45	0.00	0.50	0.00	0.64	0.00	0.80	0.00	0.86	0.00	1.11	0.00
Manufacturing	PG&E	No	RTP	Bill Savings	Yes	0.61	0.79	0.56	2.22	0.88	0.86	0.93	3.13	1.18	0.86	1.32	3.82
Manufacturing	PG&E	No	RTP	Bill Savings	No	0.50	0.00	0.61	0.00	0.73	0.00	1.00	0.00	1.01	0.00	1.40	0.00
Manufacturing	SCE	Yes	E-TOU	Bill Savings	Yes	0.59	0.62	0.45	1.62	0.83	0.78	0.80	2.65	1.11	0.86	1.22	3.52
Manufacturing	SCE	Yes	E-TOU	Bill Savings	No	0.47	0.00	0.50	0.00	0.68	0.00	0.87	0.00	0.94	0.00	1.30	0.00
Manufacturing	SCE	Yes	RTP	Bill Savings	Yes	0.67	0.22	0.27	0.70	0.99	0.21	0.35	0.89	1.37	0.20	0.44	1.06
Manufacturing	SCE	Yes	RTP	Bill Savings	No	0.55	0.00	0.32	0.00	0.84	0.00	0.41	0.00	1.20	0.00	0.51	0.00
Manufacturing	SCE	No	E-TOU	Bill Savings	Yes	0.59	0.53	0.40	1.38	0.84	0.63	0.68	2.16	1.12	0.68	1.00	2.82
Manufacturing	SCE	No	E-TOU	Bill Savings	No	0.47	0.00	0.45	0.00	0.69	0.00	0.75	0.00	0.95	0.00	1.08	0.00
Manufacturing	SCE	No	RTP	Bill Savings	Yes	0.68	0.15	0.22	0.48	1.01	0.11	0.24	0.49	1.40	0.09	0.26	0.50
Manufacturing	SCE	No	RTP	Bill Savings	No	0.56	0.00	0.28	0.00	0.86	0.00	0.31	0.00	1.24	0.00	0.34	0.00
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.81	0.51	0.56	2.23	1.30	0.59	1.06	3.65	1.91	0.62	1.64	4.85
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	No	0.70	0.00	0.62	0.00	1.16	0.00	1.13	0.00	1.75	0.00	1.72	0.00
Manufacturing	SDG&E	Yes	RTP	Bill Savings	Yes	0.56	0.67	0.44	1.58	0.77	0.72	0.69	2.21	1.03	0.73	0.97	2.73
Manufacturing	SDG&E	Yes	RTP	Bill Savings	No	0.44	0.00	0.49	0.00	0.62	0.00	0.76	0.00	0.86	0.00	1.05	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Manufacturing	SDG&E	No	E-TOU	Bill Savings	Yes	0.71	0.43	0.42	1.52	1.09	0.49	0.73	2.38	1.55	0.51	1.09	3.12
Manufacturing	SDG&E	No	E-TOU	Bill Savings	No	0.59	0.00	0.48	0.00	0.94	0.00	0.80	0.00	1.38	0.00	1.17	0.00
Manufacturing	SDG&E	No	RTP	Bill Savings	Yes	0.56	0.67	0.44	1.58	0.77	0.72	0.69	2.21	1.03	0.73	0.97	2.73
Manufacturing	SDG&E	No	RTP	Bill Savings	No	0.44	0.00	0.49	0.00	0.62	0.00	0.76	0.00	0.86	0.00	1.05	0.00
Elementary School	PG&E	Yes	E-TOU	Bill Savings	Yes	0.72	0.75	0.58	1.15	0.88	0.97	0.96	1.74	1.04	1.10	1.30	2.22
Elementary School	PG&E	Yes	E-TOU	Bill Savings	No	0.42	0.00	0.71	0.00	0.55	0.00	1.10	0.00	0.69	0.00	1.46	0.00
Elementary School	PG&E	Yes	RTP	Bill Savings	Yes	0.78	0.73	0.63	1.25	0.98	0.90	1.01	1.84	1.18	0.97	1.35	2.31
Elementary School	PG&E	Yes	RTP	Bill Savings	No	0.48	0.00	0.76	0.00	0.66	0.00	1.16	0.00	0.84	0.00	1.51	0.00
Elementary School	PG&E	No	E-TOU	Bill Savings	Yes	0.80	0.63	0.57	1.13	1.02	0.79	0.93	1.70	1.24	0.86	1.26	2.16
