Appendix J: Emissions Reductions to Date for Non-GGRF Funded Low Carbon Transportation Incentive Projects

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Table of Contents

Overview

Most of the funding to date for the Low Carbon Transportation Program comes from Cap-and-Trade auction proceeds deposited into the Greenhouse Gas Reduction Fund (GGRF). The emission benefits from these projects are entered into the California Climate Investments (CCI) Reporting and Tracking System and then publicly reported in the CCI Annual Report[1]. Recently the California Air Resources Board (CARB) has received funding for its Low Carbon Transportation Program from other sources such as the General Fund, and enforcement settlements with Volkswagen, Daimler, and Fiat-Chrysler deposited into the Air Pollution Control Fund (APCF). The emission benefits resulting from these funds are not reported into the Annual CCI Report. This Appendix reports on the emission benefits from these other sources of funding. In FY 2017-18, CARB received $25 million from the Volkswagen Settlement for Zero-Emission Vehicle (ZEV) Aspects of Vehicle Replacement Programs (VW Funds) to fund the ZEV-related aspects of the Clean Cars 4 All (CC4A) Program or similar replacement programs. Of the $25 million, $10 million was allocated to CC4A, $10 million was allocated to the Financing Assistance Project for Lower-Income Consumers (Financing Assistance), and $5 million to Access Clean California, formerly known as One-Stop-Shop. In Fiscal Year (FY) 2021-22, CARB received $838 million from the General Fund to fund a suite of projects for Clean Transportation Incentives. Of the $838 million, $415 million was allocated to the Clean Vehicle Rebate Project (CVRP), $10 million was allocated to Electric Bicycle Incentives and $413 million was allocated to Heavy-Duty and Off-Road Equipment projects. Through May 31, 2022, CVRP has spent $46,144,750 of their General Fund allocation, and CC4A, Financing Assistance and Access Clean California have expended the entirety of their VW Funds.

This Appendix provides cumulative outcomes, through May 31, 2022, including estimated GHG emissions reductions and information on benefits to disadvantaged communities and low-income communities and households (collectively referred to as priority populations) for projects funded using General Funds and VW Funds. The estimates presented in this Appendix are the emission reductions for the projects that have spent part or all of their non-GGRF allocation and provides additional details on the applied methodology and assumptions used. Published GGRF quantification methodologies[2] guided this analysis.

Table J-1 summarizes the funding amounts and emissions reductions for CVRP, CC4A, and Financing Assistance attributed to non-GGRF funding sources. It is important to note that the General Fund and APCF funds for the Electric Bicycle Incentives Project and the Heavy-Duty or Off-Road Equipment projects have not yet been spent. The project status of EBIP is that the solicitation closed on May 11, 2022. A consumer

[1] https://www.caclimateinvestments.ca.gov/annual-report

[2] Cap-and-Trade auction proceeds quantification materials are available *https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials*

facing project is expected to launch in the first quarter of 2023. Heavy-Duty incentives opened voucher applications in July 2022 and is still processing applications.

Table J-1: Summary of Funding and Emissions Reductions for Non-GGRF Funding Sources

Project	Funding Source	Funding Amount (millions)	# of Vehicles or Equipment Funded	Total Lifetime Emission Reductions (tons)			
				GHG	NOx	PM 2.5	ROG
Clean Vehicle Rebate Project	General Funds	$46.1	22,636	180,926	11.64	7.80	2.22
Clean Cars 4 All	VW	$10	854	10,467	6.41	0.35	1.30
Financing Assistance	VW	$10	1,420	11,347	0.76	0.52	0.16
Access Clean California	VW	$5	N/A	N/A	N/A	N/A	N/A
Total		**$71.1**	**24,910**	**202,740**	**18.81**	**8.67**	**3.68**

Table J-1 covers funds spent between January 1, 2018, and May 31, 2022. Projects where funds have been allocated but not yet spent do not appear on the table; however, they will be included in future emission reduction reports.

As explained in Appendix A, the goal of the Access Clean California program is to enable more efficient implementation of CARB's equity ZEV incentives and to expand participation by low-income households. Because this project streamlines participation in existing incentive programs, such as Financing Assistance, staff did not quantify any direct emission reductions for this project.

