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Rebate Influence on Electric Vehicle Adoption in California

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Executive Summary

California offers cash rebates for the purchase or lease of new electric vehicles (EVs). Important questions include: "How influential have state rebates been at encouraging EV adoption?" and "How has rebate influence varied over time, by vehicle type and price, by rebate type, and by consumer income?" We examine data characterizing 376,772 consumers, including 72,552 survey responses statistically weighted for representativeness. "*Rebate Essentiality*"—the percent of consumers who would not have purchased/leased their EV without the rebate—increased to a high of 57% in the 2016–17 edition of the survey and remained above 50% until 2020. As expected during the onset of COVID, *Rebate Essentiality* decreased in 2020, but primarily for Tesla vehicles (31%). It remained relatively high for plug-in hybrid EVs (47%) and non-Tesla battery EVs (50%), and for lower-income recipients of the Increased Rebate (66%). Findings guide strategies to cost-effectively support emission reduction and EV market growth.

Keywords: demand, electric vehicle (EV), incentive, policy, state government.

1 Introduction

Since March 2010, the California Air Resources Board's Clean Vehicle Rebate Program (CVRP) has issued post-purchase cash rebates for the purchase or lease of a new light-duty electric vehicle (EV) [1]. Evaluation of program impacts depends on an understanding of how effective the state rebate has been at influencing consumers to adopt EVs. For example, an understanding of rebate influence helps differentiate estimates of the emissions saved by all rebated vehicles (i.e., emissions reductions "associated with the program") from those saved specifically by those consumers most highly influenced by the rebate to acquire an EV (i.e., reductions "attributable to the program") [2], [3]. Further, patterns in rebate influence [4], [5] and the factors associated with it [6]–[8] highlight where to target program design, outreach, and other resources in order to cost-effectively amplify EV adoption. This work aims to update and expand the understanding of both the level of rebate influence and patterns in rebate influence across time, vehicle type and price, rebate type, and consumer income.

Prior examinations of EV purchase incentives in the literature examined their importance to, or magnitude of effect on, EV markets. A literature review of 35 studies through January 2017 [9] found, "Due to the abundance of literature using diverse methodologies this literature review can confidently state that PEV incentives are an effective policy measure in increasing PEV sales" (p. 1110). It categorizes the findings and provides recommendations for incentive design. Subsequently, analyses continue to grow in number and include, for example, early works by Jenn et al. [10] and Narassimhan and Johnson [11]. They used fixed-effects regression on databases of U.S. vehicle registrations spanning 2008–2016 to quantify the effect of various factors, including state incentives, on adoption. A more modest body of research characterizes those consumers who were most highly influenced to buy an EV (e.g., [7], [8], [12], [13]). In 2016, Tal and Nicholas [12] examined the influence of the U.S. federal tax credit on consumers, the majority of which acquired a Tesla Model S or Nissan LEAF in 2013. In 2019, Sherlock [13] examined 2016 tax records to characterize the income of recipients of the federal tax credit for EVs. Starting in 2016, Johnson, Williams, and Anderson [6]–[8], [14] used one of the consumer-provided indicators of rebate influence examined herein ("*Rebate Essentiality*") but focused on characterizing those highly influenced consumers rather than examining trends in *Rebate Essentiality* as a metric of influence. Additional discussion of the incentive literature and its findings relative to another, similar characterization of consumers most highly influenced by the federal tax credit is available in an EVS35 paper [15].

Here, we utilize survey data provided directly from a large number of rebated consumers to examine measures of rebate influence across a wide variety of EV purchases/leases rebated by the State of California spanning September 2012–2020. We focus on 2020 purchases/leases (the most recent data available and previously unexamined). We aim to enrich thinking about program design and cost-effectiveness, as well as to support assessment of program impacts, by providing a more recent examination of the influence of rebates and highlighting trends. These inform ways to target rebates away from program free riders and towards those most influenced by rebates to adopt.

2 Data & Approach

We examine consumers rebated by the State of California for purchases or leases of battery and plug-in hybrid EVs ranging from September 2012 through the end of 2020—with an emphasis on 2020 and trends that lead up to it. *All* rebate recipients are invited to take CVRP's Consumer Survey *after* being approved for a rebate. Additional survey-administration details are available online (e.g., [16]). A total of 72,552 survey responses were weighted by survey edition to represent over 376,000 program participants along the dimensions of model, vehicle technology (namely, plug-in hybrid EV [PHEV] and battery EV [BEV]), buy vs. lease, and county (Table 1). Year of acquisition was also used to weight the 2017–2020 survey edition. Further, to represent the most recent market analyzed, a dataset of 4,331 survey responses from roughly 26,500 consumers rebated for January–November 2020 purchases/leases was also separately weighted. Regardless of the dimensions used, weighting typically changed results only modestly. This is a positive sign for validity, though biases (e.g., non-response and response biases) can always remain within representative proportions.

Table 1: CVRP data analyzed (shows rebates to individuals for plug-in EVs only)

	2013–2015 Edition	2015–2016 Edition	2016–2017 Edition	2017–2020 Edition	2018 purchases/ leases subset	2019 purchases/ leases subset	"2020" purchases/ leases subset
Vehicle Purchase/ Lease Dates	Sep. 2012 – May 2015	April 2015– May 2016	May 2016 – May 2017	June 2017 – Nov.* 2020	Jan. 2018 – Dec. 2018	Jan. 2019 – Dec. 2019	Jan. 2020 – ***Nov.**** 2020
Survey Responses (total *n*)	19,460	11,611	8,957	32,524	14,757	8,991	4,331
Program Population (*N*)**	91,100	45,700	46,800	193,200	78,600 (filtered subset of weighted Edition)	61,300 (filtered subset of weighted Edition)	26,500

* ~8k 2020 purchases/leases were invited to respond to a new survey edition and are not represented in these data.
** Small numbers of rebated vehicles are not represented in the time frames due to application lags. Rounded to nearest 100.

