The Political Economy of Retail Electricity Decarbonization in California

Alison Ong[1]

July 25, 2024

Abstract

Environmental externalities are often addressed via command-and-control regulation, which imposes compliance-related costs. Yet firms subject to environmental regulation sometimes voluntarily overcomply with government mandates, often in anticipation of stricter standards or because they wish to promote a pro-environmental reputation. Such instances of voluntary self-regulation can collectively result in greater social benefits than mandates alone, but scrutiny is needed to ensure that these voluntary pledges are translating to real, additional reductions in environmental harm. I examine the efficacy of voluntary overcompliance in the context of electricity sector decarbonization: does offering customers choice in terms of the renewable energy content of their power portfolios act as an additional mechanism for decarbonization beyond renewable energy mandates?

A majority of US states have renewable portfolio standards (RPS), regulations that require minimum levels of renewable energy content for electricity providers; 37 states have utility green pricing programs that give customers the option of receiving higher renewable electricity levels. I study the case of California, which is notable for having both an aggressive RPS and a significant portion of customers taking service from retail plans that contain renewable energy levels in excess of the state's RPS. This is driven by the recent entry of Community Choice Aggregators (CCAs), publicly-owned retailers who procure power on behalf of their member cities, and who often tout environmentally-progressive reputations. California's CCAs sometimes set their default procurement portfolios to have higher renewable content than the state average, and they have the unusual feature of being opt-out rather than opt-in. I find that CCAs with high-renewable default portfolios give rise to a particularly 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 content of their power. Regression analysis demonstrates that this uptake of voluntary green procurement is correlated with community income and political support for environmental initiatives, indicating that CCAs improve matching between customer preferences and power procurement attributes.

However, even in a setting with anomalously strong levels of voluntary renewable energy overcompliance, the net effect does not clearly show additionality compared to California's existing RPS mandate. Though CCAs consistently outperform the RPS (with 12% more renewable energy than the RPS requires in 2021), stagnation or backsliding in other parts of the sector meant that the state average was actually 1% below the soft target of 35.75% in 2021. The high level of voluntary greenness exhibited by wealthier or larger CCAs does not translate to less wealthy or smaller CCAs. In addition, CCAs' elevated levels of renewable energy are mostly attributable to resources originally procured on behalf of other incumbents; relative to load size, CCAs fare no better than other types of retailers at adding new renewable generators to the system. The introduction and uptake of new "voluntary green" offerings for retail customers is not without promise, but institutional and regulatory factors may mitigate its ultimate effectiveness in furthering decarbonization goals.

---

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

I. Introduction

Decarbonizing the energy system will require generating electricity using low-carbon resources rather than fossil fuels. In order to advance environmental policy goals, policymakers often choose from several instruments and may simultaneously employ multiple approaches (Goulder and Parry 2008). Common mechanisms for advancing the transition to decarbonized electricity include regulatory mandates in the form of renewable portfolio standards (RPS), which impose minimum levels of renewable energy content for electricity providers (Barbose et al. 2016); using incentives or subsidies to stimulate investment (e.g., the Production Tax Credit/Investment Tax Credit); and increasing procurement via auctions (Haufe and Ehrhart 2018, Hastings-Simon et al. 2022). Besides changing the input costs of a good or mandating a minimum level of production, an increase in demand could serve as an additional market-based instrument to induce an increase in quantity supplied. These demand-side increases take the form of voluntary green power programs, which enable extra renewable energy purchases for consumers. Such schemes are increasingly popular, both in the US and in other liberalized electricity markets. 37 US states now offer optional utility green tariffs. In the UK, nearly every electricity supplier offers a green electricity tariff, and Australia's GreenPower program has grown to over 250,000 customers. In this paper, I study the introduction and strong uptake of voluntary green offerings for retail electricity customers in California to investigate the potential of voluntary mechanisms to significantly accelerate progress towards a decarbonized energy supply.

I provide evidence that retailer "value-add" with respect to decarbonization may be possible, but it can be undermined by institutional and regulatory barriers. I examine the case of California because it has imposed some of the most stringent decarbonization mandates in the world, but recent years have also seen the entry of several new retailers that often selectively procure power from clean energy sources. Structurally, California has a complex and rich setting to study variation in electricity procurement. Although retail competition is highly limited, the state has an unusually large proportion of customers purchasing electricity from portfolios containing renewable penetrations in excess of the state's RPS minimum. California infamously capped its efforts at introducing a competitive retail market in the midst of the 2001 energy crisis. However, it does not follow that the state currently has a small or homogenous set of retailers. There are nearly one hundred separate retailers in the state that vary greatly in size, type of service territory, scope of function, and clean energy content. Each retailer, or load-serving entity (LSE) must comply with California's RPS, meaning that the average clean energy content of the LSE's overall sales has to be at least as great as the RPS target in that compliance period. But the disaggregated portfolio offerings of LSEs actually vary in renewable content from 0% to 100%. The past decade has seen a large number of new entrants in the form of Community Choice Aggregators (CCAs), publicly-owned retailers who procure power on behalf of their member cities, and who often tout environmentally-progressive reputations. Compared to electricity institutions in other states, California's CCAs present a uniquely strong opportunity to observe the impact of a large increase in retail consumption of clean energy. Many CCAs create default procurement portfolios that have higher renewable content than the state average, and some offer portfolio options with 100% renewable energy. They 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 work studying California's CCAs has supported the idea that CCAs have procured more clean electricity than is required by California's renewable portfolio standard (Trumbull et al. 2019, 2020). In addition, some previous work 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).

The rise of CCAs could indicate evidence that voluntary greenness acts as a force for accelerated progress towards decarbonizing electricity supply. However, although the heterogeneity of electricity retailers is associated with variation in clean energy procurement, the net impact has not been a substantial hastening of progress towards economy-wide decarbonization. The analysis shows that even in a setting with strong societal support for decarbonization and widespread use of voluntary green portfolios, the resulting effect does not clearly show additionality compared to the rising RPS floor. This is for three reasons. Cracks in the RPS floor allowed instances of underperformance to persist; voluntary gains from high-performing entities were offset by a shedding of renewable contracts in other parts of the sector; and high performers had no effect on changing behavior positively for other entities in the sector due to lack of sufficient competition. Rather than encourage a faster transition to decarbonized energy, heterogeneity has apparently failed to help meaningfully advance progress.

A key goal of this study is to understand the relationship between existing regulations such as RPS mandates and voluntary actions in the form of additional consumer purchases of clean electricity. 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. This paper looks at the related but distinct area of electricity sector decarbonization. I explore the extent to which electricity retailers procure "voluntary green power," meaning levels of renewable energy purchases that exceed policy-mandated minimum percentages (Sumner et al. 2023), and whether this translates to meaningful additional decarbonization.

There is also a broader 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.

Electricity has long been thought of as a homogenous product. This is true in a physics sense, for the kilowatt-hours of energy a customer receives are functionally the same regardless of whether they are generated by burning coal or by spinning a wind turbine. Electricity is treated as a homogenous product in many economic settings as well. For example, electricity auctions are commonly modeled as multi-unit procurement of a homogenous good. The rationale for electricity deregulation has tended to focus on the ability of competition to put downward pressure on wholesale power prices rather than its potential to spur technological change at the wholesale level. But as addressing climate change has become an increasingly urgent priority, the types of fuel used for generating power have increasingly come under scrutiny (Borenstein and Bushnell 2015). For economic policy questions concerning electricity decarbonization, then, electricity may be better thought of as a heterogenous product, where kilowatt-hours of energy are differentiated by the type of fuel used to generate them. This work considers how such quality differentiation may have impacts for the larger electricity industry.

Generators supply the market; the generation sector is usually competitive and the system operator receives bids from a variety of fuel sources both renewable and nonrenewable. The quantity of electricity that each generator dispatches for consumption is also a function of retailer procurement on behalf of consumers. If enough customers choose retail plans that contain higher renewable content than the system average, the increase in demand for electricity that specifically comes from renewable sources could necessitate expanding the buildout and utilization of renewable generation. These 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 retail 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 necessarily the same thing as discussing retail competition.

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 retailers 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 theoretical explanations for retailer heterogeneity and voluntary overcompliance in this setting. Section III identifies the community characteristics associated with voluntary green procurement. Sections IV and V analyze additionality in terms of net renewables procured and improved investment in renewable generation respectively. Section VI discusses policy implications and Section VII concludes.

II. Theory/Background

A. Retailer Heterogeneity and Voluntary Overcompliance

Customer preferences, regulatory constraints, and budget constraints affect the composition of electricity retail portfolios, which implies variation between retailers even in noncompetitive settings. Under some conditions, this variation could lead to positive impacts in the wholesale provision of electricity.

Electricity can be thought of as three separate businesses: wholesale generation, network services (transmission and distribution), and retail sales of power. In systems with retail competition, multiple retailers compete for customers. In systems without any retail competition, the retailer is synonymous with the network utility and all customers purchase electricity from that firm (a single utility may offer multiple portfolio options). As transmission and distribution of electricity is considered to have natural monopoly characteristics, a typical electricity system is geographically divided into one or more utility service territories. Therefore, systems lacking retail competition may still contain multiple, noncompetitive retailers.