Emission Factor Development

To support the emission reductions analysis from the projects, staff developed a set of emission factors for light-duty vehicles (LDV). The emission factors and assumptions used in the analysis were derived from a number of sources. These sources include CARB's California-modified Greenhouse Gases, Regulated Emissions, and Energy Use

in Transportation (CA-GREET 3.0) Model,[3] CARB's Emission Factor (EMFAC2017) Model,[4] information from CARB regulation staff reports and emissions inventories, publicly available technical reports, and staff assumptions. Greenhouse gas (GHG) emission factors were developed on a well-to-wheel (WTW) basis because greenhouse gases are global pollutants. Criteria pollutant and toxic emission factors were calculated based solely on tailpipe emissions because of their localized impact.

GHG Emission Factors

Fuel economy is an important component of the GHG emission reduction analysis, as the value determines the GHG emissions generated based on the consumption of each unit of fuel for the miles traveled. Fuel economy values were derived from EMFAC2017[5]. Table J-2 provides a summary of the fuel economy values for baseline gasoline on-road vehicles. These values were used in the analysis for conventional vehicles.

Table J-2: On-Road Fuel Economy Values of Baseline Conventional Vehicles

Vehicle Class	Fuel Type	Fuel Economy Values (mpg)			
		2000	2019	2020	2022
LDV	Gasoline	24.0	34.4	35.5	38.1

As shown in Formula 1, a vehicle's fuel economy was paired with carbon intensity (CI) in units of CO2 weight per unit energy from the Low Carbon Fuel Standard (LCFS)[6] and the lower heating value (LHV) in units of energy per mass of the applicable fuel to calculate the WTW GHG emission factor for each project type. This was done so that the upstream (well-to-tank) emissions of the fuel were representative of the fuel used, paired with an illustrative potential technology. For on-road vehicles, the GHG emission factor is in units of grams of carbon dioxide (CO2) equivalent per mile (gCO2e/mi).

Formula 1: GHG Emission Factors

$$GHG\ Emission\ Factor\ \left(\frac{gCO2e}{mi}\right) = \frac{LCFS\ carbon\ intensity * LHV\ of\ fuel}{fuel\ economy\ of\ vehicle}$$

For alternative-fueled vehicles, the baseline fuel economy values were converted for a given alternative fuel, using LHVs of the baseline and alternative fuels and the energy economy ratio (EER) value, as shown in Formula 2. EER values were derived from the

[3] *http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm*
[4] *https://www.arb.ca.gov/emfac/2017/*
[5] *https://www.arb.ca.gov/emfac/2017/*
[6] *https://www.arb.ca.gov/fuels/lcfs/lcfs.htm*

LCFS Regulation[7] or based on a study comparing efficiency of battery-electric vehicles and conventional diesel vehicles operating on the same duty cycle.[8]

Formula 2: Alternative Fuel Vehicle Economy

$$Alt.Fuel\ Vehicle\ Economy\ \left(\frac{miles}{fuel\ unit}\right) = fuel\ economy_{baseline} * \frac{LHV_{alt.fuel}}{LHV_{baseline\ \ fuel}} * EER$$

Lifecycle emission factors adopted from the LCFS Program's carbon intensities represent the average or typical production processes for each fuel used in California. Staff assumed the following pathways for the fuels analyzed:

- Gasoline: California reformulated gasoline (CaRFG) from the LCFS Lookup Table[9];
- Electricity: California grid average mix, which meets the Renewable Portfolio Standard (RPS) requirements, from the LCFS 2021 Annual Update to Electricity Lookup Table Pathways[10]; and
- Hydrogen: SB 1505 compliant gaseous hydrogen reformed on-site at the refueling station from a mix of North American natural gas and 33 percent biomethane from landfill gas, from the LCFS Lookup Table.

It should be noted that as more renewables are introduced into the transportation fuel mix, lowering the average CI of the fuel, additional GHG benefits may be achieved, which may lower the emission factors. As the fuel mix changes, staff will reflect those changes in future analyses.

Criteria Pollutant and Toxics Emission Factors

To determine criteria pollutant and toxics emission factors, staff applied CARB's EMFAC2017 model to calculate the tailpipe emissions and associated emissions of the supported vehicles or equipment, such as idling emissions and PM 2.5 emissions from brake and tire wear, when applicable.

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[7] https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf
[8] https://ww2.arb.ca.gov/sites/default/files/2018-10/170425eerdraftdocument.pdf
[9] https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm
[10] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/comments/tier2/2021_elec_update.pdf

When available, staff incorporated deterioration for on-road and off-road vehicles. Staff also applied a 50 percent reduction in brake wear emissions for on-road vehicles that implement regenerative braking.[11]

Quantification Methodology for Projects

To quantify the emission reductions for each project, staff determined the annual per-vehicle emission reductions for each technology.

