# The Efficacy of Voluntary Overcompliance for Decarbonization: Evidence from California

Alison Ong[1]
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**Abstract**

Renewable portfolio standard (RPS) programs are common regulatory tools to stimulate renewable energy procurement. An alternative approach is voluntary green power, where electricity providers procure renewables in quantities that exceed mandated levels. This paper assesses whether voluntary green mechanisms have accelerated decarbonization progress relative to just an RPS. I study the case of California, which is notable for having both an aggressive RPS and high participation in voluntary green power providers. Participation has been facilitated by Community Choice Aggregators (CCAs), publicly-owned retailers who procure power on behalf of their member cities, and who often emphasize environmental sustainability values. I first study the extent to which CCAs successfully procure voluntary green power for their customers, and characterize the community traits most closely correlated with CCA participation. I find that higher income and pro-environmental political attitudes are strong predictors of selection into CCAs; measures of higher willingness-to-pay for decarbonized power among communities also correlate with higher voluntary green procurement. Second, I assess CCAs' impacts on statewide decarbonization progress. I find that CCAs amount to a reshuffling of voluntary greenness rather than statewide additionality. This is because, prior to large-scale CCA entry, California's incumbent utilities already engaged in voluntary green procurement. After CCAs began serving a larger proportion of statewide load, stagnation or backsliding in other parts of the sector occurred, such that the state performed 5% above the RPS in 2017 but 0% above it in 2022, while CCA load share grew from 2% to 21% of statewide sales in the same timeframe. Finally, I provide evidence that CCAs' elevated levels of renewable energy are mostly attributable to resources originally procured on behalf of other incumbents, such that CCAs fare no better than other types of retailers at adding new renewable generators to the system on a per-kWh basis. These findings suggest that the primary effect of voluntary green power is to affect the distribution rather than the overall magnitude of decarbonization.

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[1] Doctoral candidate, Emmett Interdisciplinary Program in Environment and Resources, Stanford University. The author wishes to thank Roger Noll, Omer Karaduman, Bruce Cain, John Weyant, and numerous conference and seminar attendees for their helpful feedback. All errors are my own.

## I. Introduction

Substituting low-carbon generation resources for traditional fossil resources is key to lowering the emissions intensity of electricity supply. Many mechanisms exist to facilitate this transition, such as renewable portfolio standards (RPS), regulatory mandates that impose minimum levels of renewable energy content for electricity providers (Barbose et al. 2016); incentives or subsidies to stimulate investment (e.g., the Production Tax Credit/Investment Tax Credit); competitive procurement auctions (Haufe and Ehrhart 2018, Hastings-Simon et al. 2022); cap-and-trade emissions schemes; carbon taxes; and "self-regulation" via voluntary purchases of renewable power. Although a carbon tax is widely considered the most economically efficient policy, political economy challenges make practical implementation difficult. Thus, programs like an RPS are more commonly implemented despite being relatively expensive forms of abatement and policymakers may even employ multiple approaches simultaneously (Goulder and Parry 2008). One such example is the coexistence of top-down regulatory standards with bottom-up voluntary overcompliance. Voluntary overcompliance, or voluntary green power programs, enable renewable energy purchases on behalf of consumers that exceed policy-mandated minimum percentages (Sumner et al. 2023). Sufficiently large voluntary green power demand would signal the wholesale sector to increase renewable energy supply and thereby boost decarbonization progress.

29 US states and the District of Columbia have an RPS; all US states offer some form of voluntary green power (NREL 2023). One form of voluntary green power is Community Choice Aggregation (CCA), a publicly-owned electricity retailer model that enables community-scale procurement of RPS-eligible[2] resources in excess of the mandated floor. CCAs exist in ten US states with four more considering authorization, and a majority of CCAs offer green options. In this paper, I examine the case of California, which has both an aggressive RPS and a high degree of participation in CCAs. I provide evidence that voluntary green power programs can advance participants' decarbonization goals, but overall system benefits can be undermined by dynamic responses to voluntary green participation.

[2] The RPS-eligible renewable energy sources are bioenergy, geothermal, small hydroelectric, solar, and wind. California recognizes nuclear and large hydroelectric plants as providing carbon-free power but at this time does not count them as RPS-eligible.

California's particular CCA design has two features that present a uniquely strong opportunity to observe the impact of a voluntary green power mechanism on overall decarbonization performance. First, California's CCAs and often tout environmentally-progressive reputations: all except one offer voluntary green power options, and many CCAs have configured their default offering to overcomply with the RPS. Second, California's CCAs have the unusual feature of being opt-out rather than opt-in. CCAs with high-renewable default portfolios therefore give rise to an unusually large set of demand for green products, as they capture both customers with high willingness-to-pay for voluntary green power and customers who are inattentive to the clean energy content of their power. Existing reports have asserted that CCAs have procured more clean electricity than is required by California's renewable portfolio standard (Trumbull et al. 2019, 2020) but the net effect on statewide performance remains unclear. In addition, some previous research explores sociopolitical aspects of the formation of CCAs, such as coalition-building (Hess 2019) and diverse community motivations for CCA formation (Gunther and Bernell 2019).

I empirically test the renewable procurement performance of CCAs relative to the RPS minimum. My model supports the hypothesis that CCAs engage in voluntary overcompliance by procuring more green power than required by the RPS, with CCA formation and participation in voluntary overcompliance strongly correlated with indicators of high willingness-to-pay for renewable energy. However, I find that the net effect is not meaningfully different from a binding RPS alone, nor is it clearly additional to pre-CCA levels of voluntary overcompliance. The lack of additionality arises for three reasons. The RPS has become more ambitious over time, making it more difficult to consistently exceed it; voluntary gains from high-performing CCAs were offset by a shedding of renewable contracts among incumbents; and CCAs had no positive spillover effect on other entities in the sector due to geographic constraints on entry. Though CCAs have often been lauded as "leadership communities," I observe that the incumbent utilities also engaged in voluntary green procurement before large-scale CCA entry. In fact, CCA expansion is correlated with a reduction in California's overall levels of voluntary green procurement. This short-term erosion of progress is unsurprising in the face of an increasingly stringent RPS and macroeconomic shocks such as the Covid-19 pandemic. But I show that it is also consistent with an economically-rational response to successful CCA expansion. My findings demonstrate that CCAs can be effective as a matching mechanism, by placing the greatest levels of renewable energy procurement in the hands of those most politically, economically, and/or socially willing to take it on. However, the CCA model's success can also be associated with a chilling effect, at least in the short term, on the rest of the sector.

This paper contributes to the literature on voluntary versus mandated action to ameliorate a market failure. Voluntary overcompliance with environmental regulation has previously been documented in contexts such as the US EPA's 33/50 program on reducing toxic chemical emissions (Arora and Gangopadhyay 1995, Khanna 2001), and more recently with the rise of environmental, social and governance (ESG) investing and corporate carbon disclosures (Hsueh 2019, Duchin et al. 2022). Findings are more mixed as to whether such self-regulation measures actually translate to meaningful declines in emissions. I look at the performance of voluntary overcompliance in the related but distinct area of electricity sector decarbonization. The work also ties in to literature studying the effects of environmental regulation on decision-making for participants in electricity markets. The impact of pollution permits on firms' generation and investment strategies is a longstanding topic of study (Laffont and Tirole 1994, Fowlie 2010), as is measuring the cost of carbon pricing schemes on energy prices (Borenstein and Kellogg 2022, Holland et al. 2022). The majority of this work, however, focuses on effects in the wholesale market. This study instead focuses on the implications of clean energy mandates for procurement decisions by retail providers.

Voluntary green portfolio offerings can be, but aren't necessarily, features of competitive retail electricity markets. In the US, electricity retail structure differs by state, ranging from zero retail choice to full retail choice. Even in fully liberalized settings, competitive retailers might offer consumers the choice of different rate structures but no option to select the clean energy content of the power being procured on their behalf. In this case, customer preferences concerning clean energy will not carry over into sending a signal to the wholesale generation sector. Conversely, a non-competitive retail sector might still contain a monopolist that offers customers a choice between a default procurement portfolio and paying a small premium to receive a portfolio with a larger proportion of clean energy. Therefore, this work focuses on the effects of portfolio heterogeneity—rather than price heterogeneity—on the wholesale sector. This could have implications for the structure of the retail sector but it is not the same as discussing retail competition in the classic sense.

However, the literature on retail competition still provides a useful theoretical framework. The effectiveness and value of competitive electricity retail markets have been debated since the concept was introduced. Joskow (2000) expresses skepticism, as competitive retailers are still inherently tethered to upstream regulated network monopolies, which constrain opportunities for meaningful innovation or cost saving. Though retailers could theoretically provide other value-added services, Joskow concludes that such opportunities are likely small. Littlechild (2000), in contrast, argues that greater competition on the demand side could induce improvements at the wholesale level, and result in better cost-minimization than systems without retail competition. Twenty years after his original argument in favor of retail competition, Littlechild (2021) asserts that sophisticated demand-side engagement is crucial for successful deep decarbonization, and that this emphasizes the importance of expanding and innovating in retail competition more than ever. Empirical literature assessing the performance of retail competition has tended to focus on measuring price impacts, in most cases finding that the introduction of retail competition into liberalized electricity markets has yielded few pricing benefits to consumers (e.g., Joskow 2006, Su 2015). This study measures how the average renewable energy content has changed with the introduction of heterogeneous procurement portfolios into a market. A complete assessment of the modern electricity retailer should account for performance in terms of clean power and not just cost-competitive power. If certain retailer models are shown to help accelerate progress to a decarbonized wholesale electricity supply, this is a substantial value-added service.