Elementary School	PG&E	No	E-TOU	Bill Savings	No	0.51	0.00	0.70	0.00	0.70	0.00	1.08	0.00	0.89	0.00	1.42	0.00
Elementary School	PG&E	No	RTP	Bill Savings	Yes	0.84	0.65	0.62	1.24	1.09	0.77	1.00	1.82	1.35	0.82	1.33	2.27
Elementary School	PG&E	No	RTP	Bill Savings	No	0.55	0.00	0.76	0.00	0.77	0.00	1.14	0.00	1.00	0.00	1.48	0.00
Elementary School	SCE	Yes	E-TOU	Bill Savings	Yes	0.87	0.65	0.65	1.30	1.15	0.86	1.17	2.14	1.43	0.98	1.69	2.90
Elementary School	SCE	Yes	E-TOU	Bill Savings	No	0.58	0.00	0.79	0.00	0.82	0.00	1.32	0.00	1.09	0.00	1.85	0.00
Elementary School	SCE	Yes	RTP	Bill Savings	Yes	0.89	0.64	0.66	1.33	1.19	0.84	1.20	2.19	1.49	0.95	1.73	2.97
Elementary School	SCE	Yes	RTP	Bill Savings	No	0.60	0.00	0.80	0.00	0.87	0.00	1.34	0.00	1.15	0.00	1.89	0.00
Elementary School	SCE	No	E-TOU	Bill Savings	Yes	1.14	0.39	0.56	1.11	1.62	0.49	1.01	1.84	2.13	0.54	1.46	2.49

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Elementary School	SCE	No	E-TOU	Bill Savings	No	0.85	0.00	0.69	0.00	1.30	0.00	1.15	0.00	1.79	0.00	1.61	0.00
Elementary School	SCE	No	RTP	Bill Savings	Yes	1.38	0.36	0.64	1.27	2.04	0.43	1.15	2.11	2.74	0.47	1.67	2.86
Elementary School	SCE	No	RTP	Bill Savings	No	1.09	0.00	0.77	0.00	1.73	0.00	1.30	0.00	2.41	0.00	1.83	0.00
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.17	0.39	0.57	1.13	1.70	0.47	1.01	1.85	2.27	0.51	1.46	2.50
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	No	0.89	0.00	0.71	0.00	1.38	0.00	1.16	0.00	1.93	0.00	1.62	0.00
Elementary School	SDG&E	Yes	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Elementary School	SDG&E	Yes	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00
Elementary School	SDG&E	No	E-TOU	Bill Savings	Yes	1.35	0.32	0.56	1.10	2.00	0.37	0.97	1.77	2.72	0.39	1.39	2.38
Elementary School	SDG&E	No	E-TOU	Bill Savings	No	1.06	0.00	0.69	0.00	1.69	0.00	1.12	0.00	2.40	0.00	1.55	0.00
Elementary School	SDG&E	No	RTP	Bill Savings	Yes	0.80	0.79	0.70	1.41	1.04	1.03	1.24	2.27	1.28	1.16	1.77	3.03
Elementary School	SDG&E	No	RTP	Bill Savings	No	0.51	0.00	0.84	0.00	0.71	0.00	1.39	0.00	0.94	0.00	1.92	0.00

TABLE C-13: NONRESIDENTIAL COST-EFFECTIVENESS RESULTS, BASE CASE WITH GHG SIGNAL (HIGH), 2018, 2024, AND 2028

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	PG&E	Yes	E-TOU	Bill Savings	Yes	0.96	0.68	0.77	1.56	1.31	0.86	1.36	2.50	1.65	0.95	1.92	3.29
Supermarket	PG&E	Yes	E-TOU	Bill Savings	No	0.67	0.00	0.91	0.00	0.98	0.00	1.51	0.00	1.31	0.00	2.08	0.00