Additionally, program features and market dynamics are examined and discussed in Section 3.1 to provide important context for interpreting these weighted descriptive statistical characterizations of incentive influence—particularly those characterizing 2020, which saw the onset of COVID-19.

3 Results & Discussion

3.1 Program & Market Context

Program features that likely had a major effect on the program's rebate-influence metrics include CVRP's cap on household income and Increased Rebate for lower-income consumers, implemented starting in 2016 and described in [17]. Additionally, a $60,000 cap on the manufacturer's suggested retail price (MSRP) and a decrease in the amount of the Standard Rebate to historic lows ($2,000 per BEV and $1,000 per PHEV) were implemented in December 2019. Further details are available in a brief characterizing program details over time [17], as well as in a presentation that is the primary precursor to this paper (which contains additional analysis not described within the space limitations herein) [18]. In addition to program design, important market dynamics to keep in mind include the disruptive release of Tesla's Models 3 & Y in mid-2018 and the onset of COVID-19 in early 2020.

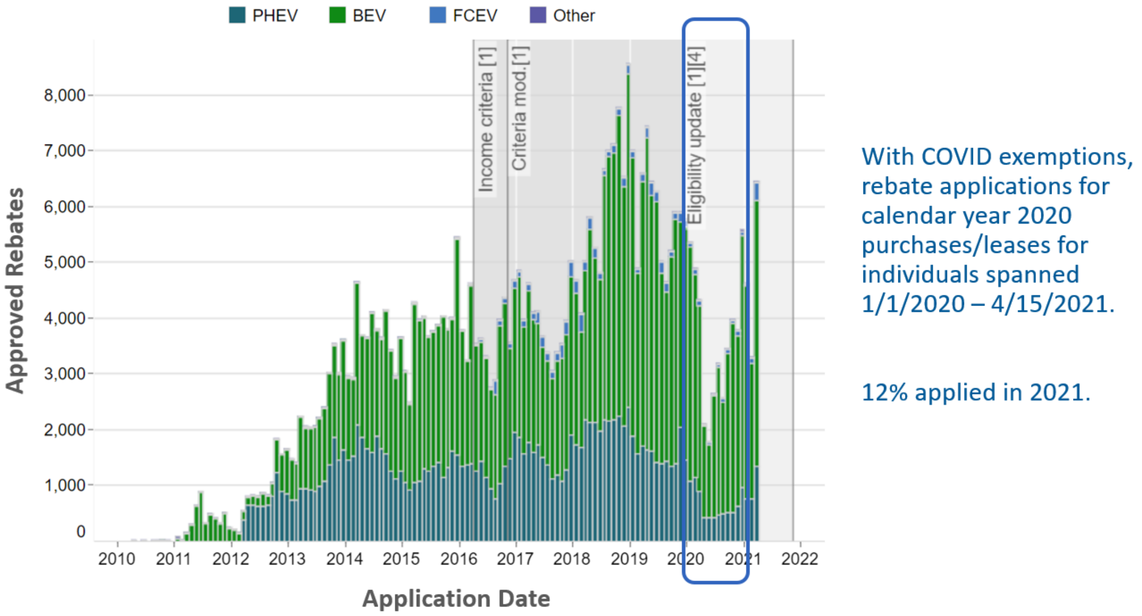


Figure 1: 2020 Results/trends should be interpreted with caution (COVID); applications saw dramatic decline but significant recovery

Figure 1 (adapted from [19]) illustrates the impact of COVID-19 on the program. During 2019 and into 2020, application demand was sliding slowly down the backside of the mountain created by the release of the Model 3 when it fell off a cliff, like most economic activity, due to COVID. Subsequently, significant (but by no means complete) recovery occurred even within 2020, resembling the shape and magnitude of applications in 2013. However, questions remain around the composition of consumers in the new-car and EV markets in 2020 and how that composition differed from years prior and hence (e.g., who was in a position to risk rejoining the vehicle market in the early months of COVID, who needed to acquire a car during 2020 and chose a new EV, etc.).

3.2 The Importance of the Rebate as an Enabling Factor

The first of two metrics of rebate influence analyzed is the importance of the rebate specifically in the context of enabling the EV purchase/lease (Fig. 2). The statistically representative weighted responses indicate that eighty-two percent of consumers receiving rebates for EVs purchased/leased in 2020 rated the rebate "moderately important," "very important," or "extremely important," in "making it possible for you to acquire your clean vehicle."

Collectively, these consumers are referred to as "*Rebate Important*" consumers. The six percent that rated the rebate "not at all important" (dubbed "confessed free riders") and 12% that rated the rebate "slightly important" are together considered "*Rebate Unimportant*." Rebate Importance decreased from 89% in 2019, with the largest decrease resulting from a 48% to 36% decrease in the consumers who rated the rebate "extremely important" (Fig. 2). This might be expected, were the consumers who were able to participate in the market during the first year of COVID largely those with a greater sense of financial and other security.

