American Journal of Industrial and Business Management, 2023, 13, 418-428
https://www.scirp.org/journal/ajibm
ISSN Online: 2164-5175
ISSN Print: 2164-5167

The Economics of Residential Solar and Battery Storage: Analyzing the California Public Utilities Commission Decision of December 2022

Prashanth Nyer*, Charu Sinha

Argyros School of Business & Economics, Chapman University, Orange, USA
Email: *nyer@chapman.edu, csinha@chapman.edu

How to cite this paper: Nyer, P., & Sinha, C. (2023). The Economics of Residential Solar and Battery Storage: Analyzing the California Public Utilities Commission Decision of December 2022. *American Journal of Industrial and Business Management, 13,* 418-428.
https://doi.org/10.4236/ajibm.2023.135026

Received: May 2, 2023
Accepted: May 28, 2023
Published: May 31, 2023

Abstract

California Public Utilities Commission (CPUC) is the California state governmental organization that regulates privately owned natural gas, water, electric, telecommunications, rail transit, railroad, and passenger transportation companies. In December 2022, the CPUC announced the latest rules—the net billing tariff (NBT) that will decide how excess solar energy generated by customers of the three major investor-owned utilities (IOU) will be compensated for. These decisions were made after a multi-year process during which the CPUC heard opinions from many interest groups, including customers with and without solar installations, IOUs, solar industry groups, environmental groups etc. In this paper, we will summarize the decisions made by the CPUC in December 2022, and we will discuss how they differ from the past programs approved by the CPUC, and what the latest decisions mean for the economics of residential solar installations, and the implications for future policy making.

Keywords

Solar Panels, Battery, Net Metering, Net Billing Tariff, NEM, NBT, California

1. Introduction

The state of California has led the efforts in the United States of America in proposing and enacting regulations designed to reduce future carbon emissions. In September 2018, California Governor Jerry Brown issued an executive order to achieve carbon neutrality for the state by 2045 (California Executive Order,

2018). The California Solar Mandate which went into effect in January 2020, requires new residential units up to three stories high to have solar panels that will generate the annual electrical energy needs of those buildings. These aggressive actions on the part of the state of California have been enacted against the backdrop of shifting, and sometimes contradictory, regulatory changes concerning net energy metering. In December 2022, the CPUC released its decisions defining the structure of the revised net energy metering program, which will determine how customers of the three major IOUs[1], who install solar panels (and battery storage) under this new program will be compensated for the excess energy they export to the grid, and the additional fees that these customers will have to pay. Starting on April 15, 2023, this new program (tentatively called the Net Billing Tariff—NBT) will replace the current Net Energy Metering 2.0 (NEM 2.0) program.

In this paper we will discuss the implications of the Net Billing Tariff, and how it will affect the economics of installing solar panels for residential customers of the major IOUs. We will also briefly comment on the implications for future policy making.

2. Net Metering

Net energy metering (also known as net metering) refers to the policies and rules that determine how customers who generate their own electrical energy (most commonly using solar panel arrays) are compensated for any excess energy exported to the electrical grid, and how they are charged for energy imported from the grid. The original net metering program (NEM 1.0) approved in 2013, did not force customers into time-of-use rate plans, and solar customers under NEM 1.0 were grandfathered under these rules for 20 years. A customer who installed a solar panel array under NEM 1.0 could stay on a tiered rate plan where they paid the same rate for electricity regardless of the time of day. Any excess electricity that the customer exported to the grid was compensated for at the retail rate. In other words, one kilowatt hour (kWh[2]) of electricity exported to the grid was compensated for at the same rate as one kWh of electricity purchased from the grid at some other time. Thus, under NEM 1.0 solar customers (i.e., IOU customers with solar panel arrays) could treat the electrical grid as an infinitely large, and 100% efficient, free battery storage facility. Despite solar panels being more expensive in the earlier years, customers found it financially attractive to go solar under NEM 1.0 (Nyer, Broughton, & Ybarra, 2019). The NEM 1.0 program terminated in 2016-2017, with the exact date varying by the IOU, and replaced by NEM 2.0.