Supermarket	PG&E	Yes	RTP	Bill Savings	Yes	1.00	0.65	0.77	1.56	1.38	0.80	1.35	2.47	1.75	0.87	1.88	3.23
Supermarket	PG&E	Yes	RTP	Bill Savings	No	0.71	0.00	0.91	0.00	1.05	0.00	1.49	0.00	1.41	0.00	2.04	0.00
Supermarket	PG&E	No	E-TOU	Bill Savings	Yes	1.10	0.54	0.72	1.45	1.54	0.67	1.28	2.35	1.99	0.72	1.81	3.10
Supermarket	PG&E	No	E-TOU	Bill Savings	No	0.81	0.00	0.86	0.00	1.22	0.00	1.43	0.00	1.65	0.00	1.97	0.00
Supermarket	PG&E	No	RTP	Bill Savings	Yes	1.13	0.51	0.71	1.43	1.59	0.62	1.23	2.26	2.06	0.66	1.73	2.96
Supermarket	PG&E	No	RTP	Bill Savings	No	0.84	0.00	0.85	0.00	1.27	0.00	1.38	0.00	1.73	0.00	1.89	0.00
Supermarket	SCE	Yes	E-TOU	Bill Savings	Yes	1.11	0.51	0.69	1.39	1.56	0.67	1.31	2.40	2.04	0.75	1.93	3.30
Supermarket	SCE	Yes	E-TOU	Bill Savings	No	0.82	0.00	0.83	0.00	1.24	0.00	1.45	0.00	1.70	0.00	2.08	0.00
Supermarket	SCE	Yes	RTP	Bill Savings	Yes	1.13	0.50	0.69	1.39	1.61	0.65	1.31	2.40	2.11	0.72	1.93	3.30
Supermarket	SCE	Yes	RTP	Bill Savings	No	0.84	0.00	0.83	0.00	1.29	0.00	1.45	0.00	1.77	0.00	2.08	0.00
Supermarket	SCE	No	E-TOU	Bill Savings	Yes	1.60	0.27	0.57	1.13	2.43	0.34	1.08	1.98	3.31	0.37	1.62	2.77
Supermarket	SCE	No	E-TOU	Bill Savings	No	1.32	0.00	0.71	0.00	2.12	0.00	1.23	0.00	2.99	0.00	1.77	0.00
Supermarket	SCE	No	RTP	Bill Savings	Yes	1.83	0.23	0.57	1.13	2.84	0.29	1.08	1.98	3.90	0.31	1.62	2.77
Supermarket	SCE	No	RTP	Bill Savings	No	1.55	0.00	0.71	0.00	2.53	0.00	1.23	0.00	3.59	0.00	1.77	0.00
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.48	0.31	0.60	1.19	2.23	0.37	1.09	1.99	3.06	0.40	1.58	2.71
Supermarket	SDG&E	Yes	E-TOU	Bill Savings	No	1.19	0.00	0.73	0.00	1.92	0.00	1.23	0.00	2.74	0.00	1.74	0.00
Supermarket	SDG&E	Yes	RTP	Bill Savings	Yes	0.78	0.82	0.71	1.41	1.00	1.10	1.27	2.32	1.23	1.26	1.82	3.12
Supermarket	SDG&E	Yes	RTP	Bill Savings	No	0.49	0.00	0.84	0.00	0.67	0.00	1.41	0.00	0.88	0.00	1.98	0.00
Supermarket	SDG&E	No	E-TOU	Bill Savings	Yes	2.18	0.16	0.50	0.98	3.47	0.19	0.88	1.60	4.92	0.19	1.27	2.18
Supermarket	SDG&E	No	E-TOU	Bill Savings	No	1.90	0.00	0.63	0.00	3.18	0.00	1.03	0.00	4.62	0.00	1.43	0.00
Supermarket	SDG&E	No	RTP	Bill Savings	Yes	0.78	0.82	0.71	1.41	1.00	1.10	1.27	2.32	1.23	1.26	1.82	3.12

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Supermarket	SDG&E	No	RTP	Bill Savings	No	0.49	0.00	0.84	0.00	0.67	0.00	1.41	0.00	0.88	0.00	1.98	0.00
Office	PG&E	Yes	E-TOU	Bill Savings	Yes	1.03	0.62	0.76	1.54	1.42	0.75	1.31	2.40	1.82	0.81	1.83	3.14
Office	PG&E	Yes	E-TOU	Bill Savings	No	0.74	0.00	0.90	0.00	1.10	0.00	1.46	0.00	1.48	0.00	1.99	0.00
