IMPACTS OF THE CHANGES MADE TO SOLAR NET METERING BY NORTHERN CALIFORNIA COMMUNITY CHOICE AGGREGATORS

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ABSTRACT

IMPACTS OF THE CHANGES MADE TO SOLAR NET METERING BY NORTHERN CALIFORNIA COMMUNITY CHOICE AGGREGATORS

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When Northern California Community Choice Aggregation Programs (CCAs) took over the role of sourcing electricity from the incumbent utility (Pacific Gas and Electric, or PG&E), they also made changes to how solar customers were treated. In the Humboldt, Sonoma, Marin, and San Mateo County regions, solar customers that were net exporters of electricity received an additional $0.01/kWh credit on the generation portion of their bill. This policy is inherited from one CCA to another, and, given that CCAs are projected to serve 18 million Californians by 2020 (Cal CCA, 2018), understanding its impact – on a solar customer's bottom line and on the local solar market - is critical for the future of the vibrant California solar industry. When a hypothetical Northern California residential customer with typical electricity consumption installs a system that offsets 100% of their annual load, the Humboldt County approach provides an estimated $13/year in additional value (in the form of end-of-year bill credits) relative to a bundled PG&E customer. When that annual load offset is raised to 110%, the Humboldt County approach provides an additional estimated $32/year. An analysis of the number of residential solar installations before and after a CCA's implementation could not isolate them as a factor that grew the local solar market; average monthly installs rose, but that

increase was strongly correlated with broader trends, including falling costs. Interviews with solar contractors revealed that, while viewed as a positive gesture, this policy has not been proven to move the financial needle for potential customers.

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INTRODUCTION

Over the past 15 years, two policy developments have had an outsize impact on the world of renewable energy policy in California. The older, more established development is solar net metering, which ensures that solar electricity that is not used onsite and is exported to the grid can offset a customer's usage at another time of day. This policy - when combined with statewide incentives and the precipitously falling cost of solar hardware – helped California's solar capacity grow from 144 megawatts (MW) in 2006 to over 4,700 MW by 2017 (California Public Utilities Commission [CPUC], 2017). The more recent of these developments is the emergence of Community Choice Aggregation (CCA) Programs. These are entities run by local governments that allow communities to create their own electricity generation portfolios to serve their residents. In California, many CCAs have worked to establish generation portfolios that include more renewable energy than the incumbent utility while delivering power at a price that is less than the rates offered by the utility. (Cal CCA, 2018) These CCA programs take over the responsibility of sourcing electricity from the existing utilities, which are still responsible for distributing that electricity. These developments intersect because CCA programs have created their own net metering policies for their constituents, and this thesis examines that intersection.

Central Questions and Thesis Structure

This thesis focuses on the impact that Northern California CCAs, specifically Marin Clean Energy, Sonoma Clean Power, Clean Power San Francisco, and the Redwood Coast Energy Authority (Humboldt County), and the changes they made to their net metering policies, had on the solar market participants in their respective areas. There are several key changes made when a Northern California customer transitions from being a bundled customer of PG&E to a CCA customer. To begin with, their bills are split into a generation portion, which is settled with the CCA, and a transmission and distribution portion, which is settled with PG&E. Solar net metering customers have the generation portion of their bill shifted from PG&E's annual cycle to a monthly one. For each kilowatt-hour (kWh) that generated by a home solar system and not used onsite, all Northern California CCAs except San Francisco credited the generation portion of the customer's account with that kilowatt-hour's full retail value *plus* an additional $0.01, all of which could offset electricity costs incurred at other times of day. The central questions of this analysis are as follows:

1) In practice, what is the financial impact of CCA policies on residential solar customers?

2) Have these CCA policy changes resulted in a noticeable increase in the number of residential solar installations in the areas where they are implemented?

3) Where do these altered net metering tariffs fit into the academic and industry debates around how exported solar electricity should be valued?

While this may seem to be a narrow topic for analysis, it worth noting that the specifics of net metering tariffs have a strong influence on the economics of solar power. When the Public Utilities Commission in Nevada allowed the state's largest utility, NV Energy, to decrease the value of exported solar credits by 75%, the state's largest solar contractor, SolarCity, ceased in-state install operations, and competitor Sunrun dropped its local workforce by over 500 people (Buhayar, 2016). Solar electricity is mostly produced in the middle of the day when the customer's electricity consumption is low. If that customer cannot use the excess electricity to fully offset later usage, then the financial case for installing a system can quickly deteriorate. Conversely, if a net metering policy were to give substantially higher credits for excess solar electricity production, than customers and contractors would be incentivized to build larger systems. Each detail has the potential to have significant downstream effects the vibrant California solar industry.

The literature review chapter provides background information on Community Choice Aggregation programs and net metering in California. This is followed by a presentation of the ways that different academic studies have valued solar electricity that is exported to the grid. This is meant to lay the groundwork for a subsequent discussion about CCA policies in Northern California and their relationship to the wider policy debate about the value of exported solar electricity. The literature review is followed by the results chapter, which provides a financial analysis of the effects that Northern California CCA policies have had on solar net metering. The analysis considers a "typical" home in a CCA region and analyzes the savings provided by CCA net metering relative to a PG&E net metering baseline. It also provides a statistical analysis of the growth in solar installations before and after the establishment of a CCA program to determine if CCA net metering led to a significant uptick in installations. This is followed by the previously described discussion of where these net metering policies fit into the debate about the exported value of solar power. Finally, the conclusions chapter provides recommendations to CCA programs as they develop and refine solar net metering tariffs.

LITERATURE REVIEW

This chapter outlines the origins of CCAs and net metering before moving into a detailed review of how exported solar energy has been valued by various research efforts. This is a critical context because a "value of solar" is built into all net metering programs; when CCAs additional $0.01 generation credits, they are raising the value of exported solar in their territories. This chapter also includes an explanation of the mechanics of PG&E and CCA billing.

The Origins of Community Choice Aggregation Programs in Northern California

Prior to the implementation of their CCA Programs, the Northern California communities studied in this thesis had their electricity sourced through Pacific Gas and Electric, a large, investor-owned utility (IOU) regulated by the California Public Utilities Commission (CPUC). Like the other two large California IOUs (Southern California Edison and San Diego Gas and Electric), PG&E is also responsible for the distribution of electricity throughout its service territory.

In the mid-1990s, in response to electricity prices higher than the national average, the California state legislature passed Assembly Bill 1890, which allowed customers to purchase electricity from providers other than the large IOUs (Faulkner, 2010). This bill also set up both the California Independent System Operator - which retained control of the state's transmission lines with the goal of ensuring equitable access - and the Power Exchange, which operated a commodity market for electricity buyers and sellers (Faulkner, 2010). While the intention was to use consumer choice to drive down electricity costs, the reality was that certain market participants (most notably Enron) deliberately held down electricity production, drove up prices, and turned immense profits. Electricity rates for residential and small commercial customers had been frozen prior to the passage of the bill, and the State of California soon had to rescue bankrupt California utilities, who had been forced to purchase power at astronomically high wholesale prices (Elkind and MacLean, 2003). This led to rescinding of the ability of Californians to choose their own electricity provider.

California's second attempt at increasing consumer choice - Assembly Bill 117 in 2002 - set much stricter rules around who could act as an electricity provider. It created "community choice aggregators" (CCAs) - which had to be municipalities and could purchase electricity on behalf of their residents. Customers would be given the opportunity to opt out, and incumbent utilities would be required to cooperate fully with CCAs in matters of billing and customer relations. CCAs were required to be regulated by both the local governments they served and the California Public Utilities Commission. (Faulkner, 2010) Although CCAs were legal at this point, it was not until 2010 that they were launched on a large scale beginning with Marin Clean Energy. Subsequently, CCAs began to form with more regularity across Northern California, including Sonoma County, San Francisco County, the Peninsula (just south of San Francisco) and eventually Humboldt County in 2017. Each of these CCAs slightly altered the net metering programs and associated tariffs that applied to their residential solar customers. (Cal CCA, 2018)

The Origins of Net Metering Policies in California

Net metering can be most aptly described as a utility tariff that allows solar customers to “bank” exported solar kilowatt-hours for later use at a time when they are not generating sufficient energy to offset their load directly. California’s early and aggressive use of net metering is emblematic of its history of leadership in renewable energy integration. In 1996, State Senate Bill 656 required utilities to develop net metering tariffs for small, residential generators. These tariffs helped precipitate an explosion in residential solar in the late 2000s and 2010s (California Public Utilities Commission [CPUC], 2017). Although recent growth has slowed slightly, the residential solar market in California is still a source of significant economic activity, and solar net metering policies are the subject of considerable debate.

The Spectrum of Academic and Practical Approaches to Valuing Exported Solar Power

Net metering’s pivotal role in the growth of the solar industry is the result of a timing issue: solar production peaks midday when most people are out of the house and tapers off in the evening when people get home and ramp up electricity use. Although this solar production curve can match the load in regions with heavy air conditioning loads (which also ramp up in the middle of the day), the ability to used exported solar to build credits that can directly offset later usage is what makes solar economically viable for a large number of US homes.

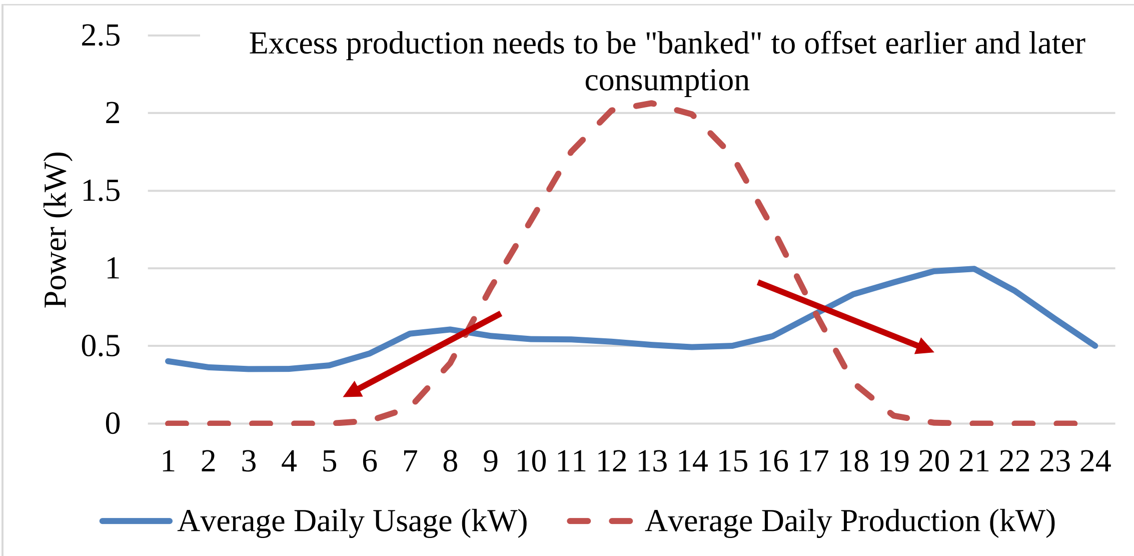

Figure 1 - Average Daily Arcata, CA Consumption and Solar Production

In many areas, the credit a customer receives for one kilowatt-hour of excess solar fully offsets a kilowatt-hour (kWh) of usage later. This means that exported solar is worth the retail price of electricity, a determination that is at the core of the net metering debate. Utilities argue that when a customer installs a home solar system, they are using the grid to export electricity to but not paying their share to cover the cost of that grid's maintenance. The solar customer, because of net metering, can generate enough excess credits to essentially offset their entire bill, meaning that they are no longer a source of revenue for the utility. The utility then must raise rates on its non-solar customers in what they describe as a cost shift. Utilities therefore argue for either raising fixed costs on solar customers or lowering the rate at which customers are credited for excess solar generation. Solar advocates, on the other hand, argue that the value that their exported solar provides to the grid and to society makes it worth more than the retail electricity rate. They argue solar customers are paying for generation that the utility will not have to build on their behalf, and that localized generation makes the grid more efficient. It is therefore permissible that solar customers pay very little to the utility, given the value they create. (Beach and McGuire, 2013)

This literature review presents a spectrum of the academic and practical approaches to net metering and the valuation of exported solar. These are attempts by consulting firms, governmental bodies, utilities, and other entities to quantify the value that export solar electricity provides to the grid and to society. That valuation is built into net metering policies. These approaches will be organized from those which place the highest monetary value on exported solar to those which place the lowest.

This overview of the valuation-of-solar debate is critical to understanding the context in which CCA net metering policies are developed. Is giving exported solar an extra $0.01 per kWh wildly generous and out of step with the relevant research? Because that extra cent only applies to the generation portion of the customer’s bill, does it really result in a financial gain? How do the minimum charges implemented by utilities affect the value that a customer receives from home solar? This literature review lays the groundwork for a more thorough treatment of these questions in the Discussion chapter.

The end of the literature review provides a detailed breakdown of how net metering works within CCA territories in Northern California and compares those policies to those in place under Pacific Gas and Electric.

High Solar Valuation: Maine PUC Study

In March of 2015, the Maine Public Utilities Commission presented a Distributed Solar Valuation Study to the 127th Maine Legislature. The goal was to determine the monetary value of the electricity that a distributed solar system sent back to the Maine electrical grid. Their methodology for quantifying the benefits of solar was shared by many of the other studies described in this thesis. It is important to note that this methodology values the gross production of a stand-alone solar system that exports everything to the grid, not a net metered system that serves an onsite load. However, the valuation is applicable to the net metering debate because it provides a means of valuing exported solar electricity on a per-kWh basis, and that value is built into net metering policies by default. The quantified benefits of exported solar are summarized in Table 1.

Table 1 - Benefits of Exported Solar (Norris et al., 2015, p.3-4)

Benefit	**Justification**
Avoided Energy Cost	Wholesale electricity market payments that the export of the distributed solar energy allows the electricity provider to avoid
Avoided Generation Capacity and Reserve Capacity	Local independent system operators (ISOs) often require electricity providers to purchase reserve capacity, and this cost is lessened by the distributed solar energy generation
Avoided Transmission Capacity Cost	Because exported solar energy is consumed locally, costs associated with transmission losses are avoided
Avoided Distribution Capacity Cost	The same logic as avoided transmission capacity losses
Net Social Cost of Carbon, SO_2, and NO_X	Environmental Protection Agency estimates of social costs of greenhouse gases (includes adverse health effects, costs of environmental mitigation, etc.)
Market Price Response	Temporary reduction in market electricity prices that result from lowered demand
Avoided Fuel Price Uncertainty	Avoided long term price uncertainty cost of natural gas fuel

Benefits were assessed within the service area of Maine’s largest local utility. The study first calculated the annual export of a solar photovoltaic system using localized irradiance information. Using the variables above, this study then placed a dollar value on that exported solar electricity. The avoided energy cost and the avoided generation capacity cost were calculated using the ISO – New England (NE) forward capacity and wholesale market prices, and the cost of transmission losses were calculated using ISO-NE figures as well. The study calculated a 25-year energy value of exported solar in dollars per kWh, setting the discount rate to the average weighted cost of capital at the time of the study. The result was a value of exported solar of $0.337/kWh, well above the $0.13/kWh price for retail electricity average in Maine at the time (Norris et al., 2017, p.6).

Table 2 - Value of distributed solar electricity that is exported to the grid (Norris et al., 2015, p.6)

Benefit	**Distributed PV Value, Maine PUC**
Avoided Energy Cost	$0.081
Avoided Generation Capacity and Reserve Capacity	$0.045
Avoided Transmission Capacity Cost	$0.016
Solar Integration Cost	($0.005)
Net Social Cost of Carbon, SO_2, and NO_X	$0.097
Market Price Response	$0.066
Avoided Fuel Price Uncertainty	$0.037
Total	$0.0337

This study also accounted for the costs of integrating solar into the grid, including utility infrastructure upgrades that are sometimes necessary when solar PV is installed. It is critical to note that parts of the estimated transmission and distribution savings come from infrastructure that won't need to be built due to more localized generation. These savings are not realized the moment that the distributed generation is installed, underlining the fact that these are indeed estimates, subject to change. Overall, it is clear than the use of the EPA estimations for the social cost of greenhouse gases is a significant factor in pushing the valuation of exported solar to well above the retail level. Conversely, if academics or policymakers chose to leave off these figures, the value of solar will shift dramatically. If the methodology of the Maine PUC is accepted, then net metering policies that merely credit the customer with the retail value are undervaluing that customer's contribution to the grid and to society.

