Title

Impact of California’s Net Billing Tariff Regulation and Bidirectional EV Charging on Demand for Residential Photovoltaic and Battery Storage Systems

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The data associated with this publication are available at:
https://github.com/ambarnag/NEM_Analysis_2026

Impact of California's Net Billing Tariff Regulation and Bidirectional EV Charging on Demand for Residential Photovoltaic and Battery Storage Systems

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Abstract

In April 2023 the California Public Utilities Commission adopted the Net Billing Tariff (NBT) replacing the NEM2 rate structure governing net energy metering for distributed generation. In this study California residential photovoltaic (PV) interconnections data for a 5-year period are utilized to retrospectively analyze trends in battery storage (BESS) adoption, average system size, third-party finance, and electric vehicle use, comparing customers on NBT to those on NEM2. An economic benefit-cost model is then set up to explain the observed trends in terms of payback period and ROI of PV and BESS investments facing a middle-income California homeowner. NBT is found to provide strong incentives for pairing PV solar with storage that were absent from the NEM2 policy. Bidirectional EV charging is then introduced into the model by setting up and solving an optimization problem to simultaneously determine least-cost EV and BESS hourly dis/charging schedules. We find that under both NEM2 and NBT, an EV-owning homeowner with bidirectional charging infrastructure has lower annual electricity costs than a homeowner running PV solar without storage.

Keywords: Net Billing Tariff (NBT); Net Energy Metering (NEM 2.0); photovoltaic (PV) solar; battery energy storage systems (BESS); electric vehicles (EVs); bidirectional charging; distributed generation

Introduction

The State of California has emerged as a leader in climate change mitigation with an ambitious target of achieving Net Zero GHG emissions by 2045. As of 2024, electricity made up more than a fifth (21%) of California's total energy consumption. Therefore, in order to achieve the state's climate goals it will be necessary to decarbonize the electric grid. According to the US Energy Information Administration, during 2024 renewable energy sources such as wind, solar, hydro power, geothermal, and biomass supplied 57% of California's electricity. Of this mix, solar is by far the largest contributor accounting for 32% of total electricity generation, with 13% being contributed by distributed generation assets like rooftop solar. These systems generate electricity for direct use on site by utility customers such as homes and offices, while exporting surplus generation to the grid.

Historically, the adoption of distributed generation (also referred to as "behind-the-meter" generation) in California has been stimulated by generous economic incentives in the form of the state's Net Energy Metering (NEM) policy first introduced in 1996. This was justified by the twin advantages of increasing the proportion of clean electricity on the grid and reducing the need for utilities to build new transmission and distribution infrastructure. The policy was, by all accounts, extremely successful in driving rooftop solar adoption in California which grew from negligible levels in the early 2000s to hit one million installations by 2019.

On the flip side, NEM was claimed to exacerbate rate increases in California which already has the highest average electricity tariffs in the contiguous United States. An even more serious issue was that of cost shift: NEM participants, typically high-income households, were bypassing the grid's fixed costs thereby placing a greater burden on non-participants. For these reasons, in December 2022 the California Public Utilities Commission (CPUC) announced a revised NEM policy, the Net Billing Tariff (NBT, colloquially known as "NEM 3.0") replacing the incumbent NEM2 policy. NBT slashed the previously offered near-retail compensation for grid exports by almost 80% based on an "Avoided Cost" calculation which quantified how desirable a given unit of exported electricity was to the grid.

While the policy shift may be expected to reduce the demand for new behind-the-meter solar installations, it provides an incentive for solar paired with battery energy storage systems (BESS). By choosing an optimal size configuration for PV and BESS, an NBT participant can drive electric bills down to zero, effectively receiving near-retail compensation for electricity generated on site.

Among the literature reviewed, Barbose (2024) profiles interconnections under NBT and NEM2 exactly one year after NBT introduction. Viteri et al. (2024) solve a smart charging optimization problem minimizing a homeowner's electricity costs under a time-of-use (ToU) rate plan assuming bidirectional power flow from BESS to grid but not EV to grid. Pabbathi et al. (2024) evaluates a home energy management system (HEMS) running mathematical optimization to minimize energy costs for a homeowner through the day under NBT. We add to the policy discourse by (1) conducting a five-year retrospective analysis comparing customers on NBT against those on NEM2 (2) explaining the observed trends in terms of economic benefit-cost analysis from a homeowner's perspective and (3) comparing cost-saving strategies under NEM2 and NBT for EVs with a bidirectional charging capability. We utilize disaggregated data on distributed generation interconnections across California's three major investor-owned utilities (IOUs) viz. PG&E, SCE, and SDG&E to construct year-on-year trends from 2021 to 2025. Next, we develop an economic benefit-cost model for residential PV and BESS under NEM2 and NBT to help explain the observed trends. Finally, we introduce bidirectional EV charging into the model, setting up and solving a constrained optimization problem to determine the least-cost hourly dis/charging cadence for BESS and EV under NEM2 and NBT.