Electricity retail product offerings might become differentiated as a result of heterogeneous consumer preferences. This is an inherent feature of competitive settings, where retailers compete for customers by tailoring their marketing and product offerings according to consumers' preferences. In grids where multiple retailers exist but do not compete, consumer preferences are still likely to differ between (monopolistic) retailers. The service territories of utilities are geographically tied, and geographic sorting by socioeconomic status or identity group is common. The resulting regional variation, such as sensitivity to electricity price or preference for certain generation resources, impacts the retail product offerings available in that service territory. Prior studies have shown that consumers value several non-price attributes of retail electricity, ranging from discounts and sign-up bonuses to contract length to type of supplier to share of renewable energy (e.g., Goett et al. 2000, Amador et al. 2013, Ndebele et al. 2019). Consumers tend to exhibit a modest willingness to pay for greener electricity even in settings where the penetration of renewable energy is already large (Ndebele 2020). To my knowledge, this is the first study to connect such preferences for clean energy to a potential larger effect on the system supply of clean energy.

Binding regulatory requirements constrain the purchasing decisions of a retailer. Regulation dictates that a retailer who would prefer procuring very low levels of renewable energy must instead procure at least the minimum mandated quantity. But if regulatory constraints are unevenly applied—for example, if only some retailers receive exemptions for clean energy purchases—then this creates further differences in the feasible sets of product offerings for retailers. The particular language of the regulation also matters. California's RPS only mandates that each retailer's overall sales must contain a certain level of renewable energy, and this percentage is assessed as the average across each multi-year compliance period. California's RPS therefore allows for the possibility of noncompliance for some years and some portfolios within a given retail supplier's overall offerings.

Electric retailers also face different budget constraints, such as whether the retailer can achieve economies of scale in purchasing power, the retailer's technical capacity to navigate favorable power contracts, and the cost of borrowing money to finance operations. The retailer's load size and its structure (whether it is vertically integrated with the network utility and whether it is a public or private entity) have large impacts on these parameters. A retailer run by a municipality, for example, may have relatively less specialized expertise in power procurement but can borrow cheaply compared to a private firm. Or a certain utility may have exclusive access to a local hydroelectric facility, which leads to variation in the cost of power procurement.

The price and procurement strategies of retailers may therefore exhibit variation across several parameters including geographic region, size, status as a retail-only business vs vertically-integrated utility, and status as a public vs private entity. In the case of decarbonization, a retailer aggregating the interests of communities with a strong preference for clean energy might create a 100% renewable retail product for these customers, when they previously had no choice but to accept a dirtier default retail option from their utility. Sufficient demand for high levels of renewable procurement would signal the wholesale sector to increase production of renewable energy, encouraging a market-based rather than regulation-based approach to promoting decarbonization. However, identifying and selling to retail customers with high willingness to pay for clean energy is not itself a sufficient condition for spurring decarbonization. Demand for these premium green products may be too low to meaningfully incentivize greater clean energy production. Absent regulatory constraints, carving out areas with high preferences for clean energy may also imply the creation of retailers capturing customers with low preference for clean energy, resulting in a mere reshuffling of the existing clean energy pool. The existence of heterogenous retail portfolio offerings therefore only helps spur decarbonization if it is associated with net additionality in renewable generation.

B. California's Various Load-Serving Entities

Prior to California's experiments with deregulation in the 1990s, customers were generally served by either vertically integrated private utilities known as investor-owned utilities (IOUs) or vertically integrated, publicly owned utilities (POUs). When the state attempted to introduce retail competition, multiple private retail companies known as Direct Access Providers (DAPs) entered the market. The California energy crisis resulted in suspension of the Direct Access program. The decision was controversial, so a year later the legislature passed AB117. Rather than re-authorize competitive private suppliers of electricity, AB117 enabled local governments to become new participants in energy procurement by forming a community choice aggregator (CCA). CCAs are particularly notable in California for their rapid growth and high market penetration. The first operational CCA launched in 2010, and today over eleven million customers participate in a CCA. As some CCAs procure very high levels of renewable power, the emergence of these "leadership communities" may indicate a benefit to allowing the formation of new retailers.

As of 2021, there are 92 separate Load Serving Entities (LSEs) 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. 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 (MWh)	Percentage of Total Sales
CCA	25	50,635,122	21.3%
CO-OP	4	395,943	0.2%
DA	10	24,383,037	10.3%
IOU	6	102,732,588	43.2%
POU	47	59,723,829	25.1%
Total	92	237,870,520	100.0%

Figure 1: Major Structural Differences between LSE Types

	Vertically Integrated	Generation/Retail Only
Public	POU, Co-Op	CCA
Private	IOU	DAP

IOUs are private companies and regulated utilities, which used to be fully vertically integrated. Though deregulation in the 1990s forced the IOUs to largely divest from their generation holdings, IOUs 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 territory. There are three major IOUs (PG&E, SCE, and SDG&E) and three Small/Multijurisdiction Utilities (Bear Valley Electric Service, Liberty Calpeco, and Pacificorp). These latter three amount to ~1.5% of IOU load and are subject to special regulations as they sometimes also serve customers outside of California. CCAs are a relatively new type of electricity provider. CCAs may only arise within the existing service territory of an IOU, and they are public entities formed via Joint Powers Agreements (JPAs) between one or more cities or counties. A CCA then purchases power on behalf of the customers living in that geographic region, meaning that any given customer in an IOU service territory will see at most one CCA. Unlike traditional competitive retailers that must entice customers to switch from a default provider, CCAs in California are opt-out entities and therefore avoid the large marketing costs generally associated with successful startup of new retailers. POUs are often municipal utilities, where the city procures and retails power in addition to owning its own transmission and distribution infrastructure. Irrigation districts, which are a type of local government that primarily serves agricultural areas, and other special purpose districts, are also classified as POUs. However, such areas are organizationally and politically very different from municipal POUs that have a dedicated department to operating a local electric utility. DAPs are private companies that procure electricity and retail it to certain commercial and industrial customers. DAPs and CCAs share the characteristic that they acquire transmission and distribution from the IOU, with the main difference being a private versus public ownership model. Finally, a very small number of customers receive electricity from member-owned electric cooperatives (Co-Ops), which are often located in remote, rural areas. Like the small/multijurisdiction IOUs, Co-Ops sometimes operate in multiple states and constitute an insignificant portion of overall load. Co-Ops are excluded from the analysis for the remainder of the paper.

C. Clean Energy Policy 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." In the California regulatory context, *renewable* energy refers to biofuel, geothermal, eligible (small) hydro, solar, and wind. Nuclear and large hydro are zero-carbon resources but are not considered renewable due to environmental impact. The sum of renewable and this other zero-carbon generation is the total amount of *clean energy* procurement in each portfolio. In the empirical analysis, I measure LSE performance with respect to both renewable energy and total clean energy. The remaining possible types of specified procurement are 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." Unspecified power indicates the extent to which an LSE is buying off the short-term market rather than contracting for power. While the exact proportions of each fuel type contributing to 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." Thus, the primary driver for decarbonizing electricity in California is not to directly restrict construction or operation of fossil plants but rather to ratchet up the percentage of clean energy retail purchases, altering retailers' decisions and thereby indirectly stimulating greater investment in renewable generation. LSEs were required to achieve 33% renewable energy by 2020, and this will ratchet up to 60% by 2030. While this sounds clear, the RPS's particulars make assessing progress far from straightforward. The exact language of the 2030 target mandates 60% *renewable energy*, while the 2045 target mandates 100% *clean energy*. The percentages are assessed on a per LSE basis, such that a retailer could offer a 100% renewable product and an out-of-compliance product as long as the average proportion of renewable energy exceeded the RPS floor. Performance is assessed per multi-year compliance period (e.g., 2016–2020), so a retailer could be out-of-compliance for some of the years as long as the overall period average is sufficient. And crucially, RPS enforcement is not centralized under one agency. The POUs are regulated by the California Energy Commission (CEC) while IOUs, CCAs, and DAPs are regulated by the California Public Utilities Commission (CPUC). Although the wording of the RPS implies that every LSE should individually meet the minimum standard, differences in the way the CEC and CPUC implement regulations may help explain why LSE performance is far from uniform.

D. Regulation Under the CPUC

The RPS came into effect in 2002 with an initial target of 20% renewable energy, which each of the three major IOUs met years ahead of schedule. Thus, voluntary overcompliance has actually been a feature of this setting even before significant entry from CCAs. Consistent with the literature, overcompliance signaled that standards could be tightened, and RPS targets were subsequently revised upwards and accelerated multiple times. 33% renewable energy was required by 2020, but this value jumps to 44% by the end of 2024. IOUs, CCAs, and DAPs are all subject to the same percentage-based requirements and fall under CPUC jurisdiction.

