Policy Brief: Distributed Solar PV and NEM 3.0

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1 Introduction

1.1 The Californian miracle

The process of reducing GHG emissions to meet the IPCC's recommendation is unlikely to be an easy or painless process. Some regions, however, are making excellent progress and may be used as a template for policymakers around the world. One of these regions is California, which, over the past 30 years, has massively transformed its energy grid since the 1990s. Currently, 33% of California's energy consumption is sourced from renewable producers, most prominently solar photovoltaic and wind. Another 24.59% is derived from carbon-free nuclear and hydroelectric plants with the remainder being natural gas-fired generators to supply peak demand Fields (California Energy Commission, 2019). The unique feature of the Californian experience that is worth exploring here is the penetration of solar energy into the energy mix. California solar energy adoption is by far and away ahead of every other state and currently accounts for over 50% of the US solar market. This can be attributed to one movement: the adoption of distributed rooftop solar PV systems.

There are many terms that generally refer to these types of systems: distributed PV, residential PV, rooftop PV etc. We will use residential PV as a catch-all to refer to small-scale systems (typically 10kW or below), installed on rooftops, that are intended to supplement or replace the energy used in the home. These have become incredibly popular in California since the late 1990s with a current installed base of 1.3 million homes with the capacity to provide power for 15-20% of the state's energy needs (Lamare, 2021). This is being hailed as a success story for solar energy and distributed energy systems more generally, therefore, we must understand the policies that catalyzed this movement. The most influential of these by far is net energy metering (NEM), which will be the focus of this policy brief.

More specifically, this policy brief will seek to answer a few key questions relating to a proposed bill that was recently tabled for review by the California state energy board on net energy metering (California NEM 3.0 Delayed Indefinitely, 2022). Colloquially referred to as NEM 3.0, if passed, the bill will represent a radical change in the distributed PV movement. Understanding the bill and its effects will contribute to not only our understanding of solar PV systems but of how we can use policy to incentivize the clean energy transition more broadly. The brief will begin with a short background on electricity pricing and net energy metering in California followed by a review of two influential papers relating to the incentives surrounding residential PV adoption. This will provide us with a framework for discussing the potential impact of NEM 3.0 which we will be broken down into three areas: (i) long-run distributed PV adoption (ii) efficiency and equity concerns and (iii) the broader clean energy transition.

2 Background

2.1 Simple Definition and History

Net energy metering refers to the process by which rooftop solar adopters offset their personal energy consumption using the power generated from their installed PV systems. The first states to adopt NEM were Arizona and Nevada in the 1980s, followed by California in 1996. The intention behind net metering is simple, to incentivize the development of a cleaner and arguably more stable electricity grid. Though the specific structure of the legislation has changed significantly over the past 30 years, the one defining rule that has remained in place is that solar adopters are compensated for the energy they return to the grid at the prevailing retail rates. This means that solar customers are essentially compensated at the same rates at which they buy energy from the grid, so the trade-off is 1-1. This is the largest point of contention surrounding the proposal that the California Public Utilities Company submitted in 2019, which formed the basis of NEM 3.0. NEM 3.0 is a radical change compared to its predecessors NEM 1.0 (1996) and NEM 2.0 (2017). To understand why this legislation is so controversial, we need to understand how energy pricing works as well as the history of energy price regulation in California.

2.2 Electricity pricing theory

The relationship between social marginal cost and retail prices is typically much more prominent in the policy debate surrounding energy pricing than for your typical consumer product. The reason for this is that electricity pricing is typically at least partially government regulated, meaning that prices (or allowable ROE) are set with the goal of maximizing social welfare rather than profits. Additionally, though there are some issues in measuring the externalities associated with energy use, it is typically a much easier process than for a consumer product. Both put the issue of the retail and social marginal cost disparity in greater focus.

2.3 How does California compare?

If we consider the case of California, we observe the opposite problem than in the example illustrated above, in that the retail rate of electricity is well above the social marginal cost (Borenstein et al., 2021). Though this is not unique to California, we observe an especially pronounced deviation here with some estimates putting retail prices at 3x the SMC(Borenstein et al., 2021). According to the CPUC in their revised proposal issued in 2019, this disparity is due to the mandate that the investor-owned utilities (IOUs) must compensate residential PV at retail rates even though these producers assume none of the fixed costs associated with the development of the grid (NEM Revisit, n.d.). We will see later that there are other explanations for this disparity.

In a very simple example to illustrate the issue raised, we can compare the relative compensation of two entities. The first being an investor seeking to build a large-scale solar PV farm in Southern California and the second being a high-income rooftop solar PV adopter in Los Angeles. According to current legislation, the first person will need to negotiate a contract with one of the IOUs and will likely be compensated for the energy they produce at the current wholesale price of electricity in at the closest hub (SoCal Citygate), which at the time of this writing is $0.06475/kWh (U.S. Energy Information Administration (EIA) - Ap, n.d.). This compensation rate is likely to be adjusted upwards by regulation to compensate for the value of displaced GHGs, but it is unlikely to exceed $0.10/kWh The compensation for the high-income rooftop solar adopter, on the other hand, depends on several factors. If we assume that he is an average user in terms of load, he will fall into the middle block-pricing quantile and his energy use will be offset at $0.2358/kWh (Electric Power Monthly - U.S. Energy Information Administration (EIA), n.d.). From a social welfare perspective, there is almost no explanation for this disparity.