Methodology

The analysis presented in this article is divided into three sections:

1. Retrospective analysis of annual interconnections under NEM2 versus NBT
2. Economic benefit-cost analysis of PV, BESS, and EV under NEM2 versus NBT
3. Cost-minimizing BESS and EV dis/charging behavior under NBT

1. Retrospective analysis of annual interconnections under NEM2 versus NBT

Data utilized for this analysis was sourced from the California Distributed Generation Statistics ("DGStats")[4] website built and maintained by Energy Solutions for the CPUC. We downloaded the Interconnected Project Sites Data Set current as of September 30$^{\text{th}}$ 2025 ("cutoff date") for each of California's three major IOUs. Each record of this disaggregated dataset represents a distributed generation interconnection i.e. a utility customer who exports excess electricity generated onsite to the grid under the terms of a NEM agreement.

Applications for NEM agreements not yet approved as of the dataset's cutoff date were excluded. Only interconnections under the NEM2 and NBT rate structures were included, which effectively excludes customers still running on the pre-2017 NEM 1.0 rate structure. The time period of analysis is from Jan 1$^{\text{st}}$ 2021 to Sept 30$^{\text{th}}$ 2025. The dataset was filtered for Residential PV interconnections leaving non-residential customers (Commercial, Government etc.) and other modes of generation (Wind, Internal Combustion Engine etc.) out of the analysis. Based on the information available in the dataset, interconnections were labelled as having PV paired with battery storage versus without it and having at least one EV versus none. PV system size was coded into three classes: "small" for 1-5 kW_{DC}, "medium" for 5-10 kW_{DC}, and "large" for 10+ kW_{DC}.

2. Economic benefit-cost analysis of PV, BESS, and EV under NEM2 versus NBT
2.1 Data and Assumptions

Although the retrospective analysis combines all three major California IOUs, for the purpose of economic modeling, we consider a single middle-income homeowner arbitrarily chosen to live in PG&E territory. Residential customer load for a typical PG&E ratepayer on full year hourly basis ("8760") was obtained from the Customer Bill Model[5] workbook developed by Energy and Environmental Economics, Inc. on behalf of CPUC. The 2025 PG&E feed-in tariff (FiT) for exported electricity under NBT was obtained from PG&E's Energy Export Credit website[6]. For NEM2 the FiT was set to equal the price of imported electricity as per the time-of-use (ToU) rate plan.

The System Advisor Model (SAM)[7] developed by the National Renewable Energy Laboratory (NREL) was used for simulating 8760 solar power generation at a single residence for a typical meteorological year (TMY). The residence, located in San Francisco, CA, is equipped with a standard, fixed roof mount PV system of 5 kW_{DC} rated capacity tilted at 20 degrees. All other system design parameters were set to SAM default values. On the cost side, a homeowner running PV/BESS but not owning an EV was assumed to be on PG&E's 'E-TOU-C' rate plan with prices differentiated by season (winter and summer) and time of use (peak and off-peak). 2025 tariffs for electricity imports for a below baseline customer on this plan were obtained from the PG&E website[8].

We use common rules of thumb to derive "optimal" PV and BESS system sizes. The PV system is sized to generate a total annual solar output very close to the total annual customer load while BESS capacity is chosen to be 50% of average daily load. The unit cost of PV solar was assumed to be \$3.50/W_{DC} working out to a total initial investment of \$17,500 for a 5kW system. The BESS system capacity and power were set to 12kWh and 5kW respectively coming at a total cost of \$12,000.

We assume an EV battery capacity of 40kWh and a Level 2 bidirectional EV charger with a maximum power of 5kW capable of charging and discharging at a flexible rate. The charger is assumed to cost \$2,500 (the cost of the EV itself is not relevant here). We further assume that the customer has a Rule 21 interconnection agreement in place with PG&E which allows vehicle-to-grid (V2G) export. For the model version including EV, we shift the customer from the 'E-TOU-C' rate plan onto the 'Home Charging EV2-A' rate plan with three ToU windows: off-peak, part-peak, and peak[9]. Next, we make some assumptions about driving behavior. We assume a 30-mile per day EV usage on weekdays, consuming 10 kWh of charge, and half of this usage on weekends. The EV is assumed to be away from home from 9am to 5pm on weekdays (Mon-Fri) and 5pm to 9pm on weekends (Sat-Sun).

2.2 Model Formulation: PV Solar and BESS

For a "PV Only" scenario, we first calculate Net Demand in kW as the difference between customer load and solar power generation:

For each hour $t = 1, \ldots, 8760$:

$$\text{Net\_Demand\_PV}_t = \text{Customer\_Load}_t - \text{PV\_Generation}_t$$

Next, the cost of electricity under NEM2 is calculated based on the PG&E ToU rate which is a function of both time of day and season and therefore a function of t:

$$\text{Cost\_NEM2}_t = \text{Net\_Demand\_PV}_t \cdot \text{PGE\_ToU\_Rate}_t$$

The cost of electricity under NBT is calculated by applying the NBT FiT as follows:

$$\text{Cost\_NBT}_t = \begin{cases} \text{Net\_Demand\_PV}_t \cdot \text{PGE\_ToU\_Rate}_t & \text{if Net\_Demand\_PV}_t > 0 \\ \text{Net\_Demand\_PV}_t \cdot \text{NBT\_FiT}_t & \text{if Net\_Demand\_PV}_t < 0 \end{cases}$$