High Solar Valuation: Environment America Meta-Study

In 2015, the Environment America Research and Policy Center completed a study of 11 net metering analyses and concluded that they showed that solar customers "deliver greater benefits to the grid and society than they receive through net metering" (Hallock and Sargent, 2015, p.4). The studies analyzed were undertaken by utilities (Xcel Energy), research firms (Clean Power Research, SAIC Energy, Crossborder Energy), cities (San Antonio), and other entities. Each study used similar benefits categories as the Maine PUC study, although the two Clean Power Research Studies included economic development from solar projects in their final benefit-per-kWh calculation. Eight out of the eleven studies showed a value of solar above the average retail price of electricity, and it was clear that the source of each analysis played a role in its valuation, with the utility-associated studies finding a lower value of solar.

The Environment America analysis justifies the inclusion of "economic development" by stating that that in 2014, "the solar energy industry added jobs at a rate 20 times that of the overall economy," with "average wages in installation and assembly ranging from $18-24 per hour" (Hallock and Sargent, 2015, p.13). Finally, this report argues for a lift on a statewide net metering caps and a methodology that includes all the economic and environmental benefits of solar, rather than just measuring the value of solar via the avoided costs.

As the meta-analysis shows, there is a decent amount of research that justifies compensating exported solar a very high rate. However, this research rarely acknowledges the complications of that high compensation. If exported solar's high value includes societal benefits such improved public health, is it practical for utilities and CCAs and utilities to pay for that improvement? Utilities typically procure electricity from third parties at a wholesale rate, and yet, in the case of net metering, they are essentially forced to "buy" it at a retail rate. When actual net metering policies are observed, it is obvious that these high valuations for exported solar are difficult to put into practice.

Low Solar Valuation: The Edison Foundation

In 2014, the Institute for Electric Innovation, which is part of the Edison Foundation, a trade association representing US electric generation and distribution companies, published an issue brief arguing that the "NEM subsidy for residential rooftop solar is overly generous and not transparent" (Borlick and Wood, 2014, p.2). The brief used a value of solar methodology developed by Energy + Environmental Economics, Inc. (E3), a consulting firm. Because the E3 model is location specific, the Edison brief used a sample solar home in Southern California, just outside of Los Angeles. The resulting per-kWh value of exported solar, which quantified the benefits from avoided energy purchases, avoided transmission and distribution losses, avoided generation capacity payments, and avoided CO_2 allowance purchases, came to roughly $0.107. (Borlick and Wood, 2014, p.9) This was well below the California retail price of electricity at the time, leading the brief to conclude that the practice of awarding exported solar retail value amounted to a subsidy. A critical difference between this brief and previously discussed studies is the omission of a valuation of the economic, health, or environmental benefits of solar, any of which can significantly alter the findings.

Low Solar Valuation: Austin Energy Value-of-Solar Tariff

While the implementation of net metering policies has not usually incorporated a unique, adaptable dollar value to exported solar, Austin Energy (AE), a municipal utility, has pioneered a tariff structure that aims to more specifically compensate solar for its grid value. The mechanism, detailed in a 2015 National Renewable Energy Laboratory (NREL) report, employs a "buy-all, sell-all approach," in which the solar homeowner purchases all their monthly electricity at one rate (as if they did not have solar at all) and "sells" their solar production (in the form of a bill credit) back to the utility a separate, value-of-solar rate. This allows for the use of a specific value of solar electricity amount. This rate can be shifted depending on the locational value of distributed energy. Austin Energy's stated goals were to "provide fair compensation for the solar generation, avoid impacts of solar programs on non-solar customers, and enable the utility to recover costs" (Taylor et al. 2015, p.13). AE employed a similar methodology to many of the previously discussed studies to come up with an initial value of solar of $0.128/kWh. That rate is adjusted annually. Because the VOS rate was below the retail rate and Austin Energy wanted to encourage solar, the utility provided an additional rebate that drove substantial PV adoption. The Austin Energy tariff is an example of how a specific VOS rate can be incorporated into utility policies.

Best Practices for the Valuation of Exported Solar Electricity

Although these studies arrived at different results, there were some consistent methodologies that are informative to developing sustainable and equitable net metering tariffs. The first is to be as location-specific as possible when assigning a value to exported electricity. If solar is installed in a particularly congested area, it may relieve pressure on grid infrastructure and delay costly upgrades. This saves ratepayers money in the long term. Most of the studies reviewed included locational analysis to varying degrees of specificity. For example, the Maine PUC study's methodology included the use of a map from the New England Independent System Operator which assigns a marginal value to exported electricity within each region under its jurisdiction. This was one factor used in the calculation of the value of exported electricity. Many of these studies also acknowledged that locational value should have been more specifically calculated and suggested it as a future area of research. Additionally, these studies incorporated the time of day that electricity is exported. This is a more established concept in the utility sector; time-of-use rates, which price electricity according to the time of day it is consumed, have been widely adopted.

Not only that, but there is still a great deal of debate around how to value distributed solar from a transmission and distribution perspective. For example, the Maine study assumes that the drop in load that distributed solar provides will lead directly to fewer or deferred investments by the utility in expensive transmission infrastructure, thereby providing value to the utility, and by extension, ratepayers. (Norris et al., 2017) While there is a sound regulatory and technical basis for this assumption – easing the load on infrastructure makes it last longer – the utility may not see those savings for a very long time. This is one of many methodologies in these valuations that can and are being debated and refined. Additionally, state policies and locational grid attributes play a huge role in these valuations. Therefore, comparing a study that focuses on the Maine grid to a study that focuses on Los Angeles is not an apples-to-apples comparison; the goal of this section was to detail the differences in approaching the task of valuing exported solar. The decision to include or exclude broad categories like the net social cost of pollutants is a critical factor in the final valuation.

Finally, it critical to acknowledge the economic equity issues bound up in net metering policies. In January of 2016, even as she voted to leave retail net metering in place, California Utility Commissioner Carla Peterman expressed concern over its structure. She stated that anything that leads to a cost shift from solar to non-solar ratepayers is untenable and pushed stakeholders toward a successor tariff (Trabish, 2018). Utilities, ratepayer advocates, and the solar industry are in agreement that retail net metering cannot stay in place indefinitely, and, as the next section will explain, the recently implemented NEM2 tariff has already raised fixed costs for solar homeowners so as to avoid any cost shifts. This is a particularly important issue for California regulators that wish to avoided imposing costs on lower-income, non-solar households to benefit solar households, which have historically had much higher incomes. A recent Greentechmedia report, which used satellite data to observe solar households by zip code and broke that data down by income, found that only 13% of the roughly 520,000 households analyzed were classified as “low-income”, defined as an annual income under $45,000. (Shallenberger, 2017) While this proportion continues to grow due to governmental programs and the falling cost of solar, it is still the case that solar households skew towards middle and upper-income households, and rate structures built to reward solar disproportionately benefit these demographics.

The Specifics of Net Metering Policies in PG&E and Northern California CCA Territories

While crediting exported solar with an additional $0.01/kWh may seem like a simple change, the reality of the differences between bundled PG&E and CCA net metering is much more complicated. This section will lay out how these net metering polices operate in practice, beginning with how a small residential bundled PG&E customer (who pays PG&E for both generation and distribution) is treated if they install solar.

Background – Time-of-Use Rates

The assessments done in this thesis use the Residential TOU-A rate, which is commonly used for residences that use a moderate amount of electricity. Time-of-Use (TOU) tariffs differentiate what the customer pays based on when electricity is consumed. Although many current solar customers are grandfathered onto older plans, all future residential solar customers in PG&E (and Northern California CCA) territories will be required to be on the TOU-A or TOU-B tariffs. Under TOU-A, peak hours are from 3 PM to 8 PM on non-holiday weekdays year-round. All other hours are off-peak. (PG&E, 2018) These blocks determine what the customer pays for both electricity generation and distribution. Under TOU-A, summer rates apply June through September and winter rates apply October through May.

Pacific Gas and Electric

All new solar customers, including those under a CCA, are required to enroll in the PG&E NEM2 tariff (for CCA customers, NEM2 governs how their transmission and distribution charges are handled). NEM2 has certain characteristics meant to address some of the issues discussed earlier in this review. NEM2 allows PG&E to recover costs through a minimum monthly charge (about $10/month). (CPUC, 2018) Additionally, PG&E imposes non-bypassable charges on solar customers. This is a portion of the per-kWh electricity rate that consists of the following charges:

- Public Purpose Programs
- Nuclear Decommissioning
- DWR Bond Charge (A legacy of the California Energy Crisis that ensures that the Department of Water and Power is paid back for electricity it purchased)
- Competition Transition Charge (A legacy of the deregulation push in California that allows utilities to recover the cost of stranded or uncompetitive assets and contracts)

Every hour that a solar customer is net consumer of electricity from grid, they are billed these four charges. That billing is presented as a line item on the customer's monthly bill. (PG&E NEM Tariff, 2018) These four charges are not included in the credits or charges that the customer sees on their NEM statement. Essentially, non-bypassable charges are structured so that a customer cannot avoid them directly by sending solar electricity out to the grid.

What Happens Each Month

The customer receives a bill and a NEM statement from PG&E. The bill contains the only charge that a solar customer owes monthly – the roughly $10 minimum ($0.33 for each day of the month, as of early 2018). The NEM statement shows what the customer's consumption and production has been that month and what their corresponding charges are. That NEM statement also includes a line item for the Non-Bypassable Charges, Baseline Credits (if applicable) and any relevant taxes. All the charges and credits on the NEM statement are added and the net total is presented (this is the total NEM charge or credit). This is the figure that will be used in the customer's annual true-up bill. (PG&E NEM Tariff, 2018)

The monthly NEM statement also contains a line item for "Energy Charges." This is simply the net total of the generation charges and credits, isolated from the rest of the bill (leaving out transmission, distribution, and all other charges). The energy charges will only be used if, at the end of the year, the customers cumulative NEM charges are less than the sum of the monthly minimum charges. (PG&E NEM Tariff, 2018) The sample monthly figures in Tables 3, 4, and 5 come from the hypothetical Arcata, CA customer developed for the financial analysis chapter of this thesis.

Table 3 - Bundled PG&E Solar Customer - Example Monthly NEM Statement

	Consumption Cost Basis (kWh)	Charge or Credit ($)
Peak	26.93	$4.71
Off-Peak	-66.89	-$10.74
Non-Bypassable Charges		$5.74
Monthly NEM Charge/Credit		-$0.29
Itemized Generation Charge – Peak	26.93	$2.78
Itemized Generation Charge – Off-Peak	-66.89	-$5.94
Itemized Net Generation Charge		$3.17
Monthly Bill Due (Min. Charge)		$10.18

What Happens Each Year

Bundled PG&E solar customers receive an annual "True-Up" bill. The NEM charge or credits from each month are added up, and if the total is greater than the cumulative total of the annual minimum monthly charges (roughly $120), then the customer pays owes the difference between $120 and the cumulative NEM charge. If, however, the cumulative NEM charge is less than $120, the customer must pay the cumulative generation charge, which has been itemized on each monthly bill. In this scenario, the customer only pays this generation charge if it is positive. If it is negative, then the customer doesn't owe anything at true-up, and their annual out of pocket expenses are just the sum of their monthly minimum charges. (PG&E NEM Tariff, 2018)

If the customer is a net generator over the course of the entire year, they receive net surplus compensation. For each annual net generated kWh, the customer is paid at the 12-month average of the wholesale power price in California (usually $0.03-$0.04). (PG&E NEM Tariff, 2018)

Redwood Coast Energy Authority (RCEA), Marin Clean Energy, Sonoma Clean Power, and Peninsula Clean Energy

The first key difference in CCA vs PG&E net metering is the fact that a CCA customer's bills are split into two sections 1) Transmission and Distribution, paid to PG&E, and 2) Generation, paid to the CCA. From a Transmissions and Distribution standpoint, the CCA customer's bill operates the same as the bundled PG&E customer's bill (both are, in fact, governed by the same NEM2 tariff).

What Happens Each Month

The customer receives a joint statement from PG&E and the CCA. The PG&E statement contains the same charges and credits as before, but these charges and credits do not contain a generation charge. Non-bypassable charges are assessed in the same manner, as are relevant taxes. However, CCA customer see an additional charge on the PG&E portion of their bill – The Power Charge Indifference Adjustment. This allows PG&E to recover the costs of any generation they procured for a CCA customer that the customer is no lower using. It currently about $0.03/kWh. (PG&E NEM Tariff, 2018) All these charges are netted against one another, and the total appears as the monthly PG&E NEM charge or credit. However, customers only owe the minimum charge that month.

Table 4 - CCA Solar Customer - PG&E Portion of Example Monthly Statement

	Consumption Cost Basis (kWh)	Charge or Credit ($)
Peak (Distribution)	26.93	$1.01
Off-Peak (Distribution)	-66.89	-$2.50
Non-Bypassable Charges		$5.74
Power Charge Indifference Adjustment	-39.97 (Net kWh)	-$1.34
All Other Charges	-39.97 (Net kWh)	-$1.37
Monthly PG&E NEM Charge/Credit		-$1.54
Monthly Bill Due (Min.)		$10.18

However, within that same monthly bill is the CCA statement. It displays the CCA generation charges and credits, and, in RCEA, MCE, PCE, and SCP regions, it includes an additional $0.01/kWh if the customer is a net generator within any time-of-use block. (Redwood Coast Energy Authority [RCEA] NEM Tariff, 2018) This credit is included in the net generation calculation. If the result of that calculation is positive, then the customer must pay that CCA charge that month. If it is negative, then that balance is carried over to the next month where it can offset CCA charges. It cannot offset PG&E charges at any time.

Table 5 – CCA Solar Customer - CCA Portion of Example Monthly Statement

	Cost Basis (kWh)	Charge or Credit ($)
Peak (Generation)	26.93	$1.17
Off-Peak (Generation)	-66.89	-$3.26
Net Generator Bonus ($0.01/kWh)	-66.89	$0.67
Monthly Charge/Credit		-$2.21

The total due that month is the PG&E minimum charge and the monthly CCA charge, if the latter is positive.

What Happens Each Year:

Although CCA customers pay for any net positive generation charges monthly, they still settle with PG&E annually with a true-up bill. The PG&E true-up shows the NEM charges or credits by month (again, these figures do not contain generation charges or credits). If the cumulative total is above $120, then the customer owes the difference between $120 and the total. If it is below $120, that the customer does not owe any additional charges. (PG&E NEM Tariff, 2018)

Additionally, CCA customers receive the end-of-year value of their CCA NEM account, if it is negative. If the absolute value is over $100, they can opt to receive a check from the CCA. Otherwise, that value will roll over to the next year.

Clean Power SF:

Clean Power SF operates in the same manner as the other Northern California CCAs but does not give the extra $0.01 for net generated electricity. Net surplus generation over the course a year is valued at $0.089 (San Francisco Public Utilities Commission [SFPUC], 2017).

