Appendix A: Emission Reductions Quantification Methodology

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Overview

In the Governor's budget for the 2019-20 fiscal year (FY), the California Air Resources Board (CARB) was appropriated $48 million for Air Quality Improvement Program (AQIP) projects and $485 million for Low Carbon Transportation Investments from Cap-and-Trade auction proceeds. This appendix conservatively estimates the emission reductions of the project categories presented in the Funding Plan and provides additional details on the methodology developed and assumptions used. This analysis was guided by Assembly Bill (AB) 8 (Perea, Chapter 401, Statutes of 2013) and published Greenhouse Gas Reduction Fund (GGRF) quantification methodologies.[1] It should be noted that while the legislature allocated $485 million for low carbon transport projects, 1 percent of the appropriated funds will be used for state administration. As a result, staff quantified the estimated emission reductions on 99 percent of the monies allocated to each project.

It is important to note that these emission reduction estimates are illustrative examples of potential emission reductions that can be achieved with the funding allocated to these projects. Refined emission reduction estimates will be quantified as projects are implemented and data becomes available.

Table A-1 summarizes the funding allocations for the projects proposed in the Funding Plan and the potential emission reductions over the project life.

[1] Cap-and-Trade auction proceeds quantification materials are available https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm.

Table A-1: Summary of Proposed Projects in the FY 2019-20 Funding Plan and Total Potential Emission Reductions

Project Category	Proposed FY 2018-19 Allocation (millions)	# of Vehicles or Equipment Funded	Total Potential Lifetime Emission Reductions (tons)			
			GHG	NOx	PM 2.5	ROG
Vehicle Purchasing Incentives - CVRP	**$235.62**					
CVRP Standard Rebates	$210.62	100,000	622,000	46.5	32.0	9.73
CVRP Increased Rebates for Lower-Income Consumer	$25	5,600	33,100	2.45	1.86	0.32
Vehicle Purchasing Incentives - Clean Transportation Equity	**$10.9**					
Financing Assistance for Lower-Income Consumers	$10.9	1,200	7,400	0.68	0.38	0.13
Clean Mobility Options - Clean Transportation Equity	**$46.45**					
Clean Mobility Options for Disadvantaged Communities	$10	200	1,500	0.11	0.065	0.027
Agricultural Worker Vanpools	$5	110	5,400	0.17	0.43	0.027
Rural School Bus Pilot	$4.45	13	3,860	47.6	0.52	0.61
Clean Mobility in Schools	$5	21	2,380	3.53	0.19	0.030
Sustainable Transportation Equity Project	$22	TBD	TBD	TBD	TBD	TBD
Outreach, Community Needs Assessments, Technical Assistance, and One-Stop-Shop	**$7**					
Outreach, Community Needs Assessments, Technical Assistance, and One-Stop Shop	$7	NA	NA	NA	NA	NA
Heavy-Duty Vehicles and Off-Road Equipment Investments	**$180.18**					
Clean Truck and Bus Vouchers	$140.58	1,140	370,000	483	11.4	3.53
Demo/Pilot	$39.6	100	96,000	196	1.83	2.93
Truck Loan Assistance Program	$47.52	15,000	NA	2,810	NA	207

* *This table reflects that up to 1% that may be used to support state operations.*
***tbd** means "to be determined" and reported in future Annuals Report on California Climate Investments based on project implementation.*

Emission Factor Development

To support the analysis of emission reductions from the proposed projects, staff developed a set of emission factors for a variety of different vehicle classes. The emission factors and assumptions used in the analysis were derived from a number of sources such as CARB's California-modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET 3.0) Model,[2] CARB's Emission Factor (EMFAC2017) Model,[3] information from CARB regulation staff reports and emissions inventories, publically available technical reports, and staff assumptions. Greenhouse gas (GHG) emission factors were developed on a well-to-wheel (WTW) basis since greenhouse gases are global pollutants. Criteria pollutant and toxic emission factors are calculated based solely on tailpipe emissions because of their localized impact.

Staff developed emission factors for the following vehicle classes:

- Light-duty vehicles (LDV)
- Light heavy-duty vehicles (LHD)
- Medium heavy-duty vehicles (MHD)
- Heavy heavy-duty vehicles (HHD)
- Urban buses
- School buses
- Cargo-handling equipment (CHE)
- Transport refrigeration units (TRU)
- Off-road mobile agricultural equipment (tractors)
- Locomotives

GHG Emission Factors

Fuel economy is an important component of the emission reduction analysis, as the value determines the emissions generated based on the consumption of each unit of fuel for the miles traveled or for off-road applications, unit of fuel consumed per hour of use. Fuel economy values were derived from EMFAC 2017[4] and CARB's off-road mobile source emissions inventories[5], specifically the 2011 Cargo Handling Equipment Inventory and the 2011 TRU Emissions Inventory models. Table A-2 provides a summary of the fuel economy values for baseline gasoline or diesel on-road vehicles, while Table A-3 provides a summary of fuel economy values for baseline diesel off-road vehicles. These values were used in the analysis for conventional vehicles.

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

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

Vehicle Class	Fuel Type	Fuel Economy Values (mpg)			
		1996	1999	2014	2019
LDV	Gasoline	23.1	-	27.3	34.4
LHD	Gasoline	-	-	-	10.1
MHD	Diesel	-	-	-	10.5
HHD	Diesel	-	-	-	7.3
Urban Bus	Diesel	-	-	-	7.9
School Bus	Diesel	-	7.4	-	9.3

Table A-3: Off-Road Fuel Economy Values of Baseline Diesel Vehicles

Vehicle Class	Horsepower Range	Fuel Economy Values (gal/hr)
		Tier 4 Final
Forklift	100-174	1.4
Yard Truck	175-299	3.5
TRU	23-25	0.7

The fuel economy was paired with carbon intensity (CI) values from the Low Carbon Fuel Standard (LCFS)[6] and the lower heating value (LHV) of applicable fuels to calculate the WTW GHG emission factor for each project type, as shown in Formula 1. 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), and for off-road vehicles, the GHG emission factor is in units of grams of CO2e per hour (gCO2e/hr).

Formula 1: GHG Emission Factors

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

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

[6] https://www.arb.ca.gov/fuels/lcfs/lcfs.htm
[7] https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf
[8] https://www.arb.ca.gov/msprog/actruck/mtg/170425eerdraftdocument.pdf

Formula 2: Alternative Fuel Vehicle Economy

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

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];
- Diesel: ultra-low sulfur diesel (ULSD), also from the LCFS Lookup Table;
- Compressed Natural Gas (CNG): volume-weighted average CI of CNG from North American natural gas consumed in California in 2016 from LCFS Reporting Tool (LRT)[10] data;
- Electricity: California grid average mix, which meets the Renewable Portfolio Standard (RPS) requirements, from the LCFS Lookup Table;
- 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;
- Renewable Diesel (RD): volume-weighted average CI of RD consumed in California in 2016 from LRT data; and
- Renewable Natural Gas (RNG): biomethane to CNG (off-site refueling), based on the average CI of RNG consumed in California in 2016 from LRT data.

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.

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9 https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm

10 https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

Criteria Pollutant and Toxics Emission Factors

For the determination of tailpipe criteria pollutant emission factors for on-road vehicles, staff used CARB's EMFAC 2017 model to calculate the tailpipe emissions and emissions associated with the usage of the supported vehicles or equipment, such as idling emissions and PM 2.5 emissions from brake and tire wear, when applicable. For off-road equipment, staff used CARB's 2011 Cargo Handling Equipment Inventory and 2011 TRU Emissions Inventory to develop emission factors associated with the usage of the supported vehicles or equipment.

As discussed in previous funding plans, preliminary data show that attaching a hybrid driveline to a vehicle without careful integration with the engine and after-treatment system can have the unintended consequence of increasing criteria pollutant emissions. Subsequently, the emission factors for hybrids are based on a certified vertically integrated hybrid vehicle. Moreover, improved fuel economy from the use of a hybrid system[11] provides improvements in the emission factors as less fuel is used and the well-to-tank GHG emissions are reduced.

Staff incorporated deterioration, when available, for both 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 capability.[12] The emission factors developed for advanced technology vehicles are supported by the proposed projects when appropriate, along with emission factors for baseline conventional vehicles.

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[11] Hybrid vehicle fuel economy improvement based on Climate Change Scoping Plan Appendices, Volume I: Supporting Documents and Measure Detail. http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf

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

Quantification Methodology for Projects

To quantify the potential emission reductions for each project, staff must first determine the annual per-vehicle emission reductions for each technology weighted by the amount of each technology funded in the project. Once the annual per-vehicle emission reductions are determined, staff estimate the average project costs to determine the number of vehicles or equipment that may be funded by the allotted funding amounts. Finally, to determine the total potential emission reductions for each project, the average annual per-vehicle emission reductions is multiplied by the number of vehicles or equipment funded and the project life. As noted in the individual project write-ups, staff have quantified emission reductions based on an illustrative example due to the uncertainty in the vehicle and equipment types that will be funded.

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.

For on-road projects, annual emission reductions are calculated using Formula 3, where emission factors are in terms of grams per mile (g/mi) and usage is based on annual vehicle miles traveled (VMT) or miles per year (mi/yr). For off-road projects, annual emission reductions are also calculated using Formula 3, however, emission factors are in terms of grams per hour (g/hr) and usage is in terms of hours per year. Additionally, the vehicle or equipment's load factor, which is an indicator of the nominal amount of work done by the engine for a particular application, and the horsepower rating of the engine are included when developing emission factors for off-road projects.

Formula 3: Annual Per-Vehicle Emission Reductions

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

Once the annual per-vehicle emission reductions are calculated for the eligible technologies in each project, technology splits are factored in so that the emission reductions on a per-vehicle basis are representative of an average vehicle or equipment replaced under the project, as shown in Formula 4. The technology splits or mix for each project are determined based on historical project data or projected demand.

Formula 4: Average Annual Per-Vehicle Emission Reductions

$$Average\ Annual\ Per\ Vehicle\ Emission\ Reductions\ (tpy) = \Sigma(annual\ emission\ reductions\ per\ vehicle\ type * fraction\ of\ vehicles\ funded)$$

Project Costs

Once staff have identified the incentive cost for each technology and potential technology split for a given project, staff can calculate the average incentive amount for each project, using Formula 5.

Formula 5: Average Incentive Cost

$$Average\ Incentive\ Cost\ (\$) = \Sigma(cost\ per\ vehicle\ type * fraction\ of\ vehicles\ funded)$$

Once the average incentive amount is determined, the allotted funding for the project minus the administrative cost can be divided by the average incentive amount to estimate the number of vehicles or equipment likely to be funded, as shown in Formula 6. Staff evaluated the appropriate administrative cost for each project, which vary depending on the amount of oversight necessary to implement the project.

Formula 6: Number of Vehicles Funded

$$Number\ of\ Vehicles\ Funded = \frac{(Proposed\ Funding\ Allocation - Administrative\ Cost)}{Average\ Incentive\ Cost}$$

Total Lifetime Emission Reductions

Once the average per-vehicle emission reductions are determined, it is multiplied by the potential number of vehicles funded and the project life to determine the total potential lifetime emission reductions for a project, as shown in Formula 7.