Next, a "PV and BESS" scenario is modeled using the same logic but recalculating Net Demand after adding battery storage which has the effect of further reducing load drawn from the grid. The initial state of charge (SoC) of the battery is assumed to be 50% of its capacity. Net Demand at each hour 't' is met by discharging the battery. In doing so, a lower bound of zero and an upper bound equal to the battery's capacity are imposed on its SoC. More formally:

$$\text{Net\_Demand\_PV\_BESS}_t = \text{Net\_Demand\_PV}_t - (\text{SoC}_{t-1} - \text{SoC}_t)$$

$$0 \leq \text{SoC}_t \leq 12 \quad \forall t$$

2.3 Model Formulation: Adding bidirectional EV charging

We start from the model described in 2.2 and introduce bidirectional EV charging on top of PV and BESS. Since the impact of bidirectional EV charging on total cost of electricity depends on the precise hourly cadence of dis/charging, we cannot rely on a simple heuristic to arrive at cost. So, we setup an optimization problem, adapted from Tostado-Véliz (2022), which simulates an HEMS program setup to minimize the home's electricity cost as follows:

Decision Variables For each hour $t = 1, \ldots, 8760$, choose:

$$\text{Grid\_Import}_t,\ \text{Grid\_Export}_t,\ \text{BESS\_Charge}_t,\ \text{BESS\_Discharge}_t,\ \text{EV\_Charge}_t,\ \text{EV\_Discharge}_t$$

Objective Function

$$\begin{aligned} \min \quad & \sum_{t=1}^{8760} (\text{Grid\_Import}_t \cdot \text{Import\_Price}_t - \text{Grid\_Export}_t \cdot \text{Export\_Price}_t) \\ & + 0.05 \sum_{t=1}^{8760} \text{EV\_Discharge}_t \end{aligned}$$

Constraints

$$\begin{aligned} \text{(C1)} \quad \text{Customer\_Load}_t = {} & \text{Grid\_Import}_t - \text{Grid\_Export}_t + \text{PV\_Generation}_t \\ & + \text{BESS\_Discharge}_t - \text{BESS\_Charge}_t \\ & + \text{EV\_Discharge}_t - \text{EV\_Charge}_t \end{aligned}$$

$$\text{(C2)} \quad \text{Grid\_Export}_t \leq \text{PV\_Generation}_t + \text{BESS\_Discharge}_t + \text{EV\_Discharge}_t$$

$$\text{(C3)} \quad \text{SoC}_t = \text{SoC}_{t-1} + 0.95 \cdot \text{Charge}_t - \frac{\text{Discharge}_t}{0.95}$$

$$\text{(C4)} \quad \text{Charge}_t \leq \text{Max\_Power}, \quad \text{Discharge}_t \leq \text{Max\_Power}$$

$$\text{(C5)} \quad 0.1 \cdot \text{Capacity} \le \text{SoC}_t \le 0.9 \cdot \text{Capacity}$$

$$\text{(C6)} \quad \sum_{t=1}^{8760} \text{Grid\_Export}_t \le \sum_{t=1}^{8760} \text{Customer\_Load}_t$$

Since the optimal solution depends on the unit compensation for exported electricity, the optimization needs to be run separately for NBT and NEM2. We set the Export_Price variable for NBT and NEM2 as follows, accounting for a 2c/kWh non-bypassable charge under NEM2:

$$\text{For NBT: Export\_Price}_{\ t} = \text{FiT\_NBT}_t$$

$$\text{For NEM2 : Export\_Price}_{\ t} = \text{PGE\_ToU\_Rate}_t - 0.02$$

Constraint C1 is simply a statement of the home's energy balance. Constraint C2 prevents export of more kWh than are physically available to export. Constraints C3 through C5 account for battery round-trip efficiency, maximum capacity, and desired minimum and maximum state of charge. These constraints apply in more or less the same way for BESS and EV batteries. However, for the EV case they were modified to account for the vehicle being away from home during certain times. During this time the EV is assumed to discharge at a constant rate through driving. Most EV home charging plans impose limits on exports to grid to prevent unlimited arbitrage on near-retail FiT offered under NEM2. To reflect this, Constraint C6 limits total grid exports to no more than total customer load.

Finally, an "optimal" solution which saves on electricity bills at the cost of rapid battery degradation due to frequent EV dis/charging is also to be avoided. To this end, the second term of the cost function adds a penalty of 5c/kWh on EV discharging which indirectly also regulates charging.