Solar customers under this successor program (NEM 2.0) were still compensated for the excess energy produced by their solar panel arrays and exported to the grid but were forced into the less desirable time-of-use (TOU) rate plans

[1]California has three major IOUs: Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDGE).

[2]A kWh is the amount of energy consumed by a 1000-watt appliance in one hour.

where the rates were typically much lower during peak sunlight hours, and significantly higher during the peak demand hours in the evening. For example, Southern California Edison (SCE) which serves large parts of southern California, currently charges customers on their TOU 4 - 9 rate plan $0.26 per kWh between 9:00 AM and 4:00 PM, and $0.47 per kWh between 4:00 PM and 9:00 PM during the summer months (for net consumption within baseline allowance limits). Under this program, a customer who exports a kWh of electricity to the grid at 11:00 AM would earn a credit of $0.26, while being charged $0.47 for a kWh purchased at 8:00 PM. Further, NEM 2.0 introduced certain mandatory "non-bypassable charges" (NBC) of approximately $0.02 per kWh that customers under the previous NEM 1.0 program were not subject to. In addition, customers going solar under the NEM 2.0 program had to pay a one-time fee ranging between $75 to $150 (depending on the IOU) for getting started with net metering. Like with customers who went solar under the previous NEM 1.0 program, customers who went solar under NEM 2.0 were also grandfathered into that program for 20 years. As one can imagine, NEM 2.0 was not as financially attractive to customers as NEM 1.0 was. However, it did provide customers a good return on investment to customers (Nyer, Ybarra, & Broughton, 2019). The net metering programs NEM 1.0 and NEM 2.0 were very successful, with 2786 Megawatts of new solar generating capacity being added in 1999-2016 by residential customers in California, and an additional 6009 Megawatts of capacity added in 2017-2022 (data from California Distributed Generation Statistics https://www.californiadgstats.ca.gov/ a database authorized by the California Public Utilities Commission). Data available as of the end of January 2023 indicate that a total of 2875 MW of residential solar installations had been completed under NEM 1.0 while 6068 MW had been completed under NEM 2.0.

Figure 1 shows the accelerating pace of solar adoption by California residential customers. Also see Ybarra, Broughton & Nyer (2021) for an analysis of the trends in residential solar installations in the state.

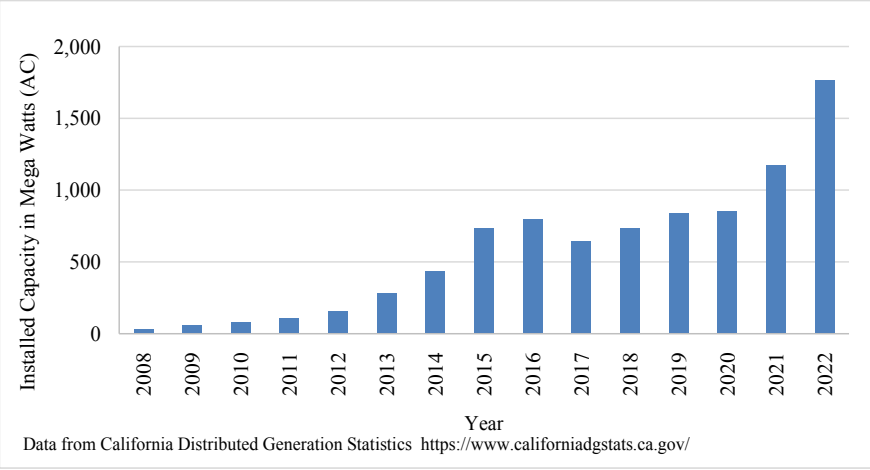

Figure 1. Residential solar installations by year.