Annual Per-Vehicle Emission Reductions

Annual emission reductions are first calculated for each eligible or representative technology in the project using the emission factors that have been developed for each project. Annual emission reductions are in units of tons per year (tpy) for the emissions reduced and are calculated by taking the difference in emission rates between the baseline vehicle and advanced technology vehicle and then multiplying by usage. This value is then converted from grams per year to metric tons per year for GHG emissions and tons per year for criteria pollutants and toxic air contaminants.

The annual emission reductions were calculated using Formula 3, where emission factors ($EF_{baseline}$ meaning baseline emission factors and EF_{ATV} referring to alternate vehicle emission factors) are in terms of grams per mile (g/mi) and usage is based on annual vehicle miles traveled or miles per year (mi/yr).

Formula 3: Annual Per-Vehicle Emission Reductions

$$Annual\ Per\ Vehicle\ Emission\ Reductions\ (tpy) = (EF_{baseline} - EF_{ATV}) * Usage$$

Total Lifetime Emission Reductions

Once the per-vehicle emission reductions are determined, it is summed over the total number of vehicles funded and multiplied by the project life to determine the total lifetime emission reductions for a project, as shown in Formula 4.

Formula 4: Lifetime Emission Reductions

$$Lifetime\ Emission\ Reductions\ (tons) = \sum vehicle\ emission\ reductions * project\ life$$

Clean Vehicle Rebate Project

CVRP achieves emission reductions by incentivizing the purchase or lease of new, eligible ZEVs, including electric, plug-in hybrid and fuel cell vehicles. The emission

[11] NREL, BAE/Orion Hybrid Electric Buses at New York City Transit, *http://www.afdc.energy.gov/pdfs/42217.pdf*, March 2008

reductions below represent $46.1 million of General Funds, which are not reported in the CCI investments. To calculate the emission reductions for this project, staff used project data to determine the model year of the baseline vehicle and the replacement vehicle. Emission quantification is based on model year 2022 clean vehicles.

Project data for the General Funds shows that 87 percent of the funding went to battery electric vehicle (BEV) purchases, 8 percent went to plug-in hybrid electric vehicles (PHEV) purchases, and 5 percent went to fuel cell vehicles. Table J-3 reflects the emission factors for the selected fuel cell electric vehicles (FCEV), PHEV, and BEV. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table J-3: Clean Vehicle Rebate Project Emission Factors

Pollutant	2022 Gasoline (g/mi)	2022 PHEV (g/mi)	2022 BEV (g/mi)	2022 FCEV (g/mi)
NOx	0.0135	0.0058	0	0
PM 2.5	0.0186	0.0103	0.0099	0.0099
ROG	0.0026	0.0011	0	0
GHG	302	162	68	136

Staff generated vehicle usage assumptions for CVRP through literature review for each of the vehicle types evaluated. The annual usage assumptions for CVRP are shown in Table J-4.

Table J-4: Clean Vehicle Rebate Project Annual Usage Assumptions

Technology	Usage (mi/yr)
PHEV	14,855[12]
BEV	14,400[13]
FCEV	12,445[14]

[12] Based on 40.7 miles per day. Smart, J., Powell, W., and Schey, S., "Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project," SAE Technical Paper 2013-01-1441, 2013, doi:10.4271/2013-01-1441. (*http://papers.sae.org/2013-01-1441/*)

[13] Based on EMFAC 2017 Volume III- Technical Documentation, California Air Resources Board *https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf*

[14] Hardman, S., Tal, G., 2019, Understanding the Early Adopters of Fuel Cell Vehicles, NCST. (*https://escholarship.org/uc/item/866706mr*)

Using the emission factors and technology mix mentioned above and the annual usage assumptions, staff calculated the annual per-vehicle emission reductions for CVRP, as shown in Table J-5.

Table J-5: Clean Vehicle Rebate Project Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per Technology (tpy)
GHG	PHEV	2.08
	BEV	3.37
	FCEV	2.07
NOx	PHEV	0.00013
	BEV	0.00021
	FCEV	0.00019
PM 2.5	PHEV	0.00014
	BEV	0.00014
	FCEV	0.00012
ROG	PHEV	0.00002
	BEV	0.00004
	FCEV	0.00004

A total of 22,636 vehicles were funded with the General Funds. Of the $46,140,250 million, 7 percent was allocated to the Center for Sustainable Energy to administer the program. CVRP has a 30-month ownership requirement; therefore, total emission reductions for the project were quantified over the course of two and a half years. The total emission reductions for CVRP are shown in Table J-6 below.