Office	PG&E	Yes	RTP	Bill Savings	Yes	1.04	0.60	0.76	1.52	1.45	0.71	1.28	2.34	1.86	0.76	1.76	3.02
Office	PG&E	Yes	RTP	Bill Savings	No	0.75	0.00	0.89	0.00	1.13	0.00	1.42	0.00	1.52	0.00	1.92	0.00
Office	PG&E	No	E-TOU	Bill Savings	Yes	1.49	0.37	0.72	1.44	2.23	0.43	1.24	2.26	2.98	0.44	1.72	2.95
Office	PG&E	No	E-TOU	Bill Savings	No	1.21	0.00	0.85	0.00	1.91	0.00	1.38	0.00	2.66	0.00	1.88	0.00
Office	PG&E	No	RTP	Bill Savings	Yes	1.49	0.38	0.74	1.49	2.22	0.43	1.25	2.29	2.98	0.45	1.73	2.96
Office	PG&E	No	RTP	Bill Savings	No	1.20	0.00	0.87	0.00	1.91	0.00	1.40	0.00	2.65	0.00	1.88	0.00
Office	SCE	Yes	E-TOU	Bill Savings	Yes	0.90	0.68	0.71	1.42	1.21	0.91	1.31	2.40	1.51	1.04	1.92	3.29
Office	SCE	Yes	E-TOU	Bill Savings	No	0.61	0.00	0.84	0.00	0.88	0.00	1.45	0.00	1.17	0.00	2.07	0.00
Office	SCE	Yes	RTP	Bill Savings	Yes	1.04	0.39	0.50	0.98	1.45	0.44	0.79	1.43	1.87	0.46	1.09	1.85
Office	SCE	Yes	RTP	Bill Savings	No	0.75	0.00	0.64	0.00	1.13	0.00	0.94	0.00	1.53	0.00	1.24	0.00
Office	SCE	No	E-TOU	Bill Savings	Yes	1.43	0.37	0.68	1.36	2.13	0.45	1.26	2.31	2.87	0.50	1.86	3.18
Office	SCE	No	E-TOU	Bill Savings	No	1.15	0.00	0.81	0.00	1.82	0.00	1.41	0.00	2.55	0.00	2.01	0.00
Office	SCE	No	RTP	Bill Savings	Yes	1.36	0.27	0.48	0.94	2.01	0.28	0.75	1.35	2.70	0.29	1.01	1.73
Office	SCE	No	RTP	Bill Savings	No	1.08	0.00	0.62	0.00	1.70	0.00	0.89	0.00	2.37	0.00	1.17	0.00
Office	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.25	0.38	0.61	1.21	1.84	0.45	1.07	1.96	2.48	0.49	1.55	2.64
Office	SDG&E	Yes	E-TOU	Bill Savings	No	0.97	0.00	0.74	0.00	1.52	0.00	1.22	0.00	2.15	0.00	1.70	0.00
Office	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Office	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
Office	SDG&E	No	E-TOU	Bill Savings	Yes	2.00	0.21	0.57	1.12	3.16	0.24	1.00	1.83	4.44	0.25	1.45	2.48
Office	SDG&E	No	E-TOU	Bill Savings	No	1.72	0.00	0.70	0.00	2.86	0.00	1.15	0.00	4.14	0.00	1.61	0.00
Office	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Office	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	Yes	1.49	0.45	0.86	1.74	2.23	0.52	1.51	2.79	2.98	0.55	2.14	3.66
EV Charging Station	PG&E	Yes	E-TOU	Bill Savings	No	1.21	0.00	0.99	0.00	1.92	0.00	1.66	0.00	2.66	0.00	2.29	0.00
EV Charging Station	PG&E	Yes	RTP	Bill Savings	Yes	1.64	0.39	0.84	1.70	2.49	0.44	1.45	2.67	3.36	0.46	2.03	3.47
EV Charging Station	PG&E	Yes	RTP	Bill Savings	No	1.36	0.00	0.98	0.00	2.18	0.00	1.60	0.00	3.04	0.00	2.18	0.00
EV Charging Station	PG&E	No	E-TOU	Bill Savings	Yes	1.73	0.37	0.85	1.72	2.63	0.43	1.49	2.74	3.57	0.45	2.09	3.59