Formula 7: Lifetime Emission Reductions

$$Lifetime\ Emission\ Reductions\ (tons) = average\ per\ vehicle\ emission\ reductions * number\ of\ vehicles * project\ life$$

Light-Duty Vehicle and Transportation Equity Investments

CARB's LDV and transportation equity investments are grouped into two broad project categories: the Clean Vehicle Rebate Project (CVRP) and transportation equity projects. CVRP supports increasing the number of zero-emission vehicles (ZEV) on California's roadways to meet the State's ZEV deployment goals and achieve the large scale transformation of the light-duty fleet. The transportation equity projects are designed to increase access to clean vehicles in disadvantaged communities and lower-income households. The transportation equity projects proposed in this year's Funding Plan include: Financing Assistance for Lower-Income Consumers, Clean Mobility Options for Disadvantaged Communities, Agricultural Worker Vanpools, Rural School Bus Pilot Project, Clean Mobility in Schools, the Sustainable Transportation Equity Project (STEP), and One-Stop Shop.

All light-duty vehicle and transportation equity investment projects use the light-duty automobile classification in EMFAC 2017 for the development of emission factors, with the exception of the Agricultural Worker Vanpools Project and Clean Mobility Options in Disadvantaged Communities, which use the LHD vehicle classification.

Quantification of the LDV and transportation equity investment projects proposed in this year's Funding Plan are described in more detail below.

CVRP

CVRP achieves emission benefits by providing incentives for plug-in hybrid electric vehicles (PHEV), battery-electric vehicles (BEV), and fuel cell vehicles (FCV) to help motivate consumer purchasing decisions and support widespread adoption. When estimating emission benefits for CVRP, staff assumed that the consumer was purchasing or leasing a new vehicle. As a result, emission reductions for CVRP are calculated as the difference between an average 2019 model year conventional LDV and an average 2019 model year advanced technology LDV that was purchased or leased.

Project data from November 2018 through May 2019 show that approximately 70 percent of standard CVRP rebates went to BEVs, 28 percent went to PHEVs, and 2 percent went to FCVs. Project data for low-income applicants for the same period show that 50 percent of rebates went to BEVs, 47 percent went to PHEVs, and 3 percent went to FCVs. Due to the waitlist and expected start of the updated CVRP program, with changes in rebate amounts, staff assumed that $80 million of rebates for FY 2019-20 would continue to fund those same technologies at similar rates and for the remaining $130.62 million, rebate amounts for the updated program would be reduced by $500 for BEVs, PHEVs, and FCVs. There are no changes in rebates to the $25 million allocated for the increased rebate program for FY 2019-20.

Furthermore, for this analysis, in particular for the standard CVRP rebate, staff assumed technology splits were the same for both the updated program and those on the waitlist. In this respect, staff assumed the $80 million of the FY 2019-20 CVRP allocation would go to fund rebates on the waitlist and the remaining $130.62 million would be used to fund vehicles rebated under the new program rules. As a result, the following tables that refer specifically to the standard rebate reductions and savings are a summation of the reductions for the 32,100 vehicles expected to be rebated under the program's old rules and the 67,900 vehicles expected to be rebated under the program's new rules and rebate amounts.

Table A-4 shows the emission factors for the selected baseline vehicle and PHEV, FCV, and BEV replacements. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-4: CVRP Emission Factors

Pollutant	2019 Gasoline (g/mi)	2019 Plug-in Hybrid Electric Vehicle (g/mi)	2019 Battery Electric Vehicle (g/mi)	2019 Fuel Cell Vehicle (g/mi)
NOx	0.0166	0.0080	0	0
PM 2.5	0.0198	0.0108	0.0099	0.0099
ROG	0.0035	0.0017	0	0
GHG	335	198	93	150

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 the table below.

Table A-5: CVRP Annual Usage Assumptions

Technology	Usage (mi/yr)
PHEV	14,855[13]
BEV	11,059[14]
FCV	12,445[15]

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[13] 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/)
[14] Based on 30.3 miles per day. Smart, J. and Schey, S., "Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project," *SAE Int. J. Alt. Power.* 1(1):27-33, 2012, doi:10.4271/2012-01-0199. (http://papers.sae.org/2012-01-0199/)
[15] Hardman, S., Tal, G., 2019, Understanding the Early Adopters of Fuel Cell Vehicles, NCST (forthcoming)

Using the emission factors, technology mix, and the annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for CVRP, as shown in Table A-6.

Table A-6: CVRP Annual Emission Benefits on a Per-Vehicle Basis

Type of Rebates	Pollutant	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)	
			Per Technology	Average
Standard Rebates	GHG	PHEV	2.03	2.49
		BEV	2.67	
		FCV	2.30	
	NOx	PHEV	0.00014	0.00019
		BEV	0.00020	
		FCV	0.00023	
	PM 2.5	PHEV	0.00015	0.00013
		BEV	0.00012	
		FCV	0.00014	
	ROG	PHEV	0.00003	0.00004
		BEV	0.00004	
		FCV	0.00005	
Rebates for Low-Income Applicants	GHG	PHEV	2.03	2.36
		BEV	2.67	
		FCV	2.30	
	NOx	PHEV	0.00014	0.00017
		BEV	0.00020	
		FCV	0.00023	
	PM 2.5	PHEV	0.00015	0.00013
		BEV	0.00012	
		FCV	0.00014	
	ROG	PHEV	0.00003	0.00004
		BEV	0.00004	
		FCV	0.00005	

As directed in the 2019-20 State Budget, staff is allocating at least $25 million to CVRP rebates for low-income applicants for FY 2019-20. Based on project data, staff anticipate the average rebate cost to be $4,105 for low-income applicants, $2,270 for standard rebates during the waitlist period, and $1,770 for standard rebates when the new program rules go into effect.

With the $210.62 million budgeted for classic CVRP included in the 2019-20 State Budget and the average cost discussed above, staff estimate that approximately 100,000 vehicles can be funded, in addition to the 5,600 vehicles that can be funded with the $25 million allocation for CVRP rebates for low-income applicants. CVRP has a 30 month (2.5 years) ownership requirement; therefore, total potential emission reductions for the project are quantified over the course of 30 months and shown in Table A-7.

Table A-7: Total Potential Emission Reductions for CVRP

Type of Rebates	Pollutant	Per Vehicle Average Annual Emission Reductions	Number of Vehicles	Average Annual Emissions	Project Life (years)	Lifetime Annual Emission Reductions
Standard Rebates	GHG	2.49	100,000	248,800	2.5	622,000
	NOx	0.00019		18.59		46.5
	PM 2.5	0.00013		12.80		32.0
	ROG	0.00004		3.89		9.73
Rebates for Low-Income Applicants	GHG	2.36	5,600	13,200	2.5	33,100
	NOx	0.00017		0.98		2.45
	PM 2.5	0.00013		0.75		1.86
	ROG	0.00004		0.13		0.32

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. According to the project data, the average replacement vehicle is a 2013 model year, so staff used a 2013 model year, conventional gasoline vehicle as the baseline.

Project data from December 2015 through May 2019 shows that approximately 37 percent of Financing Assistance grants went to BEVs, 47 percent went to PHEVs, and 15 percent went to conventional hybrids. For this analysis, staff assumed that rebates for FY 2019-20 would continue to fund those same technologies at similar rates. Emission factors for Financing Assistance are shown in Table A-8. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-8: Financing Assistance Emission Factors

Pollutant	2013 Gasoline (g/mi)	2013 Conventional Hybrid (g/mi)	2013 PHEV (g/mi)	2013 BEV (g/mi)
NOx	0.0233	0.0186	0.0112	0
PM 2.5	0.0187	0.0106	0.0103	0.0099
ROG	0.0048	0.0038	0.0023	0
GHG	385	308	228	107

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 A-9.

Table A-9: Financing Assistance Annual Usage Assumptions

Technology	Usage (mi/yr)
Conventional Hybrid/PHEV	14,855[16]
BEV	11,059[17]

Using the above assumptions and emission factors, staff calculated the potential annual per-vehicle emission reductions for Financing Assistance, as shown in Table A-10.

[16] 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/)

[17] Based on 30.3 miles per day. Smart, J. and Schey, S., "Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project," *SAE Int. J. Alt. Power.* 1(1):27-33, 2012, doi:10.4271/2012-01-0199. (http://papers.sae.org/2012-01-0199/)

Table A-10: Financing Assistance Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)	
		Per Technology	Average
GHG	Conventional Hybrid	1.14	2.43
	PHEV	2.34	
	BEV	3.08	
NOx	Conventional Hybrid	0.0001	0.00021
	PHEV	0.0002	
	BEV	0.0003	
PM 2.5	Conventional Hybrid	0.00013	0.00013
	PHEV	0.00014	
	BEV	0.00011	
ROG	Conventional Hybrid	0.00002	0.00004
	PHEV	0.00004	
	BEV	0.00006	

Staff anticipate the average cost per loan, including the vehicle price buy down and loan loss reserve, will range from $4,300 to $6,800 and thus, estimated the average incentive cost per loan would be $6,425.

Based on the proposed $10.9 million allocation for Financing Assistance and the average cost shown above, staff estimate that approximately 1,200 vehicles can be funded. Financing Assistance has a 30-month ownership requirement; therefore, total potential emission reductions for the project are quantified over the course of two and a half years, as shown in Table A-11.

Table A-11: Total Potential Emission Reductions for Financing Assistance

Pollutant	Per-Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emissions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
GHG	2.43	1,200	2,972	2.5	7,400
NOx	0.00021		0.26		0.65
PM 2.5	0.00013		0.15		0.38
ROG	0.00004		0.05		0.13

Clean Mobility Options for Disadvantaged Communities

Clean Mobility Options for Disadvantaged Communities (Clean Mobility Options) projects achieve emission reduction benefits by implementing car share programs that use advanced technology vehicles instead of conventional light-duty vehicles in disadvantaged communities. Clean Mobility Options projects also offer alternate modes of transportation that encourage the use of zero-emission and plug-in hybrid vehicles, vanpools, and other mobility options. While a number of strategies can be employed, the use of advanced technology vehicles instead of conventional light-duty vehicles in a car sharing component provides the primary GHG reductions resulting from a project. For this analysis, staff estimates reductions from the emissions offset between a brand new, conventional light-duty vehicle and an advanced technology vehicle. As project data becomes available, staff anticipate updating this analysis to also reflect alternate modes of transportation.

Two Clean Mobility Options pilot projects launched in April 2018 and May 2017, with more projects on the way. Because future projects are unknown and each project is different, for this analysis, staff assumes that vehicles funded will be 90 percent BEVs and 10 percent PHEVs, respectively. Moreover, staff assumes that 95 percent of the vehicles will be light-duty and the remaining 5 percent will be light heavy-duty. Table A-12 shows the emission factors for the selected baseline vehicle and PHEV and BEV replacements. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-12: Clean Mobility Options Emission Factors

Vehicle Class	Pollutant	2019 Gasoline (g/mi)	2019 Diesel (g/mi)	2019 Plug-in Hybrid Gasoline Electric Vehicle (g/mi)	2019 Plug-in Hybrid Diesel Electric Vehicle (g/mi)	2019 BEV (g/mi)
LDA	NOx	0.0166		0.0080		0
	PM 2.5	0.0198		0.0116		0.0099
	ROG	0.0035		0.0017		0
	GHG	335		198		93
LHD	NOx	0.0408	0.1120	0.0196	0.054	0
	PM 2.5	0.0371	0.0455	0.0221	0.021	0.0099
	ROG	0.0137	0.0722	0.0066	0.035	0
	GHG	1,176	650	695	356	326

Staff generated an annual usage assumption of 8,200 miles per year for Clean Mobility Options based on data from other car sharing programs in the United States.[18] Using

[18] Martin, E., Shaheen, S., and Lidicker, J. "Impact of Carsharing on Household Vehicle Holdings," *Transportation Research Record: Journal of the Transportation Research Board, No. 2143,* Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 150–158. DOI: 10.3141/2143-19. http://sfpark.org/wp-content/uploads/carshare/Impact_of_Carsharing_on_Household_Vehicle_Holdings.pdf

the above assumptions and emission factors, staff calculated the potential annual per-vehicle emission reductions for Clean Mobility Options, as shown in Table A-13.