Starting with the current (2021–2024) compliance period, the CPUC also imposed an additional criterion that at least 65% of procurement must be executed via long-term contracts. IOUs are decades old and have experience and financial infrastructure to sign long-term contracts. This requirement is more difficult to satisfy for CCAs and DAPs. CCAs are newer and often lean organizations that in many cases have struggled to get credit ratings. DAPs face a unique set of challenges. The DAP program was suspended after the California Energy Crisis in 2000–2001, and the total load that DAPs can serve is strictly capped. It is difficult for DAPs to add new customers, but the threat of losing customers is very real. DAP customers are commercial and industrial loads, which tend to be more price-sensitive and attentive than residential consumers. In addition, customer commitments to DAPs are on the order of just one to two years. These structural realities make DAP load forecasting uncertain. Consequently, DAPs have tended to buy most of their power on the short-term market, so the majority of their sales are ascribed to unspecified power. This translates to difficulty in fulfilling their RPS and long-term contracting obligations. According to a recent CPUC staff report, which refers to the DAPs as electric service providers or ESPs: "while the ESPs were forecasted to be in compliance on average, compliance verification indicates that only 7 of 14 ESPs were considered to be on track to meet their 2017-2020 compliance period requirements, while eleven ESPs are considered high risk in not meeting their 2021-2024 requirements. Three ESPs failed to meet RPS compliance period 2014-2016 compliance requirements." The outlook for meeting long-term contracting requirements by 2024 looks similarly bleak, as "of the twelve ESPs that forecast serving load in the 2021-2024 compliance period, three ESPs are forecasted to have procured enough long-term RPS energy, seven have procured some long-term RPS energy, and two have not procured any long-term RPS energy to meet the 65 percent requirement." This report was written in 2020. However, perhaps as an indication of the difficulties in maintaining the DAP business model, by the end of 2021 the total number of DAPs serving load had already dropped to ten.

E. Differing Regulation for POUs

Between the inception of the RPS and the passage of SBX1-2 in 2011, POUs were not subject to state regulatory oversight. POUs were instead simply directed to implement and enforce their own renewable energy purchase programs. Evidence suggests that many POUs had taken efforts to also achieve 20% renewable energy by 2013. But enforcement was not formalized under a state agency until CEC (not CPUC) regulation of POUs began in 2013. In recognition of this different timeline, the RPS trajectory for POUs was set at 20% by 2013, 20% by 2016, and 33% by 2020 (The CPUC set interim targets for the LSEs within its jurisdiction of 20% renewable by 2013, 25% by end of 2016, and 33% by 2020.). POUs were therefore only expected to procure similar proportions of renewable energy as their IOU/CCA/DAP counterparts starting in 2020. Going forward, the targets are the same for all LSEs (meaning in the eight years between 2016 and 2024, the compliance floor for POUs nearly doubles from 20% to 44%).

The CEC regulatory code for POU RPS enforcement enumerates multiple exemptions and allowances that are specifically granted to POUs. Perhaps most significantly, the early development of POUs was often driven by access to hydroelectric resources for irrigation and power production. Large hydroelectric power is generally not considered a renewable resource under CPUC definitions. However, the CEC version of the RPS enforcement guidelines states that if most of the POU's electric load is served by certain hydro generators (e.g., legacy hydro, certain eligible facilities) then under some circumstances POUs can count that hydro as "renewable" and in others they can subtract it from their total procurement obligation. Several POUs own or have very long-term contracts with other legacy forms of generation as well, particularly coal and gas peaking plants. In the current 2021–2024 RPS compliance period, POUs that can prove they are unable to feasibly exit legacy coal contracts are allowed to reduce their RPS procurement target by a certain amount that accounts for this unavoidable coal generation. Similarly, for future RPS periods, there are provisions for POUs that own gas peakers to be able to slightly reduce their RPS procurement targets. While these may be defensible concessions in the context of the economic and institutional realities that POUs face, they also undermine pure decarbonization objectives.

The CEC also acknowledges that, because POUs may own network infrastructure, there may be exceptional circumstances that prevent a POU from meeting each RPS deadline. POUs can claim a "delay of timely compliance" for multiple reasons, including inadequate transmission capacity, permitting/interconnection delays, and unanticipated increase in retail sales due to transportation electrification. In short, all the major supply-side and demand-side challenges to achieving a high RPS can be argued as exceptions for POU noncompliance. POUs are also allowed to argue that the cost of meeting RPS procurement exceeds a cost limitation that the POU itself determines will cause disproportionate rate impacts.

The regulations dictating that all retailers should eventually achieve 100% clean energy-powered electricity might seem uniformly applied, but closer inspection reveals unevenness in several important regards. RPS compliance was first enforced for LSEs under CPUC jurisdiction, and then only later did it also apply to POUs. The particulars about which resources count towards or against each LSE's procurement obligation differ depending on the regulatory authority. And extensions or exceptions are granted to only certain types of LSEs, which is justified based on the utility's obligations besides retailing.

Faced with a slightly different set of rules, and certainly a different set of constraints based on institutional histories, the various groups of LSEs are likely to take divergent approaches to procurement. Due to such institutional differences, it is also plausible that factors explaining the success of some LSEs in procuring decarbonized energy may not translate over to other groups of LSEs.

III. Regression Analysis

I conduct regressions to look at the defining characteristics that might be associated with an LSE's performance in procuring decarbonized fuel. I assess performance outcomes with respect to both renewable energy and total clean energy.

A. Data

In most cases, a single LSE is the default provider for a set of cities, towns, or counties. Because the unit of observation is one of these communities, data were collected for each city, town, and unincorporated community in each county (n = 539). The regressors are therefore assessed at this community level.

Data were compiled for 18 parameters describing socioeconomic, demographic, and other characteristics of each community. Regression tables contain a subset of these variables, as covariates that did not improve the explanatory power of the regression were removed. Table 2 lists the variables that are used in the regressions and their sources, while Table 3 lists summary statistics. The variables that are used to test for ideological sorting are four measures of the political preferences of citizens: two indicators of general political ideology (party identification and vote share for Donald Trump in 2020), and two indicators of relevant policy preferences as measured by votes on ballot propositions (one that would have disfavored public provision of electricity and another that would have suspended California's cap-and-trade program for controlling GHG emissions). The variables that test for socioeconomic sorting are median income and measures of educational attainment. Variables that potentially affect the demand for electricity, besides income, are measures of the structure of the local economy (shares of agriculture and manufacturing) and local climate (winter and summer temperatures). Indicators that the community might perceive a benefit from a CCA that purchased power locally are megawatts of power production from nearby photovoltaic and hydro installations. I also add an indicator for communities that are not in either PG&E or SCE's original service territory. The politics of the other four IOUs (SDG&E and the three small utilities) are more likely to be dominated by a single city or county, whereas PG&E and SCE have service territories that include many large political jurisdictions.

Table 2: Community Characteristics: Names, Descriptions, Units of Measurement

Variable Name	Description	Units
med_income[1]	Median household income	$100,000's
pct_white[1]	Percentage identifying as non-Latino White	%
pct_asian[1]	Percentage identifying as Asian	%
pct_some_college[1]	Percentage with at least a high school diploma, some college but no bachelor's	%
pct_bachelors[1]	Percentage with at least a bachelor's)	%
pct_democrat[2]	Percentage registered with Democratic Party	%
population[1]	Population size	Million people
med_age[1]	Median age	Decades
pct_yes_prop_16[2]	Voting Yes on Prop 16, a ballot measure where yes indicated opposition to local/public power	%
pct_yes_prop_23[2]	Voting Yes on Prop 23, a ballot measure that would have suspended AB 32	%
pct_trump[2]	Vote for Donald Trump in the 2020 presidential election	%
pct_manufacturing[1]	Manufacturing share of employment	%
pct_agri[1]	Agricultural share of employment	%
hydro[4]	Hydro production within same county	MW
pv[4]	PV production within same city/county	MW
temp_jan[3]	Average temperature in January	Tens of Degrees Fahrenheit
temp_aug[3]	Average temperature in August	Tens of Degrees Fahrenheit
lse_size[5]	LSE size	Billion MWh sales in 2020
not_PGE_SCE	Indicates if the community is outside PG&E or SCE's original service territories	Binary indicator

Notes to Table 2.

[1] Data for income, race, education, age, population, and employment category come from ACS 5-year tables, 2020 vintage. Census data was pulled with Place (i.e., city/town/CDP) as the granularity, so all CDPs in a given county were aggregated to yield a single value for the unincorporated county.

[2] Data for political party affiliation, presidential vote, vote on Prop 16, and vote on Prop 23 come from the CA Secretary of State's database. These report a single value for the unincorporated counties so no additional mapping was needed. There were six entries missing for Prop 16 (mostly unincorporated counties), so those entries were dropped from the dataset.

[3] Temperature data comes from NOAA Monthly Temperature Normals (1980–2010). Weather stations were matched to cities where this mapping was straightforward (taking simple averages where multiple stations serviced the same city). Otherwise, for smaller cities/towns, the county average value was simply applied.