This may sound slightly counter-intuitive as consumers now face a different price for supplying vs receiving the same service. This can partially be attributed to a status quo bias as solar customers have become acclimated to this system. The problem is that net-metered customers don't consider the fact that they are free-riding off transmission and distribution infrastructure that was already in place. This is essentially a mandated public goods problem that has resulted in overuse with the costs being borne by the IOUs. We will discuss the size of this cost shift later as the impact might not be as large as the utilities are claiming. Before this, it is useful to understand some of the legislative history that got us to this point.

2.4 History of Residential PV regulation in California

This disparity in compensation is a product of years of regulation on the structure of net metering and residential electricity rates more generally. NEM 1.0, introduced in 1996, ensured that customers with systems under 10kW would be compensated at retail rates for the energy they offset. The policy was limited in the sense that this would only apply until the supply of these systems reached 0.1% of peak demand or 53.3MWh across the state ("20 Years of Net Energy Metering in California," 2017). Between 2001 and 2010, this constraint was raised 4 times to 10% and then eventually removed entirely in 2017. The constraint mechanism demonstrates that policymakers viewed the compensation rates as temporary measures to help get the industry 'off its feet', believing that with falling installation costs, systems may eventually become profitable on their own. However, the changes turned out to be long-lasting and California saw its distributed PV systems grow exponentially. The CPUC always indicated that the rates would eventually have to be curtailed, and in 2017, they introduced NEM 2.0. NEM 2.0 is the current policy that regulates net metering in California. The major changes included a one-time grid connection fee of $75 - 150, a0.02$kWh charge on all energy consumed, and a change from Increasing Block-Pricing (IBP) to Time-Of-Use (TOU) rates. Though these charges were steps toward what the IOUs viewed as a more efficient rate system, the adoption of distributed PV systems continued to grow exponentially and in 2019 the CPUC was forced to reconsider the same issues.

2.5 NEM 3.0

So given this disparity, the CPUC has proposed the following changes to the compensation scheme for solar PV adopters. These form the central legislation of NEM 3.0 and I will analyze the implications of each in detail following the literature review (Modernizing California's Net Energy Metering Program to Meet Our Clean Energy Goals, n.d.).

(i) Net billing (NEM) customers are compensated for the energy they return to the grid at the avoided cost to the utility of buying clean energy elsewhere.

(ii) Customers are charged at high-differential time-of-use rates to incentivize the installation of battery storage solutions.

(iii) Creates a grid participation charge to ensure that NEM customers pay the same share of the fixed costs as the non-NEM customers.

(iv) Provides market transition credit to ensure that new systems can be paid off within 10 years of installation.

To understand the impact these are likely to have on solar PV adoption, we can draw on several resource papers. I will primarily focus on "Private Net Benefits of Solar PV" by Severin Borenstein and "Impact of Rate Design" by Naim R. Darghouth et. al.

3 Literature Review

3.1 Impact of Rate Design (Darghouth 2011)

3.1.1 Introduction

Darghouth et. al uses data from the California Independent System Operator (CAISO) to examine the impact of counterfactual rate designs on bill savings from distributed PV systems. This will help us determine the relative importance of different aspects of the NEM 3.0 proposal on the potential for future growth in the residential PV sector. It is important to note that the base case in this scenario is the NEM 1.0 policy, but the results are still very relevant for our purposes.

The authors use a sample of 218 solar users in California and analyze the projected bill savings under 3 different scenarios: (i) a Market Price Referent (MPR) based feed-in tariff (ii) Hourly netting and

(iii) Monthly netting. The market price referent is based on an avoided cost calculator which is the same price that is proposed in the NEM 3.0 legislation. It is intended to capture long-run generation costs associated with the ownership, operating, and fixed fuel costs for a new natural gas-fired power plant. This is the typical contract that is offered to wholesale renewable energy producers. In 2009, the base-load price under this contract was $0.09674/kWh which is adjusted according to time-of-use rates. Hourly netting, whereby PV generation is only allowed to offset 10% of usage each hour and any excess generation is compensated at the MPR-based feed-in tariff.

One of the most prominent results from this paper is the degree to which customers are differentially impacted across a few key metrics. The authors demonstrate significant heterogeneity across PV-Load ratios, rate policies (TOU vs traditional block pricing), and providers (IOU). This is an important result that Borenstein later refers to as it turns out these features are correlated with certain demographic attributes, particularly income, which gives rise to equity concerns.

3.1.2 Terms and Definitions

- PV-Load Ratio: Refers to the relative size of the system to the customer's energy demand. Essentially the percentage of their total electricity demand which could be theoretically offset by their system. This percentage cannot exceed 100% under net metering policies as this generation will go uncompensated to discourage installation as a business venture rather than to reduce energy costs. The average PV-Load ratio in this analysis is 56%.
- IOUs: Investor Owned Utilities. The two IOUs used in this analysis are Pacific Gas Electric (PGE) and Southern California Edison (SCE).
- TOU: Time-of-Use Rates. Vary throughout the day and year based on relative load and supply in the grid. Customers are billed according to the time at which they provide/use energy from the grid. Theoretically, this incentivizes the installation of battery systems to take advantage of peak prices by arbitrage.
- IBP: Increasing Block-Pricing. Customers are grouped into 5 tiers based on the amount of energy consumed in a day. These vary across providers. PGE ranges from $0.12/kWh in the lowest use tier to $0.5/kWh in the highest use tier. For SCE the distribution is narrower ranging from $0.12 to $0.31/kWh.