Table A-13: Clean Mobility Options Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)
GHG	LDA	PHEV - Gasoline	1.12
		BEV	1.98
	LHD	PHEV - Gasoline	3.94
		PHEV - Diesel	2.41
		BEV	6.97
NOx	LDA	PHEV - Gasoline	0.0001
		BEV	0.0002
	LHD	PHEV - Gasoline	0.0001
		PHEV - Diesel	0.0005
		BEV	0.0004
PM 2.5	LDA	PHEV - Gasoline	0.0001
		BEV	0.0001
	LHD	PHEV - Gasoline	0.0001
		PHEV - Diesel	0.0002
		BEV	0.0002
ROG	LDA	PHEV - Gasoline	0.00002
		BEV	0.00003
	LHD	PHEV - Gasoline	0.0001
		PHEV - Diesel	0.0003
		BEV	0.0001

Based on the proposed $10 million allocation for Clean Mobility Options, staff estimates that up to 200 vehicles can be funded.

For the purpose of this analysis, staff conservatively assumed that emission reductions will occur over the course of three years for light duty vehicles and over the course of six years for light heavy-duty vehicles. The total potential emission reductions for Clean Mobility Options are shown in Table A-14.

Table A-14: Total Potential Emission Reductions for Clean Mobility Options

Pollutant	Vehicle Class	Supported Technologies	Per Technology	# of Vehicles	Annual Emission Reductions (tpy)	Project Life (years)	Lifetime Emission Reductions Per Vehicle Class (tons)	Project Total Lifetime Emission Reductions (tons)
GHG	LDA	PHEV - Gasoline	1.11	19	21.33	3	63.99	1,500
		BEV	1.98	170	339	3	1,018	
	LHD	PHEV - Gasoline	3.94	1	3.95	6	23.67	
		PHEV - Diesel	2.41	1	2.41	6	14.47	
		BEV	6.97	9	62.72	6	376	
NOx	LDA	PHEV - Gasoline	0.0001	19	0.001	3	0.004	0.11
		BEV	0.0002	170	0.026	3	0.077	
	LHD	PHEV - Gasoline	0.0002	1	0.0002	6	0.001	
		PHEV - Diesel	0.0005	1	0.0005	6	0.003	
		BEV	0.0004	9	0.003	6	0.020	
PM 2.5	LDA	PHEV - Gasoline	0.0001	19	0.001	3	0.0042	0.065
		BEV	0.0001	170	0.015	3	0.0459	
	LHD	PHEV - Gasoline	0.0001	1	0.0001	6	0.001	
		PHEV - Diesel	0.0002	1	0.0002	6	0.001	
		BEV	0.0002	9	0.002	6	0.013	
ROG	LDA	PHEV - Gasoline	0.00002	19	0.0003	3	0.001	0.027
		BEV	0.00003	170	0.0054	3	0.016	
	LHD	PHEV - Gasoline	0.00006	1	0.00006	6	0.0006	
		PHEV - Diesel	0.00034	1	0.00034	6	0.002	
		BEV	0.00012	9	0.00111	6	0.007	

Agricultural Worker Vanpools

The Agricultural Worker Vanpools Pilot Project (Agricultural Worker Vanpools) achieves emission reduction benefits by providing incentives for advanced technology vehicles instead of conventional vehicles to be used for agricultural worker vanpools in disadvantaged communities. While Agricultural Worker Vanpools may achieve more significant emission benefits through VMT reductions and the displacement of single owner vehicles, there is not enough project data yet to quantify the potential emission reductions from VMT reductions or vehicle displacements. For the purposes of this analysis, staff estimated reductions from the emissions offset between a new 2020 model year conventional LHD van and a conventional hybrid van.

Emission factors for Agricultural Worker Vanpools are shown in Table A-15. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-15: Agricultural Worker Vanpools Emission Factors

Pollutant	2020 Gasoline (g/mi)	2020 Conventional Hybrid (g/mi)
NOx	0.0335	0.0268
PM 2.5	0.0363	0.0196
ROG	0.0056	0.0044
GHG	1,155	924

Staff also generated an annual usage assumption of 35,000 miles per year based on the average use of a 2020 model year, LHD van in EMFAC 2017.

Using the above assumptions and emission factors, staff calculated the potential annual per-vehicle emission reductions for Agricultural Worker Vanpools, as shown in Table A-16.

Table A-16: Agricultural Worker Vanpools Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Per-Vehicle Annual Emission Reductions (tpy)
GHG	8.09
NOx	0.00026
PM 2.5	0.00064
ROG	0.00004

Estimating the cost for all components for a van conversion to a hybrid system van equipped to carry agricultural workers, staff anticipates the average incentive amount per van would be approximately $45,000. Based on the proposed $5 million allocation for Agricultural Worker Vanpools and the average cost of $45,000 per van, staff estimate that approximately 110 vans can be funded. Using data from a similar program through CalVans, staff anticipate the funded vans would have a project life of 6 years. Using the estimated number of vehicles and project life as stated previously, staff calculated the total potential emission reductions for Agricultural Worker Vanpools, as shown in Table A-17.

Table A-17: Total Potential Emission Reductions for Agricultural Worker Vanpools

Pollutant	Per-Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emissions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
GHG	8.09	110	900	6	5,400
NOx	0.00026		0.029		0.17
PM 2.5	0.00064		0.072		0.43
ROG	0.00004		0.0048		0.029

Rural School Bus Pilot Project

The Rural School Bus Pilot Project provides emission reduction benefits by providing incentives for school districts to purchase advanced technology school buses, giving priority to districts in rural areas and small air districts in the state. The Rural School Bus Pilot Project provides funding for battery-electric school buses and school buses that operate on renewable fuels.

The Rural School Bus Pilot Project requires school buses to be at least 20 years old to be eligible for replacement, this is a 1999 or older chassis. Based on previous years of this project, staff expect that 66 percent of the buses funded will be battery-electric and the remaining 34 percent will operate on renewable diesel. Because limited data is available on vehicles utilizing renewable fuels, staff assumes that the renewable diesel vehicles will have similar emission rates as conventional diesel-fueled vehicles. Emission factors for the Rural School Bus Pilot Project are shown in Table A-18. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-18: Rural School Bus Pilot Project Emission Factors

Pollutant	1999 Diesel (g/mi)	2019 Battery Electric (g/mi)	2019 Renewable Diesel (g/mi)
NOx	17	0	1.75
PM 2.5	0.4004	0.1626	0.3268
ROG	0.2206	0	0.0163
GHG	1,830	272	441

Staff generated an annual usage assumption of 13,000 miles per year, based on the average use of 1999 model year school buses in EMFAC 2017. Applying the emission factors, technology mix, and annual usage assumptions mentioned above, staff calculated the potential per-vehicle emission reductions for the Rural School Bus Pilot Project, as shown in Table A-19.

Table A-19: Rural School Bus Pilot Project Annual Emission Reduction Benefits On a Per-Vehicle Basis

Pollutant	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)	
		Per Technology	Average
GHG	BEV	20.25	19.50
	Renewable Diesel	18.05	
NOx	BEV	0.2485	0.2400
	Renewable Diesel	0.2234	
PM 2.5	BEV	0.0034	0.0026
	Renewable Diesel	0.0011	
ROG	BEV	0.0032	0.0031
	Renewable Diesel	0.0030	

Applying the assumed technology mix from the prior year of the project, staff calculated the average incentive cost for the Rural School Bus Pilot Project, as shown in Table A-20.

Table A-20: Rural School Bus Pilot Project Average Incentive Cost

Supported Technologies	Cost Per Technology	Average
BEV	$400,000	$320,100
Renewable Diesel	$165,000	

Based on the proposed $4.45 million allocation for the Rural School Bus Pilot Project, staff anticipate that approximately 13 school buses to be funded. The average school bus has a useful life of 15 years.[19] Thus, for this analysis, staff assumed a conservative

[19] https://www.afdc.energy.gov/uploads/publication/case-study-propane-school-bus-fleets.pdf

project life of 15 years and quantified the Rural School Bus Pilot Project's potential emission reduction benefits over the course of 15 years, as shown in Table A-21.

Table A-21: Total Potential Emission Reductions for the Rural School Bus Pilot Project

Pollutant	Per-Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emissions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
GHG	19.50	13	260	15	3,860
NOx	0.2400		3.17		47.6
PM 2.5	0.0026		0.03		0.52
ROG	0.0031		0.04		0.61

Clean Mobility in Schools Pilot Project

The Clean Mobility in Schools Pilot Project (Clean Mobility in Schools) achieves emission reduction benefits by funding deployment of synergistic GHG emission reduction technologies at schools located in disadvantaged communities. Project components could include electrification of transportation fleets (both light-duty and heavy-duty vehicles used at schools); installation of necessary infrastructure to support advanced technology vehicles and equipment; advanced technology car sharing; using GHG emission reduction curriculum in the classroom; using GHG emission reduction outreach efforts to the community; and other green technologies and practices.

Because this project can fund a variety of components, staff chose three vehicle classes likely to be funded to illustrate the potential emission reductions from this project including LDV, MHD and School Bus. Emission factors for these vehicles are shown in Table A-22. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-22: Clean Mobility in Schools Emission Factors

Vehicle Class	Pollutant	2019 Baseline (g/mi)	2019 Battery Electric (g/mi)
LDV	NOx	0.017	0
	PM 2.5	0.020	0.010
	ROG	0.003	0
	GHG	335	93
MHD	NOx	1.45	0
	PM 2.5	0.066	0.031
	ROG	0.011	0
	GHG	1,298	220
School Bus	NOx	1.75	0
	PM 2.5	0.327	0.163
	ROG	0.016	0
	GHG	1,458	247

Staff used the same annual usage assumption for LDVs as is used in CVRP, the same annual usage assumptions for MHD as is used in HVIP, and the same annual usage assumptions for school bus as Rural School Bus Pilot Project. The annual usage assumptions for Clean Mobility in Schools are shown in Table A-23.

Table A-23: Clean Mobility in Schools Annual Usage Assumptions

Vehicle Class	Usage (mi/yr)
LDV	11,059
MHD	12,000
School Bus	13,000

Using the above assumptions and emission factors, staff calculated the potential annual per-vehicle emission reductions for the Clean Mobility in Schools, as shown in Table A-24.

Table A-24: Clean Mobility in Schools Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)
GHG	LDV	Battery Electric	2.68
	MHD		12.93
	School Bus		15.74
NOx	LDV		0.0002
	MHD		0.0192
	School Bus		0.0251
PM 2.5	LDV		0.0001
	MHD		0.0005
	School Bus		0.0024
ROG	LDV		0.0000
	MHD		0.0001
	School Bus		0.0002

Clean Mobility in Schools is a new project. The expected cost per technology for the three vehicle classes is shown in Table A-25. Staff anticipates the project monies will fund the full cost of the vehicles. The vehicles costs are consistent with Clean Mobility Options for light-duty vehicles, the average new vehicle cost in HVIP for MHD vehicles, and the full cost of the school buses consistent with the Rural School Bus Pilot Project, which are based on EMFAC 2017[20].

Table A-25: Clean Mobility in Schools Average Incentive Costs

Vehicle Class	Supported Technologies	Cost Per Technology
LDV	Battery Electric	$35,000
MHD		$200,000
School Bus		$400,000

Based on the proposed $5 million allocation for Clean Mobility in Schools and the costs shown above, staff anticipates that approximately 21 vehicles can be funded – 10 LDVs, 7 MHDs (delivery vehicles), and 4 school buses. Please note that this is an illustrative example of the types of vehicles that can be funded in Clean Mobility in Schools.