EV Charging Station	PG&E	No	E-TOU	Bill Savings	No	1.44	0.00	0.98	0.00	2.33	0.00	1.64	0.00	3.25	0.00	2.25	0.00
EV Charging Station	PG&E	No	RTP	Bill Savings	Yes	1.74	0.37	0.84	1.71	2.65	0.42	1.46	2.68	3.60	0.43	2.03	3.47
EV Charging Station	PG&E	No	RTP	Bill Savings	No	1.45	0.00	0.98	0.00	2.35	0.00	1.60	0.00	3.28	0.00	2.18	0.00
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	Yes	1.17	0.52	0.75	1.50	1.68	0.67	1.41	2.59	2.20	0.75	2.09	3.58
EV Charging Station	SCE	Yes	E-TOU	Bill Savings	No	0.88	0.00	0.88	0.00	1.36	0.00	1.56	0.00	1.87	0.00	2.25	0.00
EV Charging Station	SCE	Yes	RTP	Bill Savings	Yes	1.50	0.22	0.45	0.87	2.25	0.23	0.70	1.26	3.04	0.24	0.96	1.63
EV Charging Station	SCE	Yes	RTP	Bill Savings	No	1.21	0.00	0.58	0.00	1.94	0.00	0.85	0.00	2.72	0.00	1.11	0.00
EV Charging Station	SCE	No	E-TOU	Bill Savings	Yes	1.60	0.35	0.74	1.49	2.42	0.44	1.40	2.57	3.30	0.48	2.08	3.56
EV Charging Station	SCE	No	E-TOU	Bill Savings	No	1.31	0.00	0.88	0.00	2.11	0.00	1.55	0.00	2.97	0.00	2.23	0.00
EV Charging Station	SCE	No	RTP	Bill Savings	Yes	1.55	0.21	0.44	0.86	2.34	0.22	0.69	1.24	3.17	0.23	0.94	1.60

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
EV Charging Station	SCE	No	RTP	Bill Savings	No	1.26	0.00	0.58	0.00	2.03	0.00	0.83	0.00	2.85	0.00	1.09	0.00
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.60	0.30	0.64	1.28	2.45	0.36	1.17	2.14	3.39	0.38	1.70	2.91
EV Charging Station	SDG&E	Yes	E-TOU	Bill Savings	No	1.31	0.00	0.78	0.00	2.14	0.00	1.32	0.00	3.07	0.00	1.86	0.00
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
EV Charging Station	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	Yes	2.28	0.20	0.64	1.28	3.66	0.23	1.16	2.12	5.20	0.24	1.69	2.89
EV Charging Station	SDG&E	No	E-TOU	Bill Savings	No	2.01	0.00	0.77	0.00	3.37	0.00	1.31	0.00	4.90	0.00	1.84	0.00
EV Charging Station	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
EV Charging Station	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
Food Processing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.75	0.84	0.68	1.36	0.93	1.08	1.13	2.06	1.11	1.19	1.53	2.62
Food Processing	PG&E	Yes	E-TOU	Bill Savings	No	0.45	0.00	0.81	0.00	0.60	0.00	1.27	0.00	0.76	0.00	1.68	0.00
Food Processing	PG&E	Yes	RTP	Bill Savings	Yes	0.82	0.85	0.77	1.56	1.05	1.05	1.28	2.34	1.29	1.13	1.73	2.96
Food Processing	PG&E	Yes	RTP	Bill Savings	No	0.52	0.00	0.91	0.00	0.73	0.00	1.42	0.00	0.94	0.00	1.88	0.00
Food Processing	PG&E	No	E-TOU	Bill Savings	Yes	0.78	0.77	0.66	1.32	0.99	0.95	1.07	1.96	1.19	1.03	1.44	2.47
