Appendix A

Emission Reductions: Quantification Methodology

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Table of Contents

Overview

In the Governor's budget for the 2017-18 fiscal year (FY), the California Air Resources Board (CARB) was appropriated $28 million for Air Quality Improvement Program (AQIP) projects, $560 million for Low Carbon Transportation Investments from Cap-and-Trade auction proceeds, $25 million for zero-emission vehicle aspects of vehicle replacement programs from the Volkswagen 3.0 liter (L) settlement funds, and $50 million for a new Zero/Near Zero Emission Warehouse Program funded through the Trade Corridor Enhancement Account. 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]

CARB anticipates updating and revising the analysis in each subsequent Funding Plan as new data becomes available and methodologies are refined. 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 at: https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials.

Table A-1: Summary of Proposed Projects in the FY 2017-18 Funding Plan and Total Potential Emission Reductions

Category	Project	Proposed FY 2017-18 Allocation (millions)	# of Vehicles or Equipment Funded	Total Potential Lifetime Emission Reductions (tons)			
				GHG	NOx	PM 2.5	ROG
Light-Duty & Transportation Equity	CVRP	$140	58,000	360,000	48	19	10
	EFMP Plus-Up	$20	2,300	11,000	23	1.0	5.5
	Financing Assistance for Lower-Income Consumers	$20	1,700	8,600	1.4	0.55	0.28
	Clean Mobility Options for Disadvantaged Communities	$22	550	2,600	0.35	0.14	0.07
	Agricultural Worker Vanpools	$3	60	1,900	0.09	0.17	0.01
	Rural School Bus Pilot	$10	30	8,200	100	1.1	1.4
	CVRP Rebates for Low-Income Applicants	$25	6,000	35,000	4.7	2.0	0.9
	One-Stop-Shop for CARB's Equity ZEV Replacement Incentives	$5	--	--	--	--	--
Heavy-Duty & Off-Road	Zero- and Near Zero-Emission Freight Facilities	$150	473	180,000	310	9.7	180
	Zero-Emission Off-Road Freight Voucher Incentive Project	$40	300	120,000	130	5.2	92
	Clean Truck and Bus Vouchers	$188	3,100	640,000	1,300	48	11
	Truck Loan Assistance Program	$20	6,000	--	6,700	--	94

Note: the emissions reductions listed in this table do not include the $20 million to be allocated for transportation equity projects based on demand.

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 2.0) model,[2] CARB's Emission Factor (EMFAC2014) 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); and
- 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 2014[4] and CARB's off-road mobile source emissions inventories[5], specifically the 2011 Cargo Handling Equipment Inventory and the 2011 Transport Refrigeration Unit (TRU) Emissions Inventory models. Table A-2 summarizes the gasoline or diesel baseline, on-road fuel economy values and Table A-3 summarizes the baseline diesel, off-road fuel economy values used in the analysis for conventional vehicles.

[2] http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm
[3] http://www.arb.ca.gov/emfac/2014/
[4] https://www.arb.ca.gov/emfac/2014/
[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)			
		1995	1997	2013	2017
LDV	Gasoline	23.0	-	26.5	31.7
LHD	Gasoline	-	-	-	11.0
MHD	Diesel	-	-	-	8.9
HHD	Diesel	-	-	-	6.2
Urban Bus	Diesel	-	-	-	5.4
School Bus	Diesel	-	7.3	-	7.7

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

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

For alternative-fueled vehicles, the baseline fuel economy values were converted for a given alternative fuel, using LHVs of the baseline and alternative fuels and the energy economy ratio (EER) value, as shown in Formula 2. EER values were derived from the 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://ww2.arb.ca.gov/sites/default/files/2020-06/170425eerdraft_ADA.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 were adopted from the LCFS Program's carbon intensities, representing 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, thus lowering the average CI of the fuel, additional GHG benefits may be achieved, which may lower the emission factors. As the fuel mix changes, staff will reflect those changes in future analyses.

Criteria Pollutant and Toxics Emission Factors

For the determination of tailpipe criteria pollutant emission factors for on-road vehicles, staff utilized CARB's EMFAC 2014 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 utilized 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. In the off-road inventories, PM 2.5 emissions associated with brake wear and tire wear are not identified separately;

[9] https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm
[10] https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

therefore, for off-road equipment, emission factors are based solely on tailpipe emissions. Once information on PM 2.5 emissions associated with brake wear and tire wear become available for off-road equipment, staff will reflect this information in future analyses.

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 upstream (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] Emission factors were developed for advanced technology vehicles supported by the proposed projects when appropriate, along with emission factors for baseline conventional vehicles.

[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 U.S. 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

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

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

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

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 light-duty vehicle 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: the Enhanced Fleet Modernization Program (EFMP) Plus-Up Pilot Project, Financing Assistance for Lower-Income Consumers, Clean Mobility Options for Disadvantaged Communities, Agricultural Worker Vanpools, and the One-Stop-Shop for CARB's Equity ZEV Replacement Incentives.