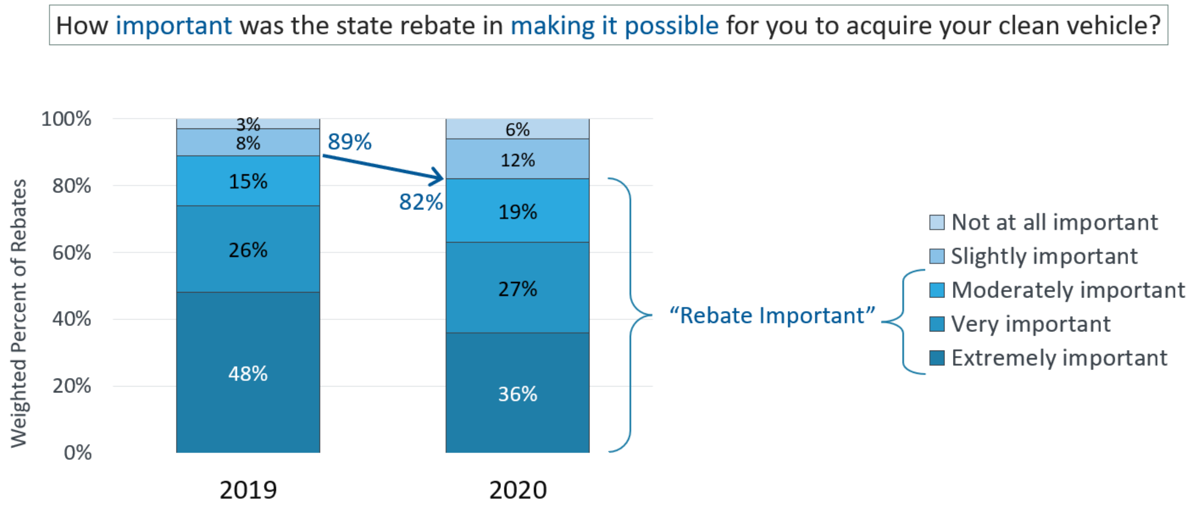


Figure 2: Rebate Importance: 2019 and 2020 purchases/leases

3.3 Rebate Essentiality

Rebate "Importance" is presented for context and because it has proven relatively robust in revealing interesting trends across multiple states (as has a similar metric for the federal tax credit [15]). Nevertheless, "Importance" is a factor that confounds the impact of the rebate with other EV enablers in ways that are unique to each individual. A more direct, more counterfactual metric less subject to interpretation biases is "*Rebate Essentiality*" [6]–[8], which is based upon the question: "Would you have purchased/leased your [clean vehicle] without the state rebate?" Those answering simply "no" are categorized as *Rebate Essential*. This metric provides a clearer and more conservative metric of program impact than other candidate measures. While *Rebate-Essential* program participants are not free riders, it is not necessarily the case that *all other* participants *are* free riders. For example, 73% of non-*Rebate-Essential* respondents reportedly found the rebate at least moderately important in making it possible for them to acquire their EV (20% extremely, 27% very, and 27% moderately important).

Program-wide, *Rebate Essentiality* increased over time from a low of 46% during the 2013–15 edition of the CVRP Consumer Survey to a high of 57% for the 2016–17 edition. This is consistent with the expansion of the program beyond early EV enthusiasts to more skeptical, more mainstream consumers [6]. *Rebate Essentiality* fell for 2018 purchases/leases to 50%, but increased again for 2019 to 52% (a modest increase but statistically significant [$p < 0.05$]). This possibly indicates ongoing expansion into the mainstream, but at a *Rebate Essentiality* level now set by more intrinsically attractive and/or higher-priced products, such as the Tesla Model 3 and its competitors. For 2020 purchases/leases, which amounted to roughly 59% of 2019 levels, *Rebate Essentiality* decreased markedly to an average of 38%. Overall, it is perhaps expected that the influence of the rebate would be lower to those consumers that were able to participate in the market during the onset of COVID, but the decline from 2019 to 2020 was much more dramatic for Tesla vehicles (from 49% to 31%) than for non-Tesla vehicles (55% to 49%), as seen in Figure 3.

Figure 3 is also consistent with the story of an EV market that initially had pent-up demand by enthusiastic early adopters of EVs, reflected in initially lower overall rebate influence that *increased* rather than decreased over time as less enthusiastic, more skeptical and more mainstream adopters entered the market [6], [20]. This trend, supported by statistical analysis by Jenn et al. in the interim [21], is in contrast to the paradigm typically applied to solar and other clean technologies—one that assumes, as volumes for a widget increase over time, incentives can be phased down accordingly. This paradigm has been discussed by the authors as an inappropriate paradigm for the EV market for two reasons. First, it focuses on cost reductions, ignoring the heterogeneity of consumers entering the market over time (e.g., those entering later are typically the type of consumer that has both greater need and greater need of convincing—and thus larger not smaller incentives). Second, it implicitly assumes cost reductions will be passed on to consumers, but stable or even increasing *prices* have been observed in the EV market [22], [23] and can be explained by automakers reinvesting any *cost* savings per kilowatt-hour due to battery learning and experience curves into things other than reduced prices (e.g., increasing EV range, paying for R&D, reducing cross-subsidization of EVs across vehicle platforms, etc.).