3.2 Results

The results of their analysis demonstrate that bill savings per kWh vary by more than 300% across these factors, the largest contributor to this variation being the block pricing scheme. Figure 1 illustrates the value of bill savings of net-metering vs base-case (feed-in tariff) across annual energy consumption and PV-Load ratios.

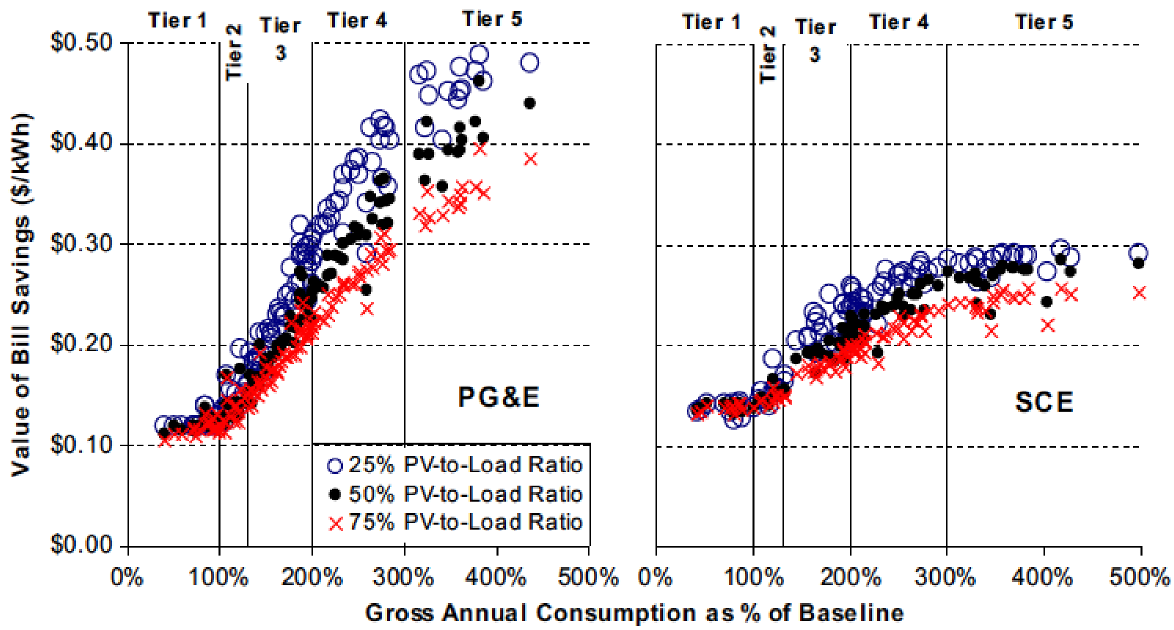

Figure 1: Variation in bill savings with customer gross annual consumption (Dargouth et. al, 2011)

This figure is very informative about the distributional effects of net metering. Firstly, we can see that the value of bill savings per kWh is increasing in gross annual consumption. This means that high-use adopters are compensated at much higher marginal rates than low-use customers. This is because these customers are much more likely to fall into higher price tiers and thus offset higher per kWh charges. High-use customers can be compensated at 5x the marginal rate of low-use customers. The second thing to note is the disparity in savings across PV-Load ratios which implies that customers with smaller systems and higher demands will gain marginally greater benefits by the same reasoning of increasing block-pricing. The difference in the marginal benefit for high-use customers across the IOUs is explained by the comparatively flatter block pricing scheme of SCE.

We can now move on to the counterfactual policy comparison. In Figure 2 we observe significant decreases in bill savings under the MPR-based feed-in tariff and comparatively smaller reductions under the counterfactual net metering policies. We can see that as block-pricing becomes flatter across the IOUs, there is significantly less variability and the overall reduction in bill savings is partially tempered.