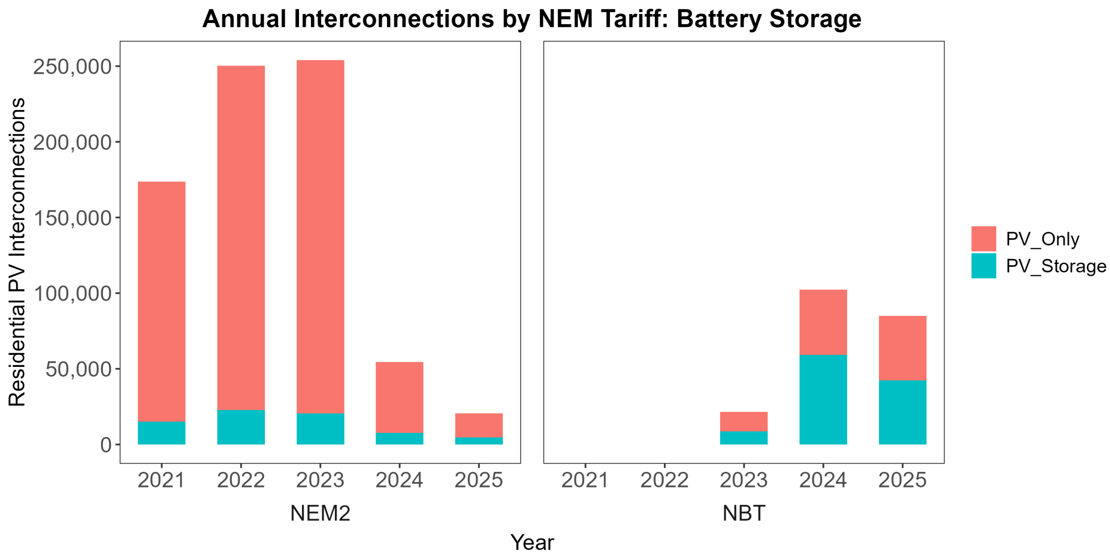
Results

1. Retrospective analysis of annual interconnections under NEM2 versus NBT

We start by examining annual trends in the number of residential PV interconnections under NEM2 and NBT split by (1) PV systems with and without battery storage, (2) average PV system size (3) ownership versus third-party finance of systems, and (4) presence of EV. The total number of NEM2 interconnections is expected to be much greater than NBT interconnections given that NEM2 was in force for eight years (2017-2023) while NBT was introduced less than three years ago. Therefore, in what follows, we will be analyzing relative trends by looking at percentages rather than absolute number of interconnections.

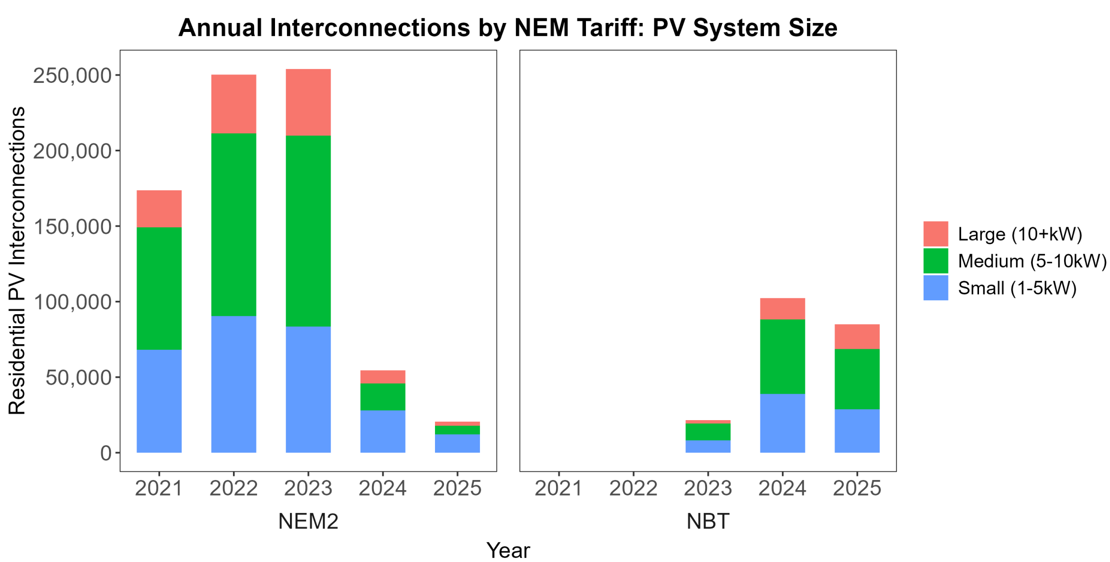
In Figure 1 we find that the proportion of PV interconnections with BESS has leaped from just 9% under NEM2 to 53% under NBT.

