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CVRP Greenhouse Gas Emission Reductions and Cost-Effectiveness

Update: 2021 Purchases/Leases

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Update: 2021 Purchases/Leases

Estimates of greenhouse gas (GHG) emission reductions associated with the Clean Vehicle Rebate Project (CVRP) were originally developed as a part of multi-program planning, were based upon average light-duty vehicle characterizations, and were described as intentionally conservative as a starting point for future refinement (CARB 2017). Subsequent program-specific work by the authors that builds on (CARB 2017) on behalf of CVRP specifically has included a life-of-program accounting through mid-2018 (Pallonetti and Williams 2021); an assessment of 2019 purchases/leases (Pallonetti and Williams 2022; Williams and Pallonetti 2022a); and an assessment of 2020 purchases/leases (Pallonetti and Williams 2023). In this update, we assess the GHG impacts and cost-effectiveness of CVRP rebates on electric vehicles purchased/leased in 2021.

Emissions are estimated using disaggregated data from 47,771 approved CVRP rebate applications for plug-in hybrid electric vehicles (PHEVs), range-extended battery electric (BEVx) vehicles, all-battery electric vehicles (BEVs), and fuel-cell electric vehicles (FCEVs); as well as from 8,100 survey responses weighted to represent program participants. As detailed in Tables 1 and 2, personal (nonfleet) consumers received one of two rebate types: Standard Rebates or Increased Rebates for Low-/Moderate-Income Consumers (CSE 2023).[1] The analysis incorporates state-specific or other best-available inputs that characterize fuel use and fuel carbon intensity for both rebated EVs and baseline vehicles (see Appendix), as well as data-based characterizations of rebate influence provided by, or tailored to, each rebated consumer.

TABLE 1

2021 Rebates by Vehicle Technology Type

Technology Type	Rebate Amount[2]	Rebate Counts	Total Rebate Dollars
PHEV	Standard/Increased: $1,000/$3,500	5,589 (12%)	$9,166,764 (7%)
BEVx	Standard/Increased: $2,000/$4,500	47 (0.1%)	$121,500 (0.1%)
BEV	Standard/Increased: $2,000/$4,500	39,653 (83%)	$101,085,389 (82%)
FCEV	Standard/Increased: $4,500/$7,000	2,482 (5%)	$12,296,450 (10%)
All	**Standard/Increased: $1,000/$7,000**	**47,771 (100%)**	**$122,670,103 (100%)**

[1] Beginning in January 2021, the income threshold for Increased Rebate eligibility was relaxed from 300% to 400% of the federal poverty level.

[2] <1% of applications had irregular rebate amounts due to extenuating circumstances.

TABLE 2

2021 Rebates by Vehicle Rebate Type

Rebate Type	Rebate Amount	Rebate Counts	Total Rebate Dollars
Standard	$1,000–$4,500	37,154 (78%)	$75,202,550 (61%)
Increased	$3,500–$7,000	10,617 (22%)	$47,467,553 (39%)
All	**$1,000–$7,000**	**47,771 (100%)**	**$122,670,103 (100%)**

Compared to new gasoline vehicles, GHG emission reductions associated with rebated EVs over the first year of ownership average 1.5–3.2 metric tons of carbon-dioxide-equivalent emissions per vehicle, depending on the EV technology type, with BEVs reducing the most on average (Table 3). When scaled up to represent 100,000-miles of driving and totaled for all 2021 purchases/leases, an estimated 1.1 million metric tons of carbon-dioxide-equivalent emissions are saved. Comparing rebate costs to all rebated-vehicle emissions benefits over a 100,000-mile quantification period produces carbon-dioxide-equivalent abatement costs averaging $112 per metric ton and ranging from $94 to $406 per metric ton for PHEVs and FCEVs, respectively. By rebate type, carbon-dioxide-equivalent abatement costs averaged $89 per metric ton for Standard Rebates and $193 per metric ton for Increased Rebates (Table 4). (See Appendix for key input values.)