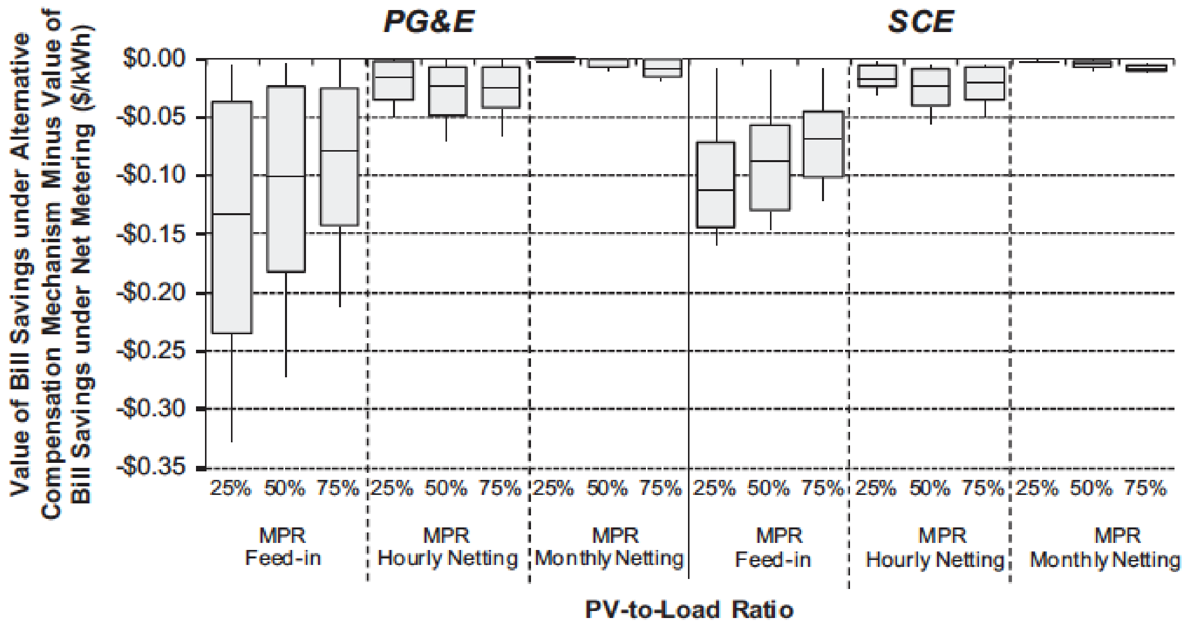

Figure 2: Value of bill savings across policy approaches with base case of NEM 1.0 (Darghouth et al, 2011)

3.2.1 Conclusions

The results of this paper provide us with three key insights that we can adapt to the impact of NEM 3.0. The fact that much of the variation in bill savings can be attributed to increasing block-pricing i.e. high-use customers benefit significantly more than low-use customers. Secondly, the inclining block rate results in diminishing returns to scale in that they incentivize the installation of smaller systems and create wedges in incentives towards the edges of these tiers. Finally, in this model, the authors allowed customers to adopt the least-cost rate policy based on their own profiles. This means they can observe the impact of different incentives on the adoption of time-of-use vs traditional block pricing. The most important result being that policies that place limitations on the amount of excess energy that can be distributed are negatively associated with time-of-use adoption.

There are significant limitations to the conclusions that we can draw from these results. This analysis is largely a theoretical exercise as the data used is not based on actual solar PV adopters but rather on potential bill savings from installing a 1kWh system. This means that we cannot account for changes in behaviour associated with the counterfactual policies, which is reminiscent of the Lucas critique of standard econometric models. We also note that the effect of moving from NEM 2.0 to 3.0 may be comparatively less costly than the changes noted above due to several structural changes in the compensation scheme. Firstly, NEM 2.0 moved all customers to a TOU compensation scheme while legislation in 2013 included provisions that allowed solar customers to sell excess energy at MPR-based rates. The combination of these removed some of the limitations that previously disincentivized TOU adoption. Being able to sell excess energy may result in customers on the lower end of the load distribution experiencing an increase in their average compensation rates under TOU.

3.3 Private Net Benefits of Solar PV: The Role of Electricity Tariffs, Tax Incentives, and Rebates (Borenstein, 2015)

3.3.1 Introduction

Borenstein examines the impact of various incentives for the adoption of residential PV systems including pricing mechanisms such as net metering and inclining block pricing (IBP). The paper also looks at the effects of other federal and state incentives such as the California Solar Initiative (CSI), federal tax credits, and accelerated depreciation. The results of the study complement our analysis well as we will be able to observe the combination of all incentives available to PV adopters and how they contribute to the lifetime NPV of a system. This is closer to the decision-making process that potential adopters would be faced with in real life rather than the per kWh savings in Darghouth's analysis. The analysis also includes an illustration of the equity concerns relating to net metering by analyzing the relationship between customer income and net benefits.

Data is gathered from the CSI and PGE on energy consumption, system size, system cost, and date of installation from 47,000 households from 2007 to 2013. This is later complemented with census data to estimate the income distribution across these households. The value of various incentives can be directly calculated from this and can be used to compare their relative value. I will now go on to summarize the various incentives available to these customers.

Direct rebates and tax credits

Two large subsidies are considered here. First is the 30% federal tax credit available for residential PV. This was introduced in 2009 and is still currently in place but has been reduced to 26%("Federal Solar Tax Credit for Homeowners," 2022). The second is the CSI which was introduced in 2007 and provided a per watt subsidy starting at \$2.50 in 2006 but was slowly phased out over the given period. This means that in 2006, a 10kW system would receive a \$2500 subsidy upon installation.

Accelerated Depreciation

Businesses that install solar PV qualify for accelerated depreciation of the value of the system. This was initially not very relevant for residential solar but has become increasingly important as now most solar PV adopters do so under a Power Purchase Agreement (PPA) or lease. There are subtle differences between how these agreements operate but in general, it means that the customers do not own the solar panels but pay a fixed charge for the energy they produce. Theoretically, accelerated depreciation allows the companies which own these systems to pass on some of the savings to the customers in the form of lower rates.

Rate Structure and Net metering

We now have a general understanding of how these policies work, but some changes were put in place since Darghouth's analysis. Firstly, customers operate on a yearly billing cycle. This means that throughout the year, customers can fully offset their consumption at the retail prices and any excess energy at the end of the year will be compensated at the MPR-based feed-in tariff.