The paper proceeds as follows. Section II introduces the empirical setting. Section III models the community characteristics associated with voluntary green procurement, and Section IV analyzes additionality in terms of net renewables procured. Sections V and VI assess CCA impacts on retail switching and improved investment in renewable generation respectively. Section VII discusses policy implications and Section VIII concludes.

## II. Background and Context

### A. Theories of Voluntary Overcompliance and Firm Behavior

General models of regulation predict that implementing mandates to address market failures increase costs for the agents subject to the regulation; consequently, rational, cost-minimizing agents will do the bare minimum to comply with the regulation but no more. In practice, agents sometimes voluntarily overcomply, procuring more of the desired good relative to the mandated quantity (Khanna 2001). A common theoretical explanation for voluntary overcompliance is that firms are acting in anticipation of heightened regulation. A belief that the regulator will soon raise the standard may lead firms to hedge against the change by building a buffer (Lyon and Maxwell 2004); anticipation of shocks to performance in the near future can have a similar effect (Toffel and Short 2011). Voluntary overcompliance can also simply be an indication that the standard is not binding, and additional progress can be achieved at low cost. A second explanation is that firms may overmeet standards to signal pro-environmental values for reputational gains (Maxwell et al. 2000, Arora and Gangopadhyay 1995). Though this has mainly been discussed in the context of corporate social responsibility, the rationale is relevant for a public entity like a CCA as well.

Determining whether CCAs' voluntary overcompliance has accelerated decarbonization efforts requires a careful definition of additionality. In the context of this study, regulatory compliance means a provider has met the RPS in a given time period. Voluntary overcompliance (or voluntary greenness) means the provider has procured more than the mandated quantity in a given time period. That is, *any* level of voluntary greenness, regardless of which provider procured it, represents additional progress relative to an RPS target.

Thus, if the question is quantifying CCAs' total voluntary overcompliance, this is simply the difference between CCAs' proportion of renewable energy and the RPS floor. But if the question is instead whether CCA contributions are *additional*, this requires comparison to whatever existing levels of voluntary greenness were present due to the actions of other providers. Voluntary overcompliance was a feature of California's incumbent investor-owned utilities (IOUs) before substantial CCA entry. As CCAs grew, overall levels of overcompliance dropped to ~0%. This reduction cannot be interpreted as being caused by CCAs per se: CCAs are carved out of the service territory of IOUs, so their actions have clear, non-negligible feedback effects on incumbents, making formal causal analysis challenging. All that can be said with confidence is that CCAs' efforts have not been sufficient to raise performance above either the RPS minimum, nor have they been sufficient to restore a voluntary green buffer for the state overall.

### B. California's Various Load-Serving Entities

California's electricity retailing sector has a particularly complex history. The state introduced a competitive retail market in the late 1990s, but abruptly reversed course in the midst of the 2001 energy crisis, when customers were largely returned to the default service provider for their geographic region. A given household generally had no choice over their selection of retail provider.[3] The entry of CCAs over the past fifteen years represents a substantial expansion in the number of electricity retailers in the state. Because a CCA arises within the territory of an incumbent private electricity provider, CCAs introduce some choice of retail provider for households.

As of 2021, there are 92 separate Load Serving Entities (LSEs) across five provider types that serve as retail electricity providers in California. The LSEs vary greatly in terms of service territory size, types of customers served, governance structure, and regulatory oversight. This paper focuses on the dynamics between two of these types, IOUs and CCAs. For a more comprehensive discussion of the state's diverse electricity providers (i.e., publicly-owned utilities (POUs), direct access providers (DAPs), and co-ops) and their decarbonization performances, see Chapter 2. Summary statistics for the five categories of LSE are given in Table 1.

Table 1: Size of each type of LSE in California

| | Number of LSEs | Total 2021 Sales (TWh) | Percentage of Total Sales |
|---|---|---|---|
| CCA | 25 | 50.6 | 21.3% |
| CO-OP | 4 | 0.4 | 0.2% |
| DA | 10 | 24.4 | 10.3% |
| IOU | 6 | 102.7 | 43.2% |
| POU | 47 | 59.7 | 25.1% |
| Total | 92 | 237.9 | 100.0% |

[3] Non-residential customers can take service from alternative retailers through California's Direct Access Providers (DAPs). However, the total allowable DAP load is capped, so in practice non-residential customers also experience barriers to switching away from incumbent providers.

IOUs are private, regulated utilities. Though deregulation in the 1990s forced California's IOUs to largely divest from their generation holdings, today they still own some power producing assets as well as a significant portion of the transmission and distribution infrastructure across the state, and they can continue to serve retail functions within their service territories. There are three major IOUs (PG&E, SCE, and SDG&E) and three Small/Multijurisdiction IOUs (BVES, Liberty Calpeco, and PacifiCorp). These latter three amount to ~1.5% of IOU load. Because they sometimes also serve customers outside of California and are subject to special regulations, I focus only on the three large IOUs for this study.

AB117, passed in 2002, enabled local governments to become new participants in energy procurement by forming a community choice aggregator (CCA). CCAs are public entities formed via Joint Powers Agreements (JPAs) between one or more cities or counties. CCAs may only form within the existing service territory of an IOU, and while a CCA purchases power on behalf of the customers living in its geographic region, it still uses the transmission and distribution network of the incumbent IOU. Thus, any given household in IOU service territory can select from at most one CCA and one IOU as its electricity supplier, and has no choice over its network service provider. Unlike traditional competitive retailers that must entice customers to switch from a default provider, CCAs in California are opt-out entities, so they avoid the large marketing costs generally associated with successful startup of new retailers. California's CCAs have experienced rapid growth and high market penetration. The first operational CCA launched in 2010, and by 2021 over eleven million customers participated in a CCA (>20% of load). As some CCAs procure very high levels of renewable power, the emergence of these "leadership communities" may indicate a decarbonization benefit to allowing the formation of new retailers.

But the literature praising CCAs for "accelerating the state's transition" (Trumbull et al. 2020) glosses over key facts about the performance of incumbent utilities. First, it assumes that the right baseline for comparison is the RPS minimum: if actual progress in the absence of CCA entry was under or over the RPS level, reported CCA impacts may be distorted either in the positive or negative direction. Second, it fails to sufficiently account for incumbents' rational responses to CCA growth. The more nuanced reality is that CCAs' voluntary procurement meaningfully accelerates progress if and only if it is both larger than incumbents' levels of voluntary procurement as well as large enough to offset any negative changes in incumbents' procurement strategies in response to CCAs. As I show in section IV.B., CCA voluntary overprocurement increases have actually correlated with short-term setbacks—both declines in incumbents' renewable procurement and in overall state levels of voluntary overcompliance.

### C. Renewable and Clean Energy Regulation in California

California's SB 100 "established a landmark policy requiring renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045" (CEC, n.d. a). In the California regulatory context, *renewable* energy refers to biofuel, geothermal, eligible (small) hydro, solar, and wind generation. Nuclear and large hydroelectric generation are zero-carbon resources but are not considered renewable due to environmental impact. The sum of renewable, nuclear, and large hydro is the total amount of *clean energy* procurement in each portfolio. I report LSE performance with respect to renewable energy in the main text and total clean energy in the Appendix. The remaining specified procurement types reported are classed as fossil carbon resources: coal, natural gas, and a residual "other" category that encompasses such fuels as petroleum, diesel, and propane. Finally, unspecified power "refers to electricity that is not traceable to specific generation sources by any auditable contract trail or equivalent" (Public Utilities Code Section 398.2). Unspecified power indicates the extent to which an LSE buys off the short-term market rather than contracting for power. While the exact composition of unspecified power may not be known, state calculations find that the average emissions intensity of unspecified power is slightly higher than that of a typical natural gas plant in California.

The primary mechanism for achieving SB 100 is the Renewable Portfolio Standard (RPS), which "sets continuously escalating renewable energy procurement requirements for the state's load-serving entities" (CEC, n.d. b). Thus, the state anticipates that electricity decarbonization will be achieved by ratcheting up the percentage of clean energy retail purchases required, altering retailers' decisions and thereby indirectly stimulating greater investment in renewable generation. LSEs were required to achieve 33% renewable energy by 2020 and will need to reach 60% by 2030.

The details of determining RPS compliance are important to understanding the dynamic behavior I observe. The RPS is a percentage-based standard, is assessed on a per-LSE basis, and is verified via multi-year compliance periods (CPs). This means that a retailer facing large declines in load could decrease its renewable procurement in absolute terms but maintain compliance on a percentage basis. A retailer could offer a 100% renewable product and an out-of-compliance product as long as its average proportion of renewable energy exceeded the RPS floor. A retailer could also be out-of-compliance for some of the years within the CP as long as the overall period average is sufficient.