For calculating the potential emission reductions, light-duty vehicles were given a conservative project life of 3 years, consistent with Clean Mobility Options for light-duty vehicles, and medium heavy-duty vehicles and school buses were given a project life of 15 years, consistent with HVIP and the Rural School Bus Pilot Project,

[20] https://www.arb.ca.gov/emfac/2017/

respectively. Staff quantified Clean Mobility in Schools' total potential emission reductions, as shown in Table A-26 below.

Table A-26: Total Potential Emission Reductions for Clean Mobility in Schools

Pollutant	Vehicle Class	Per Vehicle Annual Emission Reductions (tpy)	Number of Vehicles	Annual Emission Reductions (tpy)	Project Life (years)	Lifetime Emission Reductions Per Vehicle Class (tons)	Project Total Lifetime Emission Reductions (tons)
GHG	LDA	2.68	10	26.75	3	80	2,380
	MHD	12.93	7	90.51	15	1,358	
	School Bus	15.74	4	62.95	15	944	
NOx	LDA	0.0002	10	0.0020	3	0.0061	3.53
	MHD	0.0192	7	0.1344	15	2.02	
	School Bus	0.0251	4	0.1005	15	1.51	
PM 2.5	LDA	0.0001	10	0.0012	3	0.0036	0.19
	MHD	0.0005	7	0.0032	15	0.0483	
	School Bus	0.0024	4	0.0094	15	0.1412	
ROG	LDA	0.0000	10	0.0004	3	0.0013	0.030
	MHD	0.0001	7	0.0010	15	0.0154	
	School Bus	0.0002	4	0.0009	15	0.0140	

Sustainable Transportation Equity Project (STEP)

Sustainable Transportation Equity Project (STEP) projects may achieve GHG emission reductions through implementing a wide variety of capital and infrastructure, operations, planning, policy, and outreach projects.

While methodologies do not exist to calculate GHG emission reduction estimates for projects funded through the planning grants, staff expects the planning grant funds to facilitate GHG emission reductions by readying communities to implement GHG emission-reducing projects and programs.

Additionally, the implementation block grant will fund projects that result in mode shift away from single-occupancy vehicles toward shared, zero-emission vehicle services and/or active transportation modes. These types of projects will reduce GHG emissions by both displacing vehicle miles traveled (VMT) and providing cleaner transportation options. While staff expects projects funded through the implementation block grant to reduce GHG emissions, this funding plan does not quantify the potential emissions reductions. At this time, not enough is known about what STEP will fund to make the valid assumptions needed to quantify benefits.

Emissions reductions and other benefits of funded projects will be quantified during STEP implementation. Furthermore, staff plan on using the data gathered from the initial projects funded by STEP to develop and refine quantification methodologies and project assumptions for use in future funding plans.

Outreach, Community Needs Assessments, Technical Assistance, and One-Stop-Shop for CARB's Equity ZEV Replacement Incentives

In addition to the light-duty vehicle investment projects described previously, CARB is proposing to allocate $2 million to support technical assistance and capacity building to community-based organizations and priority communities to increase outreach of LCTI funding programs, assess community transportation needs, convene networking session to strengthen partnerships and develop clean mobility projects, and provide application assistance to prospective equity project applicants. The goal of this project is to support implementation of SB 350 key recommendations to reduce barriers faced by low-income residents in accessing clean transportation and mobility options, which includes increasing outreach and awareness of low carbon transportation investments. Because this project helps enable ZEV adoption by low-income residents through other incentive projects, such as CVRP and Financing Assistance, as well as support development of clean mobility projects, such as Clean Mobility Options for Disadvantaged Communities and STEP, staff is not quantifying any direct emission reductions for this project. Instead, this project is expected to help achieve the emission reductions projected for CARB's clean vehicle ownership and clean mobility projects.

Additionally, CARB is proposing to allocate $5 million to support the One-Stop-Shop program, a new project to develop a single application tool for accessing incentive project funding and to coordinate outreach across all these projects in order to support ZEV adoption in disadvantaged communities, low-income communities, and low-income households. The goal of this project is to enable more efficient implementation of CARB's equity ZEV incentives and to expand participation by low-income households. Because this project helps enables ZEV adoption through other incentive projects, such as CVRP and Financing Assistance, staff is not quantifying any direct emission reductions for this project. Instead, this project is expected to help achieve the emission reductions projected for CVRP and Financing Assistance.

Heavy-Duty Vehicle and Off-Road Equipment Investments

CARB continues to support a diverse portfolio of investments in heavy-duty and off-road technologies. This year's Funding Plan proposes investments in the deployment of commercialized on-road advanced technologies through the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), legacy vehicle improvements, including assistance for cleaner trucks through the Truck Loan Assistance Program, and Advanced Technology and Demonstration Projects.

Quantification of the emission reduction benefits for each of the heavy-duty vehicle and off-road equipment investment projects is described in more detail below.

Clean Truck and Bus Vouchers

Clean Truck and Bus Vouchers are intended to encourage and accelerate the deployment of zero-emission trucks and buses, vehicles using engines that meet the optional low NOx standard, and hybrid trucks and buses in California. There is a total of $142 million available for Clean Truck and Bus Vouchers projects, which include HVIP and Low NOx Engine Incentives. To illustrate the potential magnitude of emission reductions in this Funding Plan, staff assumed $55 million would be used for the current HVIP waitlist. Based on historical data, staff estimate that 16% ($8.8 million) of the $55 million would go towards Low NOx Engine Incentives. The remaining $85.5 million in HVIP would go towards purely zero emission trucks, buses, and ePTOs. Note the Per-Vehicle Average Annual Emission Reductions for Low NOx Engine Incentives appears to be greater than HVIP eligible vehicles due to the greater usage values used in staff's assumptions.

HVIP

HVIP achieves emission reduction benefits by reducing the up-front cost of hybrid or zero-emission trucks and buses, allowing fleet owners to secure a voucher through their local dealer as part of their vehicle purchase. For the purposes of this analysis, staff estimated reductions from the emissions offset between a new, 2019 model year conventional truck or bus, and an advanced technology vehicle.

For the $55 million estimated to address the current HVIP waitlist, approximately 1 percent of vouchers will go towards the purchase of MHD conventional hybrids, 36 percent for MHD battery-electric trucks, 10 percent for HHD battery-electric trucks, 29 percent battery-electric urban buses, 7 percent for battery-electric school buses, and approximately 1 percent for electric power takeoff (ePTO) systems. The remaining 16% are estimated to be for Low NOx incentives. This was based on HVIP data from the last two fiscal years as of August 2019. The technology splits applied in this analysis differ from last year's due to updated HVIP data. Of the remaining $85.5 million in HVIP, the focus will be on zero-emission technology. Approximately 49 percent for MHD battery-electric trucks, 6 percent for HHD battery-electric trucks, 29 percent battery-electric urban buses, 15 percent for battery-electric school buses, and approximately 1 percent for electric power takeoff (ePTO) systems.

For baseline urban bus emission factors, staff used an average of diesel and CNG urban bus emission rates since the current California fleet utilizes a mix of the two fuel types. Only limited data is available for heavy-duty CNG-fueled vehicles, therefore, staff assumed CNG vehicles have similar emission rates as diesel-fueled vehicles because they are certified to the same emission standard.

Based on discussions with manufacturers, ePTO systems automatically prevents engine idle by shutting the engine off while in park or neutral, preventing unnecessary engine usage during PTO operation. For emission factors associated with ePTOs, staff utilized the emission factors found in EMFAC to quantify the emissions reduction associated with ePTO systems that are currently eligible in HVIP. The emission factor used is associated with the excess emissions due to the usage of PTOs powered by a diesel engine. Emission factors for HVIP are shown in Table A-27 and emission factors used to quantify PTOs are shown in Table A-28. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-27: HVIP Emission Factors

Vehicle Class	Pollutant	2019 Diesel (g/mi)	2019 CNG (g/mi)	2019 Conv. Hybrid (g/mi)	2019 BEV (g/mi)
MHD	NOx	1.45		1.16	0
	PM 2.5	0.0657		0.0364	0.031
	ROG	0.0111		0.0089	0
	GHG	1,298		1,038	220
HHD	NOx	2.53			0
	PM 2.5	0.0563			0.022
	ROG	0.0508			0
	GHG	1,839			312
Urban Bus	NOx	0.6516	0.6516		0
	PM 2.5	0.0510	0.0510		0.026
	ROG	0.0111	0.0111		0
	GHG	1,701	1,491		289
School Bus	NOx	1.75			0
	PM 2.5	0.3268			0.163
	ROG	0.0163			0
	GHG	1,458			247

Note: MHD and HHD emission factors are based on population-weighted averages of the T6 and T7 diesel vehicle classes in EMFAC 2017, respectively, excluding out-of-state vehicles.

Table A-28: ePTO Emission Factors

Vehicle Class	Pollutant	2018 Diesel (g/hr)	2018 Battery Electric (g/hr)
ePTO	NOx	72.84	0
	PM 2.5	0.072	0
	ROG	0.417	0
	GHG	32,450	5,899

Staff generated an annual usage assumption for MHD conventional hybrid vehicles, based on the average use of a conventional MHD diesel vehicle in EMFAC 2017. For urban buses, staff used data provided by previous HVIP voucher recipients to determine the average annual usage. Data for ePTO systems were obtained from NREL's Fleet Test and Evaluation Team.[21] Based on the information, staff assumed that a vehicle typically operates in PTO mode for 4 hours a day and 250 workdays a year. Additionally, staff assumed the fuel consumption rate of 3.218 gallons per hour for ePTO systems based on data from EMFAC. For all other battery-electric vehicle classifications, the annual usage assumption was based on the California Hybrid, Efficient and Advanced Truck Research Center (CalHEAT) Research Center's report on "Battery Electric Parcel Delivery Truck Testing and Demonstration."[22] The annual usage assumptions for HVIP are shown in Table A-29.

Table A-29: HVIP Annual Usage Assumptions

Vehicle Class	Technology	Usage (mi/yr)
MHD	Conv. Hybrid	20,000
	BEV	12,000
HHD	BEV	12,000
	ePTO	1,000 hours/yr
Urban Bus	BEV	30,000
School Bus	BEV	12,000

[21] https://www.nrel.gov/transportation/assets/pdfs/67116.pdf

[22] Gallo, Jean-Baptiste, Jasna Tomić. (CalHEAT). 2013. Battery Electric Parcel Delivery Truck Testing and Demonstration. California Energy Commission.

HVIP Waitlist

Using the emission factors, technology mix, and the annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for the HVIP waitlist, as shown in Table A-30.

Table A-30: HVIP Annual Emission Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)	
			Per Technology	Average
GHG	MHD	Conv. Hybrid	5.19	25.84
		BEV	12.93	
	HHD	BEV	18.32	
		ePTO	26.55	
	Urban Bus	BEV	47.88	
	School Bus	BEV	14.53	
NOx	MHD	Conv. Hybrid	0.0064	0.0226
		BEV	0.0192	
	HHD	BEV	0.0334	
		ePTO	0.0803	
	Urban Bus	BEV	0.0215	
	School Bus	BEV	0.0232	
PM 2.5	MHD	Conv. Hybrid	0.0006	0.0007
		BEV	0.0005	
	HHD	BEV	0.0005	
		ePTO	0.0001	
	Urban Bus	BEV	0.0008	
	School Bus	BEV	0.0022	
ROG	MHD	Conv. Hybrid	0.0000	0.0003
		BEV	0.0001	
	HHD	BEV	0.0006	
		ePTO	0.0005	
	Urban Bus	BEV	0.0003	
	School Bus	BEV	0.0002	

Applying the proposed voucher amounts and the technology mix from the current HVIP data, staff calculated the average voucher cost for the HVIP waitlist as shown in Table A-31.