Figure 1: Battery Storage Adoption



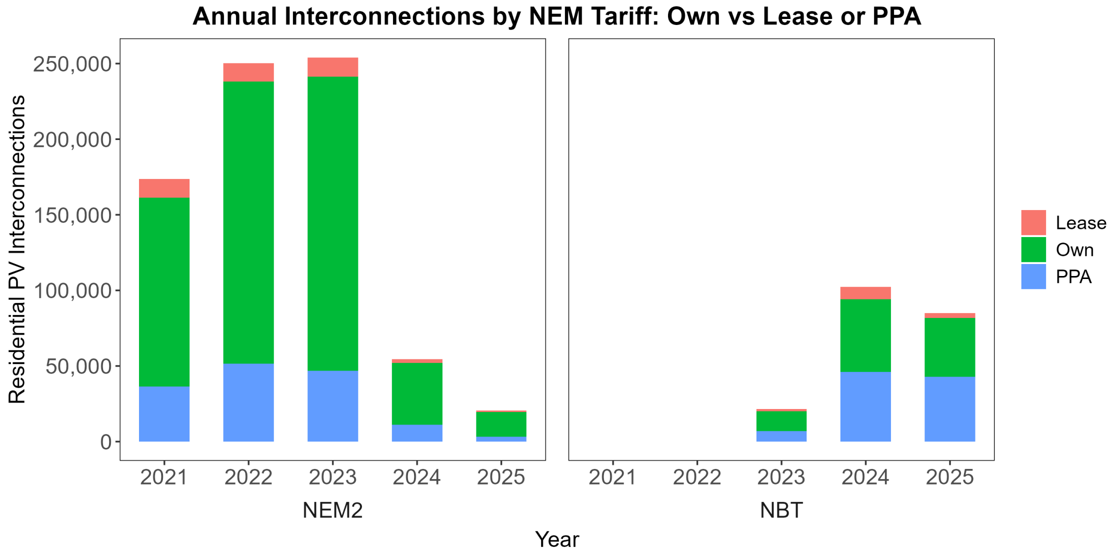
In Figure 2 we compare the distribution of small (1-5 kW_{DC}), medium (5-10 kW_{DC}), and large (10+ kW_{DC}) PV solar systems between NEM2 and NBT and find no variation. The median PV system size among NBT interconnections at 6.03 kW_{DC} has remained essentially the same as NEM2 interconnections at 5.98 kW_{DC}.

Figure 2: PV System Size



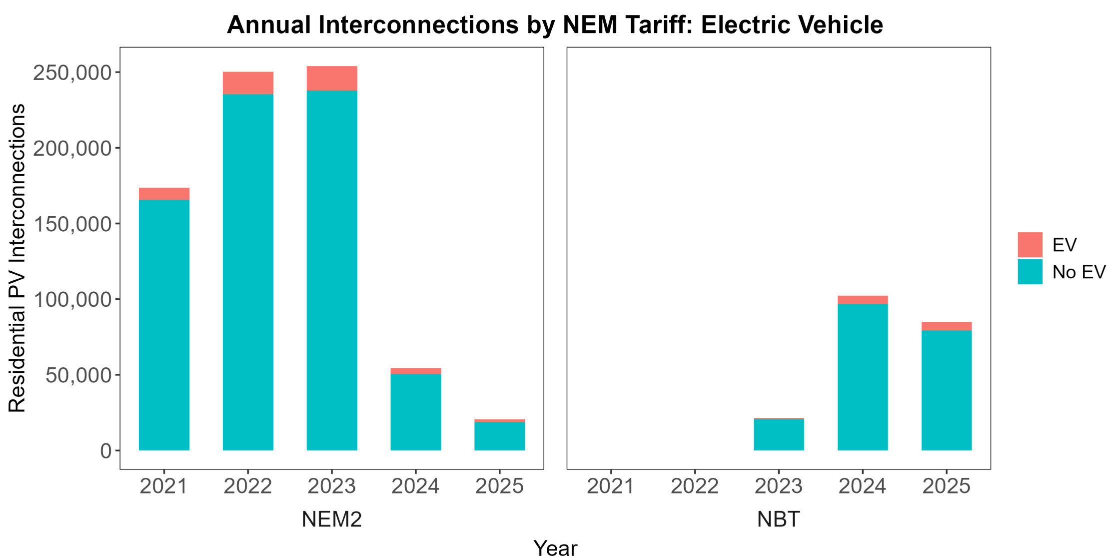
In Figure 3 we find that the proportion of owned interconnections has dropped from almost 75% under NEM2 to less than 50% under NBT. Most of the shift is on account of homes opting for power purchase agreements (PPA) which have increased from less than 20% under NEM2 to more than 45% under NBT.

Figure 3: Third-party Ownership



In Figure 4 we note that the proportion of interconnections with at least one EV remains the same under NBT (5.9%) compared to NEM2 (6.0%). It appears, therefore, that despite the bidirectional charging capabilities of the latest generation of EVs, their demand remains independent of NEM incentives.

Figure 4: EV Adoption



2. Economic benefit-cost analysis of PV, BESS, and EV under NEM2 versus NBT

The results of the benefit-cost analysis formulated in Methodology sections 2.2 and 2.3 are presented below. Our goal is to try and explain the trends presented in the previous section in terms of financial incentives and disincentives facing the homeowner.