[4] Local hydro and local PV production come from the CEC arcGIS (https://cecgis-

caenergy.opendata.arcgis.com/) and CEC Energy Almanac (https://www.energy.ca.gov/data-reports/energy-almanac/data-renewable-energy-markets-and-resources). For PV, all CEC-registered solar plants were mapped to the city or unincorporated county where they are physically located. For hydro, all cities within a given county were assigned the value of total hydro production in that county.

[5] Finally, LSE size is based on the total MWh of retail sales for that LSE in 2020, which was calculated by summing up sales across all portfolios offered by each LSE as reported in the 2020 Power Source Disclosure filings. This variable is only used for the regression analyses concerning renewable and carbon-free procurement. It is not included in the logit regression about CCA membership, since the size of a community's LSE is clearly dependent on whether it formed a CCA or not.

Table 3: New Version of Summary Statistics - CCAs, IOUs, and POUs

Statistic	N	Mean	St. Dev.	Min	Max
med_income	539	0.849	0.418	0.256	2.500
pct_white	539	0.448	0.248	0.009	0.899
pct_asian	539	0.110	0.137	0.000	0.690
pct_some_college	539	0.513	0.141	0.109	0.840
pct_bachelors	539	0.331	0.207	0.010	0.876
pct_democrat	539	0.433	0.116	0.155	0.745
population	539	0.069	0.203	0.0002	3.973
med_age	539	3.929	0.747	2.320	7.530
pct_yes_prop_16	533	0.491	0.106	0.059	0.811
pct_yes_prop_23	538	0.407	0.110	0.075	0.662
pct_trump	539	0.349	0.154	0.040	0.801
pct_manufacturing	539	0.083	0.039	0.000	0.233
pct_agri	539	0.046	0.090	0.000	0.636
hydro	539	0.499	0.816	0.000	2.594
pv	539	0.027	0.168	0.000	2.717
temp_jan	539	4.922	0.557	2.748	5.980
temp_aug	539	7.345	0.639	5.690	9.480
lse_size	523	0.026	0.023	0.00002	0.059

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.

B. Methodology

In the regressions, the outcome variable of interest is the percentage of a certain type of energy (renewable energy or overall clean energy) in each LSE’s portfolio. The renewable energy regression takes the form:

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

where each i is an LSE 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 the regression analysis is to assess which community characteristics are important determinants of clean energy procurement, and whether those characteristics have differing effects depending on the type of LSE the community belongs to. The analysis therefore encompasses the IOUs, POUs, and CCAs, which have geographic service territories that can be approximately 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.

C. Regression Results

The significance and magnitude of regression coefficients may differ between the IOU, CCA, and POU groups. Taken separately, the IOU, CCA, and POU groups would each have a small N relative to the number of potential variables in the regression. In order to still detect differences in procurement for communities in each of the three groups, I create indicator variables for each group, interact these with each covariate in turn, and conduct a Wald test to assess whether the equations pool. The results of this pooling exercise are shown in Table 4 and Table 5. Entries in these tables represent the probability that coefficients between two of the groups are equal, which would indicate that they come from the same underlying distribution. Small values with statistical significance indicate that the data cannot be pooled. That is, the form of the LSE, whether IOU, POU, or CCA, matters in governing the relationship between community characteristics and proportion of renewables (or clean energy) procured. The POU and CCA equations for renewable energy appear to pool, but are distinct from the IOU group; all three groups appear distinct across some of the variables for the total clean energy regressions.

Table 4: Probability that the difference between the coefficients for the two groups is indistinguishable from zero (for the pct_renewable regressions)

parameter name (i)	Pr(> χ^2) for test " $\beta_{i,CCA} - \beta_{i,IOU} = 0$"	Pr(>χ^2) for test "$\beta_{i,POU} - \beta_{i,IOU} = 0$"	Pr(>χ^2) for test "$\beta_{i,CCA} - \beta_{i,POU} = 0$"
med_income	6.66E-05 ***	0.023 *	0.646
pct_white	0.542	0.292	0.517
pct_asian	0.241	0.255	0.070 .
pct_some_college	1.19E-04 ***	0.062 .	0.663
pct_bachelors	9.62E-05 ***	0.016 *	0.963
pct_democrat	0.021 *	0.977	0.123
population	0.868	0.571	0.651
med_age	0.025 *	0.986	0.292
pct_yes_prop_16	0.815	0.246	0.293
pct_yes_prop_23	0.015 *	0.929	0.066 .
pct_trump	7.63E-04 ***	0.311	0.151
pct_manufacturing	0.096 .	0.911	0.151
pct_agri	0.587	0.361	0.629
hydro	8.39E-03 **	0.600	0.272
pv	0.072 .	0.588	0.070 .
temp_jan	1.30E-05 ***	1.44E-03 **	0.346
temp_aug	0.209	0.937	0.299
lse_size	2.59E-21 ***	0.018 *	5.48E-03 **

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 5: Probability that the difference between the coefficients for the two groups is indistinguishable from zero (for the pct_clean_energy regressions)

parameter name (i)	$Pr(> \chi^2)$ for test " $\beta_{i,CCA} - \beta_{i,IOU} = 0$"	$Pr(>\chi^2)$ for test "$\beta_{i,POU} - \beta_{i,IOU} = 0$"	$Pr(>\chi^2)$ for test "$\beta_{i,CCA} - \beta_{i,POU} = 0$"
med_income	9.19E-05 ***	0.524	0.243
pct_white	0.718	5.19E-09 ***	1.10E-07 ***
pct_asian	0.217	9.34E-03 **	8.86E-04 ***
pct_some_college	6.87E-05 ***	0.260	4.18E-04 ***
pct_bachelors	1.02E-04 ***	0.090 .	0.517
pct_democrat	6.47E-04 ***	6.52E-04 ***	4.13E-08 ***
population	0.297	0.743	0.322
med_age	0.037 *	5.68E-03 **	0.101
pct_yes_prop_16	0.112	0.260	0.963
pct_yes_prop_23	6.08E-05 ***	0.197	3.37E-05 ***
pct_trump	1.54E-05 ***	0.010 *	6.10E-08 ***
pct_manufacturing	0.890	0.068 .	0.063 .
pct_agri	0.923	0.515	0.605
hydro	2.18E-03 **	0.461	0.247
pv	0.022 *	0.873	0.060 .
temp_jan	0.010 **	0.312	4.37E-03 **
temp_aug	6.70E-04 ***	0.035 *	0.276
lse_size	7.02E-03 **	8.14E-07 ***	4.62E-03 **

The previous exercise only informs us where coefficients significantly differ from one another across the three groups, but it does not give us information about the magnitude or significance of the coefficients themselves. I fit a generalized linear model and perform a simple model selection procedure to discard any coefficients that lack statistical significance. The models are shown in Tables 6 and 7 below, with the pooled data for comparison to show that fit improves when the groupings are considered. Note that in the unpooled model, the coefficient indicates the difference between groups. For example, the med_income.IOU coefficient actually indicates the quantity $\beta_{income,IOU} - \beta_{income,[CCA\ or\ POU]}$.

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 6: 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

Table 7: Percent Clean Energy Regression Coefficients, Pooled vs Unpooled

	Pooled	Unpooled
med_income	0.059**	
	(0.024)	
med_income.CCA		0.106***
		(0.021)
pct_white	−0.002	
	(0.040)	
pct_white.POU		0.889***
		(0.136)
pct_asian	−0.146**	−0.103**
	(0.068)	(0.045)
pct_yes_prop_23	−0.059	
	(0.104)	
pct_yes_prop_23.POU		1.185***
		(0.415)
pct_trump	−0.125*	−0.058
	(0.068)	(0.049)
pct_trump.CCA		−0.495***
		(0.100)
pct_trump.POU		−0.928***
		(0.340)
hydro	−0.026***	
	(0.010)	
hydro.CCA		−0.133***
		(0.019)
temp_jan	−0.066***	0.055***
	(0.017)	(0.014)
lse_size	−5.740***	−17.083***
	(0.456)	(0.815)
lse_size.CCA		20.569***
		(4.038)
lse_size.POU		32.929***
		(5.261)
not_PGE_SCE	−0.407***	−0.958***
	(0.025)	(0.038)
is_POU		−0.487***
		(0.116)
is_CCA		−0.555***
		(0.057)
Constant	1.255***	1.195***
	(0.092)	(0.057)
Observations	523	523
Log Likelihood	189.577	348.086
Akaike Inf. Crit.	−359.154	−664.172
Note:	*p<0.1; **p<0.05; ***p<0.01	

3

IV. Power Source Disclosure Analysis

A. Data and Methodology

The data used primarily 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." These compliance documents are filed by all operational LSEs each year. PSD filings through 2020 were obtained via data requests to the CEC. Each document contains information on MWh procured from each generation source and total retail sales. 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 8 indicates how many LSEs of each type filed PSD documents in a given year. Over the five-year period examined, the number of CCAs has more than doubled, while the number of DAPs has decreased by nearly a third.