TABLE 3

GHG Reduction and Cost-Effectiveness Estimates by Technology Type

All Rebated Emissions

Technology Type	Total Vehicles	Average First-Year Reductions Per Vehicle (tons)	Average 100k-mi Reductions Per Vehicle (tons)	Rebate Dollars Per Ton of GHG Reductions (100k mi)
PHEV	*N* = 5,589	2.4	17	$94
BEVx	*N* = 47	2.3	22	$117
BEV	*N* = 39,653	3.2	24	$105
FCEV	*N* = 2,482	1.5	12	$406
All	***N* = 47,771**	**3.0**	**23**	**$112**

TABLE 4

GHG Reduction and Cost-Effectiveness Estimates by Rebate Type

All Rebated Emissions

Rebate Type	Total Vehicles	Average First-Year Reductions Per Vehicle (tons)	Average 100k-mi Reductions Per Vehicle (tons)	Rebate Dollars Per Ton of GHG Reductions (100k mi)
Standard Rebate	*N* = 37,154	3.0	23	$89
Low-/Moderate-Income Increased Rebate	*N* = 10,617	3.0	23	$193
All	***N* = 47,771**	**3.0**	**23**	**$112**

To isolate the emission reductions that are directly attributable to the program, case-specific indicators of *Rebate Essentiality* (Johnson and Williams 2017; Williams and Anderson 2018; Williams and Pallonetti 2022b; Williams 2022) can be used. In total, approximately 36% of the rebated reductions in 2021 are associated with "*Rebate-Essential*" participants (those who were the most highly influenced by the rebate to purchase/lease). *Rebate Essentiality* was more frequent for recipients of CVRP's Increased Rebate for consumers with lower household incomes (51%–73%) and FCEV rebates (73%–74%). *Rebate-Importance* is included in Table 5 for additional context (see (Pallonetti and Williams 2023) for further detail and discussion of interpreting rebate influence).

TABLE 5

Rebate Influence by Vehicle and Rebate Types

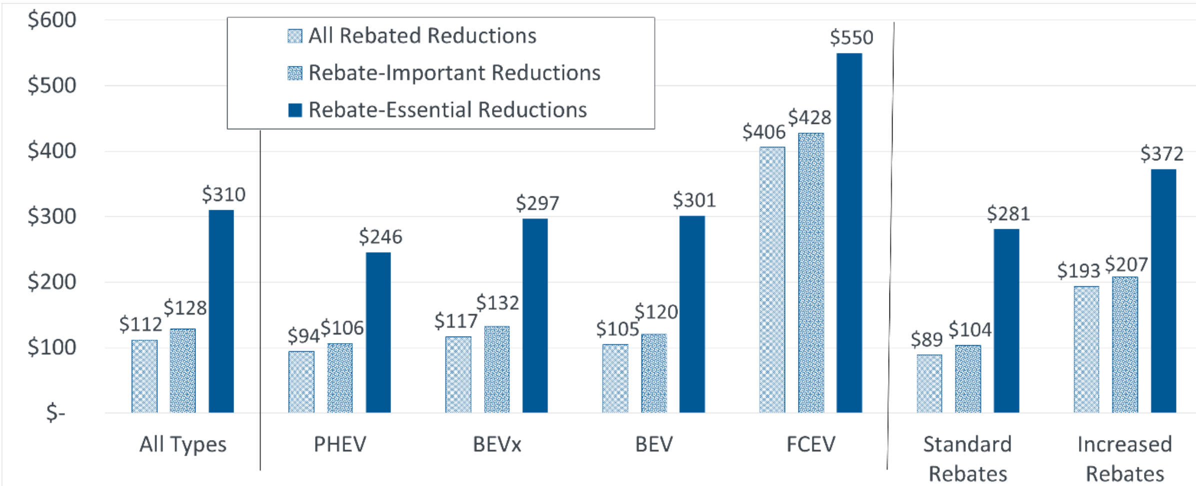
Technology Type	Standard Rebate *Rebate Essentiality*	Increased Rebate *Rebate Essentiality*	Standard Rebate *Rebate Importance*	Increased Rebate *Rebate Importance*
PHEV	33% (*n* = 708)	54% (*n* = 250)	86% (*n* = 703)	94% (*n* = 249)
BEV/BEVx	30% (*n* = 5,037)	51% (*n* = 1,665)	85% (*n* = 5,009)	93% (*n* = 1,651)
FCEV	74% (*n* = 332)	73% (*n* = 72)	94% (*n* = 333)	99% (*n* = 73)

Cost-effectiveness of *Rebate-Essential* reductions range from $246–550 per ton for PHEVs and FCEVs, respectively, and from $281–372 per ton for Standard and Increased Rebates, respectively. Figure 1 compares cost-effectiveness measures based on all rebated emission reductions to those based only on *Rebate Essential* reductions, with *Rebate-Important* reductions are included for additional context.