All light-duty vehicle and transportation equity investment projects use the light-duty automobile classification in EMFAC 2014 for the development of emission factors, with the exception of the Agricultural Worker Vanpools Project, which uses the LHD vehicle classification.

In addition to the light-duty vehicle and transportation equity investment projects mentioned above, CARB set aside $20 million to be allocated to transportation equity projects based on demand. The additional $20 million in funding is not quantified in the project write-ups below, but the funds may be used to increase the number of vehicles deployed in the transportation equity projects, which would result in additional emission reduction benefits.

Quantification of the light-duty vehicle and transportation equity investment projects proposed in this year's Funding Plan is described in more detail below.

CVRP

CVRP achieves emission benefits by providing incentives for plug-in hybrid, battery-electric, and fuel cell vehicles 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 2017 model year conventional light-duty passenger vehicle and an average 2017 model year advanced technology vehicle that was purchased or leased.

Project data from November 2016 through May 2017 shows that approximately 55 percent of standard CVRP rebates went to battery-electric vehicles and 45 percent went to plug-in hybrid vehicles. Project data for low-income applicants for the same period shows that 40 percent of rebates went to battery-electric vehicles and 60 percent went to plug-in hybrid vehicles. For this analysis, staff assumed that rebates for FY 2017-18 would continue to fund those same technologies at similar rates. While fuel cell vehicles are eligible for CVRP rebates, less than 4 percent of the rebates between

November 2016 and May 2017 were claimed for fuel cell vehicles, therefore, fuel cell vehicles are not included in the emission reduction estimates for FY 2017-18.

Table A-4 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-4: CVRP Emission Factors

Pollutant	2017 Gasoline (g/mi)	2017 PHEV (g/mi)	2017 BEV (g/mi)
NOx	0.0313	0.0150	0
PM 2.5	0.0198	0.0109	0.0099
ROG	0.0063	0.0030	0
GHG	360	218	113

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]

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.

[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/)

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

Type of Rebates	Pollutant	Supported Technologies	Per Vehicle Annual Emission Reductions	
			Per Technology	Average
Standard Rebates	GHG	PHEV	2.11	2.45
		BEV	2.73	
	NOx	PHEV	0.00027	0.0003
		BEV	0.00038	
	PM 2.5	PHEV	0.00015	0.0001
		BEV	0.00012	
	ROG	PHEV	0.00005	0.0001
		BEV	0.00008	
Rebates for Low-Income Applicants	GHG	PHEV	2.11	2.36
		BEV	2.73	
	NOx	PHEV	0.00027	0.0003
		BEV	0.00038	
	PM 2.5	PHEV	0.00015	0.0001
		BEV	0.00012	
	ROG	PHEV	0.00005	0.0001
		BEV	0.00008	

For FY 2017-18, staff propose allocating $25 million to CVRP rebates for low-income applicants. Based on project data, staff anticipate the average rebate cost to be $3,900 for low-income applicants and $2,250 for standard rebates.

With the proposed $140 million allocation for CVRP and the average cost discussed above, staff estimate that approximately 58,000 vehicles can be funded, in addition to the 6,000 vehicles that can be funded with the proposed $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	2.45	58,000	142,000	2.5	360,000
	NOx	0.0003		19.1		48
	PM 2.5	0.0001		7.67		19
	ROG	0.0001		3.87		10
Rebates for Low-Income Applicants	GHG	2.36	6,000	14,100	2.5	35,000
	NOx	0.0003		1.88		4.7
	PM 2.5	0.0001		0.82		2.0
	ROG	0.0001		0.38		0.9

EFMP Plus-Up

EFMP Plus-Up achieves emission reductions by incentivizing the scrap and replacement of old, high-emitting vehicles with cleaner advanced technology vehicles. To calculate the emission reductions for this project, staff used past project data to determine the model year of the baseline vehicle and the replacement vehicle. Based on project data from the 2016 calendar year, on average, a 1995 vehicle model year was being scrapped and was replaced by an average 2013 model year advanced technology vehicle.

Project data for the 2016 calendar year shows that 17 percent of the funding went to battery-electric vehicle purchases, 33 percent went to plug-in hybrid vehicle purchases, and the remaining 50 percent went to conventional hybrid vehicle purchases. For the purposes of this analysis, staff assumed that FY 2017-18 funding would continue to incentivize those technologies at similar rates. Table A-8 reflects the emission factors for the selected baseline, conventional hybrid, plug-in hybrid, and battery-electric vehicles. 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: EFMP Plus-Up Emission Factors

Pollutant	1995 Gasoline (g/mi)	2013 Conventional Hybrid (g/mi)	2013 PHEV (g/mi)	2013 BEV (g/mi)
NOx	0.4353	0.0402	0.0241	0
PM 2.5	0.0283	0.0106	0.0103	0.0099
ROG	0.1018	0.0081	0.0048	0
GHG	495	345	261	135

Staff generated conservative usage assumptions for EFMP Plus-Up based on data in EMFAC 2014 for the baseline vehicle. According to EMFAC 2014, a 1995 model year vehicle operates approximately 7,500 miles per year in 2018.