## III. CCAs and Preference Matching

It is trivial to verify that the CCA-wide average proportion of renewable energy is higher than the IOU-wide average. A more interesting aspect of CCA performance is understanding who tends to form CCAs and whether any community traits predict higher performance. The empirical exercises discussed in this section test whether CCAs act as a channel to match consumers with high preference for decarbonized power to electricity portfolios containing higher proportions of decarbonized power. I estimate the associations between a variety of attributes that might indicate higher willingness-to-pay for decarbonized power, and the proportion of decarbonized power present in various LSEs' default portfolios. I find that communities forming CCAs and receiving more decarbonized power tend to be higher income and politically supportive of climate change mitigation policy.

### A. Methodology

I estimate reduced-form equations to determine the effects of LSE type and community characteristics on the equilibrium quantity of green electricity procured on behalf of retail customers. This is accomplished via two empirical exercises. The first is a binomial logit model of CCA formation to gain insight into the community characteristics associated with a desire to access a mechanism for voluntary green procurement. The second is an OLS regression of green power on community characteristics to determine whether participation in a CCA and indicators of higher willingness-to-pay correlate with the actual intensity of decarbonized power procured.

The logistic regression takes the form:

$$is\_CCA_i = X'\beta + \epsilon_i$$

where each i represents a community, X is a vector of community characteristics, and $\epsilon$ is an idiosyncratic error term. The outcome variable $is\_CCA_i$ takes on the value one if the community became served by a CCA in any year between 2010 and 2020. A range of covariates that might indicate higher propensity for CCA formation are included so as to attenuate omitted variable bias. These contain measures of income, broad political preferences, specific political preferences on environmental issues, relative cost-of-service, and presence of local renewable resources that could provide local economic benefits. The model considers all communities eligible for CCA formation, that is, all communities originally within the network service territory of an IOU. I exclude any community served by POUs because these communities cannot form a CCA that enters into competition with their local POU. Communities that were in the process of forming a CCA at the end of the observed period are recorded as served only by an IOU. This group includes communities in which a CCA became operational after 2020 and other communities that abandoned the process of CCA formation in that period. A community where a CCA was formed but then went bankrupt is coded as having a CCA.

Access to or participation in an alternative retailer does not automatically mean the community must be "greener" than others. The purpose of the second regression model is to determine whether the community characteristics that correlate with CCA formation also significantly correlate with the intensity of decarbonized energy actually procured for that community. In the OLS regressions, the outcome variable of interest is the percentage of a certain type of energy (renewable energy or overall clean energy) in the default electricity portfolio for a given community. The renewable energy regression takes the form:

$$pct\_renewable_i = X'\beta + \epsilon_i$$

where each i is a community, and the vector X contains variables measuring community characteristics and size of the LSE. The clean energy regression is of the same structure.

The goal of this regression is to assess which community characteristics are important determinants of decarbonized energy procurement, and whether those characteristics have differing effects depending on the type of LSE the community belongs to. The OLS model therefore encompasses all communities served by an IOU, POU, or CCA, which have geographic service territories that can be mapped to communities. I exclude the DAPs for two reasons. First, DAP customer identities are confidential but are usually large commercial/industrial loads, where pure cost considerations are more likely to govern procurement decisions. Second, DAPs are the least geographically tied to a specific region. Therefore, it is not plausible to run them in a regression on community characteristics, although it is evident that these businesses are different in character from the other three types.

The community characteristics considered here are the same as those in the logit regression, with two additions. First, I include a covariate for the size of the LSE, to test the effect of economies of scale on decarbonized energy procurement. Second, I have a public/private governance fixed effect. Consider two identical sets of communities, where one set is served by a public power provider (i.e., CCA or POU) and the other is served by a private utility (IOU). Their procurement portfolios may look substantially different due to divergent political and economic incentives. The IOU's chosen portfolio may account for customer preferences somewhat, in terms of relevant economic interest, but ultimate accountability is to shareholders. In contrast, in public power settings, induced preference theory and positive responsiveness predict that constituent preferences are relatively more salient determinants of decisions such as power procurement. Indeed, Wald tests show that the CCAs and POUs pool in the renewable energy regression but are distinct from the IOU group (see Appendix for detail).

The goal of these regressions is to understand CCAs as a matching mechanism between communities that already have high willingness to pay for decarbonized power and increased intensity of decarbonized power received—not whether community characteristics causally altered procurement patterns. Therefore, the analysis is not threatened by identification problems involving regression of endogenous variables. Due to clustering at the community level, I cannot detect variation within a given community. As this means a coarsening of information about heterogeneity in consumer preferences, any matching I do find is likely an underestimate.

### B. Data

In most cases, a single LSE is the default provider for a set of cities, towns, or counties. The decision to join a CCA and determination of default electricity portfolio is made at the local government, not individual actor level. Therefore, data were collected for each city and town in California. In the case of unincorporated communities, the decision of electricity provider is assessed by county government such that the same LSE will serve all unincorporated portions of that county. So, data for all census designated places within a given county were aggregated into a single observation per county. This yields a total equal to 482 cities or towns + 57 counties containing unincorporated communities = 539 observations. The number is reduced to 523 after dropping observations with missing data. Of these, 470 are IOU or CCA communities and used for the binomial logit estimation. Although communities are of heterogenous sizes, this does not result in a clustering problem because the outcomes in question and level of decision-making are both at the community level (i.e., whether the community joined a CCA, and what the community decided should be the percentage of decarbonized energy they receive by default), so it is appropriate to use a community as the unit of analysis.

Data were compiled for 18 parameters describing socioeconomic, demographic, and other characteristics of each community that would indicate higher willingness to pay for green power. The main variables of interest are income, the political indicators, and LSE size. Details of the various parameters and their data sources can be found in the Appendix.

Data on electricity procurement by type of generation facility are from the Power Source Disclosure (PSD) filings by each LSE in 2020, from which are calculated weighted averages of the percent of electricity from sources that are renewable and the percent from clean energy sources. For example, MCE is a multi-jurisdiction entity composed of CCAs in several communities in Contra Costa, Marin, Napa, and Solano counties. If MCE had a 30 percent renewable portfolio that supplies 90 percent of its sales and a 100 percent renewable portfolio that supplies the other 10 percent, each community in MCE is assigned a renewable energy percentage of 37 percent (0.9x.30 +0.1x1.0).

Some cities within a multi-jurisdiction CCA select a higher renewable portfolio as their default. When this information is known, each city within a CCA is assigned the renewable and clean energy percentages that correspond to its default portfolio. For example, Calabasas has "Lean Power" as its default option, while Beverly Hills has "100 percent Green Power" as its default option. Then Calabasas is assigned 40 percent renewable, while Beverly Hills is assigned 100 percent. This procedure does not account for the fact that some customers opt for a choice other than the default rate.

### C. Logit Regression Results

The binomial logit model indicates that CCA formation is significantly correlated with higher median income, political support for local power, and political support for state regulation of GHG emissions. I run multiple specifications to reduce the risk of functional form errors, resulting in a piecewise linear structure for my preferred specification. I test for structural breaks by identifying one optimal breakpoint, creating dummies for the resulting two segments, and reestimating the generalized linear model to obtain two coefficients per independent variable.[4] A more detailed explanation of the model selection process and robustness tests can be found in the Appendix. This includes ANOVA tests confirming that the additional piecewise variables significantly improve explanatory power, and reported improvements to model fit from the piecewise versus the fully linear model.

To aid in model interpretation, I assess the relative importance of each significant variable by changing each in isolation within its range of variance in the sample. I construct a hypothetical community with average characteristics for all covariates and determine the model's prediction of the probability of CCA formation. I then perturb each covariate by one standard deviation, holding all other variables constant, and measure the difference in predicted probability of CCA formation. I find that median income, political support for local power, and political support for state regulation of GHG emissions all have large effects on the probability that a CCA had been formed by 2020. An otherwise-average community with income one standard deviation below the sample mean (from $87,000 to $44,000) has an estimated probability of CCA formation that is 27.5 percent lower (from 39.7 percent to 12.2 percent). Communities with one standard deviation more support for environmental policy ballot measures are associated with an approximate 25% increase in the probability of CCA formation.

I find that the model performs well in terms of correctly classifying CCA communities. As an additional validity check, I look at the overlap between misclassifications and communities that formed CCAs after 2020 (i.e., a time period outside the range used to train the model). There were thirteen communities for which the model predicted a probability of CCA formation higher than 70%, but which did not actually form CCAs during the observation period. Ten of these thirteen became CCA communities by 2023 (one of the other three was a POU until 2013).