3.3.2 Results

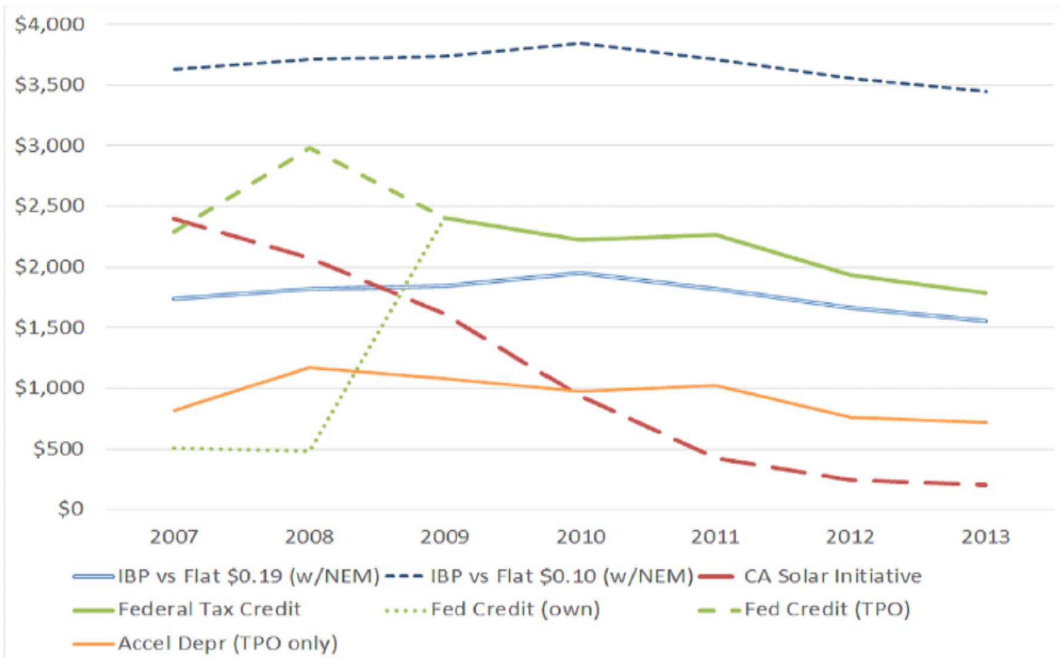

Figure 3: Average value of incentives for installing solar PV (Borenstein, 2015)

Figure 3 illustrates the expected relative value of the various incentives at different points in time. The solid blue line illustrates the value of the IBP structure, whereas the difference between the solid and dotted blue lines illustrates the value of the deviation in the retail price over the long-term avoided cost which is estimated here at $0.10/kWh. This can be thought of as the deviation from true social marginal cost even in the absence of an IBP structure. This deviation is almost equivalent in value to the 30% federal tax credit. It is important to remember here that the value of bill savings does not represent a social surplus. There is a disparity in the savings accrued to the customer in reducing consumption vs. the cost savings to the utility. Therefore, the difference in the retail price and true long-run avoided cost can be thought of as merely a rent transfer from the utilities to the customer. This is especially problematic if this rent transfer is not distributed equitably.

Table 1 captures the relationship between customer profiles and system attributes. The dependent variables are listed at the top of each column. Column 1 indicates that higher-income customers install larger systems. Column 2 tells us that higher-income customers use significantly more energy. Column 4 measures the impact of income on the average value of displaced energy. In essence, showing that higher-income customers are compensated at higher marginal rates for displacement than low-income customers. Column 5 shows that lower-income customers are less likely to take advantage of the lease/PPA agreements, which are specifically designed for them.

VARIABLES	(1) PV Capacity (kW)	(2) Annual Consump (kWh)	(3) PV generation Consumption	(4) Average Price of kWh Displaced	(5) Lease/PPA Share
Constant	4.687***	12,235***	0.572***	0.272***	0.716***
	(0.0684)	(176.1)	(0.0192)	(0.00159)	(0.00868)
Income bracket 1	-0.772***	-3,363***	0.263***	-0.0587***	-0.0525***
	(0.0676)	(203.5)	(0.0988)	(0.00214)	(0.0115)
Income bracket 2	-0.347***	-1,670***	0.0959***	-0.0317***	-0.0335***
	(0.0529)	(182.4)	(0.0328)	(0.00172)	(0.00932)
Income bracket 3	-0.268***	-1,234***	0.0491***	-0.0229***	-0.0175*
	(0.0485)	(146.2)	(0.0103)	(0.00151)	(0.00913)
Income bracket 4	-0.234***	-1,064***	0.0321***	-0.0184***	-0.00416
	(0.0389)	(117.8)	(0.00579)	(0.00119)	(0.00738)
yr2007	-0.801***	-182.8	-0.0907***	0.00203	-0.645***
	(0.0705)	(185.3)	(0.0269)	(0.00216)	(0.00893)
yr2008	-0.740***	31.39	-0.0137	0.00135	-0.585***
	(0.104)	(234.4)	(0.0828)	(0.00254)	(0.0104)
yr2009	-0.466***	-36.94	-0.0443*	0.00197	-0.578***
	(0.0785)	(216.5)	(0.0235)	(0.00238)	(0.00939)
yr2010	-0.0550	778.3***	-0.0632***	0.0119***	-0.398***
	(0.0540)	(147.4)	(0.0230)	(0.00151)	(0.0136)
yr2011	-0.442***	125.7	-0.000425	0.00760**	-0.228***
	(0.0480)	(187.0)	(0.0524)	(0.00312)	(0.0152)
yr2012	-0.284***	-77.53	-0.0356	0.00185	-0.0155
	(0.0408)	(121.6)	(0.0225)	(0.00167)	(0.0122)
Yr2014	0.187***	113.0	-0.00992	-0.00107	
	(0.0370)	(94.72)	(0.0255)	(0.000901)	
Observations	89,879	89,879	89,879	89,879	47,164

Standard errors, clustered at zip code, in parentheses ***p<0.01 **p<0.05 *p<0.1

Figure 4: Descriptive regressions of customer and system attributes (Borenstein, 2015)

The incentive we are most interested in is the compensation scheme for net metering. Figures 5a-d demonstrate the NPV per kWh installed under various pricing policies with the colours indicating income brackets.