Table 8: Number of LSEs with PSD filings by year

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

Source: CEC Power Source Disclosure program

The PSD data support the idea that types and relative quantities of power resources will be qualitatively different depending on whether the LSE is an IOU, POU, CCA, or DAP. Table 9 shows notable differences in the amounts of clean energy procurement, with the CCA group outpacing other types of LSEs. There are also differences in the extent to which each LSE type relies on specified fossil procurements versus unspecified power to satisfy the balance of its retail sales (Figure 2 plots 2021 values in bar chart form to make qualitative differences more evident). These dynamics will be explored further in the next sections.

Table 9: Electricity Sources Aggregated by Type

		Renewable	Other Carbon-Free	Carbon	Unspecified	Total
CCA	2017	51%	35%	1%	12%	100%
	2018	49%	34%	3%	14%	100%
	2019	50%	31%	0%	19%	100%
	2020	50%	30%	0%	19%	100%
	2021	48%	29%	0%	24%	100%
IOU	2017	31%	26%	23%	20%	100%
	2018	36%	23%	18%	23%	100%
	2019	33%	32%	12%	24%	100%
	2020	31%	24%	17%	28%	100%
	2021	38%	20%	19%	22%	100%
POU	2017	28%	19%	41%	12%	100%
	2018	29%	14%	41%	15%	100%
	2019	31%	25%	36%	8%	100%
	2020	34%	22%	34%	10%	100%
	2021	34%	19%	38%	9%	100%
DAP	2017	31%	5%	0%	64%	100%
	2018	26%	4%	0%	70%	100%
	2019	30%	1%	0%	69%	100%
	2020	21%	0%	0%	79%	100%
	2021	23%	10%	0%	66%	100%

Source: CEC Power Source Disclosure program

Note: Unspecified power is treated as a separate category from renewable energy and carbon-free energy, regardless of how much renewable/carbon-free energy contributed to system power throughout the year.

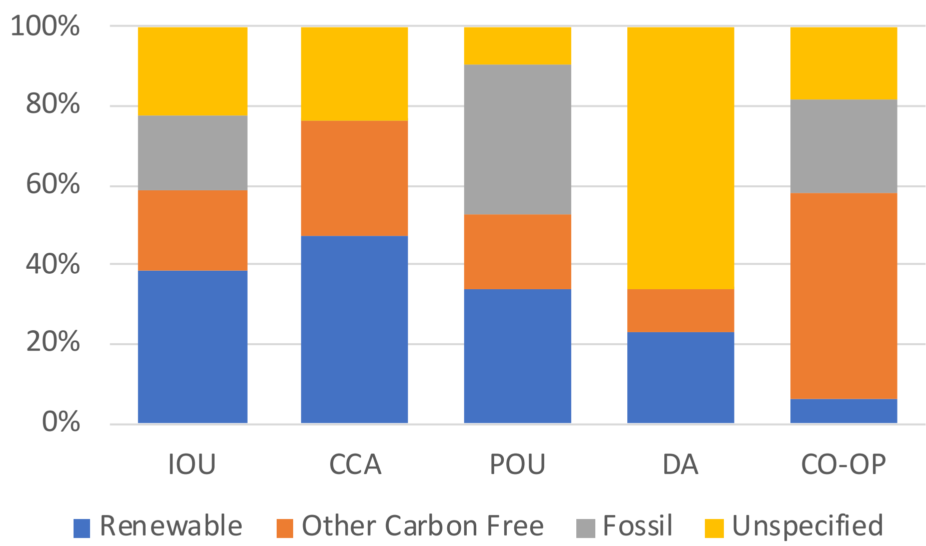

Figure 2: breakdown of power by category for each LSE type, 2021 data

B. Quantifying Voluntary Green Participation

As noted above, 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). In California, green "opt-up" options exist for some POUs, one DAP, and nearly all IOUs and CCAs. This translates to approximately 83% of statewide load having access to a voluntary green rate.

Table 10: 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 11: 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 11.

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.

C. Impacts on System-Wide Performance

I assess progress both in terms of procurement amounts (TWh) and as percentages. Significant renewable buildout has occurred in recent years, but Table 12a indicates that between 2017 and 2021 there has been no clear upward trend in total sales of renewable energy. It should be noted that total sales of electricity in California were moderately declining during this time frame. This may be due to factors such as continued improvements in energy efficiency, deployment of behind-the-meter energy resources, or declines in California's overall population and number of large commercial/industrial loads. On a percentage basis, then, there have been year-on-year increases in statewide electricity sales from renewable resources (Table 12b). However, the introduction of large-scale mandates around building and vehicle electrification will require much higher electricity usage in the coming decades, so sustaining future progress will depend on large increases in renewable energy purchases.

Disaggregating renewable energy procurement by LSE category reveals that the trends for each LSE group look very different from one another. While TWh procurement from POUs and DAPs has been quite flat, IOU procurement generally fell and CCA procurement increased. On a percentage basis, the CCAs appear to consistently outperform other types of LSEs; DAPs appear to be falling increasingly behind. The dynamics between IOUs and CCAs are discussed further in Section D. Table 12c restates LSE procurement as percentages relative to the annual RPS target in that year, making clear that CCAs are the only group to exceed mandated levels.

As no new hydroelectric or nuclear projects have been built in recent years, unsurprisingly Table 13a is qualitatively similar to Table 12a, showing roughly constant levels of clean energy purchases over the period of analysis. On a percentage basis, there is an even more evident stratification between CCAs as high performers, IOUs and POUs in the middle, and DAPs as consistent underperformers.

Table 12a: Annual renewable resource procurement by LSE type (MWh)

	2017	2018	2019	2020	2021
Total CCA	6,247,745	12,092,281	21,285,299	23,241,477	24,126,662
Total IOU	50,419,513	51,838,946	36,584,678	33,791,541	39,135,568
Total POU	17,537,270	18,188,537	18,426,213	20,150,899	20,209,191
Total DA	5,715,686	6,297,761	5,918,025	6,752,559	5,670,671
Combined	79,920,213	88,422,454	82,214,215	83,936,477	89,142,092

Table 12b: Annual renewable procurement by LSE type (%)

	2017	2018	2019	2020	2021
Total CCA	51%	49%	50%	50%	48%
Total IOU	31%	36%	33%	31%	39%
Total POU	28%	29%	31%	34%	34%
Total DA	31%	26%	30%	29%	23%
State Avg.	29%	31%	32%	33%	34%
RPS Level	27%	29%	31%	33%	35.75%

Table 12c: Annual renewable procurement by LSE type relative to RPS target (%)

	2017	2018	2019	2020	2021
Total CCA	+24%	+20%	+19%	+17%	+12%
Total IOU	+4%	+7%	+2%	–2%	+3%
Total POU	+1%	0%	0%	+1%	–2%
Total DA	+4%	–3%	–1%	–4%	–12%

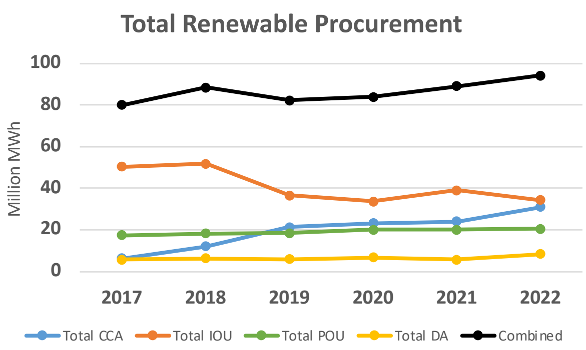

Figure 3a: Trends in renewable resource procurement by LSE type (million MWh)

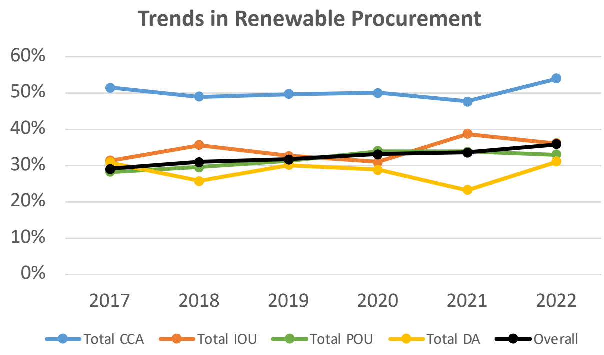

Figure 3b: Trends in renewable procurement by LSE type (%)

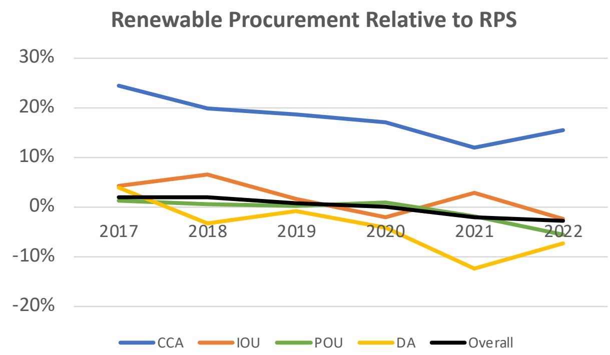

Figure 3c: Trends in renewable procurement by LSE type relative to RPS target (%)