Using the emission factors and technology mix mentioned above and the annual usage of 7,500 miles per year, staff calculated the potential annual per-vehicle emission reductions for EFMP Plus-Up, as shown in Table A-9.

Table A-9: EFMP Plus-Up Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)	
		Per Technology	Average
GHG	Conventional Hybrid	1.13	1.60
	PHEV	1.76	
	BEV	2.70	
NOx	Conventional Hybrid	0.0033	0.0034
	PHEV	0.0034	
	BEV	0.0036	
PM 2.5	Conventional Hybrid	0.0001	0.0001
	PHEV	0.0001	
	BEV	0.0002	
ROG	Conventional Hybrid	0.0008	0.0008
	PHEV	0.0008	
	BEV	0.0008	

Based on proposed funding amounts and past project data, staff anticipate the average incentive amount to be $7,500 per vehicle. With proposed $20 million allocation for EFMP Plus-Up, staff estimate that approximately 2,300 vehicles can be funded. For the purpose of this analysis, staff estimate that the remaining useful life of the baseline, 1995 model year vehicle is 3 years, therefore, emission reductions are quantified over the course of 3 years. The total potential emission reductions for EFMP Plus-Up are shown in Table A-10 below.

Table A-10: Total Potential Emission Reductions for EFMP Plus-Up

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	1.60	2,300	3,680	3	11,000
NOx	0.0034		7.74		23
PM 2.5	0.0001		0.34		1.0
ROG	0.0008		1.83		5.5

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. Because this project is designed to assist the same consumer base as EFMP Plus-Up, staff used EFMP Plus-Up project data to determine the average replacement vehicle. According to EFMP Plus-Up data, the average replacement vehicle is a 2013 model year, so staff used a 2013 model year, conventional gas vehicle as the baseline.

Because this project is designed to help facilitate the purchase of advanced technology vehicles, staff assumed the same vehicle technologies would be funded as in EFMP Plus-Up (17 percent BEVs, 33 percent PHEVs, and 50 percent conventional hybrids). Emission factors for Financing Assistance are shown in Table A-11. 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-11: Financing Assistance Emission Factors

Pollutant	2013 Gasoline (g/mi)	2013 Conventional Hybrid (g/mi)	2013 PHEV (g/mi)	2013 BEV (g/mi)
NOx	0.0503	0.0402	0.0241	0
PM 2.5	0.0187	0.0106	0.0103	0.0099
ROG	0.0101	0.0081	0.0048	0
GHG	431	345	261	135

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-12.

Table A-12: Financing Assistance Annual Usage Assumptions

Technology	Usage (mi/yr)
Conventional Hybrid/PHEV	14,855[15]
BEV	11,059[16]

Using the above assumptions and emission factors, staff calculated the potential annual per-vehicle emission reductions for Financing Assistance, as shown in Table A-13.

[15] Based on 40.7 miles per day. Smart, J., Powell, W., and Schey, S., "Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project," SAE Technical Paper 2013-01-1441, 2013, doi:10.4271/2013-01-1441. (http://papers.sae.org/2013-01-1441/)
[16] Based on 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-13: Financing Assistance Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)	
		Per Technology	Average
GHG	Conv. Hybrid	1.28	2.03
	PHEV	2.53	
	BEV	3.27	
NOx	Conv. Hybrid	0.00016	0.0003
	PHEV	0.00043	
	BEV	0.00061	
PM 2.5	Conv. Hybrid	0.00013	0.0001
	PHEV	0.00014	
	BEV	0.00011	
ROG	Conv. Hybrid	0.00003	0.0001
	PHEV	0.00009	
	BEV	0.00012	

Staff anticipate the average cost per loan, including the vehicle price buy down and loan loss reserve, will range from $9,000 to $12,000 and thus, estimated the average incentive cost per loan would be $10,500.

Based on the proposed $20 million allocation for Financing Assistance and the average cost shown above, staff estimate that approximately 1,700 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-14.

Table A-14: 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	2.03	1,700	3,450	2.5	8,600
NOx	0.0003		0.557		1.4
PM 2.5	0.0001		0.220		0.55
ROG	0.0001		0.112		0.28

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.