Figure 5: NPV per kW of systems under various pricing schemes

These figures illustrate the following results. Under the current policy, large variations in payoffs exist across income brackets. These disparities disappear under the flat rate pricing policies indicating they are driven by the IBP structure. The second important result is that under an avoided cost pricing structure, solar provides a negative NPV per kW of the system over the 6 years. This is essentially the proposed policy under NEM 3.0 but several changes have occurred since 2013 that may influence this result. It is important to note that these are the NPV disparities between solar customers. It seeks to demonstrate that the incentive for net metering is significantly greater for high-income customers. This does not mean that a move to flat pricing or a TOU scheme for NEM will correct all the pricing disparity across all customers. There will still be a cost shift effect that will disproportionately hurt non-solar, low-income households.

3.3.3 Conclusion

Several important results can be drawn from the work presented so far. Firstly, the differential in incentives to high-income and low-income customers represents a transfer from the utilities to the customers and does not represent any social surplus. Second is that the structure of electricity prices in California represents an additional subsidy to adopters that is roughly equivalent to the 30% federal tax credit and this is mostly captured by high-income customers. There are several caveats to these results, the foremost being the decline in solar installation costs and the adoption of PPA and lease agreements. These will both drive the average NPV per kWh upwards due to lower initial costs and more savings from accelerated depreciation. Some forces have decreased the impact of the IBP pricing since this study, namely the flattening of the rates across usage tiers and the switch to comparatively lower time-of-use retail rates under NEM 2.0.

4 NEM 3.0

As mentioned above the central proposals in NEM 3.0 include the following:

(i) Net billing (NEM) customers are compensated for the energy they return to the grid at the avoided cost to the utility of buying clean energy elsewhere.

(ii) Customers are charged at high-differential time-of-use rates to incentivize the installation of battery storage solutions.

(iii) Creates a grid participation charge to ensure that NEM customers pay the same share of the fixed costs as the non-NEM customers.

(iv) Provides market transition credit to ensure that new systems can be paid off within 10 years of installation.

I will provide a framework for analyzing the impact of these policies as there are numerous trade-offs to consider and I think it is important that we keep the larger picture in mind here. First, we will determine whether these policies are likely to slow the adoption of residential PV in California. I will then go on to ask how these are likely to affect electricity prices and address the associated equity concerns. In the discussion section, we can take a step back and ask how these policies will affect the transition to sustainable energy more broadly.

4.1 Changes to net billing

Drawing on the evidence presented above, we can conclude that the shift to the MPR-based feed-in tariff is equivalent to removing the largest incentive for residential PV adoption. I would contend, however, that this is unlikely to 'kill' solar energy in California as many have claimed(Publishing, 2022). There are several tailwinds that are still in place for distributed PV, the most prominent being the reduction in installation costs. Since 2013, the time of Bornstein's analysis, the cost per kWh electricity has dropped by roughly 30%, even considering large increases in 2021 and 2022 due to supply chain issues. The same claims were made about the death of solar in 2017 when NEM 2.0 was introduced yet, 2017-2021 saw the largest year-over-year increases ever, with roughly 500,000 homes installing solar energy systems last year (Roselund, 2017). Despite this headwind though, after 2023, we are likely to see slowing growth in the distributed PV market. This is going to be driven mainly by a drastic increase in the payoff period of these systems as demonstrated by Borenstein.

So given the slowing growth in the distributed PV market, and the lower compensation to net metering. Are we likely to see reductions in electricity prices for non-solar users? This is a difficult question to answer as the execution of this cost shift is not a given as it relies on the utilities to act responsibly and redistribute gains equitably. One thing that may assure citizens is that IOUs are regulated and thus are limited in the degree to which they can reward shareholders at the expense of their customers through ROE regulation. That being said, there have been allegations that the California IOU's allowable ROE is too high and doesn't reflect true market risks (Do California's Big Three Utilities Need So Much Ratepayer Money?, n.d.). Thankfully, to answer these questions, we can turn to an analysis conducted by the Energy Institute at Haas.

Figure 6 provides the structure of per kWh electricity rates by IOU in California broken down by downstream costs. Included, are estimates of the long-run private and social marginal cost of energy production. Included in the SMC are estimates of the cost of non-marketed GHGs as well as public purpose programs that are generally intended for redistribution. This means we are essentially valuing inequality as a negative externality. The brown portion is the value of fixed costs that are driven by increases in behind-the-meter PV supply. In theoretical terms, this measures the size of the deadweight loss due to net metering.