Table A-31: HVIP (waitlist) Average Incentive Cost

Vehicle Class	Supported Technologies	Cost Per Technology	Average
MHD	Conv. Hybrid	$20,000	$125,400
	BEV	$90,000	
HHD	BEV	$150,000	
	ePTO	$30,000	
Urban Bus	BEV	$143,750	
School Bus	BEV	$225,000	

The budget includes $142 million for Clean Truck and Bus Vouchers. To illustrate the potential magnitude of emission reductions in this Funding Plan, staff assumed that approximately $125 million would be used for HVIP eligible vehicles with $16 million for low NOx vehicles, which will be discussed in the next section. Of the $55 million estimated for the waitlist, staff estimate that approximately 340 vehicles can be funded.

Heavy-duty trucks can have a useful life of over 20 years[23] and the average school bus has a useful life of 15 years.[24] Therefore, staff assumed a conservative project life of 15 years and quantified HVIP's total potential emission reductions over the course of 15 years, as shown in Table A-32 below.

Table A-32: Total Potential Emission Reductions for HVIP (waitlist)

Pollutant	Per Vehicle Average Annual Emission Reductions	Number of Vehicles	Average Annual Emissions	Project Life (years)	Lifetime Annual Emission Reductions
GHG	25.84	340	8,786	15	132,000
NOx	0.0226		7.75		115
PM 2.5	0.0007		0.248		3.72
ROG	0.0003		0.091		1.37

23 http://www.calstart.org/Libraries/CalHEAT_Documents/Baseline_and_Preliminary_Pathways_Whitepaper.sflb.ashx

24 https://www.afdc.energy.gov/uploads/publication/case-study-propane-school-bus-fleets.pdf

HVIP FY 19-20

Using the emission factors, technology mix, and the annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for the HVIP FY 19-20, as shown in Table A-33.

Table A-33: HVIP Annual Emission Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)	
			Per Technology	Average
GHG	MHD	BEV	12.93	23.76
	HHD	BEV	18.32	
		ePTO	26.55	
	Urban Bus	BEV	47.88	
	School Bus	BEV	14.53	
NOx	MHD	BEV	0.0192	0.022
	HHD	BEV	0.0334	
		ePTO	0.0803	
	Urban Bus	BEV	0.0215	
	School Bus	BEV	0.0232	
PM 2.5	MHD	BEV	0.0005	0.0008
	HHD	BEV	0.0005	
		ePTO	0.0001	
	Urban Bus	BEV	0.0008	
	School Bus	BEV	0.0022	
ROG	MHD	BEV	0.0001	0.0002
	HHD	BEV	0.0006	
		ePTO	0.0005	
	Urban Bus	BEV	0.0003	
	School Bus	BEV	0.0002	

Applying the proposed voucher amounts and the technology mix from the current HVIP data, staff calculated the average voucher cost for the HVIP FY 19-20 as shown in Table A-34.

Table A-34: HVIP (FY 19-20) Average Incentive Cost

Vehicle Class	Supported Technologies	Cost Per Technology	Average
MHD	BEV	$90,000	$128,800
HHD	BEV	$150,000	
	ePTO	$30,000	
Urban Bus	BEV	$143,750	
School Bus	BEV	$225,000	

The budget includes $142 million for Clean Truck and Bus Vouchers. To illustrate the potential magnitude of emission reductions in this Funding Plan, staff assumed that approximately $125 million would be used for HVIP eligible vehicles with $16 million for low NOx vehicles, which will be discussed in the next section. Of the $85.5 million estimated for FY 19-20, staff estimate that approximately 620 vehicles can be funded.

Heavy-duty trucks can have a useful life of over 20 years[25] and the average school bus has a useful life of 15 years.[26] Therefore, staff assumed a conservative project life of 15 years and quantified HVIP's total potential emission reductions over the course of 15 years, as shown in Table A-35 below.

Table A-35: Total Potential Emission Reductions for HVIP (FY 19-20)

Pollutant	Per Vehicle Average Annual Emission Reductions	Number of Vehicles	Average Annual Emissions	Project Life (years)	Lifetime Annual Emission Reductions
GHG	23.76	620	14,734	15	221,000
NOx	0.0219		13.60		204
PM 2.5	0.0008		0.509		7.64
ROG	0.0002		0.144		2.16

Low NOx Engine Incentives

Low NOx Engine Incentives achieve emission reduction benefits by supporting the deployment of engines that meet optional low NOx standards. The optional low NOx standards provide manufacturers the ability to certify engines to NOx emission levels that are 50 percent, 75 percent, or 90 percent lower than today's mandatory heavy-duty engine emission standards. Currently, the only available low NOx engines are natural gas engines, so staff used 2019 model year, CNG-fueled vehicles and the associated fuel economy values as the primary baseline for this analysis. Based on currently available technology, staff assumed that approximately 63 percent of the

[25] http://www.calstart.org/Libraries/CalHEAT_Documents/Baseline_and_Preliminary_Pathways_Whitepaper.sflb.ashx
[26] https://www.afdc.energy.gov/uploads/publication/case-study-propane-school-bus-fleets.pdf

incentives would go to HHD vehicles, which includes most refuse haulers and trucks, and 37 percent for urban buses.

Because data available for heavy-duty CNG-fueled vehicles is limited, staff assume CNG-fueled vehicles have similar emission rates as diesel-fueled vehicles since they are certified to the same emission standard. At this time, the only optionally certified low NOx engine meets the standard that is 90 percent lower than the diesel baseline, so staff assumed a 90 percent tailpipe NOx reduction for the low NOx engines.

In order to maximize the GHG emission reduction benefits for low NOx engines, staff proposes to require the use of 100 percent renewable fuels for the first three years for vehicles funded by GGRF. Currently, low NOx engines are only available for natural gas, therefore, staff developed emission factors for low NOx engines fueled with RNG. Emission factors for Low NOx Engine Incentives are shown in Table A-36. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-36: Low NOx Engine Incentives Emission Factors

Vehicle Class	Pollutant	2019 CNG (g/mi)	2019 Diesel (g/mi)	2019 Low NOx RNG (g/mi)	2019 Low NOx Diesel (g/mi)
MHD	NOx	1.45		0.1451	
	PM 2.5	0.0657		0.0657	
	ROG	0.0111		0.0111	
	GHG	1,127		624	
HHD	NOx	2.52	2.52	0.2525	0.2525
	PM 2.5	0.0563	0.0563	0.0563	0.0563
	ROG	0.0508	0.0508	0.0508	0.0508
	GHG	1,578	1,801	873	1,801
Urban Bus	NOx	0.6516		0.0652	
	PM 2.5	0.0510		0.0510	
	ROG	0.0111		0.0111	
	GHG	1,738		962	

Note: MHD and HHD emission factors are based on population-weighted averages of the T6 and T7 diesel vehicle classes in EMFAC 2014, respectively, excluding out-of-state vehicles.

Staff generated annual usage assumptions for Low NOx Engine Incentives, based on the average use of a conventional diesel vehicle in EMFAC 2017 for the corresponding vehicle class and reports from the U.S. Department of Energy's Alternative Fuels Data Center.[27] The annual usage assumptions for Low NOx Engine Incentives are shown in Table A-37.

[27] https://www.afdc.energy.gov/data/10309

Table A-37: Low NOx Engine Incentives Annual Usage Assumptions

Vehicle Class	Usage (mi/yr)
MHD CNG	20,000
HHD Diesel	58,000
HHD CNG	25,000
Urban Bus CNG	47,000

Using the emission factors, technology mix, and the annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for Low NOx Engine Incentives, as shown in Table A-38. Engines certified to the optional low NOx standard are held to the same standards for PM 2.5 and ROG as currently certified heavy-duty engines, therefore, the only criteria pollutant emission benefit for Low NOx Engine Incentives is a reduction in NOx.

Table A-38: Low NOx Engine Incentives Annual Emission Reduction Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per Vehicle Annual Emission Reductions	
			Per Technology	Average
GHG	HHD CNG	Low NOx with RNG	17.62	31.82
	HHD Diesel	Low NOx with RNG	53.81	
	Urban Bus CNG	Low NOx with RNG	36.47	
NOx	HHD CNG	Low NOx with RNG	0.0568	0.0624
	HHD Diesel	Low NOx with RNG	0.1318	
	Urban Bus CNG	Low NOx with RNG	0.0276	

Staff proposals for Low NOx incentive amounts are reflected in Table A-39.

Table A-39: Low NOx Engine Incentive Costs

Vehicle Class	Supported Technologies	Cost Per Technology	Average
HHD CNG	Low NOx with RNG	$45,000	$47,000
HHD Diesel	Low NOx with RNG	$45,000	
Urban Bus	Low NOx with RNG	$50,000	

Using the average cost of $47,000 per engine, staff estimate that approximately 175 engines can be funded. For this analysis, staff used a project life of three years when estimating the potential GHG emission reduction benefits because GHG emission reductions are tied to the use of renewable fuel, which is required for three years. However, heavy-duty trucks can have a useful life of over 20 years,[28] therefore, staff

[28] http://www.calstart.org/Libraries/CalHEAT_Documents/Baseline_and_Preliminary_Pathways_Whitepaper.sflb.ashx

used a project life of 15 years to calculate the emission benefits for criteria pollutant and toxic air contaminants. The total potential emission reductions for Low NOx Engine Incentives are shown in Table A-40.

Table A-40: Total Potential Emission Reductions for Low NOx Engine Incentives

Pollutant	Per Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emission Reductions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
GHG	31.82	175	5,570	3	16,700
NOx	0.0624		10.91	15	164

Advanced Technology and Demonstration Projects

Demonstration projects are geared towards accelerating the introduction of advanced technologies, feeding the innovation pipeline, as well as helping to cover the costs of technology development. Because a variety of types of vehicles, equipment, and technology could be funded, it is important to note that the analyses in this section are an illustrative example of the potential emission reductions that may be achieved through this project as well as acknowledgment of which potential demonstration technologies that are still lacking in data to enable robust emission reductions quantification.

For this analysis, staff estimated the emission reductions for zero-emission drayage trucks which are likely to be funded. Emission factors for drayage trucks are shown in Table A-41. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Based on the proposed $40 million allocated for Advanced Technology and Demonstration Projects, staff assumed for the purposes of this analyses that $20 million would go towards funding approximately 100 battery electric drayage trucks. Of the remaining $20 million, $10 million is assumed to go towards an ocean going vessel emissions reduction bonnet system and the remaining $10 million will go towards an inducement prize.

Table A-41: Advanced Technology and Demonstration Projects Emission Factors

Vehicle Class	Pollutant	2019/Tier 4 Final Baseline	2019 BEV	2019 FCEV
Drayage Truck	NOx	2.96	0	0
	PM 2.5	0.050	0.022	0.022
	ROG	0.044	0	0
	GHG	1,927	327	1,127

Staff generated annual usage assumptions using EMFAC 2017 for drayage trucks as shown in Table A-42.

Table A-42: BEV Drayage Truck Annual Usage Assumptions

Vehicle Class	Technology	Usage (mi/yr)
Drayage Truck	BEV	60,000

Applying the emission factors and usage assumptions above, staff calculated the potential annual per-vehicle emissions reductions for drayage trucks as shown in Table A-43.