Food Processing	PG&E	No	E-TOU	Bill Savings	No	0.49	0.00	0.79	0.00	0.66	0.00	1.22	0.00	0.85	0.00	1.60	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	PG&E	No	RTP	Bill Savings	Yes	0.85	0.79	0.75	1.51	1.10	0.94	1.21	2.22	1.36	1.00	1.63	2.78
Food Processing	PG&E	No	RTP	Bill Savings	No	0.55	0.00	0.89	0.00	0.78	0.00	1.36	0.00	1.01	0.00	1.78	0.00
Food Processing	SCE	Yes	E-TOU	Bill Savings	Yes	0.90	0.63	0.66	1.31	1.20	0.85	1.22	2.23	1.51	0.97	1.78	3.05
Food Processing	SCE	Yes	E-TOU	Bill Savings	No	0.61	0.00	0.79	0.00	0.88	0.00	1.36	0.00	1.17	0.00	1.93	0.00
Food Processing	SCE	Yes	RTP	Bill Savings	Yes	0.91	0.62	0.66	1.31	1.22	0.83	1.22	2.23	1.54	0.95	1.78	3.05
Food Processing	SCE	Yes	RTP	Bill Savings	No	0.62	0.00	0.79	0.00	0.90	0.00	1.36	0.00	1.20	0.00	1.93	0.00
Food Processing	SCE	No	E-TOU	Bill Savings	Yes	1.03	0.48	0.60	1.20	1.43	0.63	1.11	2.03	1.85	0.71	1.63	2.78
Food Processing	SCE	No	E-TOU	Bill Savings	No	0.74	0.00	0.74	0.00	1.11	0.00	1.26	0.00	1.51	0.00	1.78	0.00
Food Processing	SCE	No	RTP	Bill Savings	Yes	1.26	0.37	0.60	1.20	1.84	0.47	1.11	2.03	2.44	0.52	1.63	2.78
Food Processing	SCE	No	RTP	Bill Savings	No	0.98	0.00	0.74	0.00	1.52	0.00	1.26	0.00	2.11	0.00	1.78	0.00
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.19	0.40	0.60	1.19	1.72	0.50	1.09	1.99	2.30	0.54	1.58	2.71
Food Processing	SDG&E	Yes	E-TOU	Bill Savings	No	0.90	0.00	0.73	0.00	1.40	0.00	1.23	0.00	1.96	0.00	1.74	0.00
Food Processing	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Food Processing	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
Food Processing	SDG&E	No	E-TOU	Bill Savings	Yes	1.26	0.35	0.56	1.11	1.85	0.42	1.00	1.82	2.49	0.45	1.44	2.46

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Food Processing	SDG&E	No	E-TOU	Bill Savings	No	0.97	0.00	0.69	0.00	1.53	0.00	1.14	0.00	2.16	0.00	1.60	0.00
Food Processing	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Food Processing	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	Yes	0.62	0.96	0.66	2.71	0.88	1.10	1.17	4.06	1.20	1.15	1.73	5.13
Manufacturing	PG&E	Yes	E-TOU	Bill Savings	No	0.50	0.00	0.71	0.00	0.74	0.00	1.24	0.00	1.03	0.00	1.81	0.00
Manufacturing	PG&E	Yes	RTP	Bill Savings	Yes	0.61	0.85	0.59	2.38	0.88	0.94	1.01	3.45	1.18	0.97	1.47	4.30
Manufacturing	PG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.65	0.00	0.73	0.00	1.08	0.00	1.01	0.00	1.55	0.00
Manufacturing	PG&E	No	E-TOU	Bill Savings	Yes	0.56	0.68	0.45	1.65	0.78	0.77	0.73	2.39	1.03	0.80	1.04	2.97