2.1. Opposition to Net Metering Programs

Despite the great success that the net metering programs have enjoyed with residential customers (as well as commercial, industrial, educational, governmental and other customer groups), these programs have faced intense opposition from IOUs and others. The IOUs who have for years been campaigning to cut back or eliminate California's net metering programs have claimed that net metering programs are excessively generous to solar customers. They argue that it is mostly the wealthier homeowners who can afford to install solar panels and that these wealthier people then pay very little for electricity, which causes the customers without solar panels to pay most of the fixed costs associated with maintaining and operating the electrical grid and generation infrastructure. Ybarra, Broughton & Nyer (2021) found evidence to support the claim that residential solar panels were being installed mostly by wealthier customers.

2.2. Joint IOU Proposal

In March 2021, the three IOUs in the state submitted a document to the CPUC (California Public Utilities Commission, 2021) with suggestions on how the net metering program should be structured in the future. In brief, this proposal included provisions assigning all future solar customers to solar specific rate plans; setting the export compensation rate (what solar customers are credited for sending excess energy to the grid) to the IOU's avoided cost, rather than to the retail rate, and limiting the amount of energy that qualifies for export compensation and imposing substantial additional monthly charges on solar customers.

The export compensation rate and the additional monthly charges proposed vary by the IOU. For SCE, the export compensation rate during the peak sunlight hours (when most of the solar energy is generated) would be only $0.07 per kWh. Compare this with the retail rate of $0.26 per kWh that customers on NEM 2.0 receive for energy that they export to the grid at the same time. This would make it financially unattractive for customers to export excess energy to the grid and may encourage them to use battery storage to save the excess energy for use when the panels are not producing. IOUs have a vested interest in encouraging customers to install solar-coupled battery storage since that reduces the peak demand experienced by the grid. However, if many customers adopt solar-coupled battery storage, that will result in lower revenues for the IOUs.

This prompted the IOUs to propose two additional charges for customers going solar in the future. The first of these was a flat monthly fee named "Customer Charge", which for SCE customers would be $12.02, but much higher for customers of PG&E ($20.66) and SDGE ($24.10). The second charge, named Grid Benefits Charge would be based on the size of each customer's solar panel array in kilowatts, and would be $7.39 per kW for SCE customers, $10.93 per kW for PG&E customers, and $11.09 per kW for SDGE customers. Thus, a PG&E customer with a modest 5.78 kW solar panel array (the average state-wide residen-

tial solar panel array size for installations in 2013-2020; data from Ybarra, Broughton, & Nyer, 2021) would incur a Grid Benefits Charge of $63.18 per month.

Additionally, the Joint IOU proposal called for the 20-year grandfathering granted to customers on NEM 1.0 and 2.0 programs to be reduced to 15 years, and for the "true-up" period to be reduced from once a year to monthly. With the current annual true-up, solar customers can bank the extra kWh credits they earn from the sunny months to pay for the excess energy they use during the less sunny months. Any excess kWh credits left over during the annual true-up is compensated at the very low Net Surplus Compensation Rate (which for SCE was approximately $0.04 per kWh in January 2023). Moving to monthly true-up would have meant that the excess kWh credits earned during a sunny month would all have to be cashed out in the same month at the very low Net Surplus Compensation Rate ($0.04 per kWh for SCE in January 2023) and cannot be carried over to compensate for excess consumption during a less sunny month.

The IOUs also proposed that the current hourly netting being done for residential customers on NEM 2.0 be replaced with a no-netting policy (also referred to as instantaneous netting) whereby all recorded imports on the first meter channel are charged at the import retail rate, and all recorded exports on the second meter channel are credited the retail export compensation rate. Imagine a home where during the 12:00 PM to 12:59 PM hour the customer imports 1.0 kWh of energy and exports 1.5 kWh of energy. With the hourly netting the customer would have exported 0.5 kWh of energy for the hour which would have earned a credit of $0.035. Under no-netting, the 1.0 kWh of import will cost $0.26 and the 1.5 kWh of export would earn a credit of $0.105 for a net cost to the customer of $0.155 for the hour. Thus no-netting has the potential to greatly reduce the value of solar-only installations. If all the proposed changes suggested by the IOUs had been implemented, it would have made residential solar panel installations very unattractive to customers (see Ybarra, Nyer, Broughton, & Turk, 2021)