### D. Community Characteristics and Decarbonized Energy Procurement

The OLS regression assesses the correlation between community characteristics and decarbonized energy procurement. I run a version of the model where the outcome variable is the

[4] Thus, the reported coefficient for the segment above the breakpoint is the difference in slopes for the two segments. For example, the coefficient for median income is 3.612 for communities with median income below the breakpoint of $108,000 and 3.612 - 4.750 = -1.138 for communities with median income above $108,000 (the median household income for the entire sample is $87,000).

percentage of renewable energy in a community's default portfolio (Table 5) and a second version where the outcome variable is the percentage of total carbon-free energy, i.e., renewable plus large hydro and nuclear (Table 6). The importance of LSE-type fixed effects is considered as well. The preferred specification for the renewable energy regression pools CCAs and POUs, while preferred specification for the total carbon-free regression does not pool any of the three groups (for the results of alternative specifications, see the Appendix). The CCA and POU group exhibits strong income and scaling effects, meaning that wealthier and larger communities tend to procure more renewable energy. Increasing CCA/POU size by one standard deviation is associated with a 6.7% increase in renewable energy. Political preferences also appear to be significant determinants of renewable procurement. Stronger Democratic party vote and preference for environmental protection are associated with CCAs and POUs that procure higher levels of renewable energy. A one standard deviation increase in these parameters yields a predicted 4% and 3.7% increase in renewable procurement, respectively. In the regression on the proportion of clean energy in each LSE's portfolio, size is once again a highly significant variable. Income effects are only significant for the CCA group.

The pooling of CCAs and POUs reflects their political similarity relative to IOUs. CCAs and POUs are linked to local governments, with each one representing a relatively small set of similar cities. In contrast, the IOU group is dominated by PG&E and SCE, which serve geographically large service territories across dozens of communities. The regressions suggest that for the types of LSEs that are more responsive to the preferences of local constituents—CCAs and POUs—income, political and policy preferences, and scale of the operation are strong predictors of how much that community would likely pursue voluntary green power. These results are in line with intuition: places with a higher willingness to pay for green power are also places leading the charge on voluntary greenness. However, as the CCA/POU pooled group is separate from the IOU group, this may also indicate that the degree of voluntary greenness in CCA/POU communities is quite distinct from that in IOU communities. CCAs are carved out of existing IOU service territory. Although CCAs with high voluntary greenness successfully facilitate matching the groups who most want renewables with the highest levels of renewables, this separation also implies that the residual—the communities remaining with the IOU—have lower preferences and willingness to pay for decarbonization. The net effect on the system will not just depend on the expansion of voluntary greenness. It will also be influenced by the degree to which LSEs representing communities with less interest in decarbonization change their behavior in response to the rise in voluntary greenness. To understand these dynamics, I turn to timeseries data on actual sales of electricity by fuel type for each LSE.

Table 4: CCA Formation

| | Linear | Piecewise Linear |
|---|---|---|
| med_income | 1.035*** | 3.612*** |
| | (0.394) | (0.845) |
| med_income.seg | | −4.750*** |
| | | (1.233) |
| pct_yes_prop_16 | −6.465*** | −9.193*** |
| | (1.976) | (2.527) |
| pct_yes_prop_16.seg | | 71.038*** |
| | | (17.796) |
| pct_yes_prop_23 | −9.347*** | −9.537*** |
| | (1.807) | (2.268) |
| temp_jan | 0.231 | 0.742* |
| | (0.316) | (0.400) |
| temp_jan.seg | | −9.282*** |
| | | (2.979) |
| temp_aug | −1.033*** | −1.842*** |
| | (0.301) | (0.392) |
| temp_aug.seg | | 3.721*** |
| | | (0.913) |
| not_PGE_SCE | −3.084*** | −3.336*** |
| | (1.081) | (1.142) |
| Constant | 11.791*** | 14.524*** |
| | (2.238) | (2.885) |
| Observations | 470 | 470 |
| Log Likelihood | −177.044 | −147.402 |
| Akaike Inf. Crit. | 368.088 | 316.805 |
| *Note:* | | *p<0.1; **p<0.05; ***p<0.01 |

Table 5: Percent Renewable Regression Coefficients, Pooled vs Two Groups

| | Pooled | [CCAs & POUs] vs IOUs |
|---|---|---|
| med_income | 0.057*** | 0.074*** |
| | (0.016) | (0.018) |
| med_income.IOU | | −0.087*** |
| | | (0.026) |
| pct_white | 0.049 | 0.098*** |
| | (0.033) | (0.029) |
| pct_democrat | 0.193 | 0.346*** |
| | (0.144) | (0.128) |
| pct_yes_prop_23 | 0.119 | 0.337*** |
| | (0.135) | (0.122) |
| pct_trump | −0.100** | −0.205*** |
| | (0.050) | (0.074) |
| pct_trump.IOU | | 0.179** |
| | | (0.074) |
| pct_manufacturing | −0.341** | −0.277** |
| | (0.149) | (0.132) |
| temp_jan | 0.077*** | 0.072*** |
| | (0.012) | (0.019) |
| temp_jan.IOU | | −0.029 |
| | | (0.023) |
| lse_size | −3.269*** | 19.617*** |
| | (0.313) | (2.246) |
| lse_size.IOU | | −20.221*** |
| | | (2.229) |
| not_PGE_SCE | −0.168*** | −0.095*** |
| | (0.017) | (0.017) |
| is_IOU | | 0.116 |
| | | (0.116) |
| Constant | −0.031 | −0.279* |
| | (0.133) | (0.145) |
| Observations | 523 | 523 |
| Log Likelihood | 379.514 | 452.059 |
| Akaike Inf. Crit. | −739.028 | −874.118 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

## IV. System Impacts

CCAs are effective at imparting greater levels of renewable power to their customers; this section places CCAs in the context of overall state performance, where I find that CCA gains have been insufficient to offset deteriorating performance by other types of LSEs. I assemble a panel of administrative data about electric generation sources and sales, and quantify the degree of voluntary overcompliance present for each LSE. I then look at the trends in CCA performance compared to other LSEs' performances. I also consider heterogeneity within CCAs, finding that relatively high-income CCAs procure far more voluntary green power than relatively low-income CCAs, and large CCAs similarly outperform smaller CCAs. I then expand the analysis from retail sales of power to implications for investment, finding that CCAs largely represent a transfer of existing resources as opposed to addition of new ones.

### A. Data and Methodology

Data come from the CEC's Power Source Disclosure (PSD) program, which is intended to provide consumers "accurate, reliable, and simple to understand information on the sources of energy that are used to provide electric services" (CEC n.d. c). These compliance documents are filed by all operational LSEs each year. PSD filings from 2010 through 2020 were obtained via data requests to the CEC (n = 953). Each filing lists the quantities procured from generation resources and total retail sales for a given portfolio. Data for 2021 and 2022 come from a summary of PSD filings published on the CEC website, which contains total retail sales and percentages procured from each generation source for all portfolios.

Table 4 indicates how many LSEs of each type filed PSD documents in recent years. Since 2017, the number of CCAs has tripled.

Table 4: Number of LSEs with PSD filings by year

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|
| CCA | 9 | 19 | 19 | 22 | 25 | 27 |
| CO-OP | 2 | 4 | 4 | 4 | 4 | 4 |
| DA | 14 | 14 | 13 | 13 | 10 | 11 |
| IOU | 6 | 6 | 6 | 6 | 6 | 6 |
| POU | 44 | 46 | 46 | 47 | 47 | 47 |
| Total | 75 | 89 | 88 | 92 | 92 | 95 |

*Source*: CEC Power Source Disclosure program

## B. Impacts on System-Wide Performance

This paper is primarily concerned with measuring voluntary overcompliance, so the figures below are presented in terms of values relative to the RPS baseline for a given year as opposed to absolute values. Figure 1 shows performance in terms of procured quantities (TWh) relative to the minimum amounts for compliance with the RPS by LSE type, and Figure 2 shows performance in terms of percentages relative to the RPS percentage in each year. The same data are shown in table form in Tables 5 and 6.

As no new hydroelectric or nuclear projects have been built in recent years, the trends for total clean energy levels are qualitatively similar to the trends for renewable procurement (see Appendix for details).