The first Clean Mobility Options pilot project launched in May 2017, with another to launch later in 2017. Because future projects are unknown, for this analysis, staff assumes that vehicles funded are an equal split of battery-electric and plug-in hybrid vehicles. Table A-15 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-15: Clean Mobility Options Emission Factors

Pollutant	2017 Gasoline (g/mi)	2017 PHEV (g/mi)	2017 BEV (g/mi)
NOx	0.0313	0.0150	0
PM 2.5	0.0198	0.0109	0.0099
ROG	0.0063	0.0030	0
GHG	360	218	113

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.[17]

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

[17] 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

Table A-16: Clean Mobility Options Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)	
		Per Technology	Average
GHG	PHEV	1.16	1.59
	BEV	2.02	
NOx	PHEV	0.00015	0.00022
	BEV	0.00028	
PM 2.5	PHEV	0.00008	0.00009
	BEV	0.00009	
ROG	PHEV	0.00003	0.00004
	BEV	0.00006	

Based on costs to lease or purchase new or used project eligible vehicles that range from below $10,000 to more than $100,000, staff believes that a reasonable estimate for the average incentive amount for is $35,000. Based on the proposed $22 million allocation for Clean Mobility Options and the average cost of $35,000, staff estimates that up to 550 vehicles can be funded.

The required project life for Clean Mobility Options vehicles is one to two and half years. However, light-duty vehicles can last about 15 years. For the purpose of this analysis, staff conservatively assumed that emission reductions will occur over the course of 3 years. The total potential emission reductions for Clean Mobility Options are shown in Table A-17.

Table A-17: Total Potential Emission Reductions for Clean Mobility Options

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	1.59	550	876	3	2,600
NOx	0.00022		0.118		0.35
PM 2.5	0.00009		0.047		0.14
ROG	0.00004		0.024		0.07

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 2017 model year, conventional light heavy-duty (LHD) van and an advanced technology van.

The Agricultural Worker Vanpools solicitation has not yet been released. There is not yet enough data to determine the technology splits, so for this analysis, staff assumes that the funded vehicles will be conventional hybrid vehicles. Emission factors for Agricultural Worker Vanpools 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: Agricultural Worker Vanpools Emission Factors

Pollutant	2017 Gasoline (g/mi)	2017 Conventional Hybrid (g/mi)
NOx	0.0457	0.0366
PM 2.5	0.0362	0.0195
ROG	0.0071	0.0057
GHG	1,038	830

Staff also generated an annual usage assumption of 25,000 miles per year based on the average use of a 2017 model year, LHD van in EMFAC 2014.

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-19.

Table A-19: Agricultural Worker Vanpools Annual Emission Reductions on a Per-Vehicle Basis

Pollutant	Per-Vehicle Annual Emission Reductions (tpy)
GHG	5.19
NOx	0.00025
PM 2.5	0.00046
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 $3 million allocation for Agricultural Worker Vanpools and the average cost of $45,000 per van, staff estimate that approximately 60 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-20.

Table A-20: 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	5.19	60	311	6	1,900
NOx	0.00025		0.015		0.09
PM 2.5	0.00046		0.028		0.17
ROG	0.00004		0.002		0.01

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.

Based on applications received for the 2016-17 fiscal year project, staff anticipate the average school bus replaced will be a 1997 model year. Using data from the project applications, staff also expect that the 55 percent of the buses funded will be battery-electric and the remaining 45 percent will operate on renewable diesel. Because limited data is available on vehicles utilizing renewable fuels, staff assume 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-21. 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-21: Rural School Bus Pilot Project Emission Factors

Pollutant	1997 Diesel (g/mi)	2017 BEV (g/mi)	2017 RD (g/mi)
NOx	16.242	0	1.408
PM 2.5	0.4105	0.1626	0.3249
ROG	0.2464	0	0.0549
GHG	1,869	335	622

Staff generated an annual usage assumption of 13,000 miles per year, based on the average use of 1997 model year school buses in EMFAC 2014. 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-22.

Table A-22: 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	Battery-Electric	19.94	18.26
	Renewable Diesel	16.20	
NOx	Battery-Electric	0.2328	0.2237
	Renewable Diesel	0.2126	
PM 2.5	Battery-Electric	0.0036	0.0025
	Renewable Diesel	0.0012	
ROG	Battery-Electric	0.0035	0.0032
	Renewable Diesel	0.0027	

Applying the assumed technology mix from FY 2016-17 project applications, staff calculated the average incentive cost for the Rural School Bus Pilot Project, as shown in Table A-23.

Table A-23: Rural School Bus Pilot Project Average Incentive Cost

Supported Technologies	Cost Per Technology	Average
Battery-Electric	$400,000	$294,250
Renewable Diesel	$165,000	

Based on the proposed $10 million allocation for the Rural School Bus Pilot Project, staff anticipate that approximately 30 school buses can be funded. The average school bus has a useful life of 15 years.[18] Thus, for this analysis, staff assumed a conservative 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-24.

Table A-24: Total Potential Emission Reductions for the Rural School Bus Pilot Project

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	18.26	30	548	15	8,200
NOx	0.2237		6.710		100
PM 2.5	0.0025		0.075		1.1
ROG	0.0032		0.095		1.4

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

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 $5 million to support 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 EFMP Plus-Up, 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 EFMP Plus-Up.

Heavy-Duty Vehicle and Off-Road Equipment Investments

The heavy-duty vehicle and off-road equipment investments proposed in this year's Funding Plan are grouped into the following categories: zero-emission freight equipment deployment projects, clean truck and bus vouchers, and the Truck Loan Assistance Program.