2.3. The CPUC Decisions

The CPUC in its decisions made in December 2022, accepted some of the provisions in the Joint IOU proposal and rejected others (California Public Utilities Commission, 2022). The CPUC decided that the export compensation rate would be limited to the IOU's avoided cost (the marginal cost of providing electric service to customers that can be avoided when the demand for energy decreases because of distributed energy resources such as residential solar panels). This rate will be set at averaged monthly values for each hour, differentiated between weekday and weekend/holiday. This decision will greatly limit how much residential solar customers are compensated for the excess energy they export to the grid during the daytime. Further, the CPUC decided that IOUs move to no-netting, as requested by the IOUs. These are big wins for the IOUs and represent a deliberate move on the part of the CPUC to encourage customers to move towards storage coupled solar panel installations which would help reduce the sharp peaks in

energy demand during the evening hours when people come home. However, the IOUs did not get everything they asked for. The CPUC decided to not shorten the grandfathering period granted to customers on the NEM 1.0 and 2.0 programs, and they decided to retain the annual true-up.

In its decision, the CPUC stated that they wanted to break from the previous nomenclature and refer to the successor program as net billing tariff (rather than as NEM 3.0). They wanted to encourage an equitable growth in the residential solar industry by targeting a nine-year simple payback period for solar only installations, and by providing a glide path (that will be available to residential customers who enroll in this successor program over the first five years of this program) to ease the transition to the new successor program. This glide path will take the form of a small additional credit for every kWh of energy exported to the grid during the first five years of being on the new program. For SCE residential customers enrolling in the net billing program in 2023, the credit will be $0.04 per kWh of exports for each of the first five years. Customers going solar in 2024 will see this credit decreasing by 20%, while those enrolling in 2025 will see credits decreasing by 40%, etc., until customers going solar in 2028 and later will not receive any additional credits.

The CPUC decision calls for the continuation of the use of a rate structure characterized by highly differentiated time-of-use rates, and non-bypassable charges. The commission required the IOUs to make critical peak pricing and peak day pricing options available to customers under the new net billing program. These pricing options are likely to be beneficial for customers with storage coupled solar systems.

While the NEM 1.0 and 2.0 programs each had 20-year grandfathering periods, the successor net billing program will have a nine-year grandfathering period, which the CPUC now refers to as the legacy period. The choice of nine years corresponds to the CPUC's stated goals of having stand-alone solar systems have a nine-year payback period.

3. Economics of Residential Solar Installations under Net Billing

In this section we will determine the economic viability of residential solar panels for a median sized home under the latest CPUC decisions.

3.1. Data

Following Broughton, Nyer & Ybarra (2021) and Ybarra, Nyer, Broughton and Turk (2021), we examine a hypothetical SCE residential customer in ZIP code area 92,867 who consumes 7411 kWh of electrical energy each year (this corresponds to the average yearly electricity consumption per household for this ZIP code in 2018-2019 (Southern California Edison, 2022a). Using data from SCE on the timing and quantity of average residential customer electricity usage (Distributed Generation Interconnection Program Data, 2023), we estimated the hourly electricity consumption for this hypothetical customer for each month of the

year.

Since this customer consumes 7411 kWh each year, we designed a south-facing 4.541 kW DC solar panel system (with a commonly used roof pitch of 20˚) that would generate 7411 kWh of energy annually (Broughton, Nyer, & Ybarra, 2021; Ybarra, Nyer, Broughton, & Turk, 2021). The solar production for this installation was estimated using National Renewable Energy Laboratory's (a national laboratory of the U.S. Department of Energy) PVWatts web application (https://pvwatts.nrel.gov/). The PVWatts web-app estimates the hourly electricity production of a solar panel installation for each day of the year using the system's location, the directional orientation of the array, tilt angle and array size. In addition, PVWatts uses the historic cloud cover and other meteorological data for the location to make their estimates. The data from PVWatts were corrected for daylight savings time.