Table 13a: Annual clean energy procurement by LSE type (MWh)

	2017	2018	2019	2020	2021
Total CCA	10,524,521	20,492,313	34,545,878	37,330,285	38,641,554
Total IOU	91,766,531	85,161,843	72,203,218	59,940,920	60,164,765
Total POU	26,417,479	27,003,394	32,877,335	33,213,188	31,359,478
Total DA	6,642,081	7,245,296	6,018,408	6,752,559	8,217,959
Combined	135,350,611	139,902,847	145,644,838	137,236,952	138,383,755

Table 13b: Annual clean energy procurement by LSE type (%)

	2017	2018	2019	2020	2021
Total CCA	87%	83%	81%	80%	76%
Total IOU	57%	58%	64%	55%	59%
Total POU	48%	44%	56%	56%	53%
Total DA	36%	30%	31%	29%	34%
Combined	53%	51%	55%	55%	52%

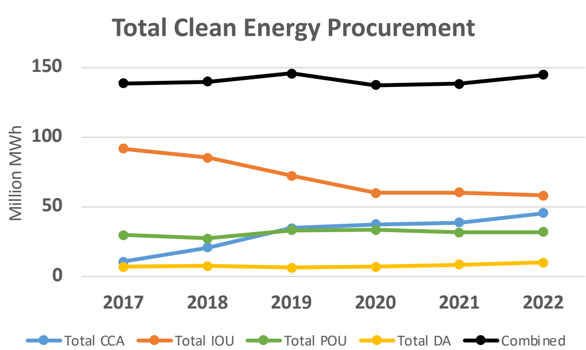

Figure 4a: Trends in clean energy procurement by LSE type (million MWh)

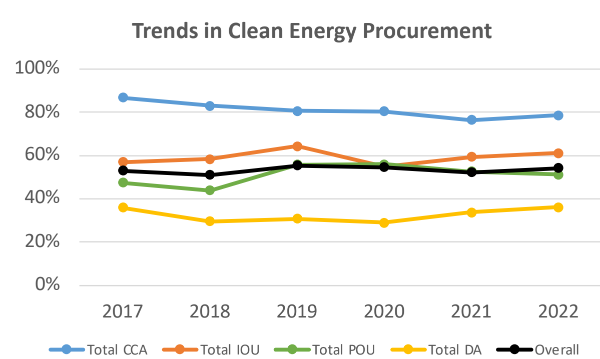

Figure 4b: Trends in clean energy procurement by LSE type (%)

D. IOU and CCA Trends

During the time period analyzed, POU and DAP performance remained fairly unchanged. While the combined effect of IOUs and CCAs was also relatively constant, this is because IOU procurement of renewables declined while CCA procurement increased.

The required minimum amount of renewable energy for each LSE is a percentage-based standard. Once load departs an IOU in favor of a CCA, an IOU continuing to hold all its existing contracts would be overprocured. Jettisoning contracts with carbon-emitting generators would inflate the relative percentage coming from clean power; jettisoning a portion of its renewable contracts could allow an IOU to still be above the state-mandated floor but would decrease its MWh of renewable procurement. Indeed, I observe that after customers left IOUs for CCAs, in subsequent years IOUs decreased their levels of renewable procurement, which also reduced their percentage of retail sales supplied by renewable resources. In fact, although CCAs consistently increased provision of renewable energy during 2017–2020, these increases were more than offset by the fall in renewable procurement by IOUs. The trend appeared to change in 2021, when IOUs procured more renewables and drove up overall state levels, but IOU procurement resumed its decline in 2022.

In addition to the difference between IOUs and CCAs in overall renewable procurement, individual CCAs also differ substantially in the share of renewables in their electricity supply. The regression modeling implies that there are both strong income and scaling effects. I separate the CCA group into two equal, smaller groups according to median income (here labeled as "rich" and "poor"). 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 Tables 12 and 13, except now I further disaggregate the CCA category into rich and poor, and large and small. Both stratifications show a significant difference between the two groups in renewable procurement.

Wealthier CCAs have indeed achieved high voluntary renewable procurement, although their renewable share has declined substantially since 2017. Meanwhile, in 2021 less wealthy CCAs procured a lower fraction of renewable electricity than the average of the three big IOUs, and this group's share of renewables in procurement is steadily declining. 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. In 2021, small CCAs had a lower renewable share than any other LSE type except for DAPs. Tracing trends in the level of renewable procurement relative to the RPS floor (Table 14b) shows that larger and wealthier CCAs succeed in voluntarily procuring renewables in excess of state requirements. However, levels of voluntary greenness have eroded for smaller or less wealthy CCAs, which now procure levels of renewables close to the RPS floor.

These data have troubling implications regarding the future of CCAs. IOUs have made gains in renewable procurement, at least on a percentage basis, while some CCAs have stagnated or even regressed. Moreover, the gap between large/wealthy and smaller/poorer CCAs is growing, and the latter are losing ground to the IOUs as suppliers of electricity from renewable sources. As a result, many CCA customers receive less green electricity than the IOU that serves their community. The results indicate that 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 outperform its IOU and POU counterparts.

Table 14a: Trends in Renewable Procurement
for High versus Low Income, and Large versus Small, CCAs

	2017	2018	2019	2020	2021
Poor CCAs	44%	41%	39%	39%	38%
Rich CCAs	55%	52%	52%	53%	50%
Small CCAs	40%	40%	35%	37%	31%
Large CCAs	53%	50%	51%	51%	50%
IOU average	31%	36%	33%	31%	39%
POU average	28%	29%	31%	34%	34%
DA average	31%	26%	30%	29%	23%

Table 14b: Trends in Renewable Procurement Relative to the RPS
for High versus Low Income, and Large versus Small, CCAs

	2017	2018	2019	2020	2021
Poor CCAs	+17%	+12%	+8%	+6%	+2%
Rich CCAs	+28%	+23%	+21%	+20%	+14%
Small CCAs	+13%	+11%	+4%	+4%	–5%
Large CCAs	+26%	+21%	+20%	+18%	+14%
IOU average	+4%	+7%	+2%	–2%	+3%
POU average	+1%	0%	0%	+1%	–2%
DA average	+4%	–3%	–1%	–4%	–12%

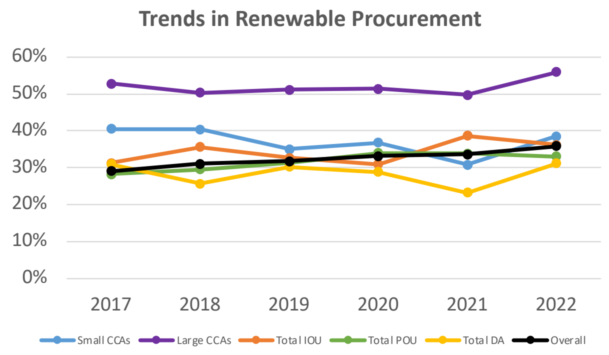

Figure 5a: Total renewable procurement, large vs small CCAs

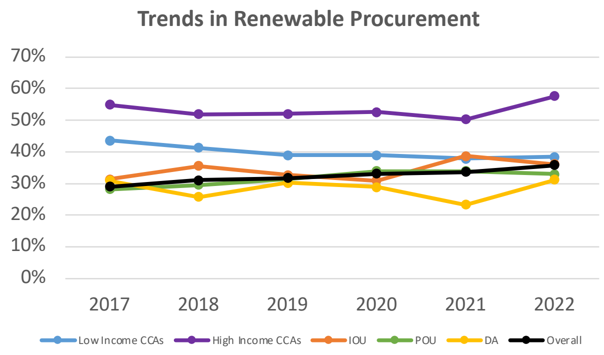

Figure 5b: Total renewable procurement, high vs low income CCAs

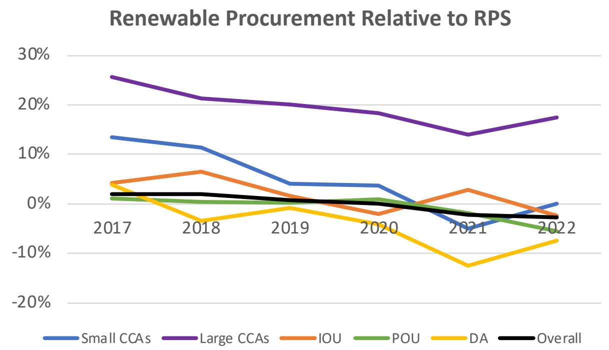

Figure 5c: Procurement relative to RPS, large vs small CCAs

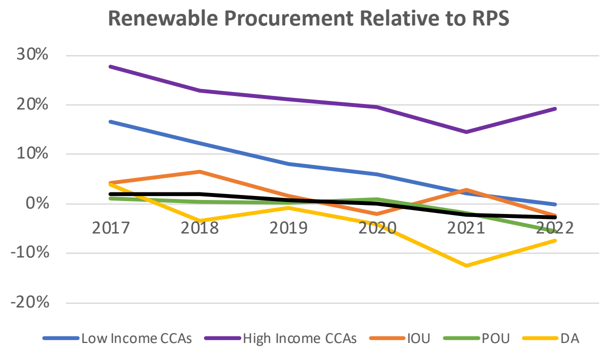

Figure 5d: Procurement relative to RPS, high vs low income CCAs

The issue extends to considerations of overall clean energy levels as well. When summing renewables and other carbon-free sources to yield total clean energy procurement, the gap between small and large CCAs persists. Here, IOUs are consistently at or above the clean energy levels that small CCAs offer. Poorer CCAs have significant levels of large hydro (and some nuclear) procurement, such that in 2018 and 2019 they are actually cleaner than either rich CCAs or IOUs (despite declining levels of renewable procurement during the same time period), but this appears to have been a temporary gain.