Table 6 - Summary of Northern California Solar Net Metering Policies (PG&E, 2018)

Provider	**Extra $0.01/kWh generation credit awarded to excess production?**	**Approach to Annual Surplus Compensation**	**Generation Charge Billing Frequency**	**Time-of-Use Rate Required for New NEM Customers?**
Bundled PG&E	No	12-month Wholesale Electricity Average/Annual Surplus kWh	Annual	Yes (PG&E NEM Tariff, 2018)
RCEA	Yes	End-of-Year Value of NEM Account	Monthly	Yes (RCEA NEM Tariff, 2018)
PCE	Yes	End-of-Year Value of NEM Account	Monthly	Yes (PCE NEM Tariff, 2018)
MCE	Yes	End-of-Year Value of NEM Account	Monthly	Yes (MCE NEM Tariff, 2018)
SCP	Yes	End-of-Year Value of NEM Account	Monthly	Yes (SCP NEM Tariff, 2018)
Clean Power SF	No	$0.089/Annual Surplus kWh	Monthly	Yes (SFPUC NEM Tariff, 2018)

In summary, CCAs essentially extract the generation portion of a solar customer's bills and apply charges and credits independently. CCA customers are still subject to PG&E transmission, distribution, non-bypassable, and other charges, and, under NEM2, all solar customers, CCA or otherwise, will pay a minimum of about $120/year regardless of system size. This minimum charge, along with non-bypassable charges, means that exported solar electricity does not offset purchased electricity at an exact 1:1 ratio. As the results section will show, a customer that generates enough annual electricity to equal their load will still owe the minimum charge every month. While this is widely accepted as an acceptable way to cover the utilities' cost of maintaining service, it is at odds with the high value of exported solar presented in some of the previously examined studies.

METHODS

The methodology for performing a contextual analysis of Northern California CCA Net Metering Net Metering policies in this thesis involves multiple approaches, each with its own set of steps.

Financial Benefits to a Typical Solar Home Under CCA Net Metering

To assess how the changes that CCAs made to net metering policies financially affect residential solar homeowners, this thesis developed a load profile for a “typical” solar homeowner in Arcata, California (a city of about 18,000 about 270 miles north of San Francisco) and measured the savings under the policies associated with two CCA net metering programs – RCEA in Humboldt County and Clean Power SF (CPSF) in San Francisco. These two programs were selected for financial analysis because they represent the full spectrum of approaches to net metering among Northern California CCAs; RCEA aligns with the rest of the Northern California CCAs by awarding a $0.01/kWh generation credit for monthly net exports, and CPSF offers a unique payout for annual surplus generation.

It is important to note that, although these two approaches represent the full range of net metering policies under Northern California CCAs, the individualized generation rates under RCEA and CPSF currently differ by an average of $0.002 across each season and time-of-use block (PG&E NEM Tariff and RCEA Net Metering, 2018). The goal of this analysis was to analyze the different approaches that CCAs can take – specifically, the practice of either offering an extra $0.01 for exported solar or offering a unique year-end cash-out rate - rather than to assess each set of per-kWh rates.

Under each set of policies, estimated savings were presented for three scenarios – one in which a homeowner purchases a system that offsets about 90% of their annual load, one in which they purchase a system that offsets about 100% of their annual load, and one in which they purchase a system that offsets about 110% of their annual load. The 110% limit is set by Pacific Gas and Electric as the maximum home solar system that the utility infrastructure can support (PG&E NEM Tariff, 2017). Savings were also compared between CCA net metering and bundled PG&E net metering. Additionally, because larger homes tend to see greater value from rooftop solar, an analysis was done for an Arcata, CA home that uses 3 times the baseline load per year and installs a system that offsets 100% of that annual load.

To establish a load profile, this thesis used the figures that PG&E uses to establish baseline residential electricity consumption. Arcata falls in to Region V (See Figure 4. The daily average usage numbers for Region V are presented in Table 7. Please note that the baseline usage for customers with the E-TOU-A Rate is used, as that is the rate that will be analyzed later.

Table 7 - Baseline Consumption Values for TOU-A Rate (PG&E, “Baseline Allowance”, 2018)

	Region V – Daily Average Usage (kWh)
Summer	8.6
Winter	10.3

PG&E states that “typical” usage is 1.5 times the baseline usage (PG&E, 2017). For Arcata, that results in 12.9 kWh/day in the summer and 15.45 kWh/day in the winter. While these figures reflect the daily consumption, they do not reflect how that consumption is distributed over the course of a day. That required the use of a US Department of Energy source called the Residential Energy Consumption Survey (RECS), which includes modeled hourly residential electricity consumption. The surveys used to create these models included over 5,600 households and tracked when and how those households used electric appliances. It was last updated in October of 2017 (US Energy Information Administration [EIA], 2017). The RECS provided the percentage of the daily load that a home in this region used each hour, which was applied to the quantities received from PG&E to create a typical summer and winter load profile. Figure 5 presents the percentage of the daily average load that a customer in Arcata, CA uses at each hour, according to the Department of Energy RECS Survey.

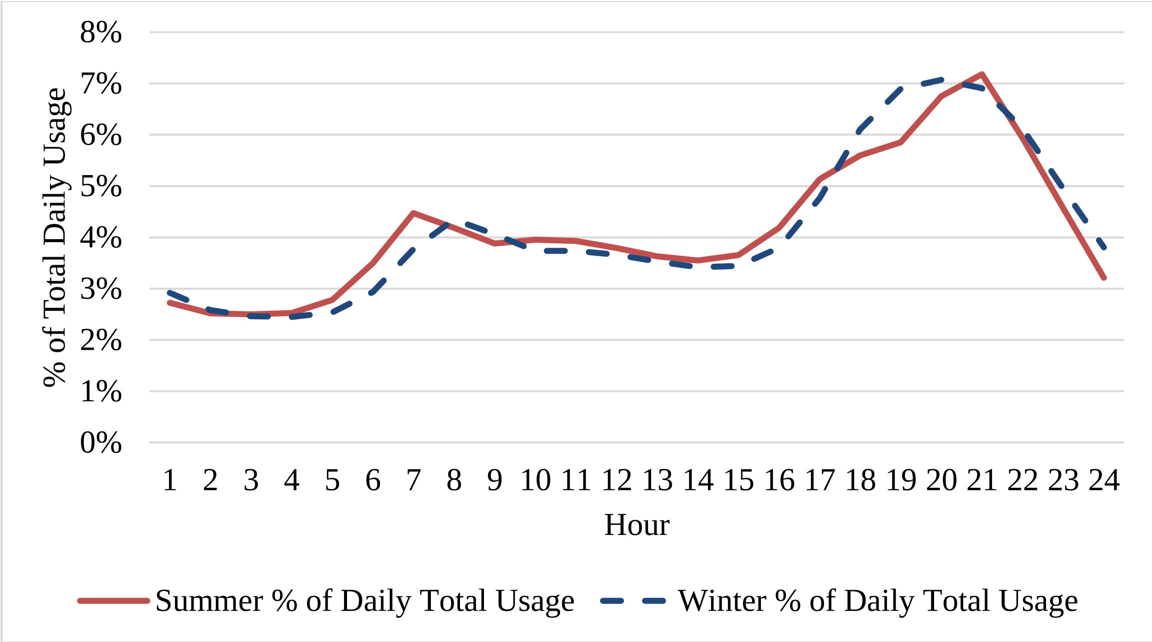

Figure 2 - Arcata, CA Percentage of Daily Electricity Consumption by Hour (US EIA, Residential Energy Consumption Survey, 2013)

When these percentages are applied to the typical electricity consumption figures from PG&E, the results are the following load curves for this average Arcata, CA home (Figure 6).

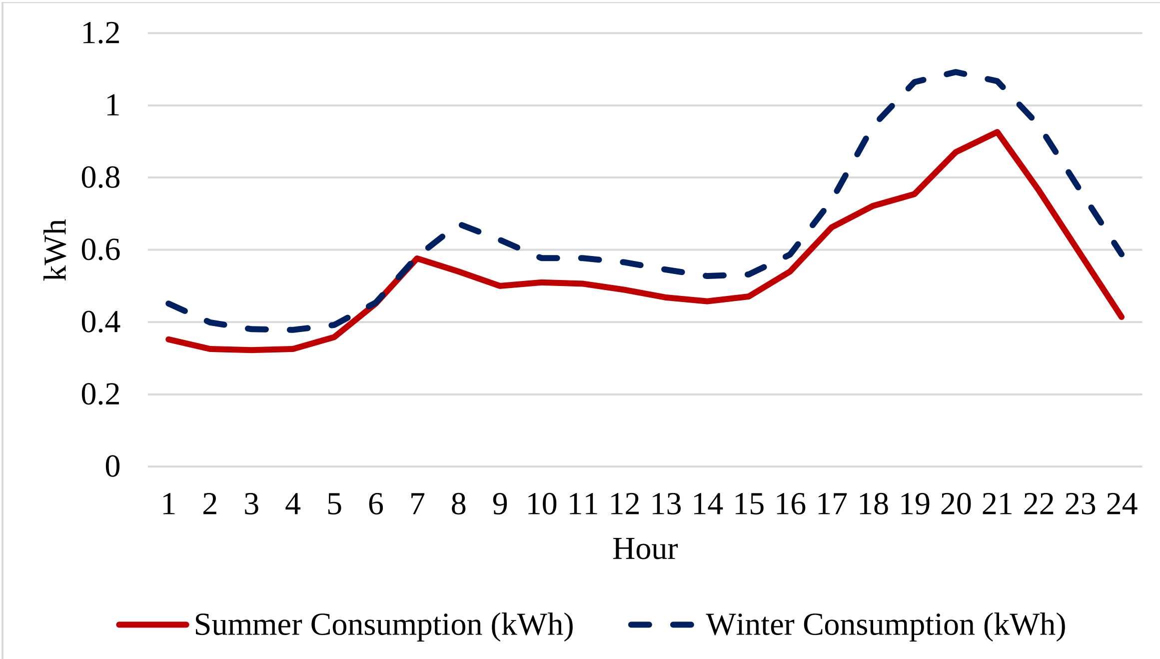

Figure 3 - Arcata, CA Average Residential Load Profile (PG&E, "Baseline Allowance", 2018 and US EIA, Residential Energy Consumption Survey, 2013)

With the typical consumption established, the amount of energy that a home solar electric system would provide was estimated using the National Renewable Energy Laboratory's PV Watts tool, which uses solar insolation data from the closest certified weather station to project the electricity output of a solar PV system. (National Renewable Energy Lab, PV Watts Tool, n.d.) PV Watts was used to determine what size system would offset 90%, 100%, and 110% of each typical load. The generated solar kilowatt-hours were distributed hourly using PV Watts and netted against a customer's typical usage. The result was used to calculate what the customer would pay in each month and year with solar.

The financial analysis presents the following findings under RCEA net metering and CPSF net metering:

- The customer's annual savings from solar under each size systems
- Those savings compared to PG&E net metering
- The added value ($) of the extra electricity (kWh) under each size system, as well as the value ($) of the end-of-year net metering credit account.
- A comparison between the CCA's net metering and PG&E's in terms of the financial payback of the system. This includes the following metrics: annual savings, simple payback in years, net present value (NPV) of savings, and internal rate of return (IRR) for rooftop solar as an investment. It is important to note that, for the scenarios in which the customer has value in their NEM account at the end of the year, that value is included in the computation of their annual savings. The NPV and IRR calculations assumed a 3% discount rate, as this is the rate used by the National Renewable Energy Lab's Levelized Cost of Energy Calculator. (National Renewable Energy Lab, Levelized Cost of Energy Calculator Tool, n.d.)

This analysis is performed on the same example home under each set of net metering policies.

Statistical Analysis of Solar Installations in CCA Territories

This section is meant to determine if the transition to CCA net metering had a substantive effect on the rate of residential solar installations in an area. Both observations and basic statistical tests are used. The California Public Utilities Commission database of interconnected solar installations provided the number of residential installations per month in an area before a CCA was launched. These data were compared with the number of installations per month after. The number of installations per month was also correlated with other variables that affect the solar market, including the retail price of electricity in California, the up-front incentives dispersed from the state of California (in dollars per watt), and the median cost of a solar installation (also in dollars per watt). The up-front incentive level was calculated by taking the monthly average of the incentives that were dispersed to residential solar customers, using the California Solar Initiative's public database. The goal was to see if these factors were demonstrably better indicators of the growth in local solar installations than the implementation of a CCA and its corresponding net metering policies.

Because this analysis required a substantive amount of time on either side of the CCA launch and most CCAs were only rolled out recently, there were very few areas that could be studied responsibly. The first was Marin Clean Energy, launched in 2010. That analysis only focused on the rate of solar installations in the areas included in the initial MCE launch - the cities of Belvedere, Fairfax, Mill Valley, San Anselmo, San Rafael, Sausalito, Tiburon and unincorporated Marin County. The second was the area covered by the Sonoma Clean Power launch in 2014 – the cities of Santa Rosa, Windsor, Sonoma, and Cotati. There were not enough data to analyze RCEA’s territory given its May 2017 launch. This was also true for Clean Power SF territory; even though it was launched in 2016, the rollout began with commercial customers, and its full rollout will not be completed until 2021.

Additionally, this section attempts to isolate the effect of a CCA by comparing residential installations in cities that did not shift to a CCA to cities that did make the shift over the same period. Cities that were comparable in population and economic makeup were chosen for analysis. The number of monthly residential installations in the city of San Rafael, with a 2017 population of about 59,000 and a median household income of about $81,000 (US Census, 2017) was compared with the number of installations in Walnut Creek, with a 2017 population of about 69,000 and a median household income of about $83,000 (US Census, 2017). These cities are about 33 miles apart and are very similar in average annual temperature and median home value. San Rafael was part of the initial MCE rollout in 2010, while Walnut Creek did not join MCE until 2016. Therefore, this section analyzes the period between 2006 and 2014 to see how San Rafael’s change in average monthly installations before and after 2010 compare to the average monthly installations in Walnut Creek. The same process was repeated for the cities of Santa Rosa (which enrolled with Sonoma Clean Power in 2014) and Concord (which enrolled with Marin Clean Energy in 2018) for the 2012 to 2016 period. Concord and Santa Rosa have relatively similar populations (about 129,000 and 175,000, respectively), similar median value of housing units ($423,000 and $415,000) and similar median household incomes ($71,000 and $63,000) according to the US Census. They are about 63 miles apart.

There are a number of issues with this analysis, some of which will be discussed in the results section. The areas analyzed are very small in size, making it hard to infer that the factors that affected them also affected the solar market in California at large. There are also a number of factors that were not analyzed that could have a substantial effect on the residential solar installation rate, including market saturation, the number of contractors in a region, and the ideological makeup of the population.

Discussions with CCA Staff and Solar Contractors

This section adds in discussions with some of the people and organizations affected by changes in solar net metering policies: solar contractors and CCA staff. The goal is to get a qualitative sense of why these net metering changes were made and what impact they are having, if any. This was not a broad survey; the goal was to have in-depth discussions with a few selected participants. A set of questions, approved by the Institutional Review Board (IRB) at Humboldt State University, was asked to current and former CCA staff at Sonoma Clean Power, the Redwood Coast Energy Authority, and Clean Power SF. A separate set of approved questions was posed to three anonymous solar contractors in the regions served by those CCAs and one nationwide contractor.

The full lists of IRB-approved questions are in Appendix A, but the goal was to answer the following questions more broadly:

For CCA Staff:

- Why do Northern California CCAs offer slightly more generous solar generation credits for exported solar electricity? Is there a particular policy goal in mind (ex: an increase in local solar installations)?
- Are the annual pay-outs to solar customers (customer with over $100 in net metering can get a check from the CCA) a significant expense? Do the CCAs coordinate on their net metering policies?

For Area Solar Contractors:

- Do you believe that the net metering changes made by Northern California Community Choice Aggregation Programs "move the needle" when it comes to a homeowner deciding to go solar? Do you encourage solar customers to stay in their local CCAs?
- What are your thoughts on the transition from PG&E to CCA solar net metering on the whole?

All participants were given the option of remaining anonymous in the final thesis. Paraphrased interview answers and associated analyses are included in the results.

RESULTS

The results are organized in the same manner as the Methods chapter: an analysis of the savings that a hypothetical Arcata, CA residence receives under Bundled PG&E, RCEA and Clean Power SF Net Metering Programs, an observational analysis of the rate of residential solar installations in areas that implemented CCAs, and a breakdown of the interviews with solar contractors and CCA staff.

Financial Analysis of Home Solar Under CCA Net Metering Programs

This section uses a typical Arcata, CA home project what the annual costs would be under each net metering policy before using those annual figures to calculate how these policies affect the attractiveness of home solar as an investment.