Table A-43: Total Potential Emission Reductions for Drayage Trucks

Pollutant	Vehicle Class	Supported Technologies	Per-Vehicle Annual Emission Reductions
GHG	Drayage Truck	BEV	95.98
NOx	Drayage Truck	BEV	0.20
PM 2.5	Drayage Truck	BEV	0.0018
ROG	Drayage Truck	BEV	0.0029

The total potential emissions reductions for drayage trucks funded under Advanced Technology and Demonstration Projects as shown in Table A-44.

Table A-44: Total Potential Emission Reductions for Advanced Technology and Demonstration Projects: Drayage Trucks

Pollutant	Vehicle Class	Per-Vehicle Annual Emission Reductions (tpy)	Number of Vehicles	Annual Emission Reductions (tpy)	Project Life (years)	Project Total Lifetime Emission Reductions (tons)
GHG	Drayage Truck BEV	95.98	100	9,598	10	96,000
NOx	Drayage Truck BEV	0.1960	100	19.60		196
PM 2.5	Drayage Truck BEV	0.0018	100	0.18		1.83
ROG	Drayage Truck BEV	0.0029	100	0.29		2.93

For ocean going vessels, there exists a wide variety of methods to reduce at-berth emissions. These include grid-based shore power, non-grid based shore power, such as distributed generation equipment, emission controls installed on the vessels, such as particulate control traps, selective catalytic reduction units, use of alternative fuels, and emission controls installed at the wharf, such as bonnet emission capture and treatment systems.

While staff expects a bonnet system funded through this project to reduce criteria pollutant and GHG emissions, this funding plan does not quantify the potential emission reductions. At this time, not enough is known about the specifications or the engineering design of a potentially funded bonnet system to make the valid assumptions needed to quantify benefits.

Emissions reductions and other benefits of funded projects will be quantified during project implementation. Furthermore, staff plan on using the data gathered from a funded bonnet system to develop and refine bonnet system quantification methodologies and project assumptions for use in future funding plans.

The $10 million allocated for an inducement prize borrows from the XPRIZE concept by the XPRIZE Foundation, a California based non-profit founded in 2005, where innovators from around the world are invited to form teams and compete to win the prize money. An inducement prize strategy can significantly multiply the investment of Low Carbon Transportation funds to maximize investment in technologies that are currently not developed or deployed to reduce GHG emissions. Bringing an inducement model to CARB's portfolio of incentive project types can greatly increase the size and scope of projects, extending the use of State resources to maximize the potential benefit while reducing the risk to State funds.

The Ansari X Prize is a good example regarding the return on investment that can be achieved thru the use of inducement prizes. The $10 million prize associated with the Ansari X Prize is reported to have fostered $100 million in investment in reusable spaceships specifically and spaceflight in general.[29] That ten to one return on investment is striking when compared to a typical CARB funded demonstration or pilot project, which for every four dollars in Low Carbon Transportation funds, a minimum of one dollar is matched by the project team.

The goal(s) of the inducement prize determines the scope of the potential emissions reductions. For example, a potential goal could be a certain threshold of zero-emission miles for heavy duty trucks or line haul locomotives. While staff expects projects competing for the inducement prize to achieve varying degrees of GHG and criteria pollutant emissions reductions, this funding plan does not attempt to quantify those potential reductions. At this time, not enough is known about the potential technologies that could be brought to the table by potential participants.

Data gathered from the inducement prize competition will help to refine quantification methodologies and project assumptions for use in future funding plans.

[29] https://www.washingtonpost.com/news/innovations/wp/2014/05/21/the-powerful-role-of-incentive-competitions-to-spur-innovation/?utm_term=.e6428092c066

Truck Loan Assistance Program

The Truck Loan Assistance Program aids small business truckers affected by CARB's In-Use Truck and Bus Regulation[30] by providing financing assistance for fleet owners to upgrade their fleets with newer trucks or with diesel exhaust retrofits. Program data from the 2018 calendar year through June 2019 shows that, on average, funds were directed toward the replacement of 2004 model year diesel trucks in both the MHD and HHD vehicle classifications.

While analyzing the annual loan trends, staff have seen an increasing number of trucks with 2010 model year or newer engines purchased through the Truck Loan Assistance Program. From the 2018 calendar year through June 2019, 9 percent of loans went towards the purchase of MHD vehicles with 2010 model year or newer engines, 2 percent towards the purchase of HHD vehicles with a 2007 to 2009 model year engine, and 89 percent towards the purchase of HHD vehicles with 2010 model year or newer engines. On average, fleet owners that purchased trucks with 2010 model year or newer engines purchased 2014 engine model year trucks.

Staff used this engine model year information to develop the emission factors as shown in Table A-45. For more information on how these emission factors were developed, please see the Emission Factor Development section at the beginning of this appendix.

Table A-45: Truck Loan Assistance Program Emission Factors

Vehicle Class	Pollutant	2004 Diesel (g/mi)	2008 Diesel (g/mi)	2014 Diesel (g/mi)
MHD	NOx	8.55		1.34
	PM 2.5	0.5217		0.0654
	ROG	0.8655		0.0097
HHD	NOx	13.10	9.94	2.4506
	PM 2.5	0.4833	0.0842	0.0560
	ROG	0.7659	0.3155	0.0488

Note: MHD and HHD emission factors are based on population-weighted averages of the T6 and T7 vehicle classes in EMFAC 2014, respectively, excluding out-of-state vehicles.

Staff generated annual usage assumptions based on the average use of a 2004 model year, conventional MHD and HHD diesel truck in EMFAC 2017. The annual usage assumptions for the Truck Loan Assistance Program are shown in Table A-46.

30 https://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm

Table A-46: Truck Loan Assistance Program Annual Usage Assumptions

Vehicle Class	VMT (mi/yr)
MHD	13,000
HHD	21,000

Using the emission factors and annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for the Truck Loan Assistance Program, as shown in Table A-47. Please note that PM reductions for the Truck Loan Assistance Program are not quantified because PM reductions are required by the Truck and Bus Regulation through the use of diesel particulate filters. Additionally, GHG emission reductions are not quantified because this program is funded through AQIP, which focuses on criteria pollutant and toxics emission reductions, and the trucks do not achieve a significant fuel economy improvement.

Table A-47: Truck Loan Assistance Program Annual Emission Reduction Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per Vehicle Annual Emission Reductions (tpy)	
			Per Technology	Average
NOx	MHD	2014 MY	0.0937	0.187
	HHD	2008 MY	0.0662	
		2014 MY	0.2236	
ROG	MHD	2014 MY	0.0111	0.0138
	HHD	2008 MY	0.0095	
		2014 MY	0.0151	

In the Truck Loan Assistance Program, staff found the average loan contribution amount per loan including administration costs since the contribution rates were last modified in 2016 is approximately $3,200. With the proposed $48 million allocation for the Truck Loan Assistance Program, staff estimate that approximately 15,000 vehicles can be funded. To achieve NOx reductions, the Truck and Bus Regulation requires the replacement of 2004 engine model year trucks with 2010 or newer engines by January 1, 2021. Therefore, when calculating the emission reduction benefits for this program, staff used a project life of one year to estimate emission reductions that have occurred prior to what is required by the Truck and Bus Regulation.

The total potential emission reductions for the Truck Loan Assistance Program are shown in Table A-48.

Table A-48: Total Potential Emission Reductions for the Truck Loan Assistance Program

Pollutant	Per Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emission Reductions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
NOx	0.1870	15,000	2,805	1	2,810
ROG	0.0138		207		207

AB 8

AB 8 extended the funding for AQIP through 2023, refined the evaluation criteria for projects supported by AQIP, and introduced the following requirements that staff followed to develop the project scoring criteria:

- The state board shall provide preference in awarding funding to those projects with higher benefit-cost scores that maximize the purposes and goals of the Air Quality Improvement Program.[31]
- "Benefit-cost score" means the reasonably expected or potential criteria pollutant emission reductions achieved per dollar awarded by the Board for the project.[32]
- The state board also may give additional preference based on the following criteria, as applicable, in funding awards to projects:[33]

    1. Proposed or potential reduction of criteria or toxic air pollutants.
    2. Contribution to regional air quality improvement.
    3. Ability to promote the use of clean alternative fuels and vehicle technologies as determined by the state board, in coordination with the Energy Commission.
    4. Ability to achieve climate change benefits in addition to criteria pollutant or air toxic emission reductions.
    5. Ability to support market transformation of California's vehicle or equipment fleet to utilize low carbon or zero-emission technologies.
    6. Ability to leverage private capital investments.

Statute directs CARB to annually evaluate potential project categories to assign preference for AQIP funding, based upon the specific criteria identified above. The analysis and methodology in this section of the appendix describes the implementation of the provisions that require CARB to assign preference to projects with a higher benefit-cost score. The AB 8 analysis is fully executed for the two

[31] Health & Safety Code Section 44274(b)
[32] Health & Safety Code Section 44270.3(e)(1)
[33] Health & Safety Code Section 44274(b)

projects that will be funded through AQIP: the Truck Loan Assistance Program and Truck Filter Replacements.

Overview

Conservative estimates for criteria pollutant and toxic air contaminants were developed using guidance provided in AB 8. Because criteria pollutant and toxic air contaminant emissions are geographically localized, criteria pollutant and toxic air contaminant emissions reductions reported in this appendix are estimated at the tailpipe. The two AQIP projects do not have Greenhouse gas emission reductions so these were not tabulated. Building upon the emission reductions and cost information from the Project Quantification section, this section of the appendix provides information on the following:

- Benefit-Cost Score Analysis;
- Additional Preference Criteria Scores; and
- Total Benefit Index Scores.

Benefit-Cost Score Analysis

Staff analyzed the expected costs and developed cost-effectiveness values for each AQIP-funded project using well-established cost-effectiveness calculation methodology for incentives, consistent with that used in the Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program). In addition, to calculate cost-effectiveness, staff also applied an appropriate discount rate and utilized a capital recovery factor (CRF) in the analysis based on 2017 Carl Moyer Program Guidelines.[34] The one percent discount rate was used and the corresponding CRF was determined based on the assumed usage life of the vehicles or equipment supported by a given project.

For each of the proposed projects funded by AQIP, a cost-effectiveness value was calculated. The cost-effectiveness of a project is determined using Formula 8 below.
Formula 8: Cost-Effectiveness

$$Cost\ Effectiveness\ (\frac{\$}{ton}) = \frac{Incentive\ Amount\ per\ Vehicle\ or\ Equipment * CRF}{Annual\ Per\ Vehicle\ Weighted\ Emission\ Reductions}$$

Weighted emission reductions are calculated using Formula 9, consistent with Carl Moyer Program Guidelines:

Formula 9: Annual Weighted Emission Reductions

$$Annual\ Weighted\ Emission\ Reductions (\frac{weighted\ tons}{year}) = NOx\ reductions + ROG\ reductions + (20 * PM\ reductions)$$

[34] https://www.arb.ca.gov/msprog/moyer/guidelines/2017gl/2017_cmp_gl_volume_1.pdf

Table A-49 provides the inputs and the resulting weighted criteria pollutant and toxic air contaminant cost-effectiveness, in terms of dollars per ton of weighted emission reductions, for projects funded by AQIP. For Truck Filter Replacements, PM 2.5 emissions are the pollutant that is reduced so staff utilized the PM 2.5 emission reduction benefits for the AB 8 analysis.