3.2. Methodology

With the customer's hourly electricity consumption and electricity generation data in place, it was then possible to determine this customer's hourly net export or import of energy. This combined with the tariff data (Southern California Edison, 2022b) made it possible for us to calculate the customer's annual electricity expenses under various scenarios, and to calculate various financial measures such as net present value and payback period.

3.3. Load Profiles

Not all customers have the same electricity usage pattern. People working and studying at home will have a different usage profile compared to people who are not home during the daytime on weekdays. To make our analyses more generalizable, we used the four hypothetical load profiles from Broughton, Nyer & Ybarra (2021). The annual electricity consumption for all four load profiles was set to 7411 kWh. The four load profiles are described below (the description below and **Figure 2** have been reproduced from Broughton, Nyer & Ybarra, 2021 and Broughton, Ybarra & Nyer, 2022 with permission.)

1) Adults working from home. These households typically have someone home throughout the day. As such, during the summer months air-conditioners get turned on earlier in the afternoon. Once the house is cooled, the electrical load will be relatively lower during the later evening hours.

2) Adults working outside the home with no children. These homes will typically be unoccupied during the workday and will see a sharp increase in electricity use in the early evening hours in summer when the residents return from work.

3) Adults working from home but away from 5 PM to 8 PM. These could be individuals who work from home and attend school or run errands in the evening. These households typically have a usage pattern similar to load profile A with the difference that the energy consumption is low between 5 PM and 8 PM.

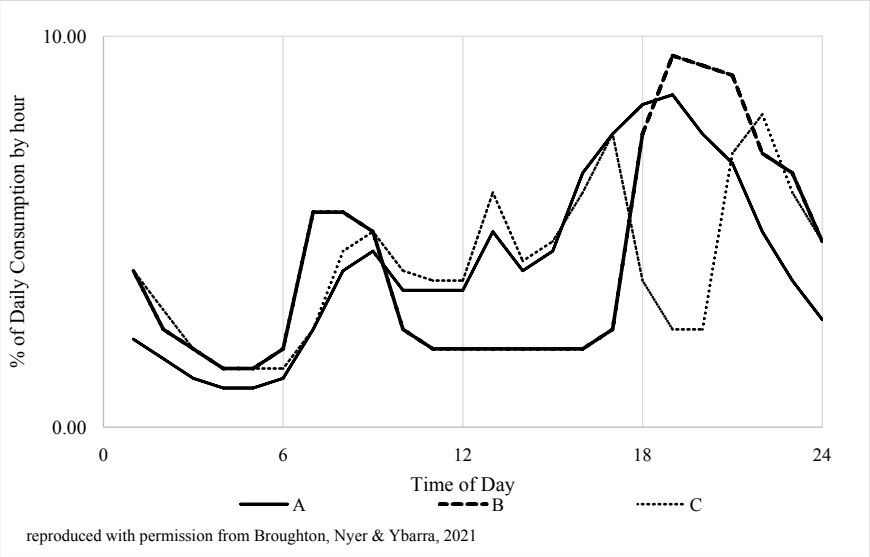

Figure 2. Load Profiles (reproduced from Broughton, Nyer and Ybarra, 2021 with permission).

4) Adults working outside the home with school-aged children. School-aged children tend to be home for part of the summer, and when in school they tend to return home earlier than their parents. Thus, during the summer months these homes tend to see their air-conditioners turned on earlier than the homes without children (load profile B above).

Some of the simulated load profiles (for the summer months) are shown in **Figure 2** (the load profile D, for working adults with school-aged children, has not been included to improve the legibility of the illustration. Load profile D is like profile B, but with a bump in electricity use when schoolchildren return home from school). While our simulations divided the year into three seasons (summer, winter and spring/fall), **Figure 2** includes only the summer load profiles to declutter the illustration.