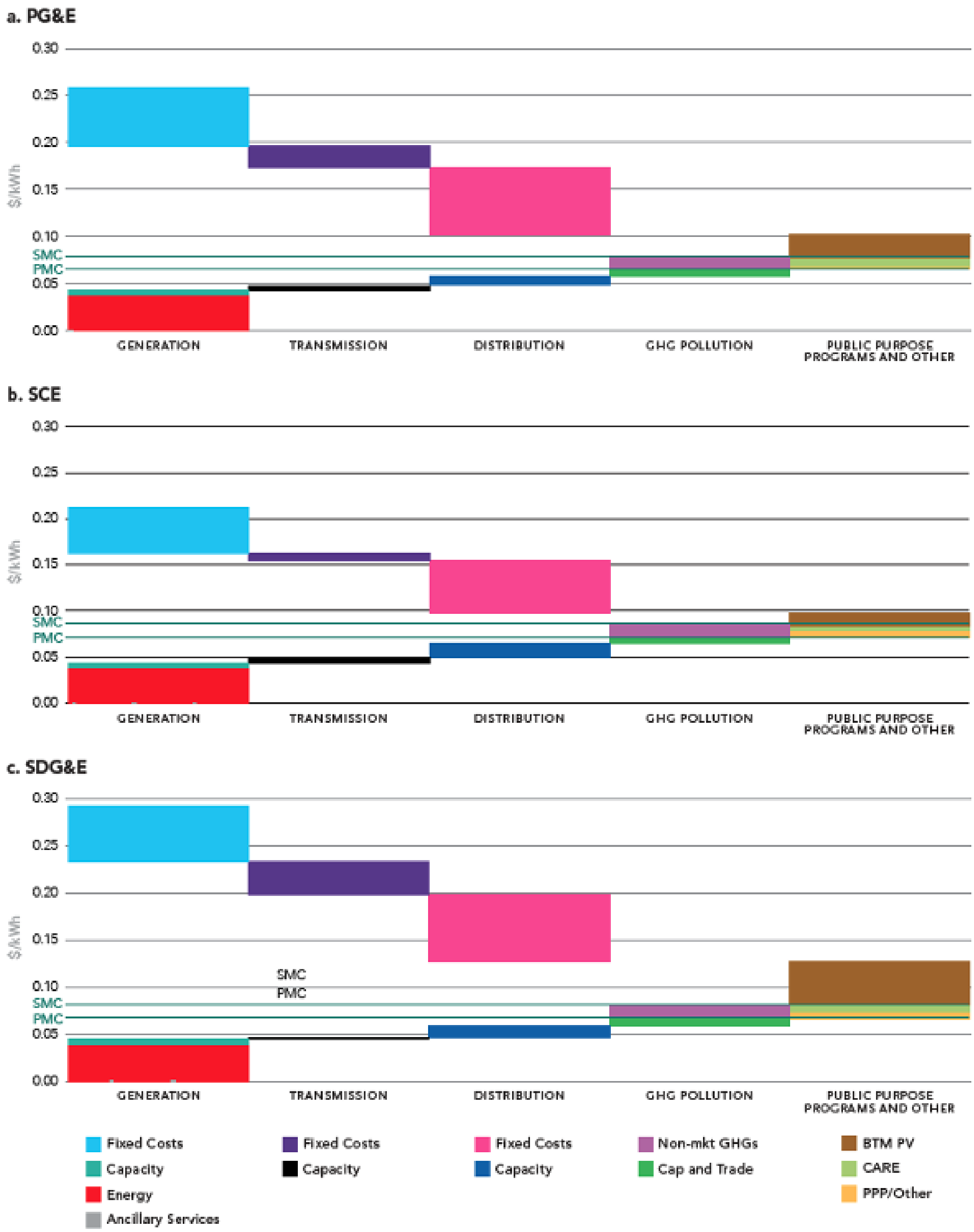

Figure 6: Downstream cost structure of California IOUs (Bornstein et. al, 2021)

Here it can be seen that most of the markup over SMC is driven by transmission, generation, and distribution costs. These costs are the main sources of the disparity in electricity prices between California and the remainder of the United States. The CPUC attributes the high generation costs to the impact of the Renewables Portfolio Standard (RPS) target of serving 29% of the electricity load from renewable energy. Between 2013 and 2019, California IOUs entered contracts with wholesale renewable energy suppliers which were "well above 2019 market prices for all types of generation" to meet these targets (Borenstein et al., 2021). As for fixed costs from transmission and distribution, there simply isn't enough data available to draw meaningful conclusions from. Included in these costs are amortization and return on capital for investment as well as wildfire mitigation costs which are believed to be significant and growing. Considering all of this, we cannot determine whether IOUs are able or willing to make the necessary cost shifts to support a more equitable electricity pricing system.

4.2 Changes to TOU Rates

The changes to TOU rates are just further extensions of the NEM 2.0 policy. Theoretically, the value of energy provided to the grid should be much more highly correlated with the time at which it is provided than the IBP tier at which the customer falls into. This is especially true for solar energy as very few of these systems have battery storage solutions in place, therefore, most of the energy they provide is concentrated between 7 am and 5 pm. This means that it is much more likely that the additional energy is displacing grid-scale renewables than natural gas-fired plants which come online to fulfill loads at peak hours from 4 pm-9 pm. This policy results in a relatively greater incentive to install battery storage to take advantage of this highly differential pricing. Overall, the shift to TOU rates will also result in significant decreases to the incentive to install residential PV, with high-income and high-energy-use households being disproportionately impacted.

4.3 Grid Participation Charge

The implementation of a flat grid-participation charge to ensure equitable distribution is difficult to justify, considering the results presented so far. This seems to put residential households at a disadvantage, even compared to grid-scale renewables. The implementation of the MPR-based TOU rate should be enough to align the marginal benefits to production with the social marginal cost. Though it will only apply to solar customers, a fixed charge is also inherently a regressive tax so it will disproportionately impact low-income households.

4.4 Market Transition Credit

Ensuring that current systems will be paid off in 10 years does not represent a significant subsidy. The current expected payoff period for a 1kW system is just over 5 years so the implementation of this floor is unlikely to retain many of the customers that were on the margin (California Solar Panel Installations: 2022 Pricing Savings — EnergySage, n.d.).