Table A-49: AB 8 Analysis – Weighted Criteria Pollutant and Toxic Air Contaminant Cost-Effectiveness

Proposed Project	Project Life	CRF	Average Annual Per-Vehicle Weighted Emission Reductions (tpy)	Average Incentive Cost	Cost-Effectiveness ($/ton)
Truck Loan Assistance	1	1.010	0.201	$3,200	$16,093

The cost-effectiveness values for each project were given points based on a scale of one to five points. The bins were determined by taking the high and low resulting benefits and scaled to develop an equal distribution of scores. Those projects with a cost-effectiveness of less than $5,000 per ton of weighted emission reductions received a high of five points. The remaining bins were increased by $5,000 increments with the least cost-effective projects, those projects that cost over $20,000 per weighted ton of emissions reduced, receiving the lowest points possible. The cost-effectiveness of each proposed project was scored based on the following scale:

5: Less than $5,000 per ton
4: $5,000 to $9,999 per ton
3: $10,000 to $14,999 per ton
2: $15,000 to $19,999 per ton
1: $20,000 per ton or more

The resulting scores from the scale shown above were then used in the "Total Benefit Index" for AB 8 project selection. Finally, per AB 8, the cost-effectiveness values were converted to benefit-cost values based on pound of weighted emission reductions per dollar spent. The cost-effectiveness, benefit-cost value, and resulting score of each of the proposed projects are shown in Table A-50.

Table A-50: AB 8 Analysis – Benefit-Cost Value and Score for Total Benefit Index

Proposed Project	Cost-Effectiveness ($/ton)	Benefit-Cost Value (lbs/$)	Benefit-Cost Score
Truck Loan Assistance	$16,093	0.124	2

Additional Preference Criteria

Per AB 8, additional preference criteria may be used to provide additional funding preference in conjunction with the benefit-cost scores summarized in Table A-11. The additional preference criteria includes:

- Proposed or potential reduction of criteria and toxic air pollutants;
- Contribution to regional air quality improvement;
- Ability to promote the use of clean alternative fuels and vehicle technologies;
- Ability to achieve GHG reductions;
- Ability to support market transformation of California's vehicle or equipment fleet to utilize low carbon or zero-emission technologies; and
- Ability to leverage private capital investments.

Recognizing the range of potential benefits and to ensure a robust mix of proposed projects to be funded, staff analyzed the associated data and equally divided the results into scores between 0 and 5 for quantitative preference criteria. The quantitative preference criteria for each project includes the proposed or potential reduction of criteria and toxic air pollutants, contribution to regional air quality, and the ability to achieve GHG reductions. Staff used the following steps to develop scoring scales and final scores for the quantitative preference criteria:

1. Quantify the results for each additional preference criteria for the proposed projects;
2. Establish scoring scale increments to generate an equal distribution in points for the proposed projects; and
3. Rank the proposed projects based on the established scoring scale, which is then used in the "Total Benefit Index."

Staff anticipate that the scales for the quantitative additional preference criteria may change each year depending on the mix of projects proposed, due to differences in the range of expected benefits or when additional information becomes available to refine the evaluation. The data and rationale used to establish each of the criteria weighting factors for the associated scores are described below.

Proposed or Potential Reduction of Criteria or Toxic Air Pollutants

This analysis considered the magnitude of emission reductions by quantifying the direct criteria pollutant and toxic air contaminant emission reductions expected per average vehicle or equipment supported under each project. With the benefit-cost score analysis primarily driven by overall project incentive amounts, this additional criteria allowed staff to make direct comparisons of the emission reductions expected by the different proposed projects, independent of the associated incentive amounts.

For this additional preference criterion, staff analyzed the emission benefits on a per-vehicle basis to account for the differences in vehicle sales volumes and statewide populations of the various vehicles supported by AQIP. Resulting total lifetime emission reductions ranged from less than one ton to almost three tons of lifetime criteria pollutant and toxic air contaminant emission reductions per-vehicle. The scoring scale for this criterion was established by evaluating the range of lifetime tons of emission reductions between the highest and lowest value to try to have an equal distribution of scores. As a result, the bins were scaled in half ton increments. Projects with less than or equal to one ton of criteria pollutant and toxic air contaminant emission reductions received one point, while those projects with greater than two and a half tons of criteria pollutant and toxic air contaminant emission reductions received a score of five points. The resulting scale for criteria pollutant and toxic air contaminant emission reductions on a per-vehicle basis is shown below.

5: Greater than 2.5 tons of criteria and toxic emission reductions per vehicle
4: 2 to 2.49 tons of criteria and toxic emission reductions per vehicle
3: 1.5 to 1.99 tons of criteria and toxic emission reductions per vehicle
2: 1 to 1.49 tons of criteria and toxic emission reductions per vehicle
1: Less than 1 ton of criteria and toxic emission reductions per vehicle

Based on the information described above, Table A-51 summarizes the results and the corresponding score for this additional preference criterion.

Table A-51: AB 8 Analysis – Potential Reduction of Criteria or Toxic Air Pollutants

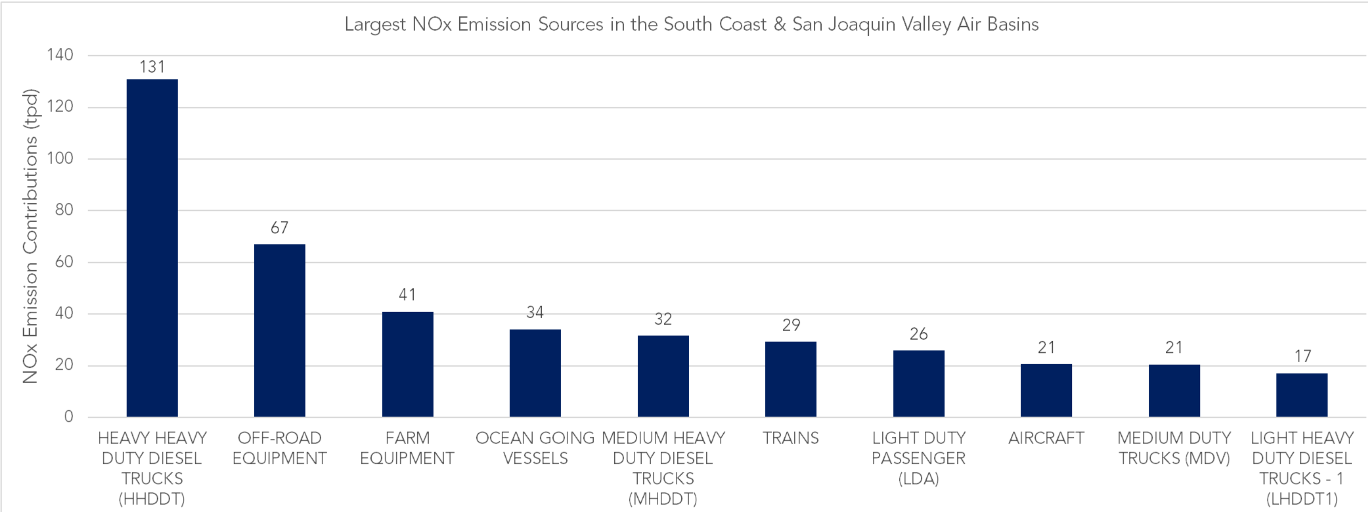
Proposed Project	Annual Per-Vehicle Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime Emission Reductions (tons)	Score
Truck Loan Assistance	0.201	1	0.20	1

Contribution to Regional Air Quality Improvement

Staff developed a scoring scale based on CARB's emissions inventory for the South Coast and San Joaquin Valley air basins, two of the state's extreme nonattainment regions, and ranked projects based on their corresponding emissions contributions from highest to lowest. Specifically, staff used the NOx emissions inventory in tons per day from the 2016 State Implementation Plan (SIP) emission projection data for the South Coast and San Joaquin Valley air basins.[35] The ranking scale is based on the emissions inventory shown in Figure A-1.

[35] https://www.arb.ca.gov/ei/maps/2017statemap/abmap.htm

Figure A-1: Largest NOx Emission Sources in the South Coast & San Joaquin Valley Air Basins



The top ten NOx emission sources were ranked in tons per day for various vehicle and equipment types, ranging from heavy heavy-duty diesel trucks, at 131 tons per day, to light heavy duty diesel trucks, at 17 tons per day. Because the HHD diesel truck category is the largest emission source by far, the scoring scale for this criterion was established for the range of NOx emissions between the second highest and lowest value. As a result, the bins were rounded and scaled in 25-ton per day increments. Projects corresponding to inventory sources with less than or equal to 25 tons of NOx per day receive one point, while those projects with greater than 100 tons of NOx per day receive five points. Each project's potential contribution to regional air quality improvement was ranked based on the scale below.

5: Category contributes more than 100 tons of NOx per day
4: Category contributes 75 to 99 tons of NOx per day
3: Category contributes 50 to 74 tons of NOx per day
2: Category contributes 25 to 49 tons of NOx per day
1: Category contributes less than 25 tons of NOx per day

Based on the information described above, Table A-52 summarizes the results and the corresponding score for this additional preference criterion.

Table A-52: AB 8 Analysis – Contribution to Regional Air Quality Improvement

Proposed Project	Annual Per-Vehicle Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime Emission Reductions (tons)	Score
Truck Loan Assistance	0.201	1	0.20	5

Ability to Promote the Use of Clean Alternative Fuels and Vehicle Technologies

Clean alternative fuels are fuels that have lower well-to-wheel emissions compared to conventional fuels, such as electricity, hydrogen, and renewable fuels. Clean vehicle technologies are technologies that emit zero tailpipe emissions, such as battery-electric and fuel cell vehicles, or enabling technologies, such as vehicles that utilize conventional hybrid or plug-in hybrid systems. This qualitative analysis ranked projects by whether or not they used a clean low carbon alternative or renewable fuel or utilized clean vehicle technologies. Staff scored this additional preference criterion on the scale below.

5: Projects that use low carbon alternative fuels and clean vehicle technologies
3: Projects that use low carbon alternative fuels or clean vehicle technologies
1: Projects that do not use low carbon alternative fuels nor clean vehicle technologies

Based on the information described above, Table A-53 summarizes the results and the corresponding score for this additional preference criterion.

Table A-53: AB 8 Analysis – Ability to Promote the Use of Cleaner Alternative Fuels and Vehicle Technologies

Proposed Project	Annual Per-Vehicle Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime Emission Reductions (tons)	Score
Truck Loan Assistance	0.201	1	0.20	3

Ability to Achieve GHG Reductions

Similar to the methodology established in the first preference criterion for criteria pollutant and toxic air contaminant emission reductions, staff conducted a full well-to-wheel GHG emissions analysis for the vehicles and equipment supported by the proposed projects. Staff determined expected lifetime GHG emission reductions achieved for each vehicle or equipment funded by the proposed projects and found that there were no GHG emission reductions. Because staff are proposing to use AQIP funding for Truck Filter replacements without reduction in fuel usage, staff found that there were no GHG emission reductions funded by AQIP. The scoring scale for GHG emission reductions is shown below.

5: Greater than 200 metric tons of CO_2e per vehicle
4: 150 to 199 metric tons of CO_2e per vehicle
3: 100 to 149 metric tons of CO_2e per vehicle
2: 50 to 99 metric tons of CO_2e per vehicle
1: Less than 50 metric tons of CO_2e per vehicle

Based on the information described above, Table A-54 summarizes the results and the corresponding score for this additional preference criterion.

Table A-54: AB 8 Analysis – Ability to Achieve GHG Emission Reductions

Proposed Project	Annual Per-Vehicle GHG Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime GHG Emission Reductions (tons)	Score
Truck Loan Assistance	N/A	1	N/A	1

<u>Ability to Support Market Transformation of California's Vehicle or Equipment Fleet to Utilize Low Carbon or Zero-Emission Technologies</u>

This qualitative analysis ranked projects by whether or not technologies with the potential for market transformation are supported by the proposed projects. Staff used CARB's Three-Year Investment Strategy for Heavy-Duty Vehicles and Off-Road Equipment from Low Carbon Transportation and Air Quality Improvement Program Investments as a key reference in scoring technologies used for this evaluation. Low NOx engines, battery-electric, and fuel cell electric vehicle technologies, for example, are considered transformative technologies that will help the State meet its air quality goals. Staff scored this preference criterion based on the scale below.