Baseline Monthly and Annual Estimated Costs

The effects of net metering policies were measured using the electricity consumption of an average home in Arcata, CA, which uses about 5,328 kWh/year. Before solar, the annual out of pocket expenses of this home are estimated at $1,242.89 (based on the bundled PG&E TOU-A Rate).

To model post solar savings, NREL's PV Watts tool was used to estimate the production of systems that offset 90%, 100%, and 110% of this home's annual load. Table 8, below, shows the annual production of the simulated solar electric systems, while Figure 7 compares the annual load with the annual production of each system size.

Table 8 - Estimated Annual Solar Production - Arcata Home

System Target (Offset)	Production Target (kWh)	System Size	PV Watts Estimated Annual Production (kWh)
90% of Annual Load	4,795	3.64 kW DC	4,816
100% of Annual Load	5,328	4.1 kW DC	5,315
110% of Annual Load	5,861	4.48 kW DC	5,880

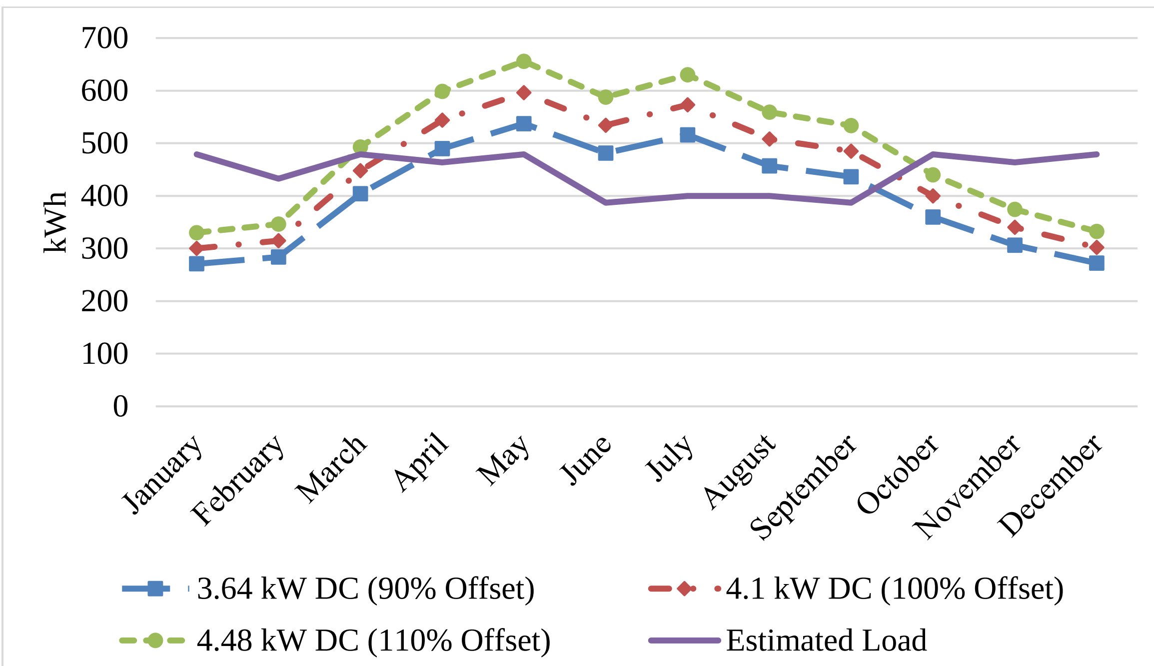

Figure 4 - Estimated Solar Production vs Estimated Load – Arcata, CA

Effect on System Payback

The first question that needed answering is as follows: Does switching to a CCA make rooftop solar a better investment for this Arcata, CA customer? This first section will present the annual savings, simple payback, the internal rate of return, net present value of 20 years of savings for each size system (90%, 100%, 110% of annual load), along with those same metrics for a home that uses three times the Arcata, CA baseline load with a 100% annual offset PV system. After the payback metrics, the detailed annual costs for each size system and for each tariff structure (Bundled PG&E, RCEA, and CPSF) will be presented.

In order to model system payback, the cost of each PV system needed to be estimated. In 2017, the average of the Humboldt County residential solar cost per installed watt, the California residential solar cost per watt, and the National Renewable Energy Lab's Nationwide residential solar cost per watt was $3.95/AC Watt (NREL, 2017). This value was used to calculate the total cost of each system size (this analysis assumes the customer has a significant enough tax appetite to include the entire 30% Federal Investment Tax Credit as calculated savings). The nationwide average was used because the previous two values are pulled from the California Solar Initiative database, which has system costs that are self-reported by solar contractors. The National Renewable Energy Lab's quarterly cost of solar report, alternatively, builds detailed models that account for component pricing and modern solar business models (NREL, 2017), and for this reason, it was included in the installed cost per watt calculation.

Table 9 - Gross System Costs

	90% of Load	**100% of Load**	**110% of Load**
Total System Cost ($):	$12,492	$14,071	$15,375
Total System Cost w/ ITC ($):	$8,744	$9,850	$10,762

To determine how the changes that CCAs made affect the attractiveness of rooftop solar as an investment, the following section presents several metrics related to system payback.

Payback Metrics: 90% of Annual Load

Table 10 shows the annual savings, simple payback, internal rate of return, and net present value for a 20-year lifetime for a system that offsets 90% of the annual load. Each of these estimates assumes a baseline of a non-solar customer with PG&E TOU-A Rates and a 20-year system lifetime. Savings are estimated to be constant from year-to-year, when, in reality, there would be annual variation due to solar insolation, weather, and other issues. The baseline is assumed to be the bundled PG&E rate without solar. It is important to note that if, for the two CCA scenarios, the baseline shifts to the CCA rate without solar, then the savings amounts decline because their non-solar annual expenses would be lower. For this analysis, however, it was important to use a single, consistent baseline.

Table 10 – Payback Metrics, 90% Annual Load Offset

	PG&E (Without Solar) to PG&E (With Solar)	**PG&E (Without Solar) to RCEA (With Solar)**	**PG&E (Without Solar) to CPSF (With Solar)**
Est. Annual Savings ($):	$1,094	$1,100	$1,093
Simple Payback (Years):	8.0	7.9	8.0
Internal Rate of Return (20-year lifespan):	10.94%	11.02%	10.93%
Net Present Value of Savings (20-year lifespan, 3% discount Rate)	$16,272	$16,362	$16,260

These metrics illustrate how, with a system that offsets only 90% of the annual load, the CCA net metering model does not provide significant financial costs or benefits relative to the incumbent PG&E net metering policy. Switching to the RCEA model provides the most value, mainly because of the end-of-year value provided in generation credits ($1.37). This value is included in the annual savings. This value is only created because the true-up year ends in April, a month with some net solar production.

Payback Metrics:100% of Annual Load

Table 11 shows these same metrics for a system that offsets (almost) 100% of the customer's annual load.

Table 11 - Payback Metrics - 100% Annual Load Offset

	PG&E (Without Solar) to PG&E (With Solar)	**PG&E (Without Solar) to RCEA (With Solar)**	**PG&E (Without Solar) to CPSF (With Solar)**
Est. Annual Savings ($):	$1,123	$1,136	$1,123
Simple Payback (Years):	8.8	8.7	8.8
Internal Rate of Return (20-year lifespan):	9.6%	9.7%	9.6%
Net Present Value of Savings (20-year lifespan, 3% discount Rate)	$16,712	$16,903	$16,712

Table 11 shows the same metrics for a Clean Power SF customer and a bundled PG&E customer. This is because both scenarios require that customers pay the annual minimum to PG&E - $119.54 – and do not require any generation payments. Because the customer's annual generation does not quite cover their annual consumption (by about 13 kWh), the PG&E and CPSF customers do not receive any annual net surplus generation credits. The RCEA customer, however, generates about $12.86 in credits at the end of the true-up period because the true-up is at the end of April. This slightly increases this customer's Internal Rate of Return (relative to a non-solar, bundled PG&E baseline) and slightly decreases their simple payback time.

Payback Metrics: 110% of Annual Load

Table 12, below, shows the savings metrics for a system that offsets roughly 110% of the customer's annual load.

Table 12 - Payback Metrics, 110% Annual Load Offset

	PG&E (Without Solar) to PG&E (With Solar)	**PG&E (Without Solar) to RCEA (With Solar)**	**PG&E (Without Solar) to CPSF (With Solar)**
Est. Annual Savings ($):	$1,141	$1,173	$1,169
Simple Payback (Years):	9.4	9.2	9.2
Internal Rate of Return (20-year lifespan):	8.6%	8.9%	8.9%
Net Present Value of Savings (20-year lifespan, 3% discount Rate)	$16,983	$17,457	$17,399

In all these scenarios, the customer receives an annual credit for net production. However, that credit is much higher in the RCEA and CPSF scenarios ($50.06 and $46.14, respectively) than in the PG&E scenario ($18.14, based on the average wholesale price of electricity). This leads to more value in savings for the CCA customers ($400-$500 more over 20 years, based on a 3% discount rate), but again does not dramatically change the simple payback or the IRR figures.

Payback Metrics: Arcata House with 3X Baseline Usage and 100% Offset System

Table 13, below, shows the savings metrics for a customer that uses 3 times the baseline consumption in a year and a system that offsets roughly 100% of the annual load. The gross cost of this system, with the ITC, is $19,460.

Table 13 - Payback Metrics, 3x Baseline Usage, 100% Annual Load Offset

	PG&E (Without Solar) to PG&E (With Solar)	**PG&E (Without Solar) to RCEA (With Solar)**	**PG&E (Without Solar) to CPSF (With Solar)**
Est. Annual Savings ($):	$2,670	$2,698	$2,670
Simple Payback (Years):	7.3	7.2	7.3
Internal Rate of Return (20-year lifespan):	12.4%	12.5%	12.4%
Net Present Value of Savings (20-year lifespan, 3% discount Rate)	$39,805	$40,216	$39,805

The large house with an 100% annual offset exhibited much higher internal rates of return across the board, although there was not a large difference between staying a bundled PG&E customer and switching the RCEA.

Savings Estimates: 90% Load Offset System

The following sections will dive into the details of what the customer’s costs are each year under each tariff structure. The results for a solar PV system that offsets 90% of this customer’s load is presented in Table 14.

Table 14 - 90% Load Offset - Annual Costs

	Bundled PG&E	**RCEA**	**Clean Power SF**
Annual Out of Pocket Expenses	$149.16	$144.46	$149.93
End-of-Year Net Surplus Compensation or NEM Account Balance	$0.00	$1.37	$0.00

RCEA provides the lowest annual out of pocket expenses ($144.46), largely due to the fact that, on the generation side, they are providing an additional $6.39/year in value (this value includes the $1.37 in end-of-year credits and the $4.70/year in lowered overall expenses). Figure 5 presents an itemized representation of how that additional credit creates value over the course of a year. Note that all calculations assume a year that ends on April 30th, because that the true-up cycle date that the CCAs use.

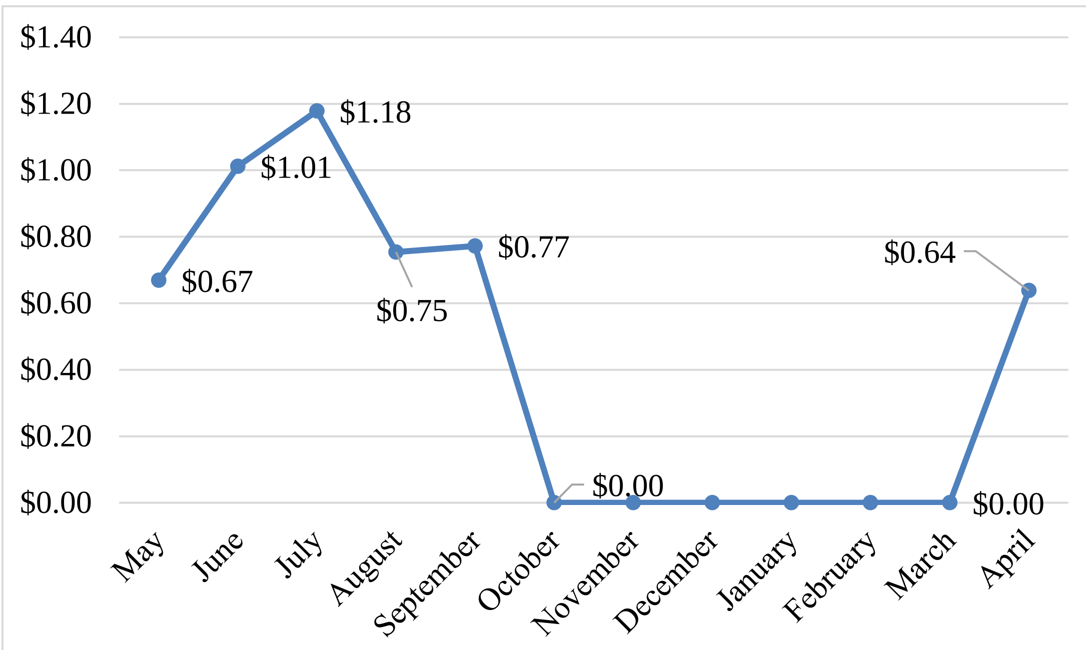

Figure 5 - Itemized Monthly Value of $0.01 Generation Credit - 90% Offset System

The customer receives credits in the summer months, when they are a net producer during a time-of-use block (usually the off-peak block, which is much longer than the peak block). This credit is used to calculate what the generation portion of the customer’s bill will look like. If it is positive, then the customer pays the CCA, and if it is negative, then the customer has a credit that rolls over to the next month.

Under bundled PG&E service, this customer’s cumulative NEM charges are $149.16. At the end of the year, this customer would be credited $119.54 (the sum of their monthly minimum charges), bringing their total annual out-of-pocket expenses to $149.16. The bundled PG&E customer does not receive any bill credits because they were a net electricity consumer over the course of the year.

Under RCEA and CPSF service, this customer would owe the minimum charges each month plus any positive generation charge that could not be offset by previous months’ credits. Figure 6, below, shows what the CCA customer owes each month for generation after the previously accumulated credits have been applied.

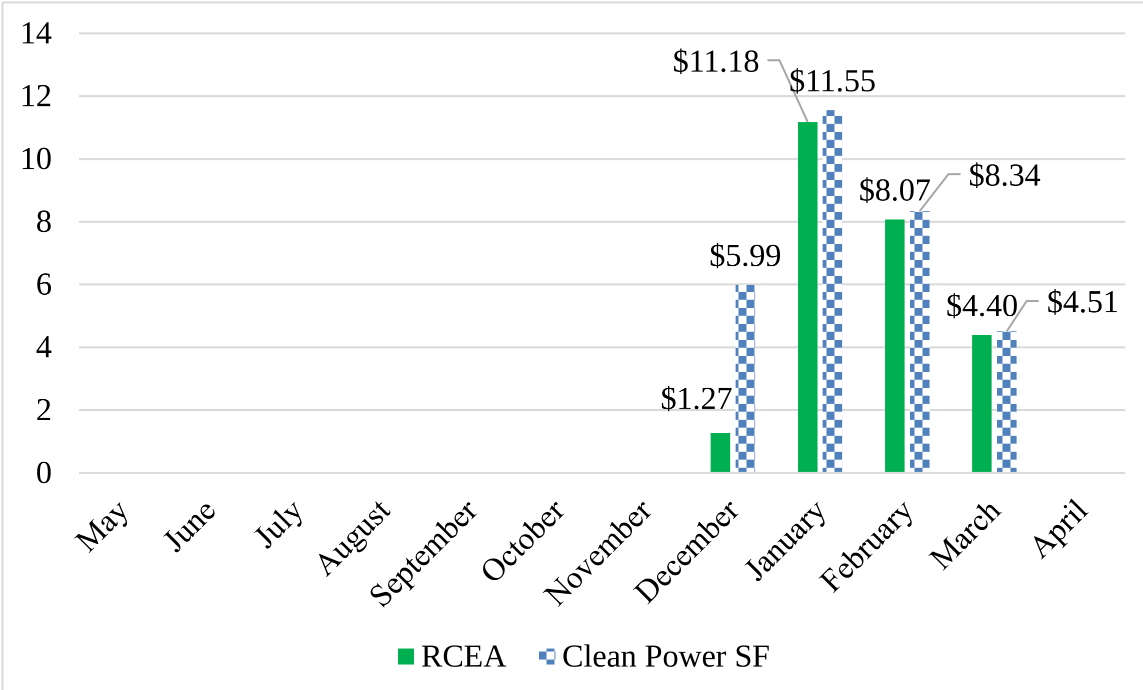

Figure 6 - Monthly Generation Charges, 90% Annual Load Offset System, CCA Solar Customers

For most of the year, the CCA customers have either produced enough net electricity or accumulated enough generation credits to not owe anything to the CCA. Those months, their monthly out of pocket expense is only the minimum PG&E charge.