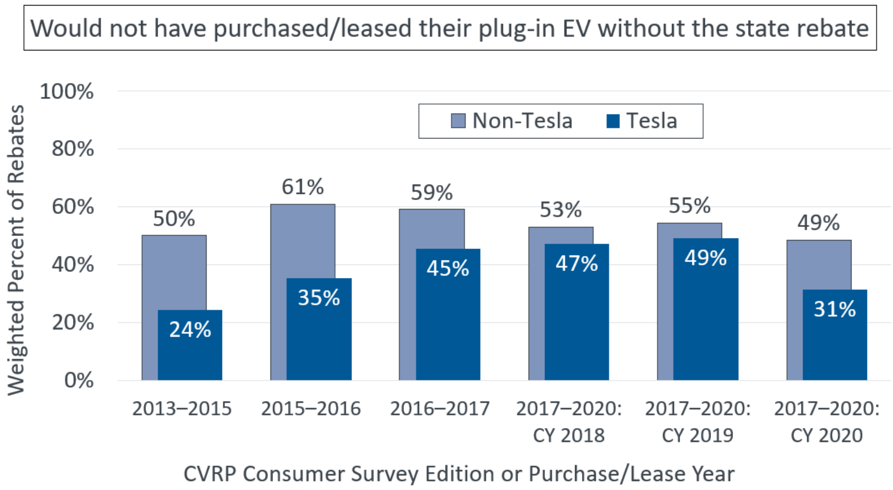


Figure 3: *Rebate Essentiality* over time: Tesla's effect

This trend of increasing rebate influence over time as more mainstream consumers enter the EV market is illustrated even more dramatically in the context of Tesla's early business model. Initial vehicles had very high prices and were targeted at high-income consumers. Over time, vehicles decreased in price and increased in variety, opening the market to a wider array of consumers, consistent with an increasing frequency of *Rebate Essential* consumers over time—until the dramatic uncertainties of COVID likely suppressed/delayed program participation by more risk-adverse and rebate-influenced consumers.

Breaking *Rebate Essentiality* down by technology and rebate type, the decrease for 2020 purchases/leases was more dramatic for BEVs than PHEVs (as expected due to Tesla's dominance in the former category) and for Standard Rebates than for Increased Rebates (as expected due to the lower incomes of the consumers in the latter group) (Fig. 4).

Note that the percentages in white text inside the columns in Figure 4 are the percent of the total number rebates given to individual (non-fleet) consumers. In absolute terms, *Rebate Essentiality* remained quite high for 2020 purchases/leases of non-Tesla BEVs (50%) and PHEVs (47%). *Rebate Essentiality* was of course the highest for the lower-income consumers receiving the Increased Rebate (66%).

Other work examining the cost-effectiveness of reducing greenhouse gas emissions with rebates has shown how high *Rebate Essentiality* among Increased Rebate recipients helps offset the higher costs of larger rebates, while simultaneously enabling participation by a swath of the market that is even less likely to have acquired an EV without the rebate [2], [3]. On the flip side, the relatively low cost of smaller rebates for PHEVs combines with relatively frequent *Rebate Essentiality* to overcome the fewer GHG emissions avoided per vehicle—making PHEVs one of the most cost-effective groups supported by the program.

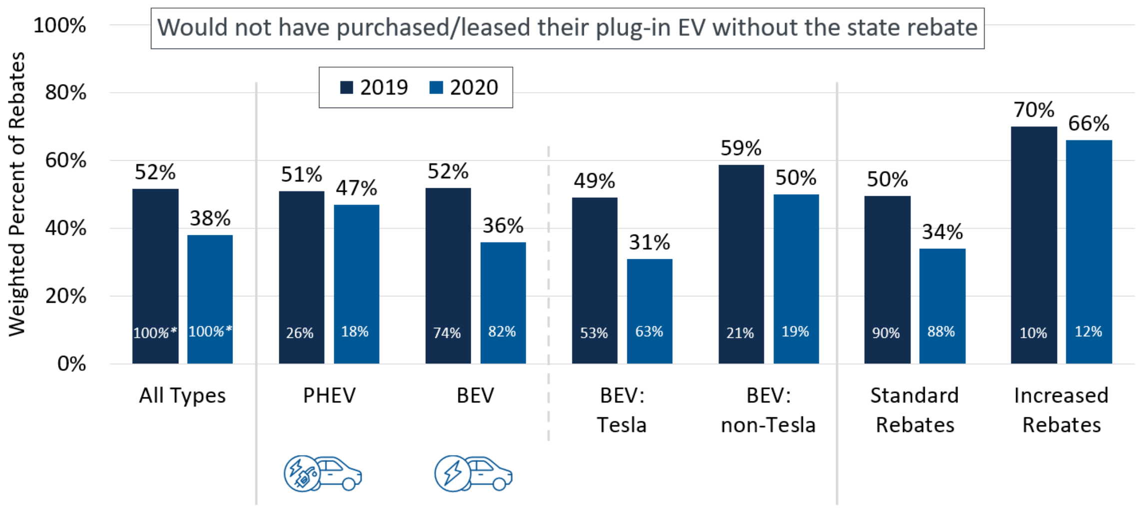


Figure 4: ***Rebate Essentiality*** **by vehicle and rebate type: 2019 and 2020 purchases/leases**

Apart from the fall in Tesla *Rebate Essentiality* (Fig. 3), and its effect on the overall BEV and Standard Rebate averages (Fig. 4), rebate influence metrics might reasonably be expected to have taken a much bigger turn for the worse during COVID in 2020 (in terms of slowed or reversed progress toward market acceleration, increased equity, and other key goals). It will be interesting to see how things fare and compare for rebated EV purchases/leases in 2021. This 2021 analysis is slated and will hopefully be available in the conference presentation to supplement the findings described herein, further enriching the efforts to inform the discussion of incentive influence and cost-effectiveness. In the meantime, extending the comparison backward to 2018 reveals that, before COVID, rebate influence was holding steady for Standard Rebates and increasing for Increased Rebates—neither trend is an indication that incentives should be phased down.