The purpose of the zero-emission freight equipment deployment projects and clean truck and bus vouchers is to advance the widespread use of advanced technologies and reduce costs by supporting increased production volumes. The proposed zero-emission freight equipment deployment projects include the Zero-Emission Off-Road Freight Voucher Incentive Project and Zero- and Near Zero-Emission Freight Facilities. The proposed clean truck and bus vouchers include the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low NOx Engine Incentives.

The purpose of the Truck Loan Assistance Program is to provide financing assistance for the purchase of commercialized clean technologies by economically challenged consumers.

There is a total of $188 million available for clean truck and bus vouchers, so staff assumed that $163 million would be used in HVIP and $25 million in Low NOx Engine Incentives to illustrate the potential magnitude of emission reductions in this Funding Plan. However, clean truck and bus voucher funding is available for either HVIP or Low NOx Engine Incentives based on project demand.

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.

Zero- and Near Zero-Emission Freight Facilities

The Zero- and Near Zero-Emission Freight Facilities project achieves emission reduction benefits by deploying zero- and near zero-emission technology associated with freight facilities. Eligible types of vehicles, equipment, and technologies in this project include forklifts, yard trucks or tractors, delivery and drayage trucks, TRUs, and supporting fueling infrastructure. Because this project includes a variety of eligible types of vehicles, equipment, and technologies, it is important to note that this analysis is an illustrative example of the potential emission reductions that may be achieved through this project.

This project can support a wide variety of vehicles and equipment that are commercially available, near commercial, or in the demonstration phase. For this analysis, staff estimated the potential emission reductions for four vehicle and equipment types that are likely to be funded under this project: Class 1 and 2 forklifts, off-road yard trucks, drayage trucks, and TRUs. Unless project data supports an alternate baseline, staff typically quantify emission reductions using the cleanest available technology as the baseline. Battery-electric Class 1 and 2 forklifts are already commercially available, therefore, staff assume that there are no additional emission reduction benefits for incentivizing forklifts under this project. Emission factors for the remaining three categories (off-road yard trucks, drayage trucks, and TRUs) are shown in Table A-25. For off-road vehicles, such as yard trucks and TRUs, emission factors are in units of grams per hour and for on-road vehicles, such as drayage trucks, emission factors are in units of grams per mile. 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-25: Zero- and Near Zero-Emission Freight Facilities Emission Factors

Vehicle Class	Pollutant	2017/Tier 4 Final Baseline	2017 BEV	2017 FCV
Yard Truck (g/hr)	NOx	8.238	0	
	PM 2.5	0.484	0	
	ROG	4.271	0	
	GHG	47,885	8,974	
Drayage Truck (g/mi)	NOx	1.905	0	0
	PM 2.5	0.040	0.022	0.022
	ROG	0.089	0	0
	GHG	2,096	393	955
TRU (g/hr)	NOx	47.26	0	
	PM 2.5	1.699	0	
	ROG	36.85	0	
	GHG	9,001	1,687	

Note: As noted in the Emission Factor Development section, PM 2.5 emissions associated with brake and tire wear for off-road vehicles are not identified separately; therefore, PM 2.5 emissions associated with brake and tire wear are currently included for on-road vehicles only.

Staff generated annual usage assumptions using CARB's CHE inventory model for yard trucks, EMFAC 2014 for drayage trucks, and TRU inventory model for TRUs, as shown in Table A-26. For off-road vehicles, such as yard trucks and TRUs, annual usage is in terms of hours per year, and for on-road vehicles, such as drayage trucks, annual usage is in terms of miles per year.

Table A-26: Zero- and Near Zero-Emission Freight Facilities Annual Usage Assumptions

Vehicle Class	Technology	Usage (mi/yr or hrs/yr)
Yard Truck	BEV	2,400
Drayage Truck	BEV & FCV	60,000
TRU	BEV	1,300

Applying the emission factors and usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for Zero- and Near Zero-Emission Freight Facilities, as shown in Table A-27.

Table A-27: Zero- and Near Zero-Emission Freight Facilities Annual Emission Reduction Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)
GHG	Yard Truck	BEV	93.4
	Drayage Truck	BEV	102
		FCV	68.4
	TRU	BEV	9.51
NOx	Yard Truck	BEV	0.0218
	Drayage Truck	BEV	0.1260
		FCV	0.1260
	TRU	BEV	0.0677
PM 2.5	Yard Truck	BEV	0.0013
	Drayage Truck	BEV	0.0012
		FCV	0.0012
	TRU	BEV	0.0024
ROG	Yard Truck	BEV	0.0113
	Drayage Truck	BEV	0.0059
		FCV	0.0059
	TRU	BEV	0.0528

Because Zero- and Near Zero-Emission Freight Facilities is a new project that has not yet launched, for this analysis, staff assumed that $30 million of the project funding will be used to support infrastructure and the match requirement will cover energy efficiencies and infrastructure costs. The remaining $120 million of the project funding will be split among the four equipment types mentioned, specifically $30 million for Class 1 and Class 2 forklifts, $30 million for off-road yard trucks, $30 million for drayage trucks with $7.5 million for fuel cell drayage trucks and $22.5 million for battery electric drayage trucks, and $30 million for TRUs. Based on applications from past demonstration and pilot projects and discussions with manufacturers, staff generated estimated incentive costs as shown in Table A-28.