At the end of the year, the CCA customers do not owe any additional charges to PG&E, because their cumulative NEM bill is less than the sum of the monthly minimum charges. The PG&E and CPSF customers do not receive any end-of-year payouts because they are net consumers over the course of a year, when the RCEA customer has an end-of-year generation credit of $1.37, which can be applied to the next year. This is due to the fact that the end of the true-up year is April 30, and April is a month that provides net generation in the off-peak hours that this customer is credited for.

Savings Estimates: 100% Load Offset

The results for a system that offsets roughly 100% of the annual load are presented in Table 15.

Table 15 - 100% Load Offset - Annual Costs

	Bundled PG&E	**RCEA**	**Clean Power SF**
Annual Out of Pocket Expenses	$119.54	$119.54	$119.54
End-of-Year Net Surplus Compensation or NEM Account Balance	$0.00	$12.86	$0.00

In each scenario, customers are only paying the minimum monthly charge to PG&E. The CCA customers are paying nothing to their respective CCAs. In the RCEA scenario, the $0.01/year results in a cumulative annual value of $12.86. This is partially because the true-up ends with April, a month with net solar production (Figure 7).

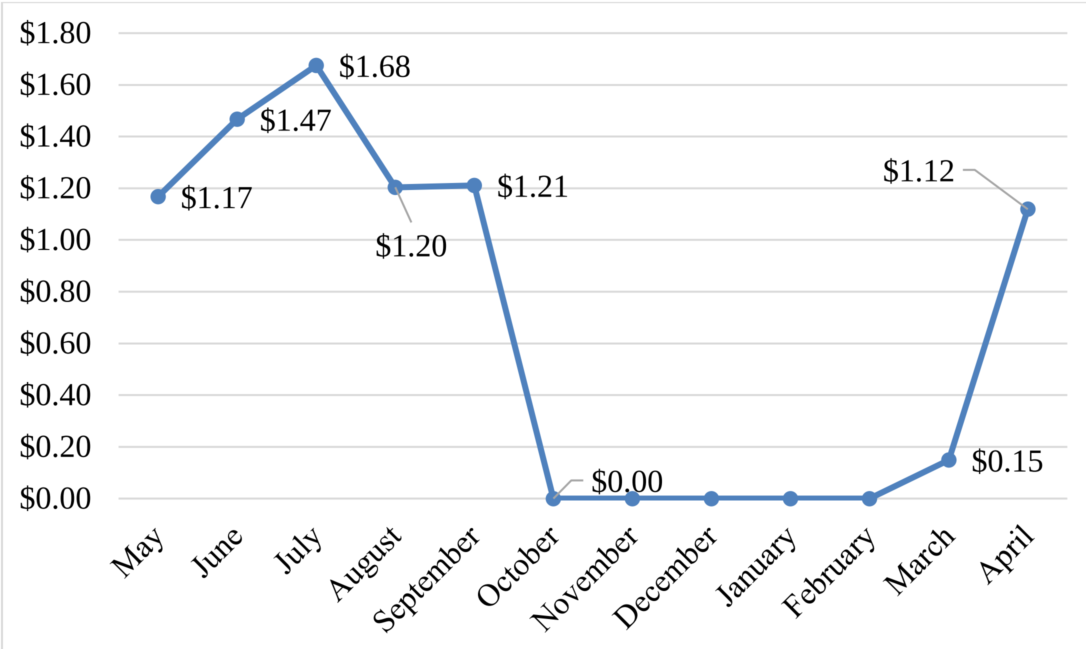

Figure 7 - Itemized Monthly Value of $0.01 Generation Credit – 100% Offset

At the end of the year, the customer has built up $12.86 in RCEA generation credits, which can be applied to the next year. Because there is still no net annual generation (by a very slight margin), there are not PG&E or CPSF net surplus generation payments. The RCEA model has shown to be more lucrative to customers with very high levels of solar production. It is worth noting that, from the CCA perspective, RCEA solar customers with an 100% load offset do not provide any revenue to the CCA and in fact cost it an additional $12.87/year.

<u>Savings Estimate: 110% Load Offset</u>

Table 11 presents results for a system that offsets roughly 110% of the annual load for the example residence used in this study.

Table 16 - 110% Load Offset - Annual Costs

	Bundled PG&E	**RCEA**	**Clean Power SF**
Annual Out of Pocket Expenses	$119.54	$119.54	$119.54
End-of-Year Net Surplus Compensation or NEM Account Balance	$18.14	$50.06	$46.14

As with the 100% offset, all scenarios require the minimum annual cumulative payment of $119.54. However, the two CCA scenarios provide much more value at the end of the year. CPSF compensates the roughly 518 kWh of excess annual production at $0.089/kWh, for a total of $46.14. At the end of April, RCEA's cumulative NEM Account balance is $50.06. If the year after this presents similar solar production values, then the RCEA scenario allows the customer to receive a roughly $100 check after two years. Because PG&E only compensates net annual excess production at the 12-month average wholesale rate ($0.02-$0.03/kWh), that scenario's end-of-year payout is only estimated at $18.14. Figure 8 shows the monthly values of the $0.01/kWh net excess production credit, under a 110% annual load offset scenario.

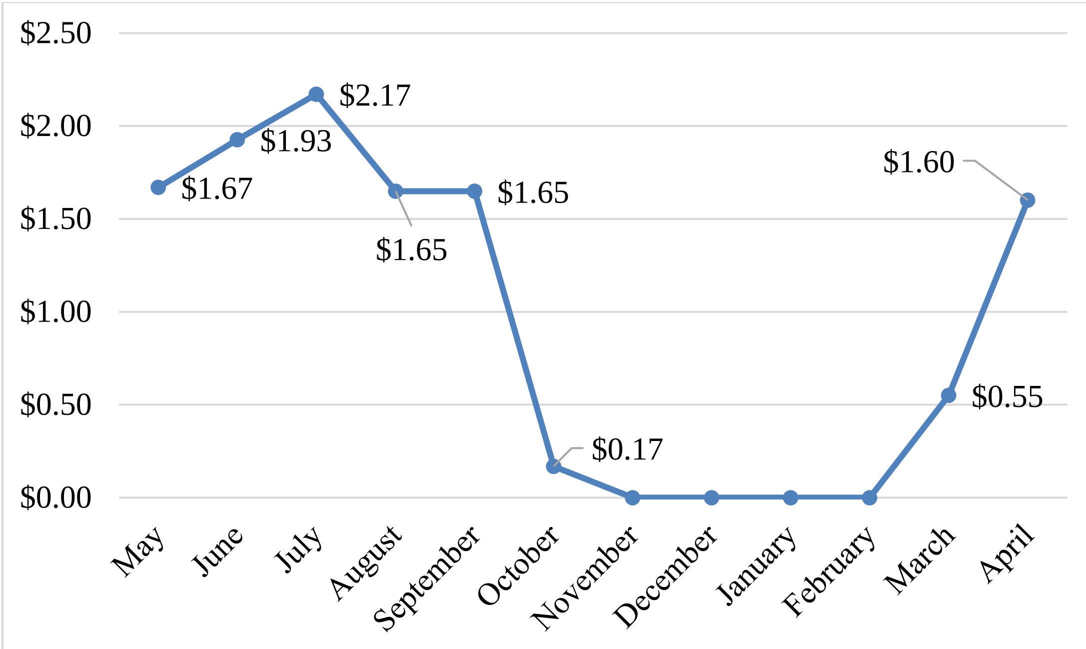

Figure 8 - Itemized Added Value of $0.01 Generation Credit - 110% Offset

As with the 100% offset, these scenarios do not require the customer to pay anything to the CCA in generation charges and result in fairly significant credits at the end of the year. As the load offset increases, so does the benefit to a solar customer to being part of a CCA.

Savings Estimate: Arcata House with 3x Baseline Annual Consumption and a System that Offsets 100% of Annual Load

Table 12 presents results for a house that uses three times the baseline annual consumption with a system that offsets roughly 100% of that annual load.

Table 17 - 3x Baseline Consumption, 100% Annual Load Offset

	Bundled PG&E	RCEA	Clean Power SF
Annual Out of Pocket Expenses	$119.54	$119.54	$119.54
End-of-Year Net Surplus Compensation or NEM Account Balance	$0.00	$27.56	$0.00

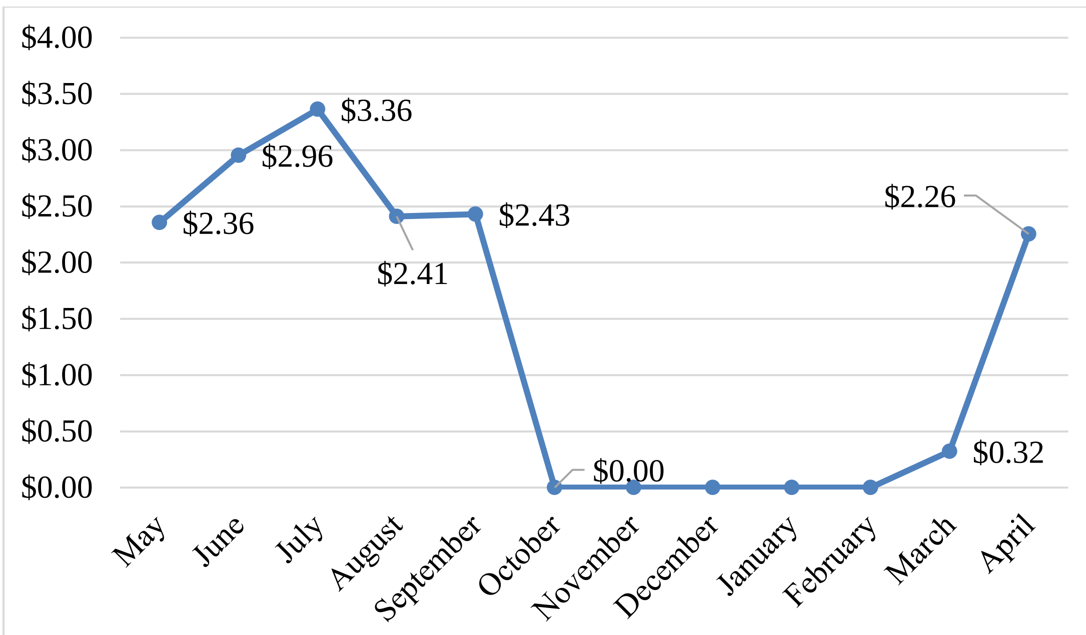

Figure 9 - Itemized Added Value of $0.01 Generation Credit - 3x Baseline Consump., 110% Offset

<u>Summary: Added Value of CCA Net Metering to Residential Solar Customers</u>

Because of minimum charges, the changes that CCAs made to net metering policies are most evident when the system offsets a higher percentage of the customer's annual load. These are the scenarios in which the customer can build value in the form of NEM credits awarded to excess production. In total, the CCA's changes to metering programs, and in particular the RCEA approach of crediting an additional cent per kWh for exported electricity, appear to provide the most value to customers who produce at or above their annual consumption. This is because of the higher generation credits that the CCAs provide. However, these additional credits do not make rooftop solar a dramatically better investment for this hypothetical residential customer because the added generation credit amounts are relatively small.

Statistical Analysis of Solar Installations in CCA Territories

The goal of this section is to use both observations and basic statistical tests to determine if the average number of residential solar installations increased after the launch of a CCA. As discussed previously, installations in Marin Clean Energy and Sonoma Clean Power territory were observed.

Solar Installation Rates in Marin Clean Energy Territory

Figure 12, below, shows the number of interconnected residential solar installations by month in the areas that were included in the initial MCE Rollout in May of 2010. This included the cities of Belvedere, Fairfax, Mill Valley, San Anselmo, San Rafael, Sausalito, Tiburon and the unincorporated Marin County but excluded the remaining Marin County cities/towns of Larkspur, Corte Madera, Ross and Novato, which were enrolled later. The four years before and after the May 2010 rollout are included.

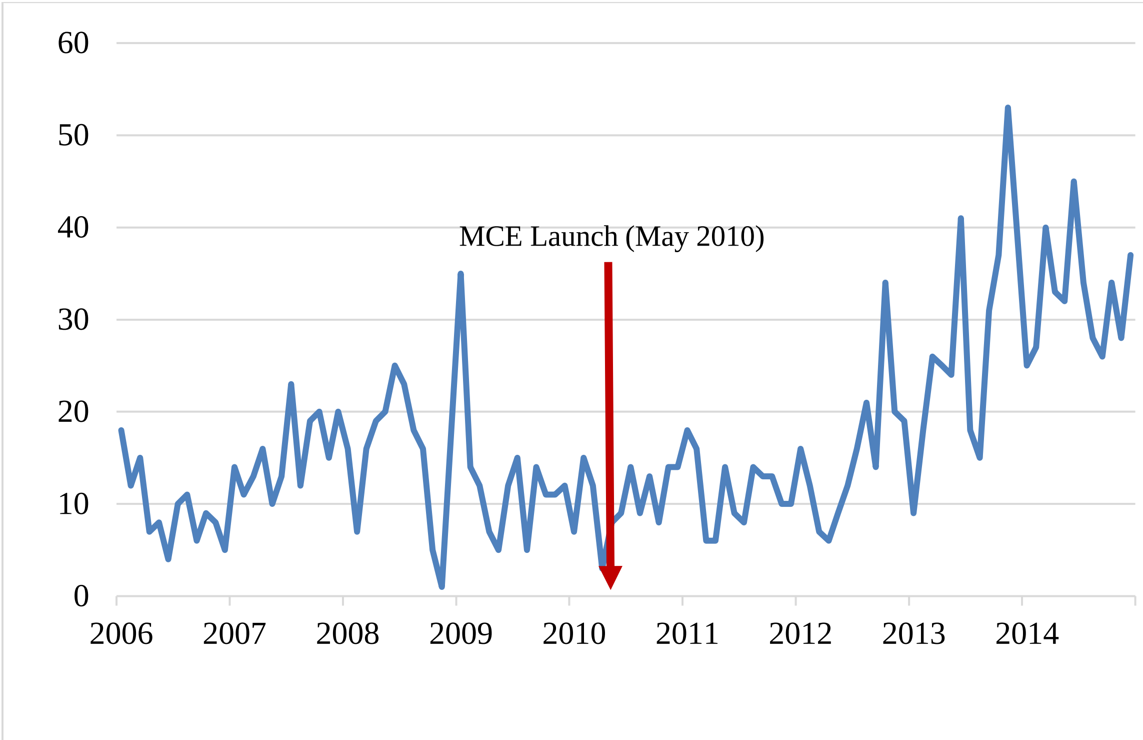

Figure 10 - Residential Installations per Month, 2006-2014, Initial MCE Service Area (CPUC, 2018)

From an observational standpoint, Figure 10 shows an upward trend from 2012 to 2014, after the CCA was implemented in 2010. To corroborate this, a t-test was performed to compare the average number of installations per month before May of 2010 to the average number of installations per month after to see if there was a statistically significant increase. According to the test, the mean number of installations per month before the CCA was 12.84, and the mean number of installations after was 19.96. The p-value was 0.0001, indicating that the difference in the means was not equal to 0. This suggests that the average number of installations per month was significantly higher after the CCA launch in 2010.