FIGURE 1

Cost-Effectiveness and Rebate Influence

Rebate dollars per ton of GHG emissions reduced, 100k miles



Summary of results: Cost-effectiveness of GHG emission reductions varies widely by vehicle and rebate types. Costs increase when incorporating rebate influence, however, increases are less drastic for FCEVs and Increased Rebates that are associated with higher *Rebate Essentiality*. *Rebate-Importance* provides additional context and indicates that many consumers who were not *Rebate-Essential* were nonetheless influenced by the rebate in some substantial but less straightforward way.

The emission-reduction and cost-effectiveness results should be interpreted in the context of program design and market dynamics at the time. Due to the onset of COVID-19, the 2020 program population was much smaller in size than in previous years. The program size did increase year-over-year in 2021, though not yet back up to pre-COVID-19 levels. *Rebate Essentiality* decreased during the onset of COVID-19 (Williams and Pallonetti 2022b) and this decrease persisted into 2021. As described in (Williams and Pallonetti 2023a), the decline was largely driven by Tesla consumers, which composed a large portion of the program in 2020. Unlike *Rebate Importance, Rebate Essentiality* did not recover in 2021. Rather, it has continued to decrease across each vehicle and rebate type (Williams and Pallonetti 2023b).

Rebate Essentiality among Increased Rebate recipients had been relatively stable in prior years and into 2020, but also decreased in 2021. However, in this case, the 2021 decrease is likely due to a significant broadening of the Increased Rebate's eligibility criteria to include applicants with higher incomes: beginning in January 2021, the income threshold was increased from 300% to 400% of the federal poverty level.

Based on the analysis of 2020 purchases/leases (Pallonetti and Williams 2023), cost-effectiveness results are particularly sensitive to baseline vehicle fuel efficiency inputs and the quantification period (i.e., total number of operational miles or miles/year). While these factors have been the focus of ongoing refinement, remaining uncertainty presents opportunities for further analysis. As such, next steps underway for reporting on 2022 purchases/leases will include analysis of counterfactual behaviors as indicated in survey responses from program participants. Further, 2022 reporting will include detailed comparison of year-over-year GHG impact findings (out of the scope of this 2021 data update, though input comparisons to the 2020 analysis are provided in the Appendix below).

For further detail on methods and inputs, as well as further discussion of results, please see the appendix below and the 2020 Purchases/Leases Report.

Appendix: First-Year Input Values

Compared to 2020, the carbon intensity of gasoline in California improved in 2021 (from 10,654 grams of CO_2-equivalent emissions (gCO_2e) per gallon) while electricity worsened (from 276 gCO_2e/kWh).

TABLE A1

2021 Fuel Life-Cycle Carbon Intensity Values and Sources

Fuel	Carbon intensity	Detail and sources
Gasoline	10,510 gCO_2e/gal	LCFS benchmark for 2021, converted from (CARB 2020)
Electricity	292 gCO_2e/kWh	LCFS annual update for 2021 data year, converted from (CARB 2020; 2022)
Hydrogen	13,393 gCO_2e/kg	SB 1505-compliant 33% renewable mix, converted from (CARB 2020)

Compared to 2020, the estimated fuel efficiency of new gasoline cars sold in California improved slightly in 2021 (from 31.4 mi/gal) while the efficiency of the rebated EV mix decreased slightly (for 2020 values, see Table A2, Pallonetti and Williams 2023).

TABLE A2

2021 Fuel Efficiency Averages and Sources

Technology Type	Rebate Counts	Average Fuel Efficiency*	Detail and Sources
PHEV (on electricity, on gasoline)	5,637	3.1 mi/kWh, 43 mi/gal	Calculated based on 2021 CVRP application data and ratings from (DOE and EPA 2023) for each rebate.
BEVx (on electricity, on gasoline)	47	3.1 mi/kWh, 31 mi/gal	Calculated based on 2021 CVRP application data and ratings from (DOE and EPA 2023) for each rebate.
BEV	39,653	3.3 mi/kWh	Calculated based on 2021 CVRP application data and ratings from (DOE and EPA 2023) for each rebate.
FCEV	2,482	63 mi/kg	Calculated based on 2021 CVRP application data and ratings from (DOE and EPA 2023) for each rebate.
Baseline Vehicle	n.a.	31.5 mi/gal	CA-sales-weighted avg. for the 30 top-selling new light-duty gasoline models. Calculated using MY 2021–2022 registration data from S&P Global Mobility and ratings from (DOE and EPA 2023)

*** Note**: Fuel efficiency values converted from fuel consumption rates (e.g., gallons/mile) used in GHG calculations.

See Appendix A of the 2020 Purchases/Leases Report for VMT inputs and other additional detail.

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References

California Air Resources Board (CARB). 2017. “Proposed Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives.” CARB. https://ww2.arb.ca.gov/resources/documents/low-carbon-transportation-investments-and-aqip-funding-plan-archive.