Manufacturing	PG&E	No	E-TOU	Bill Savings	No	0.45	0.00	0.50	0.00	0.63	0.00	0.80	0.00	0.86	0.00	1.13	0.00
Manufacturing	PG&E	No	RTP	Bill Savings	Yes	0.61	0.80	0.56	2.23	0.88	0.86	0.93	3.14	1.18	0.87	1.32	3.85
Manufacturing	PG&E	No	RTP	Bill Savings	No	0.50	0.00	0.62	0.00	0.73	0.00	1.00	0.00	1.01	0.00	1.40	0.00
Manufacturing	SCE	Yes	E-TOU	Bill Savings	Yes	0.58	0.63	0.45	1.63	0.82	0.79	0.80	2.65	1.10	0.87	1.22	3.52
Manufacturing	SCE	Yes	E-TOU	Bill Savings	No	0.47	0.00	0.50	0.00	0.68	0.00	0.87	0.00	0.93	0.00	1.30	0.00
Manufacturing	SCE	Yes	RTP	Bill Savings	Yes	0.66	0.25	0.29	0.81	0.98	0.25	0.39	1.08	1.35	0.25	0.52	1.32
Manufacturing	SCE	Yes	RTP	Bill Savings	No	0.55	0.00	0.34	0.00	0.83	0.00	0.46	0.00	1.19	0.00	0.60	0.00
Manufacturing	SCE	No	E-TOU	Bill Savings	Yes	0.59	0.54	0.40	1.40	0.83	0.64	0.68	2.19	1.12	0.69	1.00	2.85
Manufacturing	SCE	No	E-TOU	Bill Savings	No	0.47	0.00	0.46	0.00	0.69	0.00	0.75	0.00	0.94	0.00	1.09	0.00
Manufacturing	SCE	No	RTP	Bill Savings	Yes	0.67	0.17	0.24	0.56	1.00	0.14	0.28	0.63	1.39	0.13	0.32	0.70
Manufacturing	SCE	No	RTP	Bill Savings	No	0.56	0.00	0.29	0.00	0.86	0.00	0.35	0.00	1.22	0.00	0.40	0.00
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	Yes	0.81	0.52	0.57	2.26	1.30	0.60	1.08	3.69	1.91	0.63	1.66	4.91
Manufacturing	SDG&E	Yes	E-TOU	Bill Savings	No	0.70	0.00	0.62	0.00	1.16	0.00	1.14	0.00	1.75	0.00	1.74	0.00
Manufacturing	SDG&E	Yes	RTP	Bill Savings	Yes	0.55	0.75	0.47	1.75	0.77	0.83	0.76	2.50	1.02	0.85	1.09	3.11
Manufacturing	SDG&E	Yes	RTP	Bill Savings	No	0.44	0.00	0.52	0.00	0.62	0.00	0.83	0.00	0.85	0.00	1.17	0.00

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Manufacturing	SDG&E	No	E-TOU	Bill Savings	Yes	0.70	0.44	0.43	1.56	1.08	0.50	0.75	2.46	1.55	0.53	1.12	3.22
Manufacturing	SDG&E	No	E-TOU	Bill Savings	No	0.59	0.00	0.49	0.00	0.94	0.00	0.82	0.00	1.38	0.00	1.20	0.00
Manufacturing	SDG&E	No	RTP	Bill Savings	Yes	0.55	0.75	0.47	1.75	0.77	0.83	0.76	2.50	1.02	0.85	1.09	3.11
Manufacturing	SDG&E	No	RTP	Bill Savings	No	0.44	0.00	0.52	0.00	0.62	0.00	0.83	0.00	0.85	0.00	1.17	0.00
Elementary School	PG&E	Yes	E-TOU	Bill Savings	Yes	0.72	0.76	0.58	1.15	0.88	0.98	0.96	1.75	1.03	1.11	1.31	2.24
Elementary School	PG&E	Yes	E-TOU	Bill Savings	No	0.42	0.00	0.72	0.00	0.55	0.00	1.11	0.00	0.69	0.00	1.46	0.00
Elementary School	PG&E	Yes	RTP	Bill Savings	Yes	0.78	0.74	0.63	1.26	0.98	0.91	1.02	1.87	1.18	0.99	1.37	2.35
Elementary School	PG&E	Yes	RTP	Bill Savings	No	0.48	0.00	0.77	0.00	0.65	0.00	1.17	0.00	0.83	0.00	1.53	0.00
Elementary School	PG&E	No	E-TOU	Bill Savings	Yes	0.80	0.64	0.57	1.13	1.02	0.80	0.94	1.71	1.24	0.87	1.28	2.18