However, this is a very “noisy” dataset. The number of residential solar installations in a given area is influenced by a myriad of outside factors and controlling for all of them is beyond the scope of this thesis. However, three of the more prominent outside factors were tested to determine if they helped explain the trend in monthly installations – the median cost per installed watt of residential solar in the US (which declined in this time period), the average incentive level available at the time (expressed in $/watt), and the average price of electricity in the state of California (expressed in $/kWh). See Figures 11, 12, and 13.

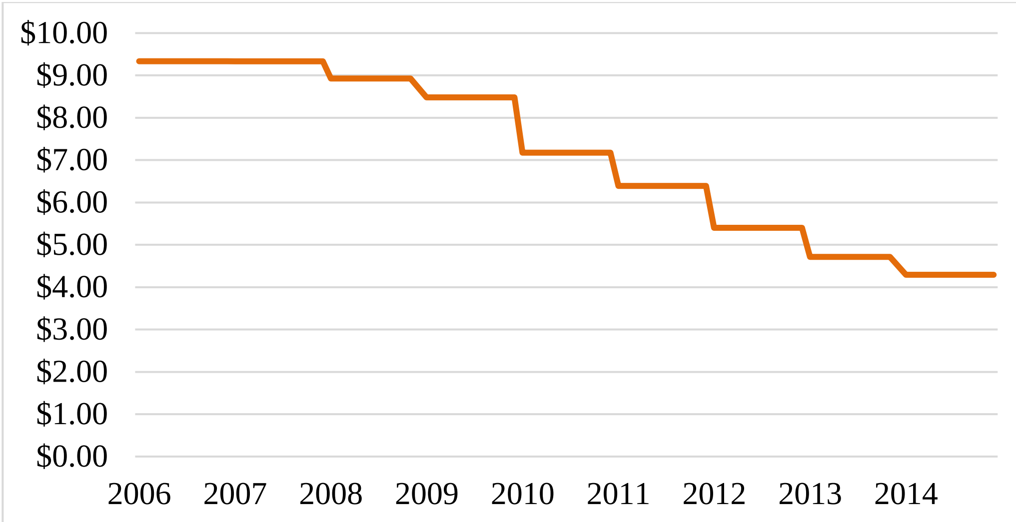

Figure 11 - US Residential Solar Cost per Installed Watt, 2006-2014 (National Renewable Energy Lab, 2015)

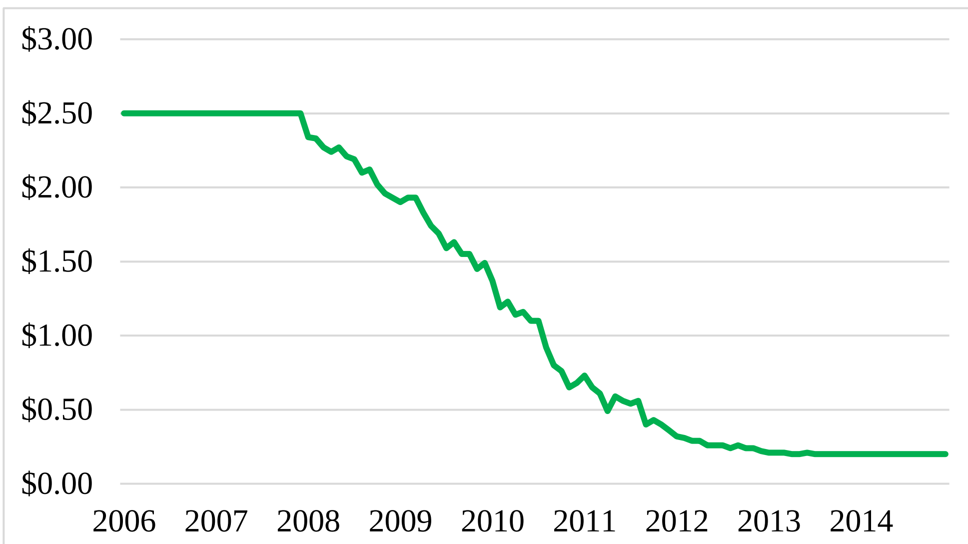

Figure 12 - Average Residential Solar Incentive Dispersed in Marin County, 2006-2014 (CPUC, 2018)

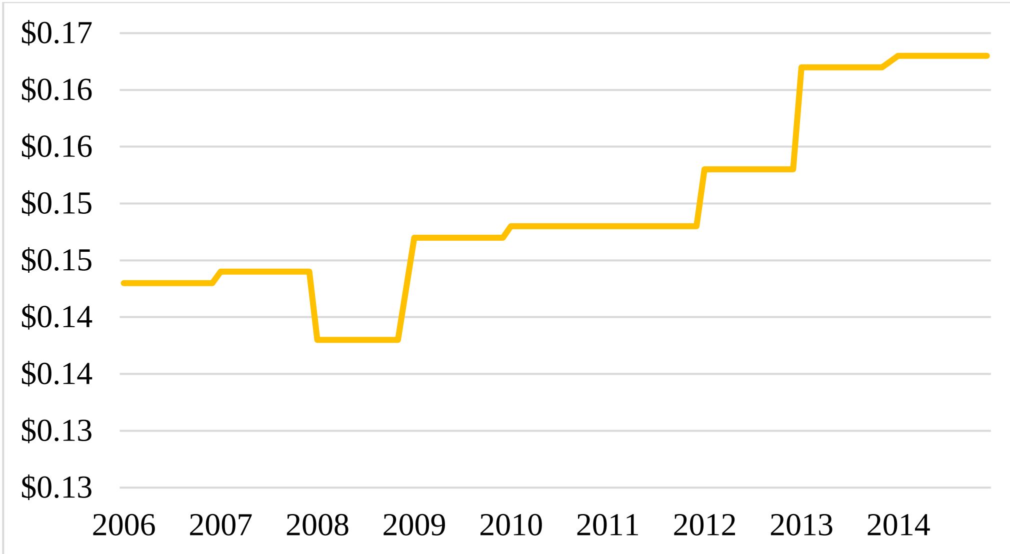

Figure 13 - CA Mean Retail Electricity Cost, 2006-2014 (EIA, 2015)

Each variable from Figures 11, 12, and 13 was tested to determine if a change in that factor tracked the same or opposite directional change in the number of installations per month.

Table 18 - Correlation of MCE-Area Monthly Installations with Outside Variables

Variable	**Correlation Coefficient**
Median Residential Solar US Cost per Watt	-0.53
Average Marin County Avail. Incentive Level ($/Watt)	-0.40
California Mean Retail Electricity Cost	0.62

Given the uncertainty inherent in this dataset, these factors show fairly high correlation coefficients. It makes sense that as the cost per watt of solar drops, the number of installations per month increases, which is what is shown by the -0.53 coefficient in Table 18, above. It is less intuitive that installations go up as the incentive level goes down, but that incentive drop was largely offset by a maturing market and falling costs. Finally, it stands to reason that as the retail price of electricity goes up, so do the number of solar installations because consumers have a bigger incentive to lower their growing electricity bills with solar.

To gain further insight in to the effect that CCAs can have a local solar market, the rate of installations in a city that enrolled with MCE in 2010 (San Rafael) was compared with a similar city that did not (Walnut Creek, which did not enroll with MCE until 2016). The same period was observed (2006 to 2014), and below are the residential installations by month (Figure 14).

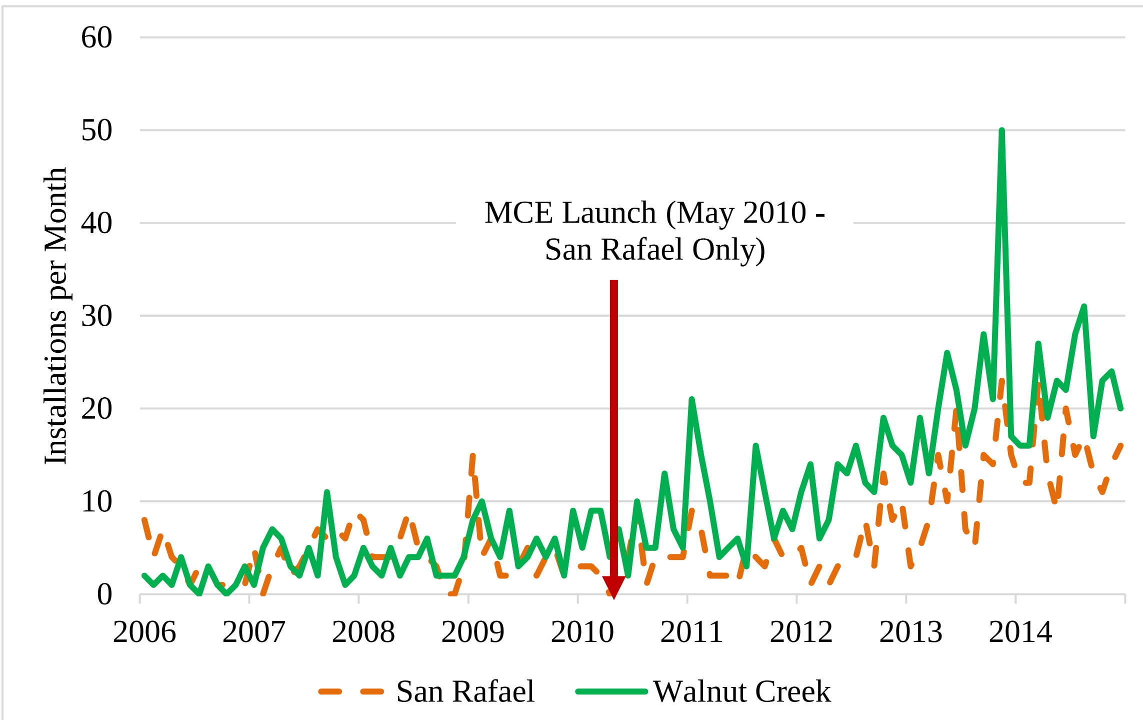

Figure 14 - Residential Installations by Month. 2006 – 2014, San Rafael vs. Walnut Creek (CPUC, 2018)

Figure 15, below, shows the average number of monthly residential interconnected installations in each city before and after the launch of MCE in 2010 (which only applied to San Rafael).

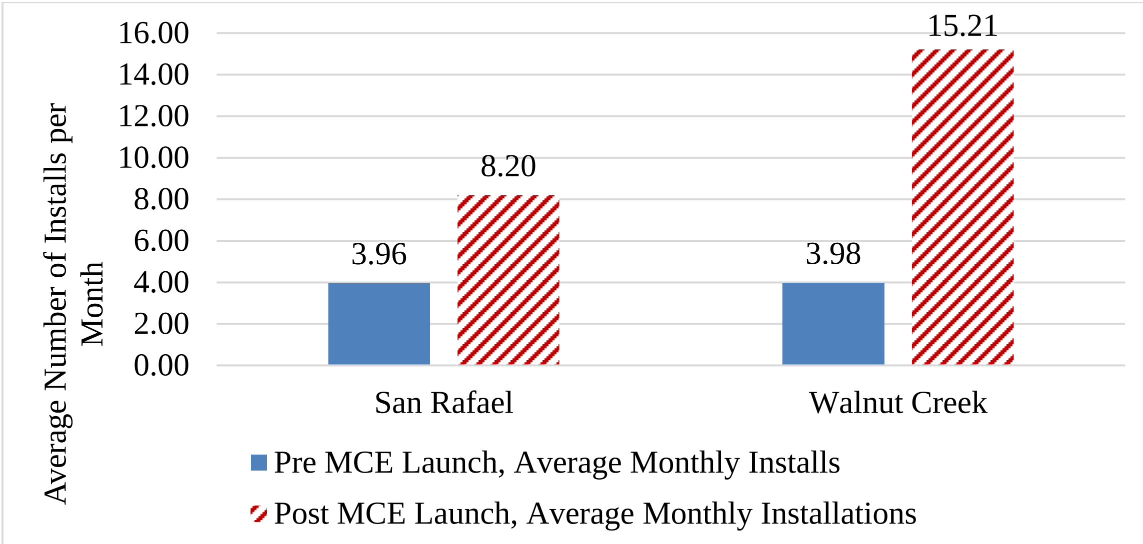

Figure 15 - Average Monthly Installations, Before and After MCE Launch (CPUC, 2018)

In the four years before the launch of MCE (between 2006 and 2010), San Rafael and Walnut Creek had roughly the same number of monthly average residential installs. In the four years after the launch in 2010, San Rafael's average monthly installations jumped by about 107% and Walnut Creek's average monthly installations jumped by about 282%. Essentially, San Rafael did not have a markedly higher increase in monthly average installations when compared with the non-CCA city of Walnut Creek; in fact, the latter city's monthly average residential installation increase was almost double that of San Rafael. The monthly installations in the two cities showed a relatively high 0.76 correlation between 2006 and 2014, meaning that they tracked each other fairly closely. It is critical to note that all the same outside factors previously observed in this thesis, along with many that were not, applied to these cities. Additionally, there are numerous additional factors that could have contributed to the fact that Walnut Creek had a higher average number of monthly installations from 2006 to 2014, including contractor availability, advertising prevalence, and others.

In total, these observations and tests show that while the average number of installations per month increased after the establishment of MCE, there are multiple other factors that could have contributed to that rise. Additionally, solar growth in a non-CCA city did not show to be dramatically less than growth in a comparable CCA city.

Solar Installation Rates in Sonoma Clean Power Territory

Sonoma Clean Power was launched in December of 2014, at which point it was made the default provider to the cities of Santa Rosa, Windsor, Sonoma, and Cotati. Figure 16, below, shows the number of installations per month in those areas in roughly the two years before and after the SCP launch.

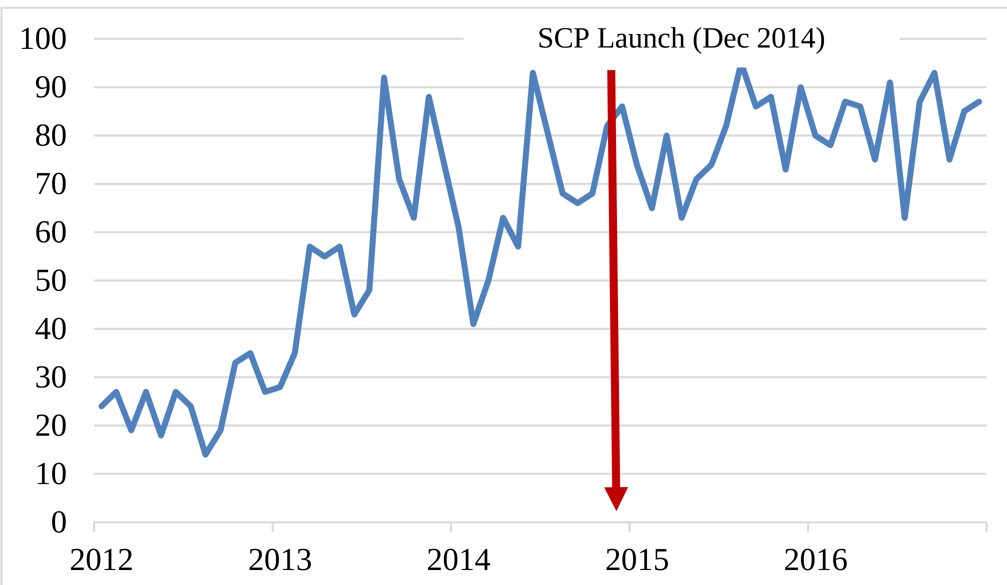

Figure 16 - Residential Solar Installations per Month in SCP Territory, 2012 – 2016 (CPUC, 2018)

This graph shows an upward trajectory that precedes the launch of SCP in late 2014. Additionally, the installs remain at higher levels after the launch. When the same t-test is performed, it reveals that the average number of installations per month before the launch was 47.88, while the average number of installations after is 80.56. There is also a p-value well below 0.05, which leads to the conclusion that there is a statistically significant difference between the means before and after the launch. However, the same external factors that applied to the MCE area apply here as well. The same cost per watt and retail electricity datasets were used, and the installations were also tested against the average incentive dispersed in Sonoma County during this period.