Table J-6: Total Emission Reductions for CVRP

Project	General Fund Allocation (millions)	# of Vehicles or Equipment Funded	Total Lifetime Emission Reductions (tons)			
			GHG	NOx	PM 2.5	ROG
Clean Vehicle Rebate Project	$46,140,250	22,636	180,926	11.64	7.80	2.22

Clean Cars 4 All

CC4A achieves emission reductions by incentivizing the scrap and replacement of old, high-emitting vehicles with cleaner advanced technology vehicles. The emission reductions below represent $10 million of Volkswagen funds, which are not reported in the Annual CCI Report. To calculate the emission reductions for this project, staff used project data to determine the model year of the baseline vehicle and the replacement vehicle. Based on projects that were funded using VW Funds, on average, a 2000 model year vehicle was being scrapped and replaced by an average 2019 model year advanced technology vehicle.

Project data for the VW Funds shows that 35 percent of the funding went to BEV purchases, 65 percent went to PHEV purchases. Table J-7 reflects the emission factors for the selected PHEV and BEVs. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table J-7: Clean Cars 4 All Emission Factors

Pollutant	2000 Gasoline (g/mi)	2019 PHEV (g/mi)	2019 BEV (g/mi)
NOx	0.1918	0.0077	0
PM 2.5	0.0208	0.0107	0.0099
ROG	0.0388	0.0016	0
GHG	480	179	75

Staff generated vehicle usage assumptions for CC4A through literature review for each of the vehicle types evaluated, similar to CVRP. The annual usage assumptions for CC4A are shown in Table J-8.

Table J-8: Clean Cars 4 All Annual Usage Assumptions

Technology	Usage (mi/yr)
PHEV	14,855[15]
BEV	14,400[16]

Using the emission factors and technology mix mentioned above and the annual usage assumptions, staff calculated the annual per-vehicle emission reductions for CC4A, as shown in Table J-9.

Table J-9: Clean Cars 4 All Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per-Technology Annual Emission Reductions (tpy)
GHG	PHEV	4.48
	BEV	5.83
NOx	PHEV	0.00302
	BEV	0.00305
PM 2.5	PHEV	0.00016
	BEV	0.00017
ROG	PHEV	0.00061
	BEV	0.00062

A total of 854 vehicles were funded with the VW Funds. Of the $10 million, 15 percent went to the air districts to administer the program. CC4A has a 30-month ownership requirement; therefore, total emission reductions for the project were quantified over the course of two and a half years. The total emission reductions for CC4A are shown in Table J-10 below.

[15] Based on 40.7 miles per day. Smart, J., Powell, W., and Schey, S., "Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project," SAE Technical Paper 2013-01-1441, 2013, doi:10.4271/2013-01-1441. (*http://papers.sae.org/2013-01-1441/*)

[16] Based on EMFAC 2017 Volume III- Technical Documentation, California Air Resources Board *https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf*

Table J-103: Total Emission Reductions for Clean Cars 4 All

Project	VW Fund Allocation (millions)	# of Vehicles or Equipment Funded	Total Lifetime Emission Reductions (tons)			
			GHG	NOx	PM 2.5	ROG
Clean Cars 4 All	$10	854	10,467	6.42	0.35	1.30

Financing Assistance for Lower-Income Consumers

The Financing Assistance for Lower-Income Consumers project (Financing Assistance) achieves emission reduction benefits by assisting lower-income consumers in purchasing clean vehicles by improving access to more affordable financing options. The emission reductions below represent $10 million of Volkswagen funds, which are not reported in the CCI investments. These funds were spent through the Statewide Financing Assistance program, the Clean Vehicle Assistance Program (CVA Program). To calculate the emission reductions for this project, staff used project data to determine the model year of the baseline vehicle. Based on projects that were funded using VW Funds, on average, participants purchased a 2020 model year vehicle; accordingly, the baseline vehicle is a 2020 conventional gasoline vehicle.

Project data for the VW Funds shows that 70 percent of the funding went to BEV purchases, 30 percent went to PHEV purchases. Table J-11 reflects the emission factors for the selected PHEV and BEVs. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table J-11: CVA Program Emission Factors

Pollutant	2020 Gasoline (g/mi)	2020 PHEV (g/mi)	2020 BEV (g/mi)	2020 FCEV (g/mi)
NOx	0.0154	0.0066	0	0
PM 2.5	0.0192	0.0105	0.0099	0.0099
ROG	0.0032	0.0014	0	0
GHG	324	173	73	145

Staff generated vehicle usage assumptions for Financing Assistance through literature review for each of the vehicle types evaluated, similar to CVRP. The annual usage assumptions for Financing Assistance are shown in Table J-12.