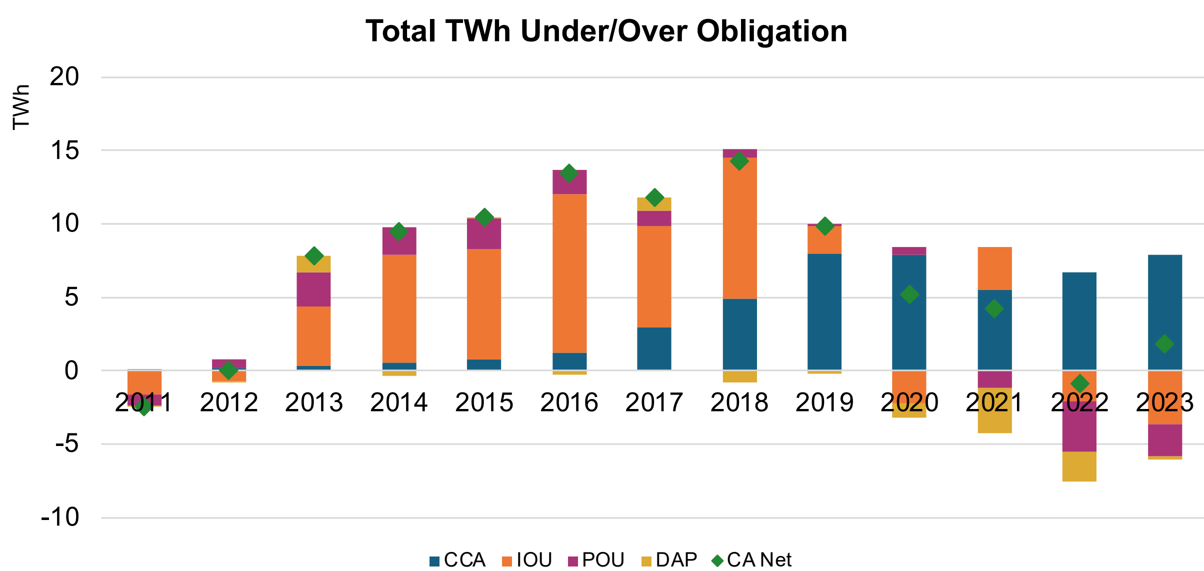


Figure 1: Total TWh under/over RPS obligation for a given year, by provider type

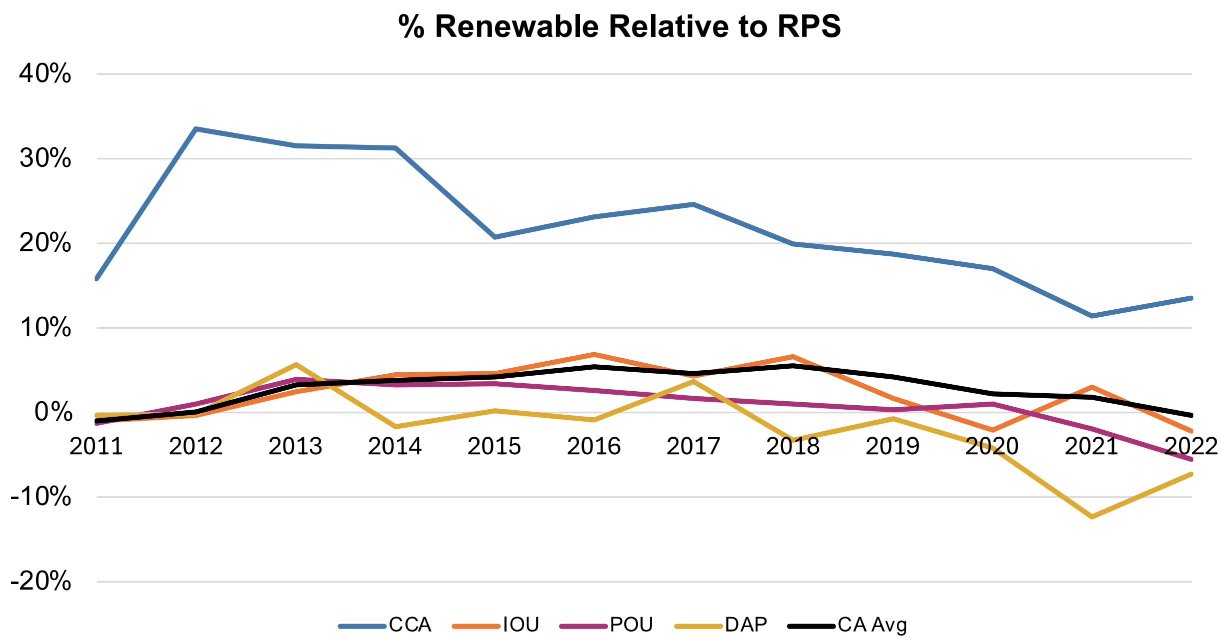


Figure 2: Trends in renewable procurement by LSE type relative to RPS target (%)

Table 5: Annual procurement by LSE type, relative to minimum RPS quantity (TWh)

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CCA | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.2 | 3.0 | 4.9 | 8.0 | 7.9 | 5.5 | 6.7 |
| IOU | -1.6 | -0.7 | 4.0 | 7.3 | 7.5 | 10.8 | 6.9 | 9.6 | 1.8 | -2.2 | 2.9 | -2.1 |
| POU | -0.8 | 0.6 | 2.3 | 1.9 | 2.1 | 1.6 | 1.1 | 0.6 | 0.2 | 0.6 | -1.1 | -3.4 |
| DAP | -0.1 | 0.0 | 1.1 | -0.4 | 0.0 | -0.2 | 0.9 | -0.8 | -0.2 | -1.0 | -3.1 | -2.0 |
| CA Net | -2.5 | 0.1 | 7.8 | 9.4 | 10.4 | 13.4 | 11.8 | 14.3 | 9.8 | 5.2 | 4.2 | -0.8 |

Table 6: Annual renewable procurement by LSE type relative to RPS target (%)

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CCA | 16% | 33% | 32% | 31% | 21% | 23% | 24% | 20% | 19% | 17% | 11% | 14% |
| IOU | -1% | 0% | 2% | 4% | 5% | 7% | 4% | 7% | 2% | -2% | 3% | -2% |
| POU | -1% | 1% | 4% | 3% | 3% | 3% | 2% | 1% | 0% | 1% | -2% | -6% |
| DAP | 0% | 0% | 6% | -2% | 0% | -1% | 4% | -3% | -1% | -4% | -12% | -7% |
| CA Avg | -1% | 0% | 3% | 4% | 4% | 5% | 5% | 6% | 4% | 2% | 2% | 0% |

Figures 1 and 2 demonstrate that voluntary overprocurement existed in substantial quantities separate from CCA action, and greater CCA entry was coincident with a shift from over- to underprocurement on the part of other LSEs. CCAs appear to be the only group to consistently exceed mandated levels. After 2018, IOUs no longer consistently procured renewables in excess of the RPS, and the overall state average declined until it reached parity with the RPS floor. POU performance has generally been near to the RPS floor while DAP performance has been mixed; explanations for these trends are discussed in greater detail in Chapter 2.

Substantial declines in IOU renewable procurement—and elimination of the voluntary green buffer the state previously enjoyed—are undesirable from a decarbonization policy standpoint. However, these trends are consistent with rational, profit-maximizing behavior. The RPS is a percentage-based standard (renewable MWh/total MWh sales). Once load departs an IOU in favor of a CCA, an IOU continuing to hold all its existing contracts would be overprocured. An IOU could decrease its quantity of renewable procurement while still being above the state-mandated floor in percentage terms. Because RPS compliance is assessed based on overall performance across a multi-year compliance period (CP), an IOU could even drop under the floor as long as their CP average is sufficient. Indeed, this appears to be the case for the CP spanning 2017 to 2020: IOU performance was well above the RPS target for 2017 and 2018, fell to 2% above the 2019 RPS target, then fell further to 2% below the 2020 RPS target.

The two major theoretical explanations for voluntary overcompliance are as reputational signals, and as hedging for future conditions. As shown in Section III, the communities who tend to most value a "green reputation" strongly select into CCA participation. Thus, any incentive for IOUs to signal environmental priorities is attenuated (or possibly even reversed). IOUs may have also overprocured in anticipation of future conditions, as the state has made clear it intends to continue ratcheting up the RPS. Consider the case where the IOU expects future supply of renewables to be tight, and therefore RECs will be a scarce resource. Then there is insufficient supply for new CCAs to entirely procure novel resources, so some portion of CCA compliance must come from transferring contracts held by IOUs, presenting an opportunity for the IOU to accrue rents from the resulting transaction. Consider instead the case where the IOU expects future costs to decline, perhaps as a result of CCAs' voluntary green demand successfully inducing an expansion in renewable supply. Then the IOU would anticipate a lower cost of compliance in the future, making it irrational to continue building a stockpile of renewable procurement. In either case, the IOU's best short-term response is to jettison its voluntary overprocurement.

The data are consistent with this pattern of CCA growth followed by IOU reduction in voluntary overcompliance. Due to the unusually severe shocks the California electricity system also experienced during this timeframe—e.g., the Covid-19 pandemic and the PG&E bankruptcy due to the Camp Fire—it is certainly plausible that reductions in IOU performance would have been observed even without CCA entry. Regardless, CCAs' high level of voluntary green procurement has proven insufficient to stop the erosion of the state's overall voluntary green buffer.