5: Technologies that support market transformation
0: Technologies that do not support market transformation

Based on the information described above, Table A-55 summarizes the results and the corresponding score for this additional preference criterion.

Table A-55: AB 8 Analysis – Ability to Support Market Transformation of California's Vehicle or Equipment Fleet to Utilize Low Carbon or Zero-Emission Technologies

Proposed Project	Annual Per-Vehicle Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime Emission Reductions (tons)	Score
Truck Loan Assistance	0.201	1	0.20	0

<u>Ability to Leverage Private Capital Investments</u>

Staff is proposing not to include this criterion for FY 2018-19 as staff works on developing methodologies to analyze the private capital investments leveraged by projects. Staff intends to identify information sources and may include this preference criterion in future years.

Total Benefit Index

Staff utilized the benefit-cost/cost-effectiveness scores of the proposed projects and the additional preference criteria in the consideration of the projects to be given funding preference under AB 8. Staff developed the Total Benefit Index (TBI) score that preferentially weights the benefit-cost score (at 75 percent of the total score) with additional preference scores (at 25 percent of the total score). Staff weighted the benefit-cost/cost-effectiveness scores in this manner because AB 8 identified the benefit-cost score as the primary metric to assign funding preference for proposed projects.

Table A-56 summarizes the individual scores and the TBI scores for all of the AQIP projects currently proposed in the FY 2018-19 Funding Plan.

Table A-56: AB 8 Analysis – Project Scores and Total Benefit Index Score of Proposed Projects

Proposed Project	Additional Preference Criteria					25% of TBI	75% of TBI	Total Benefit Index Score
	Potential Reduction of Criteria or Toxic Air Pollutants	Contribution to Regional Air Quality Improvement	Ability to Promote Use of Clean Fuels and Technologies	Ability to Achieve GHG Emission Reductions	Ability to Support Market Transformation	Average of Additional Preference Criteria Score	Benefit-Cost Score	
Truck Loan Assistance	1	5	3	1	0	2	2	2

Job Co-Benefit Assessment

In addition to achieving GHG and criteria pollutant emissions reductions, CARB's Low Carbon Transportation Investments yield a whole host of other co-benefits. Quantifying these co-benefits allows stakeholders to take a much more holistic and robust approach on assessing the positive impacts from these projects. Of particular interest is the impact on jobs.

Job co-benefits refer to California jobs supported, not created. A job is defined as one full-time equivalent (FTE) employee position over one year, equal to approximately 2,000 hours of work. Jobs supported include direct, indirect, and induced employment:

- Directly supported jobs refer to labor to complete projects, through direct employment or contracted work paid with Low Carbon Transportation investment dollars (e.g., housing construction, ecosystem restoration, or technical assistance) and labor to produce equipment or materials purchased with Low Carbon Transportation investment dollars (e.g., manufacturing zero-emission vehicles or anaerobic digesters).
- Indirectly supported jobs exist in the supply chains supporting Low Carbon Transportation investment projects. Funding a project generates demand for intermediate inputs of materials and equipment needed to complete the project, leading to expanded production and employment in the relevant upstream industries (e.g., manufacturing construction equipment, zero-emission vehicle parts, or solar panel components).
- Induced jobs are linked to the spending of income from directly and indirectly supported jobs. The personal consumption expenditures of workers in jobs directly and indirectly supported by Low Carbon Transportation investment projects (i.e., increased household spending) stimulate demand for goods and services in the wider California economy.

The methodology for assessing the number of jobs supported was developed by CARB in consultation with the Center for Resource Efficient Communities at the University of California, Berkeley (UC Berkeley). A detailed documentation of the methodology itself and the comprehensive steps that went into its development can be found on CARB's California Climate Investments (CCI) Co-benefit Assessment Methodologies page: https://www.arb.ca.gov/resources/documents/cci-methodologies

Based on such inputs as proposed funding allocation, the fraction of the allocation going to the actual procurement of vehicles and/or equipment, the fraction of the allocation going to implementation and administrative expenses, among other inputs, staff determined the number of jobs supported for each of the Low Carbon Transportation project categories using the aforementioned jobs assessment methodology. For some programs, such as STEP, where there wasn't a methodology to quantify emissions reductions, the number of supported jobs wasn't assessed. The results are shown in Table A-57.

Table A-57: Estimate of the Number of Jobs Supported by Low Carbon Transportation Investments

Project Category	Total Supported Jobs	Directly Supported Jobs	Indirectly Supported Jobs	Induced Jobs
Clean Vehicle Rebate Program	1,009	389	228	392
Financing Assistance for Lower Income Consumers	50	9	7	34
Clean Mobility Options for Disadvantaged Communities	62	28	12	22
Agricultural Worker Vanpools	28	10	8	10
Rural School Bus Pilot	24	8	6	10
Clean Mobility in Schools	33	10	7	16
Clean Truck and Bus Vouchers	871	334	218	319
Truck Loan Assistance Program	293	114	74	105
Demo/Pilot	298	120	76	102
Total	**2,668**	**1,022**	**636**	**1,010**

AB 1550: Disadvantaged Community, Low-Income Community, Low-Income Household Investment Targets

In the proposed Funding Plan, staff proposes that at least 50 percent of CARB's Low Carbon Transportation appropriation be invested in projects meeting one of the AB 1550 criteria with the following targets:

- At least 35 percent of funds for projects located within and benefiting disadvantaged communities.
- At least 15 percent of funds for projects within and benefiting low-income communities or benefiting low-income households. The subset of these funds meeting the additional AB 1550 requirement for low-income community/ household investments that are within ½ mile of a disadvantaged community would be determined based on program implementation and reported in future Annual Reports to the Legislature on California Climate Investments.

Staff considers the investment targets to be a floor and expects to exceed them. This section provides additional detail showing how CARB will meet, and very likely exceed these targets, based on a historical performance of Low Carbon Transportation funded projects and the project criteria established in this Funding Plan.

This minimum CARB commitment of at least 50 percent would exceed the overall target set in AB 1550 for the State's collective California Climate Investments in disadvantaged communities, low-income communities, and low-income households. AB 1550 does not set targets for individual agencies, but requires that the State overall invest at least 25 percent in project located in and benefiting disadvantaged communities, at least 5 percent in and benefiting low-income communities or benefiting low-income households, and at least 5 percent low-income communities located within one half mile of a disadvantaged community for a total AB 1550 investment of at least 35 percent of California Climate investment funds.

Table A-58 shows staff estimates of the minimum percent of funds for each project expected to be spent within and benefiting disadvantaged community census tracts as well as the non-overlapping minimum percent of funds expected to be 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. Staff used several different methods for these estimates.

For ongoing projects with several years of implementation data such as CVRP and HVIP, staff used the historical percent of funds spent in disadvantaged communities as reported in the *2019 Annual Report on California Climate Investments* to project future performance. For other programs, such as Financing Assistance, staff used the most recent reporting period to estimate the implementation in disadvantaged communities and low-income communities. In the case of the Rural School Bus program, staff used the data from the life of the project to estimate the implementation in disadvantaged and low-income communities.

As shown in Table A-58 several project categories are limited to disadvantaged and low-income communities, so staff can say with certainty 100 percent of these funds will be spent in these communities. These include Clean Mobility in Schools, Agricultural Worker Vanpools, Clean Mobility Options, and STEP.

There are also a number of proposed projects that lack sufficient historical data upon which to make an informed estimate of the percent of funds that will be spent in disadvantaged and low-income communities, such as the Outreach program (One-Stop Shop, Community Needs Assessments, and Technical Assistance) and the Advanced Vehicle Technologies for Freight (e.g. demos and pilots). In these cases, staff took the most conservative approach and left the estimates as "to be determined" even though staff expects an appreciable amount of this funding will meet one of the AB 1550 criteria. For example, the One-Stop Shop is designed to support individuals in disadvantaged and low-income communities, but it has yet to launch. Staff expects 50% of this funding will be spent in disadvantaged communities, in low-income communities, or for consumers meeting the AB 1550 low-income household definition.

Even with these conservative estimates, staff estimates that 35 percent of the proposed Low Carbon Transportation funds would be spent in disadvantaged communities and over 15 percent in non-overlapping low-income communities for a total of over 50 percent meeting one of the AB 1550 criteria as shown in Table A-58. When data are included for all the projects based on actual performance including those for which no AB 1550 is estimated at this time, staff expects CARB will exceed its AB 1550 targets by a considerable margin. CARB will report on these projects' performance in future Annual Reports to the Legislature on California Climate Investments as funds are awarded and spent.

Table A-58: Estimate of the Minimum Proposed FY 2019-20 Low Carbon Transportation Investments in Disadvantaged Communities, Low-Income Communities, and Low-Income Households

Project Category	Allocation (millions)	% in DC	$ in DC (millions)	% in LIC (non-overlapping)	$ in LIC (non-overlapping) (millions)	%DC/LIC Combined	$DC/LIC Combined (millions)	Data Source for Disadvantaged Community (DC)/Low-Income Community or Household (LIC) Estimates
CVRP	$ 236	9%	$ 21.2	14%	$ 33.0	23%	$ 54.2	9% spent in DCs and 14% spent in LICs in 2018 from 2019 Annual Report of California Climate Investments, page 40.
Light-Duty Equity Projects								
Clean Mobility Options	$ 10.00	97%	$ 10	3%	$ 0.3	100%	$ 10	This project is designed to primarily support DCs with some focus on LICs.
Financing Assistance for Lower-Income Consumers	$ 10.90	26%	$ 2.8	64%	$ 7.0	90%	$ 9.8	26% spent in DCs and 64% spent in LICs and LIC households in the most recent reporting period (December 2018 - May 2019).
Ag Vanpools	$ 5.00	75%	$ 3.8	25%	$ 1.3	100%	$ 5.0	This project is designed to support DCs and is mandated by the Legislature (AB 2006) to appropriate 25% for LICs.
Clean Mobility in Schools	$ 5.00	100%	$ 5.0		$ -	100%	$ 5.0	This project is limited to DCs.
Rural School Bus	$ 4.45	13%	$ 0.6	45%	$ 2.0	58%	$ 2.6	13% spent in DCs and 45% spent in LICs throughout the life of the project.
Sustainable Transportation Equity Project	$ 22.00	96%	$ 21.1	4%	$ 0.9	100%	$ 22.0	This project is designed to support DCs and LICS. Staff estimates 96% of funding will go to DCs.
Outreach: Community Needs Assessments, Technical Assistance, and One-Stop Shop	$ 7.00	25%	$ 1.8	25%	$ 1.8	50%	$ 3.5	This project is designed to support DCs and LICS but has not launched.
Heavy-Duty, Freight, Off-Road Projects								
Clean Truck and Bus Vouchers (HVIP)	$ 141	52%	$ 73.1	18%	$ 25.3	70%	$ 98.4	52% spent in DCs and 18% spent in LICs in 2018 from 2019 Annual Report of California Climate Investments, page 39.
Advanced Vehicle Technologies for Freight	$ 40	80%	$ 31.7	10%	$ 4.0	90%	$35.6	This project is designed to support DCs and LICS but has not launched.
1% for State Admin	$ 5							
Total	**$ 485**	**35.2%**	**$ 171**	**15.5%**	**$ 75**	**50.7%**	**$ 246**	

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 EFMP Plus-up) 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.*