For those consumers in a position to acquire a new EV in 2020 (or needing to acquire a vehicle in 2020 and choosing a new EV), the frequency of *Rebate Essentiality* fell slightly for PHEVs and modestly for non-Tesla BEVs (Fig. 4). Large decreases are observed for Tesla vehicles and, due to Tesla's prominence, heavily weigh down the BEV and program averages (Fig. 4). The percentage fell even more steeply for Tesla Standard Rebates specifically (to 29% for 2020). Non-Tesla BEV *Rebate Essentiality* (Fig. 4) was the highest of the vehicle categories in 2020 and similar to past-year values for BEVs overall.

By vehicle class (Fig. 5), *Rebate Essentiality* is markedly higher for cars than SUVs/minivans. This might be expected to some degree if the average price of SUVs is higher and thus the rebate represents a relatively smaller percentage reduction. *Rebate Essentiality* is also higher for non-Tesla vehicles than Teslas. Indeed, non-Tesla SUVs/minivan *Rebate Essentiality* is more comparable to that for Tesla car consumers.

Taken together, these findings are consistent with the idea that products seen as inherently attractive, or that otherwise provide intrinsic or other motivations, do some of the work that the rebate might otherwise be needed to do to convince consumers to adopt an EV. It also presents policymakers with an interesting dilemma: cost-effectiveness argues for policy designs that maximize rebate influence and minimize free-ridership. But targeting rebates away from Teslas and SUVs would to some degree effectively punish desirable products and OEMs that have been successful at catalyzing the early EV market. Note that other work has shown that additional long-range EVs like the Chevrolet Bolt also tend to be associated with less frequent *Rebate Essentiality* [7], [8], albeit to a lesser degree and with less program-wide effect. Further, midsize and larger SUV and crossover EVs are relatively new products. They are only now beginning to fill notable gaps in large and profitable segments of the market. Accordingly, they are critical to changing the hearts and minds of the mainstream. Additionally, they may be experiencing their own version of the progression in *Rebate Essentiality* that the program as a whole did, that of relatively lower initial *Rebate Essentiality* due to pent-up demand by enthusiasts that increases over time as the consumer base broadens and becomes more skeptical. Should these products not receive the rebates that early-market vehicle products did? For these and other reasons, focusing solely on cost-effectiveness in isolation of other considerations may be less desirable for policymakers. More desirable may be to take a multi-criteria, multi-initiative approach that explicitly acknowledges multiple, overlapping (and sometimes competing) goals—such as rapid acceleration vs. cost-effectiveness vs. advancing EVs farther toward mainstream markets vs. supporting access and adoption by priority populations [24].

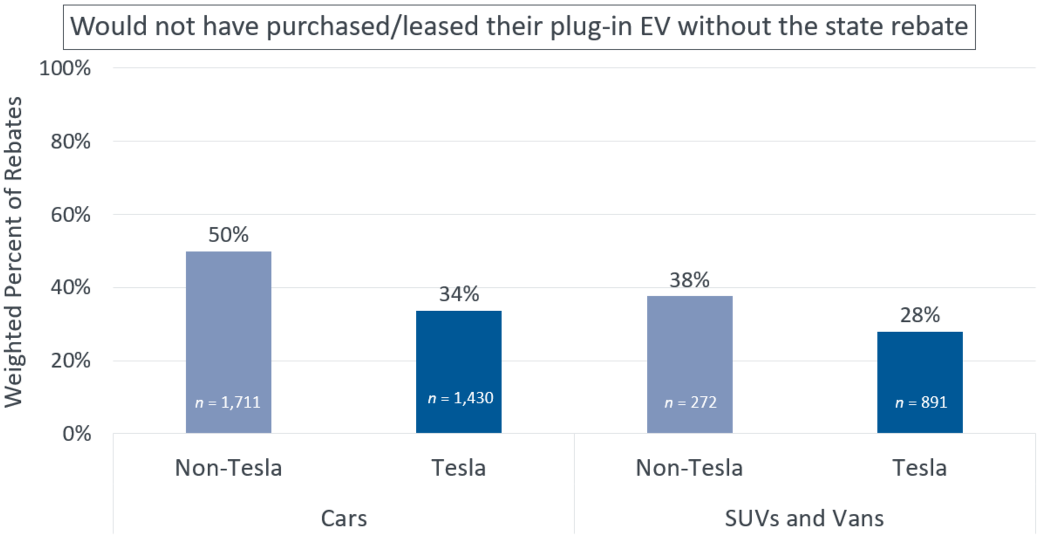
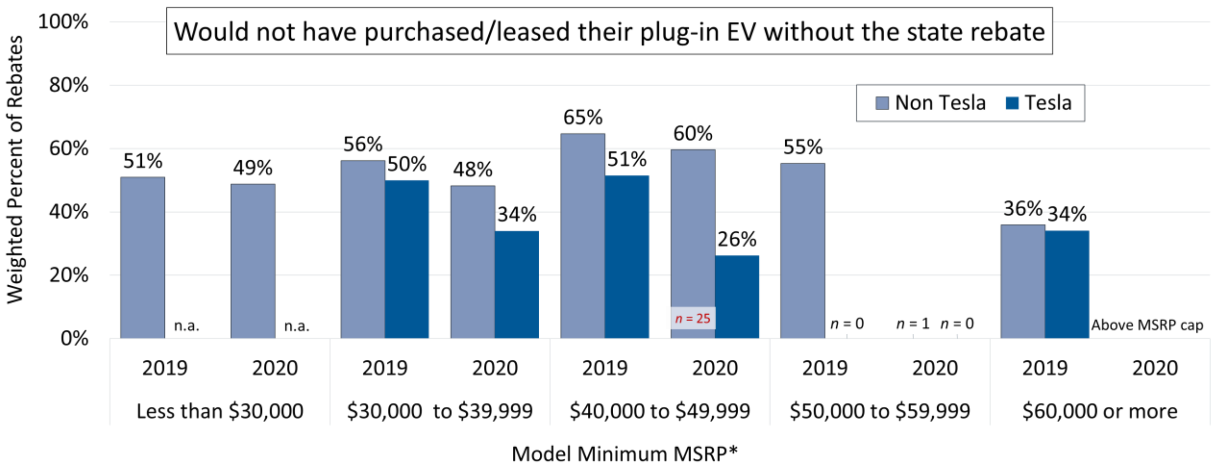