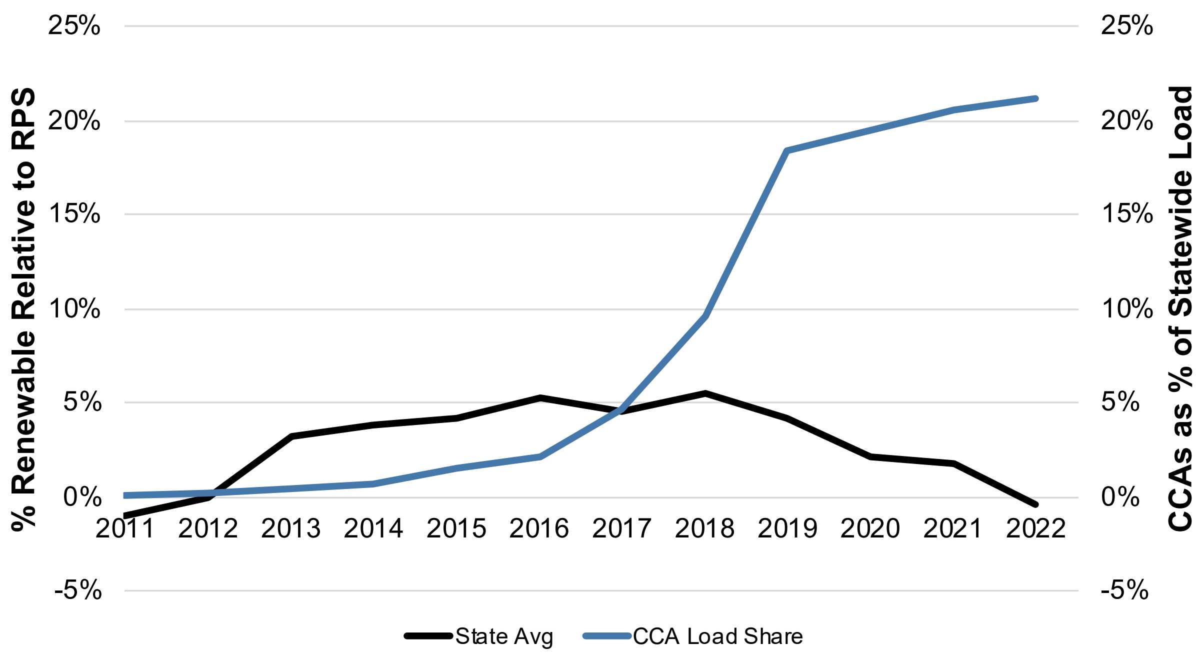


Figure 3: Detail of the statewide average level of voluntary greenness over time, with the CCA proportion of statewide load plotted for comparison.

### C. Performance Heterogeneity Among CCAs

IOUs and CCAs clearly differ in their overall levels of renewable procurement, but there is also substantial heterogeneity in performance within the set of CCAs. The regression modeling implies that there are strong income and scaling effects. To examine this as a timeseries, I separate the CCA group into two equal, smaller groups according to median income (here labeled as "high income" and "low income"). Likewise, CCAs can be divided into two equal groups according to MWh of electricity sales in 2020, here labeled as “large” and “small.” I then reproduce Table 6 and Figure 2, except now I further disaggregate the CCA category into high and low income, and large and small. Both stratifications show a stark difference between the two groups in performance.

Tracing trends in the level of renewable procurement relative to the RPS floor shows that wealthier CCAs succeed in voluntarily procuring renewables in excess of state requirements. However, the degree of overcompliance has declined over time due to both decreases in the percentage of renewables that wealthy CCAs procured and increases in the RPS mandate. In contrast, levels of voluntary greenness have eroded substantially for less wealthy CCAs, which now procure levels of renewables close to the RPS floor. By 2021, the less wealthy CCAs procured a lower fraction of renewable electricity than the IOU average. Similar results hold for large versus small CCAs. The renewables share has gradually declined for large CCAs, but the fall has been precipitous for small CCAs. By 2021, small CCAs had a lower renewable share than any other LSE type except for DAPs.

While CCAs overall demonstrate voluntary overcompliance with the RPS mandate, these results emphasize that the performance of individual CCAs is highly variable. Moreover, the gap between large/wealthy and smaller/poorer CCAs appears to be growing, with the latter losing ground to the IOUs as suppliers of electricity from renewable sources. As a result, there are now CCA customers who receive less green electricity than comparable IOU customers. Unless CCAs serve wealthier communities or are able to achieve economies of scale—perhaps by aggregating themselves into larger CCAs—then this new model of LSE fails to persistently outperform its IOU counterparts.

Table 7: Trends in Renewable Procurement Relative to the RPS for High versus Low Income, and Large versus Small, CCAs

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High Income CCA | 16% | 33% | 32% | 35% | 30% | 28% | 27% | 21% | 21% | 20% | 14% | 17% |
| Low Income CCA | #N/A | #N/A | #N/A | 22% | 13% | 16% | 18% | 11% | 8% | 6% | 2% | 1% |
| Large CCA | 16% | 33% | 32% | 31% | 25% | 26% | 26% | 20% | 20% | 18% | 14% | 16% |
| Small CCA | #N/A | #N/A | #N/A | #N/A | 13% | 14% | 17% | 12% | 4% | 4% | -7% | -4% |
| IOU | -1% | 0% | 2% | 4% | 5% | 7% | 4% | 7% | 2% | -2% | 3% | -2% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POU | -1% | 1% | 4% | 3% | 3% | 3% | 2% | 1% | 0% | 1% | -2% | -6% |
| DAP | 0% | 0% | 6% | -2% | 0% | -1% | 4% | -3% | -1% | -4% | -12% | -7% |
| CA Avg | -1% | 0% | 3% | 4% | 4% | 5% | 5% | 6% | 4% | 2% | 2% | 0% |