Table 15: Trends in Clean Energy Procurement for High versus Low Income, and Large versus Small, CCAs

	2017	2018	2019	2020	2021
Poor CCAs	76%	87%	89%	80%	57%
Rich CCAs	91%	81%	79%	80%	81%
Small CCAs	56%	57%	57%	55%	47%
Large CCAs	90%	87%	83%	83%	80%
IOU average	57%	58%	64%	55%	59%
POU average	48%	44%	56%	56%	53%
DA average	36%	30%	31%	29%	34%

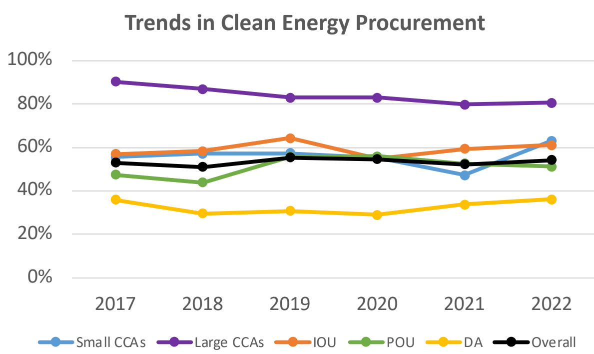

Figure 6a: Total clean energy procurement, large vs small CCAs

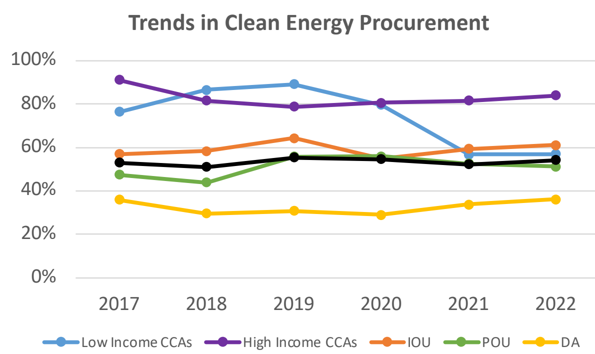

Figure 6b: Total clean energy procurement, high vs low income CCAs

E. Fossil Fuel Procurement

Fossil generation refers to coal, natural gas, and residual amounts of other sources such as fuel oil or diesel. I have so far emphasized progress with respect to the type of power the state wants more of—clean energy—but have not touched upon the distribution of the remaining carbon-emitting resources. I find that a majority of the specified fossil fuel procurement in California resides with the POUs. Nearly all specified coal generation is from POUs (Table 16a). About half of the total MWh from natural gas generation is from POUs and the other half is from IOUs (Table 16b). As POUs serve 25% of total load and IOUs serve 43%, POUs are therefore responsible for a disproportionate amount of gas-powered electricity sales. Even if CCAs and IOUs became entirely powered by clean energy, there may still be significant amounts of fossil fuel used to generate power in California. Combined with the exceptions for POU legacy fossil contracts mentioned in Section II, these investments may constrain the speed and extent to which California achieves meaningful deep decarbonization of the power sector.

Table 16a: Specified coal procurements in 2021

LSE Type	MWh Procured	Percentage
IOU	370,671	5.6%
CCA	-	0.0%
POU	6,257,613	94.1%
DA	-	0.0%
CO-OP	19,266	0.3%

Table 16b: Specified natural gas procurements in 2021

LSE Type	MWh Procured	Percentage
IOU	18,953,048	53.4%
CCA	-	0.0%
POU	16,470,537	46.4%
DA	-	0.0%
CO-OP	73,885	0.2%

V. 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 affect expansion of 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 do seek out new sources of procurement to a larger extent than IOUs do, then they may demonstrate an additional dimension to voluntary overcompliance: responsibility for increasing the total capacity of the system. 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, because 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 17 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 renewable procurement in terms of raw MWh sold, 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 17: 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 7 shows cumulative totals of MW long-term contracts signed by IOUs and CCAs respectively by year since 2010, when CCAs entered the market. 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.

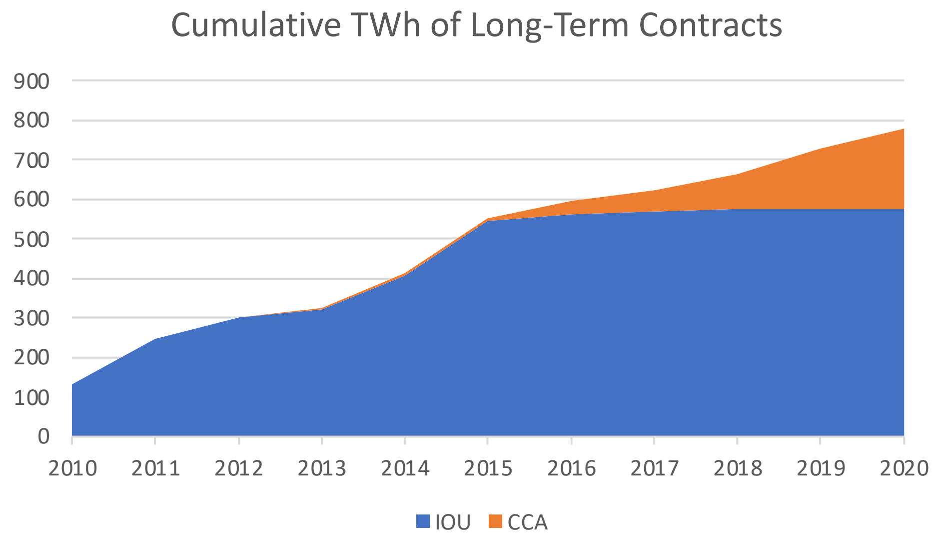

Figure 7: Trends in cumulative long-term contracts signed between 2010 and 2020 (TWh)

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 18 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 8 shows that the overall trend is for the time lag to decrease as renewable technologies have become more mature over time. And as noted in Figure 7, the onus of long-term contracting procurement shifted almost entirely from IOUs to CCAs. As the lack of comparable data make formal analysis difficult, it remains unclear whether this is a structural advantage of CCAs or simply a reflection of a time trend.

Table 18: 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

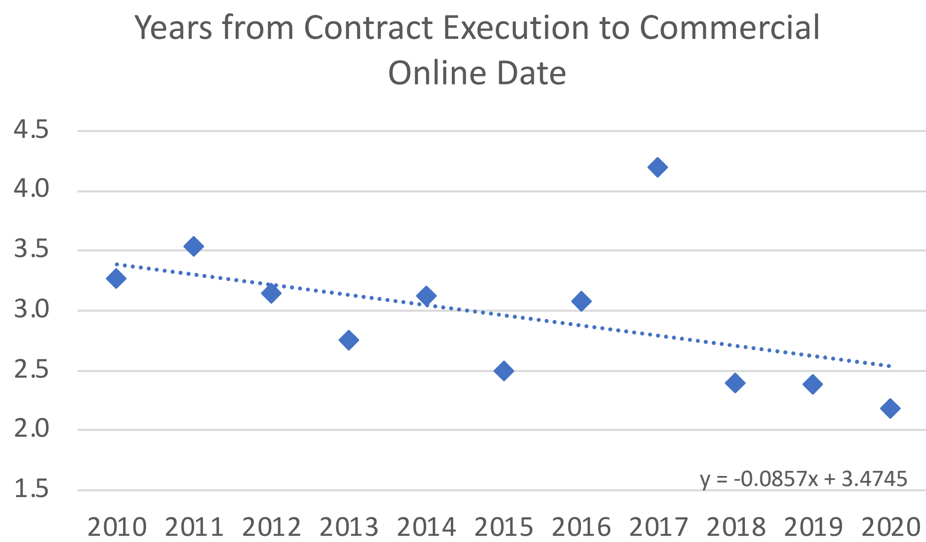

Figure 8: Trends in time delay between contract execution and commercial online dates (years)

VI. Policy Implications and Discussion

California is attempting to achieve total decarbonization of its energy sector, with just over 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. Not all retailers in the state have been keeping pace. And 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. In the next decade, the necessary rate of progress will dramatically ramp up. Retailers had to manage a 13% increase over seven years (20% in 2013 to 33% in 2020), which some struggled to meet. Now they face a 27% increase in ten years (33% in 2020 to 60% by 2030), with the additional imposition of long-term contracting requirements. In the same timeframe, electricity demand is going to drastically increase, as California transitions from petroleum-fueled cars and natural gas-fueled homes to electrified options. Given such significant structural changes, we cannot speculate about the exact trajectories of each LSE. But is not a large stretch to suppose that if we see some groups struggle to meet state standards now, intervention may be needed to avoid more severe problems with noncompliance later on. 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.