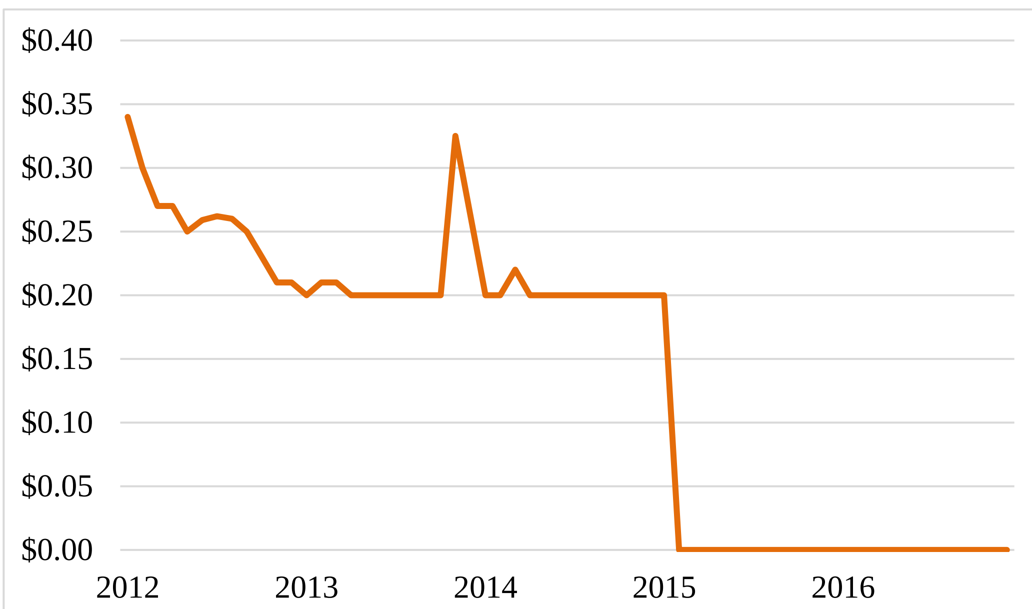

Figure 17 - Average Residential Incentive Dispersed per Watt in Sonoma County, 2012-2016 (CPUC, 2018)

The incentive level, already very low by late 2014, effectively ran out for residential installations in early 2015. Table 19 shows how the same variables used in the

Marin County analysis – mean residential installed cost per watt, average incentive level dispersed, and California mean retail electricity cost – correlate with the monthly SCP-area installations from 2012 to 2014.

Table 19 - Correlation of SCP-Area Monthly Installations with Outside Variables

Variable	**Correlation Coefficient**
Median Residential Solar US Cost per Installed Watt	-0.86
Average Marin County Avail. Incentive Dispersed($/Watt)	-0.69
California Mean Retail Electricity Cost	0.85

The SCP-Area analysis exhibited higher correlation coefficients than the MCE one. As the cost per watt of solar and the incentive level went down, the number of installs per month went up. Additionally, as the retail price of electricity went up, so did the number of installs per month. This leads to the conclusion that, while there is an observed and statistically significant jump in installations after the SCP launch, there are other substantial factors that correlate with that jump. Therefore, the implementation of a CCA cannot be isolated as the factor that leads to a jump in residential solar installations.

The same CCA city to non-CCA city comparison was made for the Sonoma Clean Power service area. In this case, the comparison was made between Santa Rosa, which was part of the original SCP rollout in 2014, and Concord, which did not join a CCA (Marin Clean Energy) until April of 2018. A comparison was made between the residential installations in Santa Rosa and Concord for the 2012 to 2016 period (Figures 18 and 19).

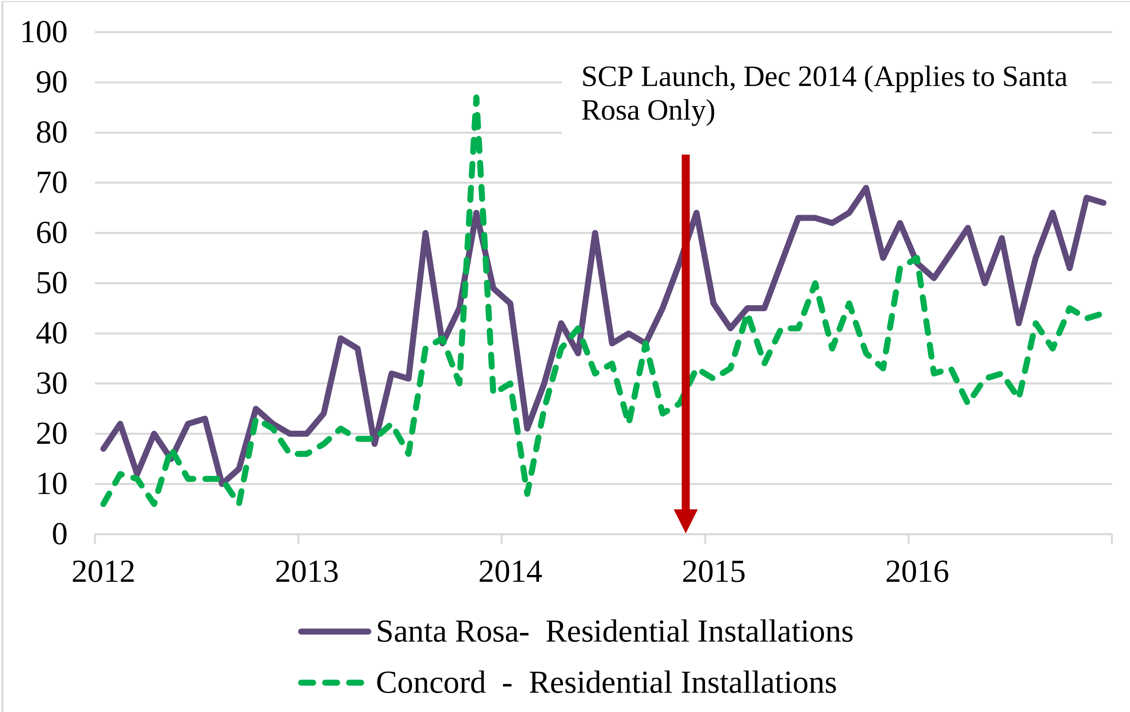

Figure 18 - Residential Installations by Month, 2012 - 2016 - Santa Rosa v. Concord (CPUC, 2018)

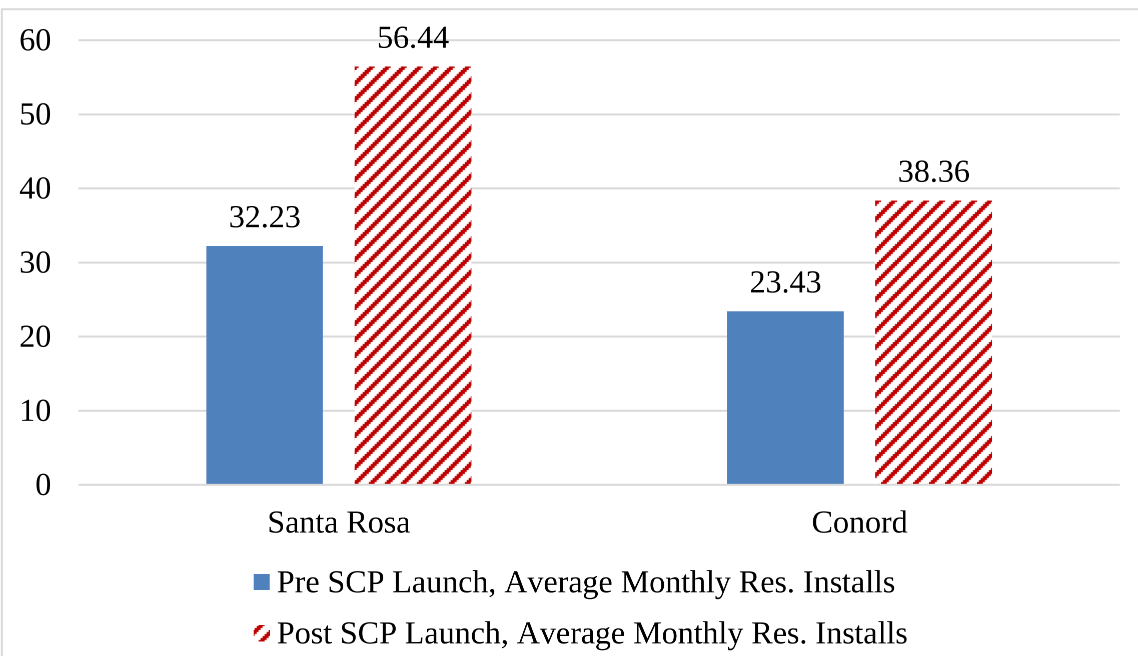

Figure 19 - Average Monthly Installs, Before and After SCP Launch (CPUC, 2018)

In Santa Rosa, average monthly residential installations increased by roughly 75% in the period after the SCP launch when compared with the period before it. In Concord, average monthly installations increased by roughly 64%. Although Concord had lower monthly average installations overall, there was a 0.77 correlation between the two cities' monthly installations between 2012 and 2016, meaning that the residential installation totals moved in a relatively similar manner over that period. Observationally, there does not appear to be a huge discrepancy in the increase in installations in the CCA city (Santa Rosa) when compared with the non-CCA city (Concord).

There are many factors that affect any local solar market. Contractors can go in and out of business, a local area can become saturated, and residents in a large neighborhood can all install systems in a short period. All these factors are unaccounted for in this analysis. When these observations are viewed in the context of the rest of thesis, however, it supports the conclusion that CCA net metering represents a small financial benefit to solar customers, but it does not have a substantial impact on the number of local residential solar installations.

Discussions with CCA Staff and Solar Contractors

Interviews with CCA Staff and local solar contractors yielded a variety of responses but some consistent themes. The results will be presented as answers to several overarching questions.

Question to CCA Staff: Why do Northern California CCAs offer slightly more generous solar net metering policies? Is there a particular policy goal in mind (e.g., an increase in local solar installations)?

These questions were posed to current and former staff members from the Redwood Coast Energy Authority, Sonoma Clean Power, and Clean Power SF. A former staff member for the Redwood Coast Energy Authority stated that the additional $0.01/kWh generation credit for exported solar was to compensate for the fact that CCA's have lower generation rates, which in turn means exported energy is worth slightly less. Adding the extra $0.01 puts exported solar electricity roughly on par with what it had been previously worth under PG&E. This RCEA staffer also stated that the additional cent was a small affirmation of RCEA's renewable energy commitment. Homeowners who are considering solar are restricted by, "their roof and their budget" (Former RCEA Staff Member, Personal Interview, November 15, 2017). The staffer believes that this policy adjustment is unlikely to make a huge difference in the size system they install. Given the Humboldt County climate and the PG&E 110% cap, the former staffer did not express a concern over customers over-producing to secure higher annual payouts. Finally, they stated that Northern California CCAs were largely following the lead of Marin Clean Energy when offering the additional cent per kilowatt-hour.

Similarly, a representative from Sonoma Clean Power wrote that the goal of enhanced net metering was to be slightly more generous and help customers offset the cost of their PG&E true-up bill (PG&E still charges solar CCA customers for transmission and distribution). In San Francisco, a Clean Power SF representative stated that their unique policy of not offering the $0.01/kWh but offering an annual net surplus rate of $0.089/kWh is meant "chart a middle ground" in terms of solar incentives. The method of only increasing incentives to energy that is net produced annually "incentivizes true excess generation," unlike the policies in the other CCAs, in which customer can be net consumers over a year but still receive a (small) end-of-year credit. The Clean Power SF representative characterized their approach as an "efficient use of public funds" that doesn't "go overboard" (Current CPSF Staff Member, Email Interview, March 14, 2018) in terms of adding additional incentives to solar power.

Question to CCA Staff: Are the annual pay-outs to solar customers with over $100 in credits a significant expense to the CCA?

Because RCEA had been launched so recently when this thesis was written, their representatives were unable to say whether the annual payments to solar customers were a significant budgetary line item. However, Sonoma Clean Power was able to provide annual payment amounts to solar customers (see Table 20, below).

Table 20 - SCP Cumulative Annual Solar Over-Generation Payments

Year	Total Amount Paid by SCP for Solar Over-Generation ($)
2015	Just under $207,000
2016	Just under $690,000
2017	Just under $574,000

For reference, SCP's fiscal year 2017-18 budget showed over $175 million in revenue from electricity sales and interest (Sonoma Clean Power, 2017). The payments to solar customers for over-generation, while exhibiting a commitment to local solar, do not seem large in comparison to the operation as a whole. The Clean Power SF representative did not believe that their enhanced end-of-year cash-out rate was causing customers to install bigger systems, citing the fact that San Francisco homeowners have limited space for solar and are also constrained by their budget. This representative stated that only 14% of solar customers received a net surplus generation payout last year, and those payouts were in the range of $50 to $100. This representative did not believe that these payouts were going to be a significant expense to Clean Power SF going forward but acknowledged that they are early in their rollout process.

Question to Solar Contractors: Do you believe that the net metering changes made by Northern California Community Choice Aggregation Programs "move the needle" when it comes to a homeowner deciding to go solar? Do you encourage solar customers to stay in their local CCAs?

Both nationwide and regional solar contractors were interviewed for this thesis. A policy analyst at one of the nationwide providers wrote in an email that the extra $0.01/kWh for net excess generation "sounds great but doesn't add up to much" and that "currently, we are not recommending CCAs over PG&E/SCE or vice versa as their rates and net metering policies are very close to one another" (Rates Analyst, Email Interview, May 25, 2017). Given the market share of this contractor, their ambivalent perspective influences a great deal of the advice given to potential solar customers.

However, another local contractor in Sonoma Clean Power territory wrote that they constantly discuss the issue of staying with or opting out of the CCA with their customers. This contractor recommends that, because of the annual billing and the fact that there is one point of contact for incorrect bills, customers without the potential for over-generation should stay with PG&E and opt out of the local CCA. There was a surprising emphasis on how important utility-customer communication was, and this was brought up consistently among contractors. This SCP-area contractor wrote that it is easier to work through issues with one organization (just PG&E) than two (PG&E for distribution and the CCA for generation).

The importance of communication was echoed by a local contractor in San Francisco. This contractor stated that the CCA model was absolutely a step in the right direction. While the increase in excess generation payouts was an important gesture, this contractor noted that it does not regularly result in increased customer savings. They also commented that one of the biggest impacts of the CCA was the move from annual to monthly billing. Customers that installed solar in the winter months were understandably upset that their bills did not go down by very much (those customers were still required to pay for generation in those months, and they would not have been required to do so under an annual billing cycle). This is an issue that resolves itself as the year goes on but results in short-term pain for contractors and customers. They stated that the CCA implementation meant that a solar customer must interface with three entities – PG&E, the CCA, and the solar contractor – all of which have competing interests. This confusion was the primary concern of this contractor, and while they did not recommend that solar customers opt out of the CCA, they did express a desire for better communication and collaboration between these entities.

In Humboldt County, a prominent local contractor stated that their customers (usually businesses) were sophisticated enough to have already decided if they were staying with or opting out of the local CCA. Some large customers were nervous about the CCA when it launched, but primarily because they were unfamiliar with it. Once they learned more about it, this contractor stated that many of their customers stayed in. This contractor also stated that while the extra $0.01/kWh did not move the needle for marginal customers, many customers came to prefer the monthly billing as it saved them from a large annual payment to PG&E. On the whole, like the contractor in San Francisco, this contractor felt that the CCA was a definite step in the right direction for the energy sector and they wanted to support it.

In conclusion, these interviews supported the previous findings that CCA net metering does not result in a significant financial benefit to solar customers. One of the most notable takeaways is the repeated insistence by contractors that confusion over what the CCA is and how customer will be billed is one their largest CCA-related concerns.

DISCUSSION

The value provided by the changes that CCAs made to net metering policies are most evident in the larger system sizes, and, because of minimum charges, this value mostly comes in the form of end-of-year credits or payouts (Figure 20).