Table A-28: Zero- and Near Zero-Emission Freight Facilities Average Incentive Cost

Vehicle Class	Supported Technologies	Cost Per Technology
Yard Truck	BEV	$300,000
Drayage Truck	BEV	$440,000
	FCV	$2,300,000
TRU	BEV	$90,000

Based on the proposed $150 million allocation for Zero- and Near Zero-Emission Freight Facilities and the estimated costs shown above, staff anticipate that approximately 100 battery-electric yard trucks, 50 battery-electric drayage trucks, 3 fuel cell drayage truck, and 320 battery-electric TRUs may be funded. Considering the expected life of heavy-duty diesel trucks and equipment, staff conservatively quantified the emission reductions over the course of 10 years, as shown in Table A-29.

Table A-29: Total Potential Emission Reductions for Zero- and Near Zero-Emission Freight Facilities

Pollutant	Vehicle Class & Technology	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	Yard Truck BEV	93.4	100	9,340	10	93,400	180,000
	Drayage Truck BEV	102	50	5,110		51,100	
	Drayage Truck FCV	68.4	3	205		2,050	
	TRU BEV	9.51	320	3,040		30,400	
NOx	Yard Truck BEV	0.0218	100	2.18		21.8	310
	Drayage Truck BEV	0.1260	50	6.30		63.0	
	Drayage Truck FCV	0.1260	3	0.378		3.78	
	TRU BEV	0.0677	320	21.7		217	
PM 2.5	Yard Truck BEV	0.0013	100	0.128		1.28	9.7
	Drayage Truck BEV	0.0012	50	0.060		0.600	
	Drayage Truck FCV	0.0012	3	0.004		0.040	
	TRU BEV	0.0024	320	0.779		7.79	
ROG	Yard Truck BEV	0.0113	100	1.13		11.3	180
	Drayage Truck BEV	0.0059	50	0.294		2.94	
	Drayage Truck FCV	0.0059	3	0.018		0.180	
	TRU BEV	0.0528	320	16.9		169	

Zero-Emission Off-Road Freight Voucher Incentive Project

The Zero-Emission Off-Road Freight Voucher Incentive Project achieves emission reduction benefits by incentivizing the purchase of zero-emission off-road freight equipment, resulting in larger deployments of zero-emission technologies that are just entering the market or have not yet achieved substantial market penetration for many other freight applications. Eligible equipment in this project include off-road yard trucks, small-lift capacity forklifts (less than 8,000 lbs. lift capacity), heavy-lift capacity forklifts (greater than 8,000 lbs. lift capacity), cargo handling equipment (such as reach stackers, top handlers, side handlers, and rubber tired gantry cranes), TRUs, railcar movers, locomotive switchers, and cargo loaders.

Because this project can fund a wide variety of equipment, staff estimated the potential emission reductions for four of the equipment types that are likely to be funded under this project: battery-electric small- and heavy-lift capacity forklifts, battery-electric off-road yard trucks, and battery-electric TRUs. As discussed in the Zero- and Near Zero-Emission Freight Facilities project, unless project data supports an alternate baseline, staff typically quantify emission reductions using the cleanest available technology as the baseline. Battery-electric forklifts are already commercially available for smaller lift capacity forklifts, therefore, staff assume that there are no additional emission reduction benefits for incentivizing smaller lift capacity forklifts under this project. Emission factors for the remaining three equipment types (heavy-lift capacity forklifts, off-road yard trucks, and TRUs) are shown in Table A-30. 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-30: Zero-Emission Off-Road Freight Voucher Incentive Project Emission Factors

Vehicle Class	Pollutant	Tier 4 Final Diesel (g/hr)	BEV (g/hr)
Heavy-Lift Capacity Forklift	NOx	0.781	0
	PM 2.5	0.281	0
	ROG	1.748	0
	GHG	19,604	5,318
Yard Truck	NOx	8.238	0
	PM 2.5	0.484	0
	ROG	4.271	0
	GHG	47,885	8,974
TRU	NOx	47.26	0
	PM 2.5	1.699	0
	ROG	36.85	0
	GHG	9,001	1,687

Staff generated annual usage assumptions using CARB’s CHE inventory model for heavy-lift capacity forklifts and yard trucks and TRU inventory model for TRUs, as shown in Table A-31.

Table A-31: Zero-Emission Off-Road Freight Voucher Incentive Project Annual Usage Assumptions

Vehicle Class	Usage (hrs/yr)
Heavy-Lift Capacity Forklift	800
Yard Truck	2,400
TRU	1,300

Applying the emission factors and usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for the Zero-Emission Off-Road Freight Voucher Incentive Project, as shown in Table A-32.