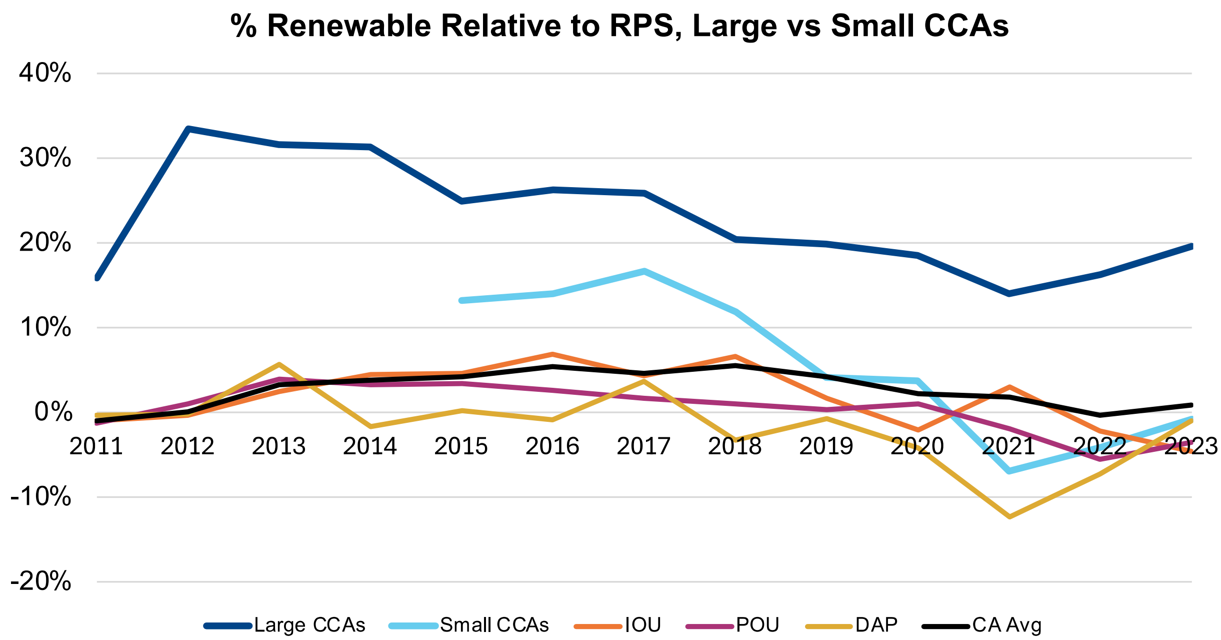


Figure 4: Procurement relative to RPS, large vs small CCAs

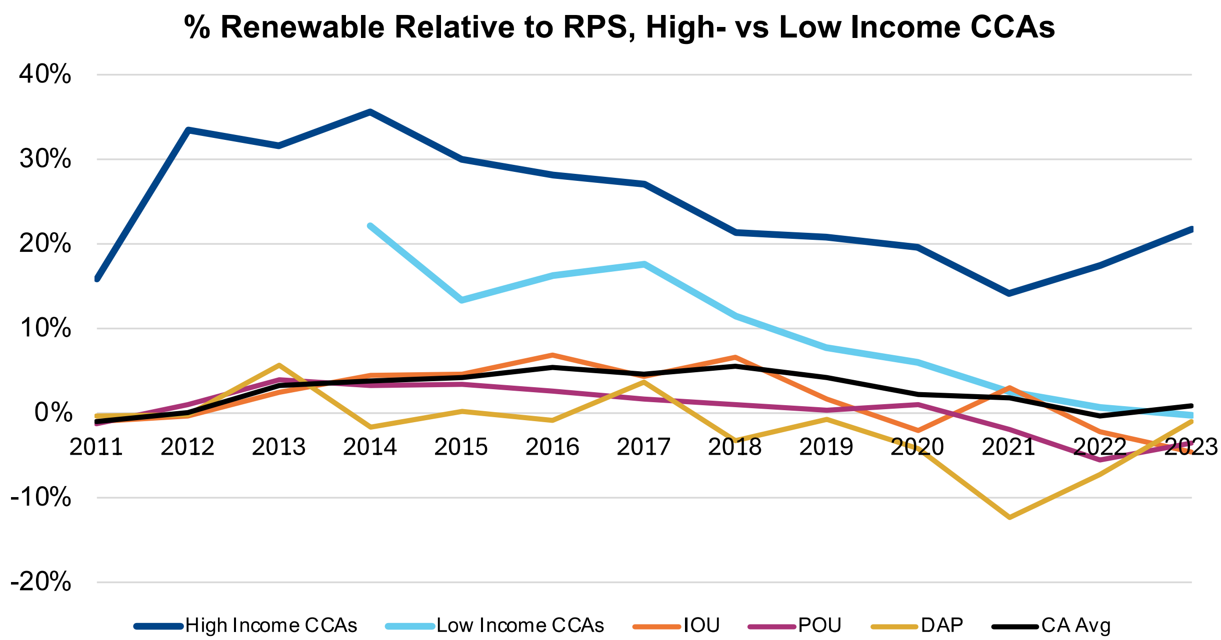


Figure 5: Procurement relative to RPS, high vs low income CCAs

## V. Customer Inattention and Voluntary Green Participation

Empirical papers assessing customer motivations for switching between retailers in deregulated electricity retail settings find that renewable energy content is an important feature for some, and customers are willing to pay a premium for greener energy. But existing literature also shows that customers in liberalized retail markets exhibit high levels of inertia in switching, which has made it more difficult for new retailers to attract customers (Hortacsu et al. 2017). Is the CCA model's success mainly due to deliberate customer action, or due to the opt-out nature of CCAs? As shown in Table 8, green "opt-up" options exist in California for nearly all IOUs and CCAs (as well as for some POUs and one DAP). This translates to approximately 83% of statewide load having access to a voluntary green rate.

Table 8: California LSEs Offering Choice of Multiple Procurement Portfolios, 2021

| | Number of LSEs | Number Offering Portfolio Choice | Percentage (by load) Offering Portfolio Choice |
|---|---|---|---|
| IOU | 6 | 4 | 99.3% |
| CCA | 25 | 24 | 99.9% |
| POU | 47 | 13 | 75.2% |
| DA | 10 | 1 | 2.2% |
| CO-OP | 4 | 0 | 0.0% |

When a city joins a CCA, all customers are automatically enrolled in that CCA. The city can further select between the CCA's portfolio offerings as its default. Some CCAs only offer portfolios with clean energy content set significantly above the RPS threshold, meaning 100% of their customers participate in voluntary green power. Further, some cities choose to default all their constituents onto the most expensive and most green option straight away. This unique structure means that the pool of CCA participants actually taking service from a voluntary green rate equals the set of customers who would actively switch to a voluntary green power portfolio, plus all CCA customers on voluntary green service who are too inattentive to opt back to the IOU. In most cases, the set of customers opting up from the LSE's default portfolio to an even cleaner portfolio is quite small. The set of customers who are located in jurisdictions with an automatic 100% clean energy default and who chose to opt down to a less expensive, less green rate, is also small. This agrees with the literature that the majority of customers are inattentive.

Table 9: Opt-Up Rates for California LSEs Offering Multiple Portfolios, 2021

| LSE | Type | % on Least Green Plan | % on More Green Plans |
|---|---|---|---|
| Apple Valley Choice Energy | CCA | 99.8% | 0.2% |
| Baldwin | CCA | 100.0% | 0.0% |
| Central Coast Community Energy (3CE) | CCA | 99.2% | 0.8% |
| Clean Energy Alliance | CCA | 1.3% | 98.7% [1] |
| Clean Power Alliance of Southern California | CCA | 21.6% | 78.4% [2] |
| CleanPowerSF | CCA | 93.9% | 6.1% |
| Desert Community Energy | CCA | 9.7% | 90.3% [1] |
| East Bay Community Energy | CCA | 83.3% | 16.7% [2] |
| Lancaster Choice Energy | CCA | 99.1% | 0.9% |
| Marin Clean Energy | CCA | 96.4% | 3.6% |
| Peninsula Clean Energy | CCA | 91.8% | 8.2% [3] |
| Pico Rivera Innovative Municipal Energy | CCA | 97.3% | 2.7% |
| Pioneer Community Energy | CCA | 100.0% | 0.0% |
| Pomona | CCA | 100.0% | 0.0% |
| Rancho Mirage Energy Authority | CCA | 99.4% | 0.6% |
| Redwood Coast Energy Authority | CCA | 99.1% | 0.9% |
| San Diego Community Power | CCA | 93.7% | 6.3% |
| San Jacinto Power | CCA | 99.9% | 0.1% |
| San Jose Clean Energy | CCA | 96.6% | 3.4% |
| Santa Barbara Clean Energy | CCA | 12.7% | 87.3% [1] |
| Silicon Valley Clean Energy | CCA | 96.6% | 3.4% |
| Solana Energy Alliance | CCA | 99.1% | 0.9% |
| Sonoma Clean Power Authority | CCA | 96.6% | 3.4% |
| Valley Clean Energy Alliance | CCA | 99.4% | 0.6% |
| 3 Phases Renewables | DA | 1.0% | 99.0% |
| PG&E | IOU | 98.0% | 2.0% |
| PacifiCorp | IOU | 98.8% | 1.2% |
| SDG&E | IOU | 99.6% | 0.4% |
| SCE | IOU | 99.9% | 0.1% |
| Alameda Municipal Power | POU | 95.2% | 4.8% |
| Burbank Water and Power | POU | 99.9% | 0.1% |
| City of Healdsburg Electric Utility | POU | 91.5% | 8.5% [4] |

| | | | |
|---|---|---|---|
| CCSF | POU | 93.4% | 6.6% |
| LADWP | POU | 99.8% | 0.2% |
| City of Palo Alto Utilities | POU | 97.0% | 3.0% |
| City of Pasadena | POU | 95.2% | 4.8% |
| PWRPA | POU | 88.4% | 11.6% |
| City of Riverside Public Utilities | POU | 99.9% | 0.1% |
| City of Roseville | POU | 99.8% | 0.2% |
| Silicon Valley Power | POU | 97.0% | 3.0% |
| SMUD | POU | 90.9% | 9.1% |
| Turlock Irrigation District | POU | 100.0% | 0.0% |

Notes to Table 9.

1. All communities in this CCA were automatically enrolled in the most premium, most green rate. Therefore, the "% on Least Green Plan" really represents active opt-downs from the default option.
2. Some communities in this CCA were automatically enrolled in the most premium, most green rate. However, data on the precise breakdown of load by member community are unavailable.
3. One community in this CCA was automatically enrolled in the most premium, most green rate.
4. Municipal electricity use was automatically enrolled in the most premium, most green rate.

The results on opt-ups and opt-downs reported here are on a per-LSE basis, which does not show how many customers opted to leave CCA service to return to the incumbent IOU. Data obtained from select CCAs indicates that the proportion of opt-outs tends to be less than ten percent. Opt-out rates are unlikely to be large enough to significantly affect the analysis. Hortacsu et al. (2017) identifies search frictions/inattention and an incumbent provider brand advantage as two major sources of inertia in competitive retail electricity markets. In this paper's setting, CCAs tend to offer either the same rate as the incumbent IOU or moderate cost savings on the order of 5%, and they automatically enroll all customers of member cities, so pricing considerations are unlikely to overcome consumer inattention. Further, any brand loyalty—at least for the CCAs in Northern California—is not likely to lie with incumbent utility PG&E, due to that utility's unpopularity following its role in the deadly 2018 Camp Fire. Overall, then, the entry of CCAs has led to a particularly large increase in the proportion of customers taking service from voluntary green power portfolios, and this increase is mainly driven by automatic enrollments rather than active consumer switching.

## VI. Implications for Investment

Assuring sustained progress towards system-wide decarbonization is more nuanced than simply measuring year-on-year gains in renewable electricity sales. The ultimate goal of voluntary increases in the demand for renewable energy is to induce expanding the supply of renewable electricity. CCAs must therefore also be assessed in terms of their impacts on the supply of new renewable energy generators. Three aspects of this are explored below: relative success in procuring novel renewable resources, effects on long-term contracting, and differences in the speed of bringing new construction online.

Even if CCAs procure total renewable energy levels in excess of state mandates, it is not immediately obvious whether they also have higher levels of *new* resources in their portfolios than incumbents do. If CCAs seek out new sources of procurement to a larger extent than IOUs do, then they demonstrate an additional dimension to voluntary overcompliance: responsibility for increasing the total capacity of the system. I consider the set of new renewable resources procured in California between 2010 (the first year of CCA operations) and 2020. Each plant in this set can be matched to the retailer(s) that procured power from it in the first year it sold power. This may be different from the allocation of generation in later years—unless 100% of a generator's capacity is under a long-term contract to a particular LSE, the set of retailers buying power may change year to year. Table 10 shows the total amount of added procurement originally attributable to IOUs, the total amount originally attributed to CCAs, and these values normalized to 2020 load size. Though CCAs claim a larger share of retail sales from renewable power, much of this turns out to be reallocated from resources originally procured on behalf of incumbent IOUs. Proportionately, CCAs are actually responsible for a smaller percentage of new renewable generation sources than IOUs are.