5 Conclusion

This policy brief has sought to analyze the potential impact of NEM 3.0 on the long-run adoption of residential PV systems, equitable energy pricing, and the clean energy transition. The results section covered the first two as these are relatively more observable metrics. The implications this has for the clean energy transition and policy implications are much more speculative and will be saved for the discussion section.

Regarding the adoption of distributed PV, in the absence of significant technological advancement or increased wholesale electricity prices, we are likely to see a reduction in the new installations of these systems. This will be driven by longer payoff periods due to high fixed charges, lower compensation rates, and uncertainty about future policy. Given the grandfathered nature of these policies and the delay of their implementation, this will likely begin in 2024, before which we may see substantial increases in adoption rates to take advantage of the rates under NEM 2.0.

As for electricity prices, the reduction in compensation to net-metered customers should allow the retail prices to better reflect the social marginal cost. This change is likely to be minimal, varying from $0.025to0.10$/kWh across providers. This reduction will be concentrated in low- and middle-income households as providers will continue to employ the IBP structure for non-solar customers.

6 Discussion

So, what can we learn from the Californian experience with net metering? Should NEM 3.0 serve as a policy benchmark for other regions? Considering environmental economic theory, the distorted subsidies that net metering provides are far from the lowest cost solution. Ignoring the fact that on a pure cost per kWh basis residential PV is 3 to 5 times more expensive than grid-scale solutions, we can still conclude that it is inefficient and disproportionately benefits high-income consumers (Facebook et al., 2022). This does not mean that there is no place for net metering or residential solar. In the absence of government action, subsidies for the residential PV sector have been the main driving force behind California's decarbonization. The growing cost shift is not a concern, as long as there is a limit on residential PV load as a percentage of peak demand as per earlier legislation. This kind of system combined with a progressive tax or fixed fee to address equity concerns may be closer to a correct solution.

This kind of solution is a natural conclusion to the fact that residential solar energy without battery investments provides diminishing incremental benefits over time. Each new solar installation that gets compensated at retail rates provides marginal less value than the one before during most hours of the day and is likely displacing fewer and fewer GHG emissions. This result changes if we include mandated battery storage solutions but this is not currently in place.

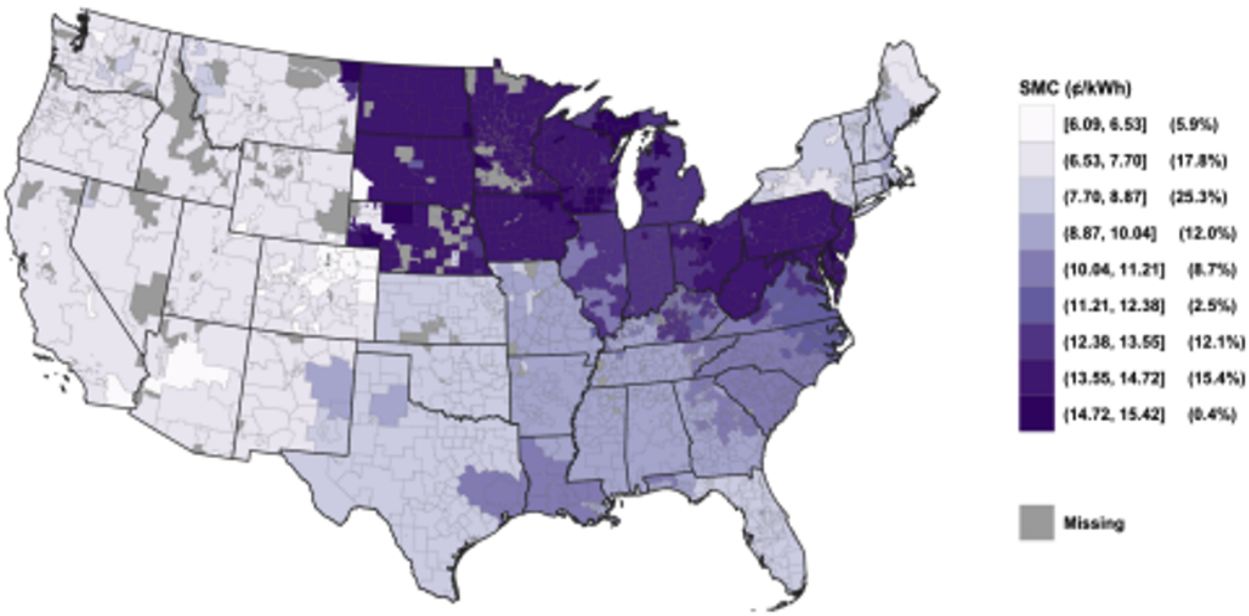

Figure 7: SMC of Electricity Across the United States

So how can other regions learn from this? Many states have removed or are considering removing net metering policies. I believe these are generally flawed solutions for states that are early in the transition to clean energy solutions and the concern of utilities are overblown. It is important to consider the relative benefit that solar provides across different regions. In our calculations, we are looking at the states with the lowest social marginal cost of energy production. If we looked at a place like North Dakota, the compensation for net metering may have had the opposite issues due to the heavy concentration of GHG sources in the energy mix and the lack of a carbon price. Above, I have included a figure that illustrates the wide differential in the SMC of electricity across the United States.

I hope this policy brief can serve as a benchmark for understanding NEM 3.0, the surrounding policy debate, and some broader issues relating to the global transition to clean energy.

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