———. 2020. “Low Carbon Fuel Standard Regulation.” CARB. https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf.

———. 2022. “Low Carbon Fuel Standard Annual Updates To Lookup Table Pathways.” November 2, 2022. CARB. https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/comments/tier2/2023_elec_update.pdf?_ga=2.22847419.1890554105.1691012824-1906468418.1665163078.

Center for Sustainable Energy (CSE). 2023. “Eligibility & Requirements.” Clean Vehicle Rebate Project. https://cleanvehiclerebate.org/en/eligibility-guidelines. Accessed 8/21/2023.

Johnson, Clair, and Brett Williams. 2017. “Characterizing Plug-In Hybrid Electric Vehicle Consumers Most Influenced by California’s Electric Vehicle Rebate:” *Transportation Research Record: Journal of the Transportation Research Board* 2628 (1): 23–31. https://doi.org/10.3141/2628-03.

Pallonetti, Nicholas, and Brett D. H. Williams. 2021. “Refining Estimates of Fuel-Cycle Greenhouse-Gas Emission Reductions Associated with California’s Clean Vehicle Rebate Project with Program Data and Other Case-Specific Inputs.” *Energies* 14 (15). https://doi.org/10.3390/en14154640.

———. 2022. “Evaluating the Cost-Effectiveness of Greenhouse Gas Emission Reductions Associated with Statewide Electric Vehicle Rebate Programs in California and Massachusetts in 2019.” https://cleanvehiclerebate.org/en/content/evaluating-cost-effectiveness-greenhouse-gas-emission-reductions-associated-statewide.

———. 2023. “CVRP Greenhouse Gas Emission Reductions and Cost-Effectiveness: 2020 Purchases/Leases.” https://cleanvehiclerebate.org/en/content/evaluating-cost-effectiveness-greenhouse-gas-emission-reductions-associated-statewide.

United States Department of Energy and Environmental Protection Agency (DOE and EPA). 2023. “Fueleconomy.Gov.” 2023. https://www.fueleconomy.gov/.

Williams, Brett. 2022. “Targeting Incentives Cost Effectively: ‘Rebate Essential’ Consumers in the New York State Electric Vehicle Rebate Program.” In *35th International Electric Vehicle Symposium*. Oslo, Norway. https://www.researchgate.net/publication/365977245_Targeting_Incentives_Cost_Effectively_Rebate_Essential_Consumers_in_the_New_York_State_Electric_Vehicle_Rebate_Program.

Williams, Brett, and John Anderson. 2018. “Strategically Targeting Plug-in Electric Vehicle Rebates and Outreach Using Characteristics of ‘Rebate-Essential’ Consumers in 2016-2017.” In *31st International Electric Vehicle Symposium*. Kobe, Japan. https://www.researchgate.net/publication/350530560_Strategically_Targeting_Plug-in_Electric_Vehicle_Rebates_and_Outreach_Using_Characteristics_of_Rebate-Essential_Consumers_in_2016-2017.

Williams, Brett, and Nicholas Pallonetti. 2022a. “Cost-Effectiveness of Greenhouse Gas Emission Reductions Associated with California’s Clean Vehicle Rebate Project in 2019 (and 2020).” Video Recording presented at the CARB’s First Public Workshop on the Fiscal Year 2022-23 Update to the Three Year Plan for Light-Duty Vehicles and Clean Transportation Equity Investments, February 10. https://www.youtube.com/watch?v=XhnXEoFb7Wo&t=7340s.

———. 2022b. “CVRP 2020 Data Brief: Incentive Influence.” 2022. https://cleanvehiclerebate.org/sites/default/files/attachments/2020-CVRP-Incentive-Influence-Data-Brief_2022-05_0.pdf.

Williams, Brett, and Nicholas Pallonetti. 2023a. “Rebate Influence on Electric Vehicle Adoption in California.” In *Proceedings of the 36th International Electric Vehicle Symposium*, Sacramento, California. http://evs36.com/wp-content/uploads/finalpapers/FinalPaper_Williams_Brett%20(2).pdf.

———. 2023b. “CVRP Rebate Influence on EV Adoption in California Through 2021.” Presentation for the *36th International Electric Vehicle Symposium*, Sacramento, California, June 11–14, 2023. https://www.researchgate.net/publication/371906845_CVRP_Rebate_Influence_on_EV_Adoption_in_California_Through_2021?channel=doi&linkId=649b8e0bc41fb852dd36bd15&showFulltext=true