Table 10: Relative Procurement of Additional Renewable Generation Sources, 2010–2020

| | IOU | CCA |
|---|---|---|
| Procurement of New Resources, 2010–2020 | 14,997,935 | 5,281,521 |
| 2020 Load | 109,209,697 | 46,478,145 |
| New MWh/sold MWh | 0.14 | 0.11 |

The CPUC's publicly-available database of RPS projects includes a list of all long-term contracts signed by IOUs and CCAs through 2021. Long-term contracting is important because it gives greater certainty to renewable developers and is necessary for ensuring sufficient capacity into the future. Figure 6 shows annual cumulative long-term contract quantities signed by IOUs and CCAs respectively. Two key features stand out. First, the rate of total additional capacity under long-term contracts has remained relatively constant, regardless of the rising popularity of CCAs. Second, IOUs virtually stopped signing new long-term contracts in the latter half of the 2010s, instead shifting this responsibility to CCAs. This implies that CCAs do have sufficient capability to contribute to California's long-term contracting needs, but again this is offset by stagnation on the part of IOUs—a reallocation rather than an indication of additional progress.

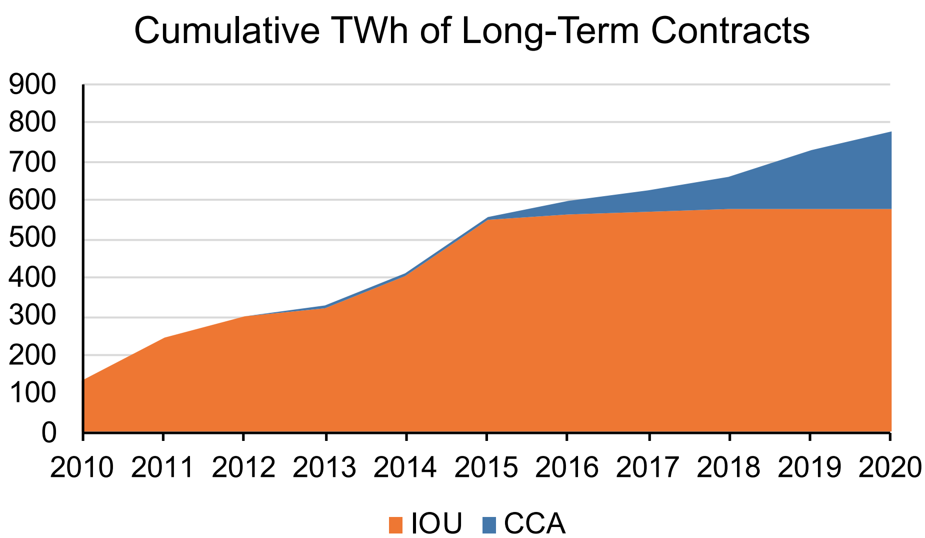


Figure 6: Trends in cumulative long-term contracts signed between 2010 and 2020 (TWh)

The same database can be used to assess how the length of time between initial contract signing and commencement of power delivery has evolved over time. The large time lags inherent to investing in new power generation infrastructure are a challenge for accurate forecasting, and delays create uncertainty around meeting short-term renewable deployment targets. Table 11 measures the average difference in years between the date of contract execution and the commercial online date for renewable generators under long-term contracts. CCAs bring new resources online more quickly than incumbents on average. This may be an indication of an important advantage. Even if additionality (in terms of total procurement, or total new procurement) is not evident, the ability to bring resources online sooner would be beneficial for project developers, LSEs, and state planners alike. However, Figure 7 shows declining time lags overall, so this may simply be a function of renewable technologies becoming more mature over time. And as noted in Figure 6, the onus of long-term contracting procurement shifted almost entirely from IOUs to CCAs, so there is little comparable data from IOUs in recent years. It remains unclear whether this is a structural advantage of CCAs or simply a reflection of technological improvements.

Table 11: Average time (years) between Contract Execution and Commercial Online Date for long-term contracts signed between 2010 and 2020

| **Overall Average** | **IOU Average** | **CCA Average** |
|---|---|---|
| 2.94 | 3.1 | 2.5 |

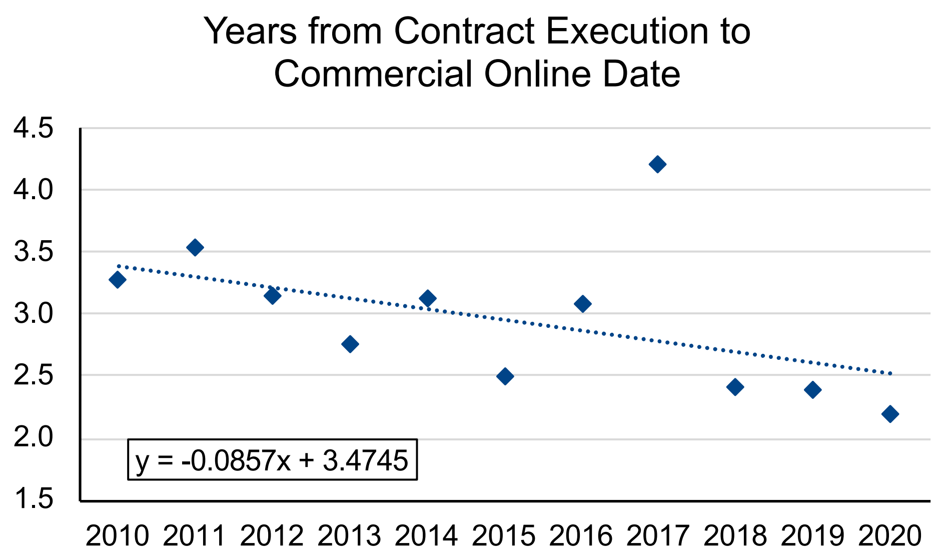


Figure 7: Trends in time delay between contract execution and commercial online dates (years)

## VII. Policy Implications and Discussion

California is attempting to achieve total decarbonization of its energy sector, with around 20 years to go. Overall numbers suggest that so far, we have been meeting our benchmarks and are on schedule. Disaggregating these numbers reveals a more complex picture. Despite the efforts of a select group of CCAs in procuring very high levels of renewable energy, the state on the whole is still hewing close to the RPS floor. Communities that have surged ahead in the race to decarbonize should be appropriately recognized for their achievement. However, the fact that these CCA gains occurred alongside undesirable indirect effects for IOU communities—and that such successes have generally not extended to less wealthy or small CCAs—needs to be recognized too.

Power purchases do not exactly reflect the physical realities of the grid. The actual mixture of power delivered at any single instance reflects real-time grid dispatch, which may be very different than what is contracted for. The physics of the power grid dictate that consumers cannot be selective about their electrons. Eventually, if California achieves a grid entirely powered by clean energy resources, then delivered power would indeed be carbon-free at all times. Currently, however, a customer who chooses a retail portfolio comprised of 100% renewable energy purchases is still actually receiving electricity generated by the same mixture of generators that serves everyone on California's grid. Thus, the impact of CCAs offering nominally high levels of renewable power procurement is much more modest in a physical grid sense if systemwide levels remain largely unchanged.

One motivation for forming CCAs was so communities could break away from the IOU, gaining the ability to make their own decisions over power procurement rather than being forced to take the IOU's default power offering. The findings about LSE size imply that scaling up does allow for improved technical capacity. Ironically then, one way for communities to unlock higher levels of renewable energy may be to band back together rather than fracture the retail space further.

Besides the scaling implications, the regression results suggest that the types of communities most likely to participate in voluntary greenness are well-matched with expectations: these portions of California tend to be wealthier and more politically in favor of environmental causes. Voluntary greenness may therefore be considered a successful mechanism in terms of facilitating the matching of consumers with higher preferences for green energy with higher percentages of green energy actually procured on their behalf. These patterns in voluntary green participation also imply that the remaining group is on average less wealthy with lower preference for greenness. Moreover, the very success of CCA growth can have important indirect effects on incumbents' behavior. This is clearly illustrated with the departure of CCAs from IOU service territories. IOUs have rationally clustered closer to the RPS floor, attenuating the overall value of CCAs' contributions to the grid. Despite a significant proportion of the state's customers taking service from a voluntary green portfolio, the resulting swell in renewable energy sales is not clearly additional relative to the rising statewide RPS floor.

## VIII. Conclusion

The evidence from California sheds light on tactics for enhancing the successful adoption of voluntary greenness as well as potential pitfalls that may weaken its efficacy. For other jurisdictions considering voluntary greenness as a mechanism for decarbonization, the findings impart three key lessons. First, the strategies employed by California's CCAs demonstrate that so-called voluntary greenness might better be thought of as "inattentively green." Active customer switching between default portfolios and voluntary green portfolios is small. Rather than offer opt-in green options, LSEs gained a large portion of customers participating in voluntary greenness by making their default offering a voluntary green portfolio and giving customers the choice to opt back down. Second, the communities most likely to pursue voluntary greenness share certain traits like high income and strong preferences for decarbonization. Voluntary greenness better reflects consumers' preferences by matching portfolios with more decarbonized energy to customers with high willingness to pay for decarbonization. Third, uptake of CCAs will also have important indirect effects on incumbent providers, which can undermine overall progress. Even in a setting such as California where CCAs serve one-fifth of load, this does not appear to have boosted statewide progress relative to simply enforcing an RPS minimum.

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