4. Findings

4.1. Financial Impact of Solar Panels under Net Billing

Table 1 summarizes the annual electricity bills for the hypothetical home, with and without solar panels, under the TOU D Prime rate plan for the four load profiles (tariffs from 2022 were used). To reduce the number of scenarios that we examine, we assume that the solar panels are installed facing south and that the array is sized to exactly match the annual electricity consumption of the household of 7411 kWh (in other words, the usage offset is 100%). The annual avoided electricity cost was computed for each load profile, and from that the payback period, net present value (NPV) and internal rate of return (IRR) were calculated. NPV is the discounted present value of the stream of avoided costs minus the installed cost of the solar system. Positive values of NPV indicate that the solar system creates value for the homeowner and is a good investment. The

discount rate used to calculate NPV is the cost of financing the solar installation. We conducted an informal survey of solar installers and financial institutions to gauge the approximate financing cost for residential solar systems. The lowest rates by loan term were 4.49% (8 year), 5.49% (12 year), and 6.49% (20 year). These rates required a FICO score of 720 or higher. In Table 1 we compute the NPV using both 4.49% and 6.49%. IRR is the discount rate that would result in an NPV of exactly zero and provides a threshold financing rate. If it is possible to finance the solar system at a rate below the IRR, the NPV is positive.

Table 1. Financial Impact of Solar Panels under the new Net Billing rules (100% Usage Offset).

	Load Profiles			
	A	B	C	D
Annual electricity charge without solar	$2435.16	$2421.54	$2159.35	$2417.39
Annual electricity charge with solar	$1358.39	$1634.15	$1084.86	$1487.98
Annual avoided electricity charge (years 6 - 25)	$1076.77	$787.39	$1074.48	$929.41
Glide path credit for first 5 years (for installations in 2023)	158.09	211.65	154.90	190.00
Cost of solar installation after tax credit	$8868.14			
Solar Installation in 2023[3]				
Payback Period (years)[4]	7.67	9.93	7.70	8.66
Net present value at discount rate of 4.49%	$7809.03	$3748.86	$7761.15	$5761.95
Net present value at discount rate of 6.49%	$4935.43	$1625.02	$4894.32	$3269.04
Internal rate of return	12.25%	8.54%	12.20%	10.44%
Solar Installation in 2025				
Payback Period (years)	7.89	10.42	7.91	8.99
Net present value at discount rate of 4.49%	$7531.34	$3377.11	$7489.07	$5428.21
Net present value at discount rate of 6.49%	$4672.57	$1273.11	$4636.76	$2953.12
Internal rate of return	11.86%	8.06%	11.82%	10.00%
Solar Installation in 2028				
Payback Period (years)	8.24	11.26	8.25	9.54
Net present value at discount rate of 4.49%	$7114.81	$2819.47	$7080.95	$4927.60
Net present value at discount rate of 6.49%	$4278.27	$745.24	$4250.42	$2479.24
Internal rate of return	11.31%	7.38%	11.28%	9.36%

[3]The glide path credit which lasts for five years for a new solar customer is at the maximum for installations in 2023 and decreases by 20% each year for installations in subsequent years. Installations in 2028 and later will not receive any glide path credits.

[4]Since the avoided costs are higher in years 1 - 5, and lower in years 6 - 25, the average of the avoided costs for the first 10 years was used in calculating the simple payback period.

In our analysis, we assumed that the solar panels would last 25 years (25 years is the typical warrantied life of solar panels). We did not adjust for the slight degradation in the energy generation of solar panels as they age (typically a 10% reduction by the 25th year) since this is offset by the increasing cost of electricity. Table 1 makes it obvious that it is financially beneficial for homeowners to install solar panels under the new Net Billing program, however the financial benefits decrease for installations in future years as the glide path credits get reduced. This analysis assumes that the cost of solar panels and the electricity rates will remain at current levels for a long time. Our analysis reinforces the CPUC stance that its decisions are designed to yield a simple payback period of approximately nine years for solar-only installations made under the net billing program.

4.2. Conclusion

As has been speculated by others (see Ybarra, Nyer, Broughton, & Turk, 2021) the Joint IOU proposal was potentially a negotiation strategy on the part of the IOUs where they asked for a lot in the hope that several, if not all, of their demands would be fulfilled. As Ybarra, Nyer, Broughton & Turk (2021) determined, if the CPUC had adopted all of the Joint IOU recommendations, then residential solar and battery installations in the state would have become economically unviable to most homeowners. However, the CPUC chose to not adopt all the IOU recommendations, and as such, as we determine in this paper, even stand-alone solar installations will continue to be economically viable for customers installing solar panels in the near future.