Table 1: Financial Analysis – Homeowner Perspective

Variable (1)	Units (2)	No PV (3)	PV Only (4)		PV+BESS (5)		PV+BESS+EV (6)	
			NEM2	NBT	NEM2	NBT	NEM2	NBT
Initial Investment	$	$0	$17,500		$29,500		$32,000	
Annual Billing	$	$3,094	$60	$1,736	-$24	$498	-$309	$922
Cost Savings	$	$0	$3,033	$1,357	$3,118	$2,596	$3,402	$2,172
Simple Payback	years	N.A.	5.8	12.9	9.5	11.4	9.4	14.7
20-year ROI	%	N.A.	16.5%	4.6%	8.5%	6.1%	8.6%	3.1%

In Figure 1 we noted a sharp spike in the proportion of PV interconnections paired with BESS from NEM2 moving to NBT. The key factors driving this trend are clearly evident from comparing Cols (4) and (5) in Table 1. A homeowner under NEM2 faces a simple payback of under 6 years at a 20-year ROI of 16.5% for a system running only PV solar. When battery storage is added, however, the simple payback increases to almost 10 years and ROI is halved. This pattern is reversed under NBT where the simple payback of PV paired with BESS, at just over 11 years, is shorter than the 13-year payback of a standalone PV system. This is driven by a doubling of annual cost savings under NBT from $1,357 to $2,596 justifying the additional investment in battery storage. Thus, NBT provides strong incentives for pairing PV with BESS while NEM2 provides no such incentive.

Another interesting trend noted above in Figure 3 was the rapid shift away from owned PV/BESS systems to PPA-financed systems. The reasons for this trend could be two-fold. First, at $29,500 a PV system paired with BESS costs almost 70% more than standalone PV solar costing $17,500. Thus, low-to-middle-income homeowners may be opting for third-party financing to circumvent liquidity barriers. Second, compensation for electricity exported to the grid under NBT, at an average of less than 9 cents per kWh, is a fraction of NEM2's near-retail FiT. This could imply higher savings through self-consumption at a discounted rate (typical in a PPA arrangement) than from exports to the grid.

We also noted in Figure 4 that the proportion of interconnections with EVs is nearly identical between customers on NEM2 and those on NBT. Given that the average EV battery is at least 5 to 10 times more powerful than BESS systems typically paired with residential solar, an EV with bidirectional charging capability would constitute a home's largest flexible load. Most EV owners, however, view the EV battery more as a backup for blackouts or PSPS events rather than an avenue for cost saving. However, looking at Table 1 Col 6 we find that, despite the large additional load of EV charging, it is possible to achieve siginificant cost savings under both NEM2 and NBT through optimization of BESS and EV charging schedules. For instance, under NBT we see annual cost savings of $2,172 compared to the "No PV" baseline.

Shifting our perspective from a homeowner to a policymaker, we would like to examine the demands being made on the grid under each of the scenarios analyzed. This is presented in Table 2 below.

Table 2: Grid Impacts – Policymaker Perspective

Variable	Units	No PV	PV Only	PV+BESS	PV+BESS+EV	
					NEM2	NBT
Grid Imports	kWh	8,043	4,971	1,491	12,340	5,784
Grid Exports	kWh	0	4,958	1,481	8,025	2,012
Demand Reduction	%	0	38.2%	81.5%	-53.4%	28.1%

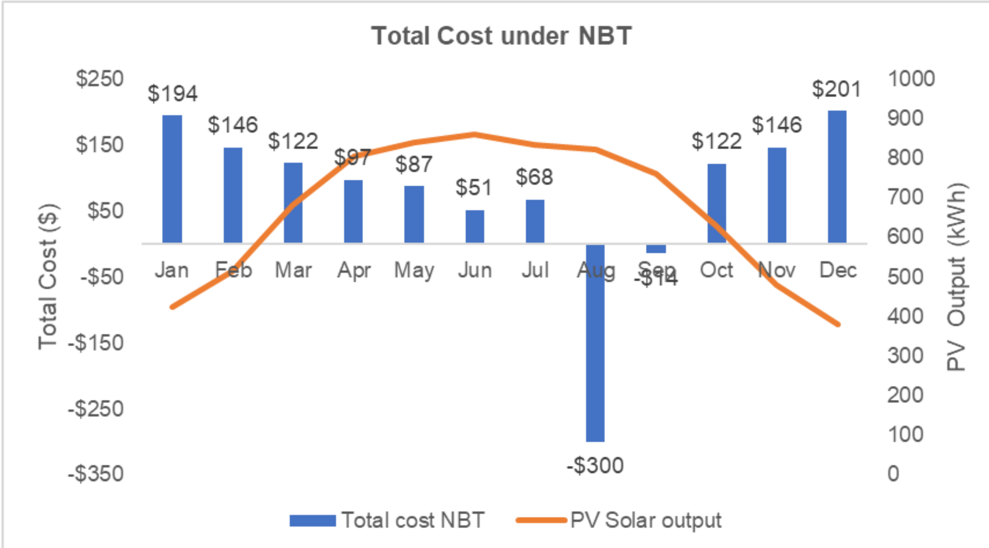
As expected, PV and BESS have the effect of substantially reducing grid imports. PV alone achieves a 38.2% reduction (from 8,043 kWh down to 4,971 kWh), and PV in combination with BESS, a reduction of 81.5% (all the way down to 1,491 kWh). On the other hand, an EV augments total load but due to the presence of solar we still see a net reduction of 28.1% in grid imports under NBT compared to the "No PV" baseline. This is also expected since NBT rate design encourages self-consumption over grid exports. The massive increase in both grid imports *and* grid exports under NEM2 is not realistic and would likely be flagged as grid arbitrage – leveraging ToU rates to export back electricity stored from the grid rather than electricity generated on site. Although grid arbitrage can actually help smooth out net demand on the grid, it is strongly discouraged under NEM interconnection rules. Our discussion brings up the question of whether EV owners on NEM2 with V2G permission in place would be incentivized to engage in grid arbitrage. This could be important because, looking at Figures 1-4, the number of residential customers grandfathered onto NEM2 is roughly three times the number of customers on NBT and most of these customers still have at least ten years left on their NEM2 contracts.