Table A-32: Zero-Emission Off-Road Freight Voucher Incentive Project Annual Emission Reduction Benefits on a Per-Vehicle Basis

Pollutant	Vehicle Class	Per-Vehicle Annual Emission Reductions (tpy)
GHG	Heavy-Lift Capacity Forklift	11.43
	Yard Truck	93.39
	TRU	9.51
NOx	Heavy-Lift Capacity Forklift	0.0007
	Yard Truck	0.0218
	TRU	0.0677
PM 2.5	Heavy-Lift Capacity Forklift	0.0002
	Yard Truck	0.0013
	TRU	0.0024
ROG	Heavy-Lift Capacity Forklift	0.0015
	Yard Truck	0.0113
	TRU	0.0528

Because the Zero-Emission Off-Road Freight Voucher Incentive Project is a new project that has not yet launched, for this analysis, staff assumed that approximately $4 million (or 10 percent) of the project funding will be used for infrastructure, $12 million (or 30 percent) would be used for small-lift capacity forklifts, and the remaining project funding would be split among yard trucks, heavy-lift capacity forklifts, and TRUs. Based on applications from past demonstration and pilot projects and discussions with manufacturers, staff generated estimated incentive costs as shown in Table A-33.

Table A-33: Zero-Emission Off-Road Freight Voucher Incentive Project Average Incentive Cost

Vehicle Class	Supported Technologies	Cost Per Technology
Heavy-Lift Capacity Forklift	BEV	$50,000
Yard Truck	BEV	$110,000
TRU	BEV	$50,000

Based on the proposed $40 million allocation for the Zero-Emission Off-Road Freight Voucher Incentive Project and the costs shown above, staff estimate that approximately 300 pieces of equipment can be funded across the three equipment types (40 heavy-lift capacity forklifts, 110 yard trucks, and 150 TRUs). Considering the expected life of heavy-duty diesel equipment, staff conservatively quantified the emission reductions over the course of 10 years, as shown in Table A-34.

Table A-34: Total Potential Emission Reductions for the Zero-Emission Off-Road Freight Voucher Incentive Project

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	Forklift	11.43	40	457	10	4,570	120,000
	Yard Truck	93.39	110	10,300		103,000	
	TRUs	9.51	150	1,430		14,300	
NOx	Forklift	0.0007	40	0.028		0.280	130
	Yard Truck	0.0218	110	2.40		24.0	
	TRUs	0.0677	150	10.2		102	
PM 2.5	Forklift	0.0002	40	0.010		0.100	5.2
	Yard Truck	0.0013	110	0.141		1.41	
	TRUs	0.0024	150	0.365		3.65	
ROG	Forklift	0.0015	40	0.062		0.62	92
	Yard Truck	0.0113	110	1.24		12.4	
	TRUs	0.0528	150	7.92		79.2	

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 $188 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 $163 million would be used for HVIP and $25 million for Low NOx Engine Incentives, as described below. However, funding for HVIP and Low NOx Engine Incentives may change based on demand.

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 2017 model year, conventional truck or bus and an advanced technology vehicle.

According to the HVIP waitlist as of June 2017, approximately 50 percent of vouchers will go towards the purchase of MHD conventional hybrids, 5 percent for MHD battery-electric trucks, 5 percent for HHD battery-electric trucks, 20 percent battery-electric urban buses, and 20 percent for battery-electric school buses. Staff assume that the current waitlist represents the voucher demand expected for the 2017-18 fiscal year, therefore, for this analysis, staff used the vehicle class and technology splits mentioned above.

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 assume CNG vehicles have similar emission rates as diesel-fueled vehicles because they are certified to the same emission standard. Emission factors for HVIP are shown in Table A-35. 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-35: HVIP Emission Factors

Vehicle Class	Pollutant	2017 Diesel (g/mi)	2017 CNG (g/mi)	2017 Conventional Hybrid (g/mi)	2017 BEV (g/mi)
MHD	NOx	0.8579		0.6863	0
	PM 2.5	0.0616		0.0331	0.0309
	ROG	0.0371		0.0297	0
	GHG	1,540		1,232	289
HHD	NOx	1.4310			0
	PM 2.5	0.0408			0.0222
	ROG	0.0789			0
	GHG	2,223			417
Urban Bus	NOx	0.8140	0.8140		0
	PM 2.5	0.3669	0.3669		0.1834
	ROG	0.0228	0.0228		0
	GHG	2,539	2,079		476
School Bus	NOx	1.4076			0
	PM 2.5	0.3249			0.1626
	ROG	0.0549			0
	GHG	1,786			335

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 an annual usage assumption for MHD conventional hybrid vehicles, based on the average use of a conventional MHD diesel vehicle in EMFAC 2014. For urban buses, staff used data provided by previous HVIP voucher recipients to determine the average annual usage. 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."[19] The annual usage assumptions for HVIP are shown in Table A-36.