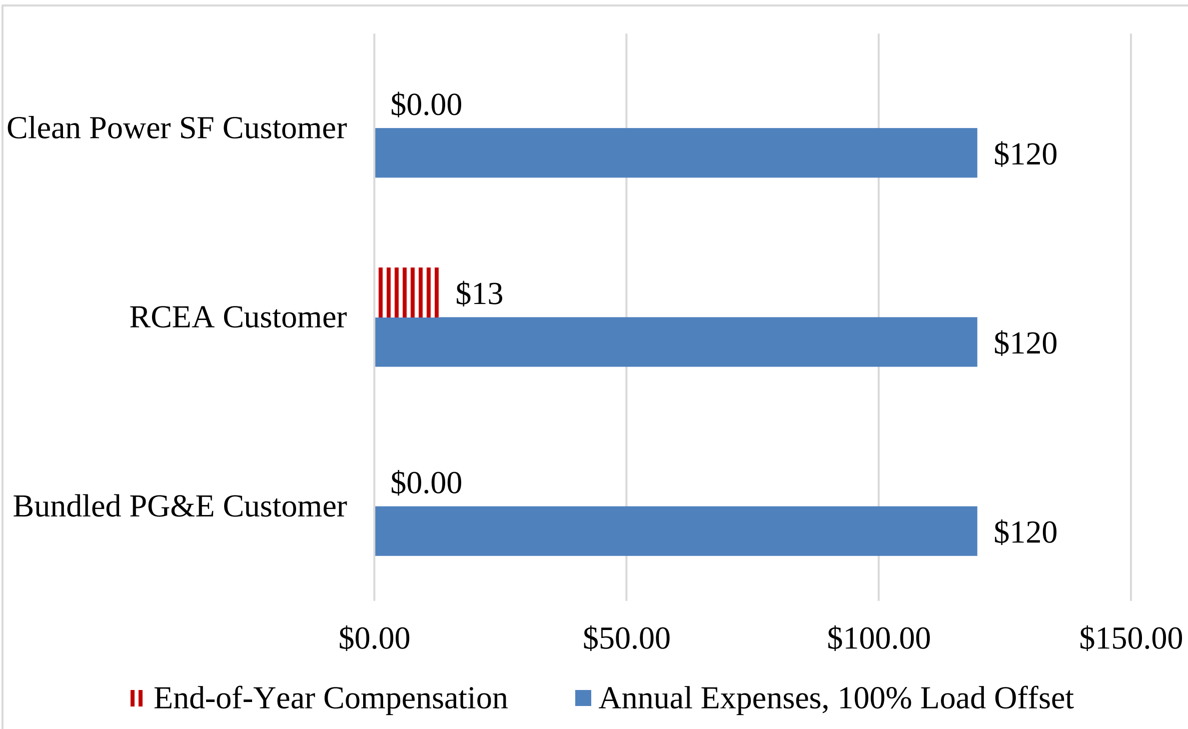

Figure 20 - Annual Expenses and Credits for a 100% Annual Load Offset System

Because of the PG&E minimum charges, each customer will owe $119.54/year, regardless of system size. When the load offset increases to 110%, the end-of-year payout for RCEA increases to $50.06, with $18.14 and $46.14 for PG&E Bundled and Clean Power SF, respectively.

When weighed against a non-solar, bundled PG&E baseline, switching to a CCA when installing solar does not dramatically improve the attractiveness of that solar investment, although the RCEA model did slightly increase the internal rate of return due to the additional value provided each year in NEM credits, which are incorporated into the annual savings (Figure 21).

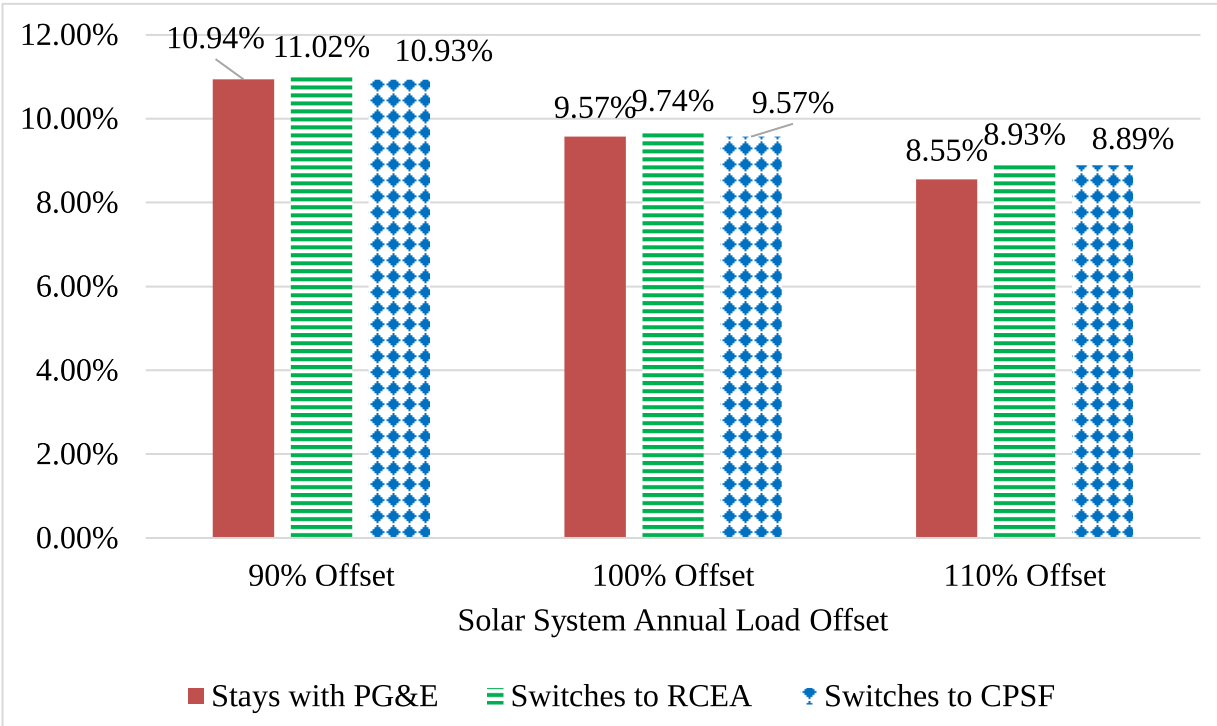

Figure 21 - Internal Rate of Return (20-year System Lifetime) Comparisons under each NEM Policy and System Size

An observational and statistical analysis of residential solar installations in CCA regions revealed an increase in monthly installations after the launch of the CCA but also recognized that there are other, broader factors correlated with that increase. Cities that implemented CCAs showed a decently high correlation with comparable cities that did not join a CCA over the period that included the CCA's launch, suggesting that the CCA did not, in isolation, lead to dramatically more residential installations. Discussions with

CCA staff and solar contractors support the conclusion that, while the slightly more generous net metering policies offered by CCAs are viewed as a legitimate show of support for solar, they do not “move the needle” when it comes to the homeowner’s financial decision to install a system. Below are a few lessons that can be drawn from these conclusions.

1) Policies enforced by PG&E – including minimum monthly charges, non-bypassable charges, and maximum system sizes – mean that even if CCAs give more in generation credits, exported solar is still not valued at a full retail level.

Many of the studies in the literature review established a per-kWh “value” of solar that was higher than the prevailing retail cost of electricity. To use these values in practice, net metering policies would need to give out credits for exported solar that are valued above the retail price that the customer pays for electricity. Even valuing solar at exactly the retail rate would mean that a system that offset 100% of a customer’s annual load would mean that customer paying nothing in annual utility bills. This is clearly not how any of the actual tariff setups studied in this thesis work. Under NEM2, PG&E imposes minimum monthly charges and non-bypassable charges on all solar customers, which means that offsetting consumption with solar at a 1:1 ratio is not possible. Even when the CCAs added an additional cent in generation credits to exported solar, this only applies to the CCA half of the bill. The NEM2 charges still apply, meaning that the practical “value” of exported solar is still below the retail level. The system that the Northern California CCAs have set up does not seem to “overvalue” exported solar from the perspective of the Maine PUC study or those similar to it that include the social cost of pollutants and greenhouse gases. However, from the perspective of the Edison Foundation and other utility-sponsored studies, CCA/PG&E setup's near-retail value is too generous to exported solar. Minimum charges and the fact that CCAs only control half of a customer's bill ensure that CCAs have not raised exported solar to above the retail rate.

2) The benefits of CCA net metering are more pronounced in PV systems that offset a higher percentage of annual load

Due to minimum monthly charges, even homeowners with solar PV systems that produce more than their annual consumption will pay about $120/year. Therefore, the value that CCA net metering can provide is mostly manifested in the end-of-year NEM credits or net surplus compensation payouts. When a system met 110% of the annual load, the hypothetical RCEA customer received $50.06 in end-of-years credits (the bundled PG&E customer receives only $18.14 in that scenario). When the annual offset drops to 90%, the bundled PG&E customer and the CPSF customer receive no annual credits, and the RCEA customer receives only $1.37 and is only paying $4.70 less out-of-pocket per year than the bundled PG&E customer.

3) If the goal is to explicitly increase the number of local solar installations, the extra $0.01/kWh is probably insufficient

To be clear, no CCA representative or documentation ever suggested that it was the express goal of CCAs to increase the number of local solar installations. The practice of offering an extra $0.01/kWh is largely seen by the solar community for what it is: a token of support for the local industry that is not meant to markedly grow the market. An observational and basic statistical analysis of residential installations in CCA regions showed that, while the number of residential installs grew after the CCA, this correlates with other, larger industry trends, and that CCA implementation cannot, at least by basic observations and statistical tests, be isolated as a cause of an increase in installations. If, at some point in the future, CCAs do want to boost their local markets, there are other, more effective ways to do so than slightly increasing the credit value of exported electricity. The success of the California Solar Initiative shows that perhaps an upfront rebate can be one effective measure, keeping in mind that such a program would be a significant, non-recoverable cost to the CCA.

4) Ease of billing and communication can be as important as generation net metering

One of the more striking contractor interviews revealed that the contractor advised customers to not stay with their local CCA because it was easier to resolve billing errors with just PG&E. This sentiment was echoed, albeit not quite as strongly, by the other two contractors interviewed, both of which expressed concern about the confusion customers face as a result of the CCA. The more CCAs invest in customer service and understandable bills, the happier solar customers and contractors seem to be.

RECOMMENDATIONS

With these lessons in mind, below are some recommendations for how CCAs can approach the net metering issue going forward that are informed by the observations and analyses in this thesis.

1) CCAs can pro-actively articulate priorities toward local solar

The former RCEA staff member interviewed for this thesis was upfront about the fact that net metering policies are inherited from one CCA to the other in a somewhat perfunctory manner. This is, of course, not inherently problematic; this research has shown that these policies are slightly beneficial to solar customers and the contractors that were interviewed were mostly positive about them. However, it does not seem that these net metering policies are being critically examined while they are being inherited. Given the recent launch of a CCA in Los Angeles County (with a population of over 10 million) and impending CCAs in Santa Barbara, Riverside, San Diego, and Luis Obispo Counties, whatever CCAs decide to do around net metering will affect millions of ratepayers. Discussions with contractors for this thesis implied that the solar community could benefit from knowing exactly what these CCAs' priorities are around residential and commercial solar. Do they want to take direct action to grow these markets? Do they want to ensure that solar markets are supported, but slowly drop the generation compensation to save the CCA money in the long run? Having a well-defined action plan that the solar community can view could be an excellent step in improving communication. This plan can be expressed by individual CCAs (which would allow for more localized priorities) or by Cal CCA, the trade organization that is advocating for pro-CCA policies. If a CCA decides that growing their local solar market is indeed a priority, they can observe how the additional $0.01/exported kWh has not expressly done so and pivot to either an up-front rebate or another appropriate method.

2) CCAs can play a role in promoting net metering research specific to their service areas

One of the selling points of a Community Choice Aggregation program is its locational proximity to ratepayers. CCAs promise local generation and local jobs and have attempted to align their policies with the needs of their service area. For example, the Redwood Coast Energy Authority has entered into biomass contracts with local generators because of the abundant timber resources in Humboldt County. (Cresswell, 2017) As the net metering debate progresses towards a successor tariff, CCAs can advocate for solutions that take locational specifics into account. For example, Locational Net Benefit Analysis (LNBA) is one methodology that was used by the studies in the literature review and is a large part of California's potential net metering solutions. LNBA values exported electricity differently at different locations, taking into account grid conditions, demand, and other factors. A study promoted or completed by RCEA could acknowledge the unique nature of Humboldt County's electricity infrastructure – namely its congested transmission system – and perhaps ensure that such valuations or methodology are included in a statewide successor tariff. Additionally, having a completed study would help RCEA start a dialogue with solar customers and contractors in advance of any large policy shifts from the CPUC.

3) CCAs can keep investing in ratepayer outreach

Reiterating what was stated earlier in the thesis, ease of communication between customers and CCAs around billing concerns is critical for the solar industry. While CCAs may represent a positive step toward local generation, they introduce additional complexity into an already-complex process. It is easy for potential customers to throw up their hands, and if the CCAs want to support this market, then improving responsiveness to customer and contractor questions is a good way to do so.

4) CCAs can consider net metering in the context of a broader equity debate

The Greentechmedia report on the income of solar households cited in the literature review found that over 35% of solar households observed had annual incomes over $100,000, and only 13% had annual incomes under $45,000 (Shallenberger, 2017) The incentives that CCAs give to solar households, no matter how small, will likely benefit the members of their community that least need financial assistance. Sonoma Clean Power shared that their annual expenses from year-end solar payouts can reach as high as $690,000, and this is only the payouts; it doesn't include all of the revenue that SCP does not collect due to their net metering policies. That money could be used to pay staff and avoid rate hikes, or on low-income rate relief, or on any number of other priorities. This is another area where clearly articulated priorities would be beneficial. If it is the CCAs' goal to push for as much solar as possible, then these net metering policies, while not terribly effective, are at least defensible. If the CCA wants to push for other priorities – workforce development, rate assistance, etc. – then the costs of the net metering policies should be considered in that context.

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APPENDIX A – INTERVIEW QUESTIONS POSED TO CCA STAFF AND SOLAR CONTRACTORS

Appendix A consists of a list of interview questions posed to solar contractors that work in CCA service territories and current and former CCA staff members.

Contractors

1. Can you help me outline how the CCA in your area approaches net metering, and specifically how it differs from PG&E?
2. Do you pro-actively bring up enhanced net metering through the local CCA when meeting with potential customers, and if so, does it make acquisition easier?
3. Overall, are you finding that **potential** PV customers are already familiar with the additional $0.01/kWh that they can get for excess solar production?
4. Does the additional $0.01/kWh alter how you size home PV systems?
5. Does the enhanced net metering policy register as significant to your business relative to all the other issues affecting rooftop solar (tariffs, equipment pricing, financing options, etc.)?
6. In your experience, which of the following options is most common when it comes to the advice you give to new residential PV customers in a CCA territory?
    - A. The customer should opt out of the CCA
    - B. The customer should stay in the CCA

C. The customer should stay in the CCA, but be strategic about when the solar is interconnected
D. It is up to the customer whether to opt out or stay in; there is little financial impact either way
E. We don't usually give this kind of advice to solar PV customers
F. Other (please specify)

7. Do you have any recommendations as to how CCAs can support your industry going forward?

CCA Staff

1. Can you outline how the CCA's net metering policy differs from PG&E's?
2. What is the policy goal of enhanced net metering for residential solar customers?
3. Do you have a sense of whether the increase in enhanced net metering payments to homeowners have been a significant annual financial burden on the CCA, relative to other expenses?
4. What kind of outreach was done to homeowners and contractors around the enhanced net metering policy prior to the CCA rollout?
5. Are there plans to alter the enhanced net metering program, or is it considered a permanent feature of CCAs in California? Do the California CCAs coordinate on this kind of decision-making?

6. When customers reach out to the CCA regarding net metering, are they primarily concerned with this additional $0.01/kWh? Or are there other issues (required monthly payments, bill confusion, etc.) that make up most the calls?