Table J-12: CVA Program Annual Usage Assumptions

Technology	Usage (mi/yr)
PHEV	14,855[17]
BEV	14,400[18]
FCEV	12,445[19]

Using the emission factors and technology mix mentioned above and the annual usage assumptions, staff calculated the annual per-vehicle emission reductions for CVA Program, as shown in Table J-13.

Table J-13: Clean Vehicle Assistance Program Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per Technology (tpy)
GHG	PHEV	2.24
	BEV	3.62
	FCEV	2.22
NOx	PHEV	0.00014
	BEV	0.00024
	FCEV	0.00021
PM 2.5	PHEV	0.00014
	BEV	0.00015
	FCEV	0.00013
ROG	PHEV	0.00003
	BEV	0.00005
	FCEV	0.00004

A total of 1,420 vehicles were funded with the VW Funds. Of the $10 million, 13 percent went to the districts to administer the program. CVA Program has a 30-month ownership requirement; therefore, total emission reductions for the project were quantified over the course of two and a half years. The total emission reductions for CVA Program are shown in Table J-14 below.

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[17] Based on 40.7 miles per day. Smart, J., Powell, W., and Schey, S., "Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project," SAE Technical Paper 2013-01-1441, 2013, doi:10.4271/2013-01-1441. (*http://papers.sae.org/2013-01-1441/*)

[18] Based on EMFAC 2017 Volume III- Technical Documentation, California Air Resources Board *https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf*

[19] Hardman, S., Tal, G., 2019, Understanding the Early Adopters of Fuel Cell Vehicles, NCST. (*https://escholarship.org/uc/item/866706mr*)

Table J-14: Total Emission Reductions for the Clean Vehicle Assistance Program

Project	VW Fund Allocation (millions)	# of Vehicles or Equipment Funded	Total Lifetime Emission Reductions (tons)			
			GHG	NOx	PM 2.5	ROG
Clean Vehicle Assistance Program	$10	1,420	11,347	0.76	0.52	0.16

AB 1550: Disadvantaged Community, Low-Income Community, Low-Income Household Investments for Non-GGRF investments

Clean Transportation Incentives is dedicated to providing benefits to the state's most disadvantaged communities and low-income communities and households, collectively referred to as priority populations.

Table J-15 shows the percent of funds spent within and benefiting disadvantaged community census tracts as well as the non-overlapping[20] minimum percent of funds spent within and benefiting low-income communities. Staff only counted an investment as being in a low--income community if it had not already been counted as being spent in disadvantaged communities because AB 1550 does not allow funds to be counted twice for reporting purposes. Furthermore, AB 1550 only statutorily applies to projects funded from GGRF; however, CARB is committed to target all these projects on priority populations as defined in AB 1550 and SB 535. Even though these projects are funded through non-GGRF investments, we are reporting the priority population benefits for these other funding sources, as well.

[20] *Low-income communities that have not already been counted as being spent in disadvantaged communities because AB 1550 does not allow funds to be counted twice for reporting purposes.*

Table J-15: Non-GGRF Clean Transportation Incentive Investments in Disadvantaged Communities, Low-Income Communities, and Low-Income Households

Project Category	Amount Spent (millions)	% in DC	$ in DC (millions)	% in LIC (non-overlapping)	$ in LIC (non-overlapping) (millions)	%DC/LIC Combined	$DC/LIC Combined (millions)
Clean Vehicle Rebate Project	$46.1	11.5%	$5.2	18.2%	$8.5	29.7%	$13.7
Clean Cars 4 All	$10	5.8%	$.47	87.6%	$7.2	93.4%	$7.6
Financing Assistance for Lower-Income Consumers	$10	19.9%	$1.7	66%	$6	85.9%	$7.9
Access Clean California	$5	45%	$2.3	30%	$1.5	75%	$3.8
Total	**$71.1**	**82.2%**	**$9.67**	**-**	**$23.2**	-	**$33**

DC *means disadvantaged community as described in Health and Safety Code Section 39711.*
LIC *means low-income community (or low-income household in the case of CC4A) as defined in Health and Safety Code Section 39713. "% in LIC" shown in this table means the percent of funds spent in low-income communities that have not already been counted as being spent in disadvantaged communities because AB 1550 does not allow funds to be counted twice for reporting purposes.*