Figure 5: Rebate Essentiality by vehicle class: 2020 purchases/leases

Other work examining *Rebate Essentiality* using logistic regressions to simultaneously control for a variety of factors confirmed that both vehicle make and price can play a significant role [6]–[8]. To further piece apart the dynamics of *Rebate Essentiality,* Figure 6 quantifies how *Rebate Essentiality* varies by the vehicle's manufacturer suggested retail price (MSRP). Tesla consumers are shown in dark blue, non-Tesla consumers in a lighter blue, and two columns are shown at each price level, the first for 2019 purchases/leases and the second for those acquired in 2020.



* Each vehicle was assigned the minimum manufacturer's suggested retail price (MSRP) for that model/MY on fueleconomy.gov and does not reflect sale price. Where MSRPs were unavailable, MSRPs from the previous or following MY were used. Tesla MSRPs do change mid-MY; Model 3's were assigned an MSRP of $49k for MY 2018, $35k for MY 2019 and 2020, and $39,990 for MY 2021. Model Y's were assigned $48k for MY 2020 and $39,990 for MY 2021.

Figure 6: *Rebate Essentiality* by MSRP decreased in 2020, particularly for Tesla: 2019 & 2020 purchases/leases

The evidence is more complicated than might be expected. The reasonable expectation that *Rebate Essentiality* might decrease as price incrementally increases is observed only for Tesla consumers in 2020. Data for 2019 indicate that *Rebate Essentiality* was actually relatively frequent among consumers acquiring vehicles with minimum MSRPs up to $60,000 (though no data characterize Tesla in the $50,000–60,000 range). More work needs to be done to piece apart the influences in each category (e.g., portion of cars vs. SUVs and whether the gasoline competitors to a rebated model are in the same price category). Nevertheless, above $60,000, we observe decreased *Rebate Essentiality* for both Tesla and non-Tesla vehicles, providing support for programs that exclude such luxury vehicles or reduce the expenditures on them.

It is also worth noting that, before COVID, the difference in rebate influence between luxury and non-luxury vehicles was greater than that between Tesla and non-Tesla vehicles. As also seen in Figures 3 and 4, 2020 exhibited greater differentiation between the Tesla and non-Tesla groups. It will be interesting to see how things progress in subsequent years as markets "normalize" after the initial shocks of COVID and as other OEMs increase their competition with Tesla vehicles.

When examining *Rebate Essentiality* by income, a less complicated, but still nuanced, picture can be seen for 2020 purchases/leases (Fig. 7). For context, in previous work, income has of course been found to be an important factor related to rebate influence [6]–[8]. It should be noted, however, that the relationship between income and rebate influence was not found to be uniformly significant and may not be as strong one might expect. For example, early work using logistic regressions that controlled for several factors using the 2013–15 survey edition found income to be a significant factor for PHEV consumers [6]. However, in a similar analysis of the 2016–17 survey edition, an income variable characterizing consumers according to 11 levels of income was *not* a top-ranked predictor of *Rebate Essentiality* for PHEV consumers [7]. Rather, only the large, single-step difference in income between recipients of Standard Rebates and Increased Rebates (for households with incomes under 300% or 400% of the federal poverty level [17]) was significant. One possible explanation discussed was that, on the one hand, you have CVRP's cap on the income level of eligible participants (starting in 2016). On the other, you have the income typically needed to be a consumer in the new-car market. Together, these may already be excluding the most extreme variation in rebate influence that would be observed in the population as a whole. As such, the relationship between rebate influence and a consumer's precise income level may be dampened. Only larger differences, such as those between Standard Rebate and Increased Rebate recipients, remain prominent—particularly when simultaneously controlling for a variety of other factors such as race/ethnicity, age, etc.

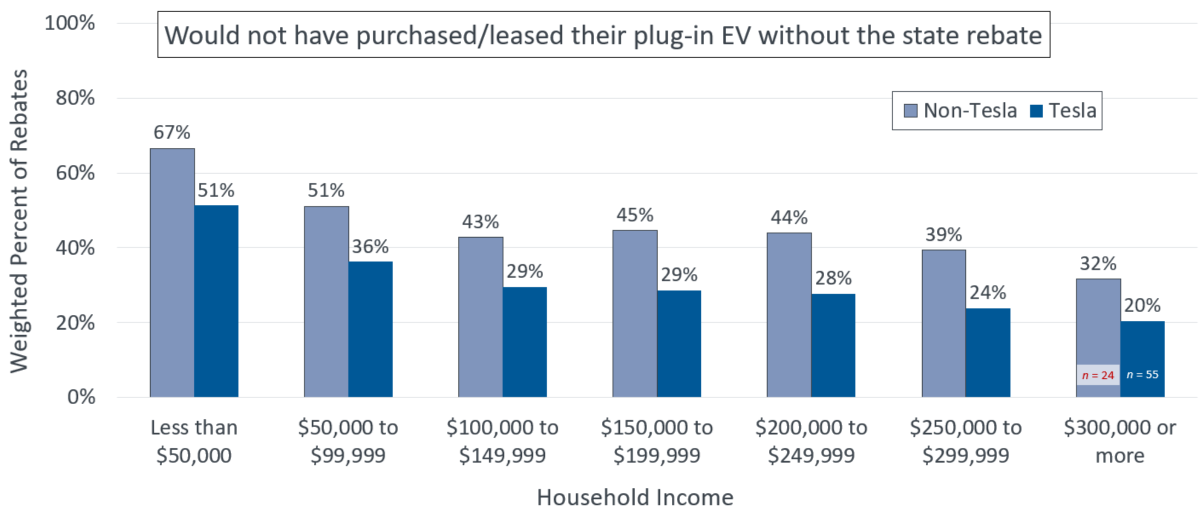


Figure 7: *Rebate Essentiality* decreases as income increases, lower for Tesla: 2020 purchases/leases