5. Limitations and Future Research

The analyses done in this paper examine the financial implications of installing solar panels under the CPUC decisions of December 2022. Some of the finer details such as the calculations of avoided costs, and the details of no-netting (among others) remain to be finalized, and these changes could slightly modify the economic implications of the CPUC decisions. In this paper, we examine the financial implications of Net Billing from the perspective of a customer of one IOU - SCE. Perhaps future research could examine the financials for customers of PG&E and SDGE. While the pricing models we have used to price solar panels are robust, the prices for these are falling, and so future research could incorporate updated pricing models. In addition, the CPUC has requested all interested parties to submit proposals to make the Net Billing program even more equitable, and as of this writing, proposals have been submitted by the IOUs that would impose income based monthly fixed charges on all residential customers regardless of whether they had solar panels and/or energy storage installed. Customers whose household income falls below the federal poverty level (FPL) would see their average monthly fixed charges drop by approximately $36, while households making 650% or more of the FPL will incur $34 of additional

monthly fixed charges. The impact of this proposal on the economics of residential solar panel installations is something that should be examined. A stated goal of the December 2022 policy was to accelerate the adoption of residential energy storage (battery) installations to reduce the peak demand imposed on the grid. Future research should examine if the pace of battery installations increased in the months following Net Billing going into effect.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Broughton, J. B., Nyer, P. U., & Ybarra, C. E. (2021). The Economics of Battery Storage for Residential Solar Customers in Southern California. *American Journal of Industrial and Business Management, 11,* 924-932. https://doi.org/10.4236/ajibm.2021.118056

Broughton, J. B., Ybarra, C. E., & Nyer, P. U. (2022). The Economics of Residential Solar Panels: A Comparison of Energy Charges for Different Load Profiles, Rate Plans, and Panel Orientations. *American Journal of Industrial and Business Management, 12,* 180-194. https://doi.org/10.4236/ajibm.2022.122012

California Executive Order (2018). *B-55-18 to Achieve Carbon Neutrality*. https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

California Public Utilities Commission (2021). *Joint Proposal of IOUs*. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M371/K711/371711892.PDF

California Public Utilities Commission (2022). *Decision Revising Net Energy Metering Tariff and Subtariffs*. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K043/500043682.PDF

Distributed Generation Interconnection Program Data (2023). https://www.californiadgstats.ca.gov/downloads

Nyer, P. U., Broughton, J. B., & Ybarra, C. E. (2019). The Economics of Residential Solar Panel Installations for Customers on Tiered Rate Plans. *Open Journal of Business and Management, 7,* 1999-2008. https://doi.org/10.4236/ojbm.2019.74137

Nyer, P. U., Ybarra, C. E., & Broughton, J. B. (2019). The Economics of Residential Solar Panels: Comparing Tiered and Time of Use Plans. *Open Journal of Business and Management, 8,* 56-67. https://doi.org/10.4236/ojbm.2020.81004

Southern California Edison (2022a). *Energy Data—Reports and Compliance*. https://www.sce.com/regulatory/energy-data---reports-and-compliances

Southern California Edison (2022b). *Historical Prices and Rate Schedules*. https://www.sce.com/regulatory/tariff-books/historical-rates

Ybarra, C. E., Broughton, J. B., & Nyer, P. U. (2021). Trends in the Installation of Residential Solar Panels in California. *Low Carbon Economy, 12,* 63-72. https://doi.org/10.4236/lce.2021.122004

Ybarra, C. E., Nyer, P. U., Broughton, J. B., & Turk, T. A. (2021). The Economics of Residential Solar and Battery Storage: Analyzing the Impact of the Joint IOU Proposal for Net Metering 3.0 in California. *Low Carbon Economy, 12,* 137-150. https://doi.org/10.4236/lce.2021.124007