In the final section we will look at a few visualizations of EV scheduling optimization at work to understand its likely impact on the grid when occuring at scale, restricting ourselves to the NBT case.

3. Cost-minimizing BESS and EV dis/charging behavior under NBT

In Figure 5 we can see the monthly split of the $922 annual billing under NBT for a homeowner running PV, BESS, and bidirectional EV (Table 1 Col 6). The month of August stands out for the negative $300 billing, a credit which helps offset the relatively high cost during Winter months. However, it is not clear why August should be the outlier here. Certainly it is not explained by PV solar output which is relatively high throughout the summer, peaking in June.

Figure 5: Total Cost under NBT for PV+BESS+EV (optimized)



The answer lies in the economics of NBT: specifically in the FiT structure which determines compensation for exports to the grid. As can be seen from the heatmap in Figure 6, during August peak hours (5pm – 10pm) grid exports are credited at a rate ten times higher than the average of all other days in the year! Since solar output would be minimal so late in the evening, the grid is looking at storage devices to feed in stored excess power.

Figure 6: Net Billing Tariff – PG&E Energy Export Credits (EEC)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12:00 AM	0.0934	0.0931	0.0805	0.0770	0.0775	0.0776	0.0728	0.0909	0.0954	0.0895	0.0862	0.0896
1:00 AM	0.0916	0.0915	0.0774	0.0760	0.0736	0.0762	0.0745	0.0911	0.0935	0.0896	0.0870	0.0892
2:00 AM	0.0901	0.0926	0.0740	0.0797	0.0758	0.0748	0.0727	0.0894	0.0914	0.0875	0.0857	0.0869
3:00 AM	0.0890	0.0928	0.0737	0.0786	0.0791	0.0770	0.0742	0.0865	0.0885	0.0860	0.0845	0.0875
4:00 AM	0.0910	0.0937	0.0752	0.0768	0.0805	0.0753	0.0711	0.0861	0.0871	0.0852	0.0857	0.0888
5:00 AM	0.0932	0.0914	0.0782	0.0768	0.0750	0.0752	0.0721	0.0871	0.0891	0.0846	0.0861	0.0919
6:00 AM	0.0941	0.0881	0.0790	0.0705	0.0692	0.0723	0.0762	0.0847	0.0866	0.0851	0.0826	0.0987
7:00 AM	0.0887	0.0832	0.0724	0.0609	0.0636	0.0659	0.0729	0.0739	0.0771	0.0767	0.0730	0.0868
8:00 AM	0.0767	0.0640	0.0523	0.0171	0.0254	0.0465	0.0681	0.0678	0.0673	0.0657	0.0628	0.0748
9:00 AM	0.0686	0.0535	0.0260	0.0070	0.0136	0.0393	0.0603	0.0672	0.0643	0.0597	0.0602	0.0702
10:00 AM	0.0680	0.0514	0.0218	0.0083	0.0144	0.0379	0.0628	0.0669	0.0626	0.0601	0.0592	0.0694
11:00 AM	0.0679	0.0503	0.0199	0.0083	0.0123	0.0328	0.0612	0.0663	0.0624	0.0580	0.0575	0.0654
12:00 PM	0.0666	0.0463	0.0191	0.0084	0.0131	0.0325	0.0569	0.0671	0.0615	0.0571	0.0557	0.0628
1:00 PM	0.0649	0.0422	0.0172	0.0038	0.0157	0.0326	0.0535	0.0675	0.0607	0.0564	0.0500	0.0621
2:00 PM	0.0635	0.0345	0.0167	0.0017	0.0123	0.0374	0.0534	0.0669	0.0611	0.0562	0.0511	0.0633
3:00 PM	0.0659	0.0344	0.0173	0.0001	0.0121	0.0321	0.0552	0.0703	0.0615	0.0558	0.0654	0.0716
4:00 PM	0.0817	0.0670	0.0253	0.0013	0.0149	0.0374	0.0547	0.0827	0.0751	0.0614	0.0927	0.0920
5:00 PM	0.1084	0.1066	0.0615	0.0069	0.0342	0.0487	0.0662	0.8497	0.1375	0.0900	0.0969	0.0972
6:00 PM	0.1014	0.0944	0.0857	0.0775	0.0808	0.0875	0.0959	0.8837	0.4586	0.0925	0.0889	0.0972
7:00 PM	0.0933	0.0882	0.0838	0.0775	0.0865	0.0898	0.1071	0.9135	0.5931	0.0908	0.0860	0.0899
8:00 PM	0.0926	0.0873	0.0795	0.0734	0.0753	0.0867	0.0910	0.9982	0.3170	0.0865	0.0852	0.0897
9:00 PM	0.0936	0.0885	0.0758	0.0718	0.0714	0.0823	0.0825	0.8960	0.1541	0.0837	0.0860	0.0916
10:00 PM	0.0965	0.0933	0.0752	0.0711	0.0723	0.0802	0.0811	0.8890	0.1541	0.0887	0.0871	0.0918
11:00 PM	0.0950	0.0906	0.0766	0.0756	0.0745	0.0753	0.0749	0.0926	0.0958	0.0904	0.0923	0.0905