Similarly, Figure 7 is both an illustration of the importance of the relationship between income and rebate influence and of some unexpected features. Firstly, rebate influence falls as income increases for the first three levels (up to the $100,000–150,000 household income level). However, it then stays relatively stable (and relatively frequent in absolute terms, particularly for non-Tesla consumers) up to and including the level that includes households with income between $200,000–250,000 per year. It then starts to decline again, and decreases markedly at incomes above $300,000 (for which there is little data due to the program's income cap). As such, the relationship appears to be the most dramatic at lower incomes. But then, analogous to the vehicle-price relationship, *Rebate Essentiality* is relatively steady up to levels that might exceed expectations (and, in the case of CVRP, includes most of the eligible program population). As throughout the results, the distinctions between Tesla and non-Tesla household incomes are starker for 2020 purchases/leases: at each household income level, *Rebate Essentiality* is significantly lower for Tesla than non-Tesla consumers.

4 Summary, Recommendations & Next Steps

This work examines incentive influence based on data collected from over 72,500 California consumers representing nearly 377,000 rebated EVs purchased or leased since September 2012. Analysis focuses on 2020 purchases/leases (the most recent year of available data) and trends across time, vehicle type and price, and consumer type and income.

The primary metric examined focuses attention on the consumers that were the most highly influenced by the rebate to adopt. "*Rebate Essential"* consumers, who simply claim they would not have purchased/leased their EV without the state rebate specifically, represent "true additions" to the EV market (in contrast to program free riders who would have acquired an EV regardless). The frequency of these highly influenced consumers within a group or time period (termed "*Rebate Essentiality*") provides a quantitative indicator of the program's influence on EV adoption. As such, groups with high *Rebate Essentiality* indicate where the program was most cost-effective at increasing adoption. And trends in rebate influence inform where to focus program design, outreach, and other resources to maximize cost-effective support of EV commercialization.

This work descriptively updates and builds upon prior analysis of trends in *Rebate Essentiality* [4], [5], as well as on work that used logistic regressions to determine which consumer, household, regional, and transactional factors help predict whether a consumer was *Rebate Essential* or not (while controlling for the other factors) [6]–[8]. Such work, which is also being updated, aims to identify and rank-order predictors of *Rebate Essentiality* rather than quantify it or examine trends. Further, case-specific measures of *Rebate Essentiality* are used in other works that calculate the portion of total greenhouse gas emissions reductions associated with rebated vehicles that are most attributable to the program [2], [3].

It is important to remember that the results are shaped by program design, for example CVRP's eligibility criteria that limit the household income of eligible consumers and the price of eligible vehicles. Unique to the most recent data, Standard Rebate amounts were lowered to their lowest levels in December of 2019. Even more unique to 2020 was of course the onset of the COVID-19 epidemic with economy-wide impacts. Rebate applications fell dramatically in 2020. Significant recovery happened even within 2020, but only to levels roughly comparable to 2013 and significant questions remain about who was and was not in the position to rejoin the auto and EV markets in the first nine months of the pandemic.

With that important context in mind, eight key rebate-influence results follow, accompanied by select conclusions and recommendations:

1. **82% of consumers rebated for 2020 purchases/leases found the rebate an important enabler of their EV acquisition**

Even during the onset of COVID, when fewer consumers were in a position to risk investments in buying/leasing cars, rebate importance remained strong.

2. **Rebate influence decreased in 2020, primarily for Tesla consumers**
3. **In 2020, 38% would not have purchased/leased without a rebate**
   - **31% for Teslas, but 47% for PHEVs, 50% for non-Tesla BEVs, and 66% for Increased Rebate recipients**

Expectedly, rebate influence dropped, but this was primarily driven by those Tesla consumers that were in the market in 2020, participated in the program (63% of all rebates), and received a Standard Rebate. Rebate influence remained relatively high for other vehicles (including PHEVs) and consumer groups, particularly for lower-income recipients of the Increased Rebate. Further, before COVID, rebate influence was holding steady for Standard Rebates and increasing for Increased Rebates—neither trend an indication that these incentives should be phased down.

4. **No evidence yet found for lowering MSRP cap below $60k for non-Tesla vehicles**

MSRP caps of $60k remained appropriate. For all consumers in 2019 and 2020, we observe markedly decreased *Rebate Essentiality* at MSRP above $60k, providing support for programs that exclude such luxury vehicles or reduce the expenditures on them. Although no clear evidence was observed for further lowering MSRP caps based on cost-effectiveness considerations, additional detailed examination of price buckets below $60k (e.g., model-specific and market-context considerations) might provide further insight.