It is important to note that power purchases do not exactly reflect the physical realities of the grid. Procurement data tend to reflect annual accounting. But 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. However, these patterns in voluntary green participation also imply that the remaining group is on average less wealthy with lower preference for greenness. This is clearly illustrated with the departure of CCAs from incumbent IOU service territories. Given that their median customer now has relatively lower willingness to pay for voluntary greenness, IOUs will rationally cluster closer to the RPS floor, attenuating the overall value of voluntary greenness 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.

VII. 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 and some of its POUs 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. Instead of treating electricity as a homogenous good, voluntary greenness better reflects consumers' preferences by matching portfolios with more decarbonized energy to customers with high willingness to pay for decarbonization. Third, this matching also implies changes in procurement strategies for retailers serving customers with low interest in voluntary greenness, which can undermine overall progress. Even with a large number of customers defaulted onto voluntary green service, such efforts may not be as effective as simply enforcing a renewable portfolio standard. This does not suggest that voluntary greenness lacks promise: as long as it is implemented with an understanding of potential larger system impacts, it can still be a significant policy instrument. It may be particularly effective in cases where there are political frictions to passing larger, sweeping policies like a state- or federal-level RPS, but where there are nonetheless local communities with strong preferences for decarbonization.

References

Amador, Francisco Javier, Rosa Marina González, and Francisco Javier Ramos-Real. "Supplier Choice and WTP for Electricity Attributes in an Emerging Market: The Role of Perceived Past Experience, Environmental Concern and Energy Saving Behavior." *Energy Economics* 40 (November 2013): 953–66. https://doi.org/10.1016/j.eneco.2013.06.007.

Arora, Seema, and Shubhashis Gangopadhyay. "Toward a Theoretical Model of Voluntary Overcompliance." *Journal of Economic Behavior & Organization* 28, no. 3 (December 1995): 289–309. https://doi.org/10.1016/0167-2681(95)00037-2.

Barbose, Galen, Ryan Wiser, Jenny Heeter, Trieu Mai, Lori Bird, Mark Bolinger, Alberta Carpenter, et al. "A Retrospective Analysis of Benefits and Impacts of U.S. Renewable Portfolio Standards." *Energy Policy* 96 (September 2016): 645–60. https://doi.org/10.1016/j.enpol.2016.06.035.

Borenstein, Severin, and James Bushnell. "The U.S. Electricity Industry After 20 Years of Restructuring." Cambridge, MA: National Bureau of Economic Research, April 2015. https://doi.org/10.3386/w21113.

Borenstein, Severin, and Ryan Kellogg. "Carbon Pricing, Clean Electricity Standards, and Clean Electricity Subsidies on the Path to Zero Emissions." Cambridge, MA: National Bureau of Economic Research, July 2022. https://doi.org/10.3386/w30263.

DeShazo, JR, Julien Gattaciecca, and Trumbull, Kelly. "The Growth in Community Choice Aggregation: Impacts to California's Grid." Next 10, July 2018.

Duchin, Ran, Janet Gao, and Qiping Xu. "Sustainability or Greenwashing: Evidence from the Asset Market for Industrial Pollution." *SSRN Electronic Journal*, 2022. https://doi.org/10.2139/ssrn.4095885.

Fowlie, Meredith. "Emissions Trading, Electricity Restructuring, and Investment in Pollution Abatement." *American Economic Review* 100, no. 3 (June 1, 2010): 837–69. https://doi.org/10.1257/aer.100.3.837.

Goett, Andrew A., Kathleen Hudson, and Kenneth E. Train. "Customers' Choice Among Retail Energy Suppliers: The Willingness-to-Pay for Service Attributes." *The Energy Journal* 21, no. 4 (October 2000): 1–28. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol21-No4-1.

Goulder, Lawrence H., and Ian W. H. Parry. "Instrument Choice in Environmental Policy." *Review of Environmental Economics and Policy* 2, no. 2 (July 1, 2008): 152–74. https://doi.org/10.1093/reep/ren005.

Gunther, Stephen J., and David Bernell. "Challenging the System: The Role of Community Choice Aggregation in California's Transition to a Renewable Energy Future." *The Electricity Journal* 32, no. 10 (December 2019): 106679. https://doi.org/10.1016/j.tej.2019.106679.

Hastings-Simon, Sara, Andrew Leach, Blake Shaffer, and Tim Weis. "Alberta's Renewable Electricity Program: Design, Results, and Lessons Learned." *Energy Policy* 171 (December 2022): 113266. https://doi.org/10.1016/j.enpol.2022.113266.

Haufe, Marie-Christin, and Karl-Martin Ehrhart. “Auctions for Renewable Energy Support – Suitability, Design, and First Lessons Learned.” *Energy Policy* 121 (October 2018): 217–24. https://doi.org/10.1016/j.enpol.2018.06.027.

Hess, David J. “Coalitions, Framing, and the Politics of Energy Transitions: Local Democracy and Community Choice in California.” *Energy Research & Social Science* 50 (April 2019): 38–50. https://doi.org/10.1016/j.erss.2018.11.013.

Holland, Stephen, Erin Mansur, and Andrew Yates. “Decarbonization and Electrification in the Long Run.” Cambridge, MA: National Bureau of Economic Research, May 2022. https://doi.org/10.3386/w30082.

Hortaçsu, Ali, Seyed Ali Madanizadeh, and Steven L. Puller. “Power to Choose? An Analysis of Consumer Inertia in the Residential Electricity Market.” *American Economic Journal: Economic Policy* 9, no. 4 (November 1, 2017): 192–226. https://doi.org/10.1257/pol.20150235.

Hsueh, Lily. “Voluntary Climate Action and Credible Regulatory Threat: Evidence from the Carbon Disclosure Project.” *Journal of Regulatory Economics* 56, no. 2–3 (December 2019): 188–225. https://doi.org/10.1007/s11149-019-09390-z.

Joskow, Paul L. “Markets for Power in the United States: An Interim Assessment,” n.d., 36.

———. “Why Do We Need Electricity Retailers?; Or, Can You Get It Cheaper Wholesale?” MIT-CEEPR. MIT Center for Energy and Environmental Policy Research, 2000. http://hdl.handle.net/1721.1/44965.

Khanna, Madhu. “Non-Mandatory Approaches to Environmental Protection.” *Journal of Economic Surveys* 15, no. 3 (July 2001): 291–324. https://doi.org/10.1111/1467-6419.00141.

Littlechild, Stephen. “The Evolution of Competitive Retail Electricity Markets.” In *Handbook on Electricity Markets*, edited by Jean-Michel Glachant, Paul L. Joskow, and Michael G. Pollitt. Edward Elgar Publishing, 2021. https://doi.org/10.4337/9781788979955.00011.

———. “Why We Need Electricity Retailers: A Reply to Joskow on Wholesale Spot Price Pass-Through.” Research Papers in Management Studies. University of Cambridge, August 22, 2000. https://www.jbs.cam.ac.uk/wp-content/uploads/2020/12/wp0021.pdf.

Ndebele, Tom. “Assessing the Potential for Consumer-Driven Renewable Energy Development in Deregulated Electricity Markets Dominated by Renewables.” *Energy Policy* 136 (January 2020): 111057. https://doi.org/10.1016/j.enpol.2019.111057.

Ndebele, Tom, Dan Marsh, and Riccardo Scarpa. “Consumer Switching in Retail Electricity Markets: Is Price All That Matters?” *Energy Economics* 83 (September 2019): 88–103. https://doi.org/10.1016/j.eneco.2019.06.012.

Su, Xuejuan. “Have Customers Benefited from Electricity Retail Competition?” *Journal of Regulatory Economics* 47, no. 2 (April 2015): 146–82. https://doi.org/10.1007/s11149-014-9263-x.

Sumner, Jenny, Eric O’Shaughnessy, Sushmita Jena, and Jesse Carey. “Status and Trends in the U.S. Voluntary Green Power Market (2021 Data).” Golden, CO: NREL, 2023. https://www.nrel.gov/docs/fy23osti/86162.pdf.

Tirole, Jean, and Jean-Jacques Laffont. "A Note on Environmental Innovation." *Working Papers MIT Department of Economics*, 1994.

Trumbull, Kelly, JR DeShazo, Julien Gattaciecca, Colleen Callahan, and Michelle Einstein. "The Rapid Growth of Community Choice Energy and Its Acceleration of Renewable Energy: A California Case Study." Working Paper. UCLA Luskin Center for Innovation, November 6, 2019.

Trumbull, Kelly, Julien Gattaciecca, and J R DeShazo. "The Role of Community Choice Aggregators in Advancing Clean Energy Transitions:" UCLA Luskin Center for Innovation, October 2020.