To see how the EV scheduling optimization takes advantage of this windfall price signal, we can look at the EV's SoC curve for a single week in August (Figure 7). Each weekday morning at 8am the EV battery is charged all the way up to 36 kWh or 90% of battery capacity, the maximum allowed under optimization constraints. Since, as per assumptions, only 10 kWh is required for driving, the EV returns home with 26 kWh of charge. Between 6pm and 10pm the EV discharges at its maximum power of 5kW, racking up NBT credits. Then, between midnight and 8am the next morning the EV again charges upto 36 kWh. This cycle repeats on all weekdays. On weekends the EV is assumed to be away from home between 5pm and 9pm, so we get a different pattern.

Figure 7: EV SoC Curve for one week in August '25

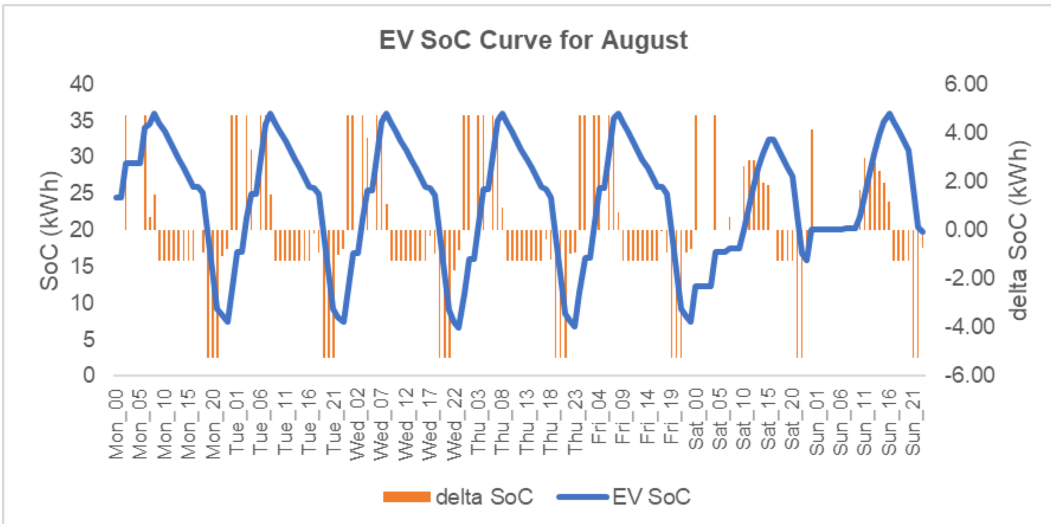


Figure 7 Notes

- SoC or state of charge is usually expressed as a percentage but here it is expressed in kWh to allow easier comparison with other variables viz PV output, BESS capacity, EV driving use etc.
- delta SoC (kWh) refers to the change in SoC from time t-1 to t i.e. $delta\ SoC = SoC_t - SoC_{t-1}$

Conclusion

In December 2022 the California Public Utilities Commission announced the Net Billing Tariff (NBT) as the successor to the previous NEM2 net energy metering rate design. NBT sharply cut compensation for electricity exported to the grid from distributed generation systems such as photovoltaic (PV) solar. In this study we use residential PV interconnections data for 2021-2025 covering all three major California utilities to perform a retrospective comparison of customers on NBT against those on NEM2. We examine trends in battery storage (BESS) adoption, PV system size, third-party finance, and electric vehicle (EV) use. We setup economic benefit-cost modeling of a rational, middle-income homeowner's decision process and use it to form hypotheses to explain the trends observed in the retrospective analysis. We find that NBT provides strong incentives for pairing PV with BESS while NEM2 provides no such incentive. We extend the model to include bidirectional EV charging and perform optimization of EV and BESS charging schedules. This helps us to predict the likely behavior of EV-owning utility customers in terms of intraday and seasonal patterns of imports from and exports to the grid. We find that despite the additional load of EV charging, an EV-owning homeowner under NBT saves more than a homeowner running PV solar without storage.

The unrealistic optimization outcomes under NEM2 may constitute a limitation of the model developed here. More sophisticated optimization constraints may be needed to address this. On the upside, the benefit-cost model used is general enough to be adapted to any state or region subject to data availability. Future work could address the limitations as well as leverage the strengths of the current model.

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Supplementary Materials

Retrospective trends analysis and economic benefit-cost analysis were done in R version 4.5.2. EV and BESS schedule optimization was done in Python 3.10.9 using CVXPY with Gurobi solver. Project code, input data, and code outputs are available at github.com/ambarnag/NEM_Analysis_2026. A Tableau animation plotting optimized EV SoC week on week for the full year is available here.

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