5. **Expectedly, rebate influence was higher for households with annual incomes less than $100k. Nevertheless, substantial rebate influence still existed for all eligible consumers. The level of influence was relatively high for non-Tesla consumers and steady for all consumers between $100k and $250k.**

The data support limiting eligibility to households with incomes less than $300k per year, above which rebate influence drops off significantly (but recent data are limited due to existing caps). Evidence does not support excluding households with incomes up to $250k. For households between $250k and $300k, the evidence is mixed: rebate influence does start to drop above $250k, but the drop is not as substantial as that observed above $300k. On the one hand, from a market acceleration point of view, substantial program impact remains in this category: roughly one-quarter of Tesla purchases/leases may not have happened without the rebate and roughly two-fifths of non-Tesla purchases/leases—a significant loss to the market if excluded. On the other hand, from an equity point of view, incomes above $250k are considered high and consumers in that category not a priority for public support, particularly if resource constraints would limit rebates to those under $100k (who are indeed found to be the most highly influenced by the rebate).

6. **Rebate influence decreases as income increases, particularly for Tesla**
7. **Tesla rebate influence decreases as MSRP increases**
8. **Attractive offerings (including SUVs and Tesla vehicles) have lower *Rebate Essentiality***

Policymakers face a balancing act: maximizing cost-effectiveness would result in removing support for (i.e., effectively penalizing) successful, market-catalyzing and -dominant manufacturers and popular, intrinsically attractive products. Many of the products with lower *Rebate Essentiality* in 2020 represent vehicle classes/types that have only recently been electrified. From the demand-side perspective, these products include new options with a pent-up demand and that appeal to a wider consumer base. From a supply-side perspective, new products have less mature manufacturing and supply-chain economics for producers. Both perspectives, and others, offer potential justification for public subsidy that should be balanced against lower cost-effectiveness based upon metrics of *Rebate Essentiality*. These and other difficult balancing acts highlight the importance of multi-criteria, multi-initiative approach that explicitly acknowledges multiple, overlapping but often competing goals—such as rapid acceleration vs. cost-effectiveness vs. advancing EVs farther toward mainstream markets vs. supporting access and adoption by priority populations [24].

Overall, rebate influence expectedly declined for 2020 purchases/leases, in contrast to steady or growing influence in previous years for Standard and Increased Rebate recipients, respectively. But the decreases were modest, with the exception of Tesla vehicles. The distinctions between Tesla and non-Tesla vehicles were particularly pronounced in 2020, more so than the differences between cars and SUVs and between luxury and non-luxury vehicles. Perhaps unexpectedly, rebate influence appears relatively steady across wide ranges of eligible vehicle price and eligible consumer household income, and for non-Tesla consumers over time. Expectedly, rebate influence remains strong for lower-income participants.

Although cost-effectiveness cannot be the sole determinant of program evaluation, it is hoped these findings enrich thinking about rebate influence in ways that support robust analysis of EVs and help target resources impactfully. Next steps include updating related logistic regression modeling that identifies and rank-orders factors predictive of *Rebate Essentiality*, while simultaneously controlling for other factors. Next steps also include updating the analysis described herein with 2021 purchases/leases as data become available. These results will be used to produce, for the first time, a "Free Rider Abatement Curve" to inform a methodical process of considering program design changes that meet a constraint (e.g., budget) or goal (e.g., minimum GHG cost-effectiveness threshold) while minimizing free-ridership. For example, Figure 8 illustrates the *beginning* of this process by simply aggregating and ordering the groups analyzed herein according to their 2020 *Rebate Essentiality*. Due to space constraints, Figure 8 focuses on the portion of the list falling below program-average *Rebate Essentiality*—opening the door for further assessment and operationalization into sequenced recommendations to help programs meet their goals cost-effectively.

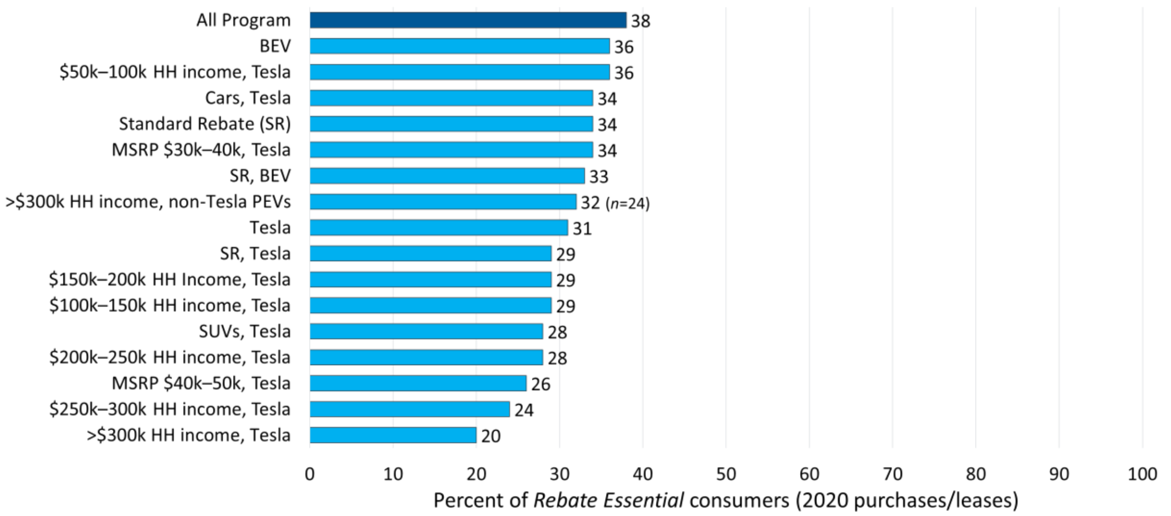


Figure 8: *Rebate Essentiality* below the program average, a precursor to a "Free Rider Abatement Curve"

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