Elementary School	PG&E	No	E-TOU	Bill Savings	No	0.50	0.00	0.71	0.00	0.69	0.00	1.09	0.00	0.89	0.00	1.43	0.00
Elementary School	PG&E	No	RTP	Bill Savings	Yes	0.84	0.66	0.63	1.25	1.09	0.78	1.00	1.83	1.34	0.83	1.34	2.28
Elementary School	PG&E	No	RTP	Bill Savings	No	0.55	0.00	0.76	0.00	0.77	0.00	1.15	0.00	1.00	0.00	1.49	0.00
Elementary School	SCE	Yes	E-TOU	Bill Savings	Yes	0.87	0.67	0.66	1.33	1.14	0.88	1.20	2.19	1.43	1.01	1.73	2.97
Elementary School	SCE	Yes	E-TOU	Bill Savings	No	0.57	0.00	0.80	0.00	0.82	0.00	1.34	0.00	1.08	0.00	1.89	0.00
Elementary School	SCE	Yes	RTP	Bill Savings	Yes	0.89	0.65	0.66	1.33	1.18	0.85	1.20	2.19	1.47	0.97	1.73	2.97
Elementary School	SCE	Yes	RTP	Bill Savings	No	0.59	0.00	0.80	0.00	0.85	0.00	1.34	0.00	1.13	0.00	1.89	0.00
Elementary School	SCE	No	E-TOU	Bill Savings	Yes	1.14	0.45	0.64	1.27	1.62	0.57	1.15	2.11	2.11	0.62	1.67	2.86

Load Shape Name	IOU	PV	Rate	Storage Dispatch Mode	SGIP Incentive	2018				2024				2028			
						PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA Ratio
Elementary School	SCE	No	E-TOU	Bill Savings	No	0.85	0.00	0.77	0.00	1.30	0.00	1.30	0.00	1.78	0.00	1.83	0.00
Elementary School	SCE	No	RTP	Bill Savings	Yes	1.37	0.36	0.64	1.27	2.03	0.44	1.15	2.11	2.72	0.48	1.67	2.86
Elementary School	SCE	No	RTP	Bill Savings	No	1.09	0.00	0.77	0.00	1.72	0.00	1.30	0.00	2.39	0.00	1.83	0.00
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	Yes	1.17	0.40	0.58	1.15	1.69	0.48	1.04	1.89	2.26	0.52	1.50	2.56
Elementary School	SDG&E	Yes	E-TOU	Bill Savings	No	0.88	0.00	0.72	0.00	1.37	0.00	1.18	0.00	1.93	0.00	1.65	0.00
Elementary School	SDG&E	Yes	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Elementary School	SDG&E	Yes	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00
Elementary School	SDG&E	No	E-TOU	Bill Savings	Yes	1.34	0.33	0.57	1.12	1.99	0.38	1.00	1.82	2.71	0.41	1.43	2.45
Elementary School	SDG&E	No	E-TOU	Bill Savings	No	1.06	0.00	0.70	0.00	1.68	0.00	1.14	0.00	2.38	0.00	1.59	0.00
Elementary School	SDG&E	No	RTP	Bill Savings	Yes	0.79	0.85	0.74	1.49	1.02	1.13	1.34	2.45	1.26	1.29	1.92	3.29
Elementary School	SDG&E	No	RTP	Bill Savings	No	0.50	0.00	0.88	0.00	0.70	0.00	1.48	0.00	0.92	0.00	2.08	0.00

TABLE C-14: UTILITY SCALE IN FRONT OF METER COST-EFFECTIVENESS RESULTS, 2018, 2024, AND 2028

IOU	Operating Mode	TRC Benefits Ratio		
		2018	2024	2028
PG&E	Avoided Cost Arbitrage	3.12	3.91	4.28
SCE	Avoided Cost Arbitrage	3.10	3.92	4.30
SDG&E	Avoided Cost Arbitrage	2.77	3.63	4.05