Table A-36: HVIP Annual Usage Assumptions

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

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

Using the emission factors, technology mix, and the annual usage assumptions above, staff calculated the potential annual per-vehicle emission reductions for HVIP, as shown in Table A-37.

Table A-37: 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	6.16	19.40
		BEV	15.02	
	HHD	BEV	21.68	
	Urban Bus	BEV	54.99	
	School Bus	BEV	17.41	
NOx	MHD	Conv. Hybrid	0.0038	0.0125
		BEV	0.0113	
	HHD	BEV	0.0189	
	Urban Bus	BEV	0.0269	
	School Bus	BEV	0.0186	
PM 2.5	MHD	Conv. Hybrid	0.0006	0.0020
		BEV	0.0004	
	HHD	BEV	0.0002	
	Urban Bus	BEV	0.0061	
	School Bus	BEV	0.0021	
ROG	MHD	Conv. Hybrid	0.0002	0.0005
		BEV	0.0005	
	HHD	BEV	0.0010	
	Urban Bus	BEV	0.0008	
	School Bus	BEV	0.0007	

Applying the proposed voucher amounts for the 2017-18 fiscal year and the technology mix from the current HVIP waitlist data, staff calculated the average voucher cost for HVIP as shown in Table A-38.

Table A-38: HVIP Average Incentive Cost

Vehicle Class	Supported Technologies	Cost Per Technology	Average Cost
MHD	Conv. Hybrid	$20,000	$95,750
	BEV	$90,000	
HHD	BEV	$150,000	
Urban Bus	BEV	$143,750	
School Bus	BEV	$225,000	

The budget includes $188 million for Clean Truck and Bus Vouchers. To illustrate the potential magnitude of emission reductions in this Funding Plan, staff assumed that $163 million would be used for HVIP. Of the $163 million, staff assumed $2 million will be used for infrastructure. With the remaining $161 million for HVIP and the average cost shown above, staff estimate that approximately 1,600 vehicles can be funded. The budget requires that at least $35 million is used for the purchase of zero-emission buses. Based on expected voucher demand for zero-emission urban buses and school buses, staff anticipate that the minimum allocation for zero-emission buses will be exceeded.

Heavy-duty trucks can have a useful life of over 20 years[20] and the average school bus has a useful life of 15 years.[21] 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-39 below.

Table A-39: Total Potential Emission Reductions for HVIP

Pollutant	Per-Vehicle Average Annual Emission Reductions (tpy)	Number of Vehicles	Average Annual Emissions Reductions (tpy)	Project Life (years)	Lifetime Annual Emission Reductions (tons)
GHG	19.40	1,600	31,000	15	470,000
NOx	0.0125		20.0		300
PM 2.5	0.0020		3.18		48
ROG	0.0005		0.727		11

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 2017 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 50 percent of the incentives would go to HHD vehicles, which includes most refuse haulers, 45 percent for urban buses, and 5 percent for MHD vehicles. With the 8.9 liter engine currently available, we anticipate the market share for HHD and urban bus classifications will be similar, but because the 11.9 liter engine could be commercially available toward the end of the next fiscal year, staff gave the HHD classification a slightly higher share. Staff anticipate that the 11.9 liter low NOx engine is likely to

[20] (link no longer available)
[21] https://www.afdc.energy.gov/uploads/publication/case-study-propane-school-bus-fleets.pdf

replace conventional HHD diesel engines, therefore, staff also developed emission factors for HHD diesel vehicles.

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 3 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-40. 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-40: Low NOx Engine Incentives Emission Factors

Vehicle Class	Pollutant	2017 CNG (g/mi)	2017 Diesel (g/mi)	2017 Low NOx RNG (g/mi)	2017 Low NOx Diesel (g/mi)
MHD	NOx	0.8579		0.0858	
	PM 2.5	0.0616		0.0616	
	ROG	0.0371		0.0371	
	GHG	1,261		557	
HHD	NOx	1.4310	1.4310	0.1431	0.1431
	PM 2.5	0.0408	0.0408	0.0408	0.0408
	ROG	0.0789	0.0789	0.0789	0.0789
	GHG	1,821	2,223	804	2,223
Urban Bus	NOx	0.8140		0.0814	
	PM 2.5	0.3669		0.3669	
	ROG	0.0228		0.0228	
	GHG	2,079		918	

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 2014 for the corresponding vehicle class and reports from the U.S. Department of Energy's Alternative Fuels Data Center.[22] The annual usage assumptions for Low NOx Engine Incentives are shown in Table A-41.

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

Table A-41: Low NOx Engine Incentives Annual Usage Assumptions

Baseline Vehicle	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-42. 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-42: Low NOx Engine Incentives Annual Emission Reduction Benefits on a Per-Vehicle Basis

Pollutant	Baseline Vehicle	Supported Technologies	Per-Vehicle Annual Emission Reductions (tpy)	
			Per Technology	Average
GHG	MHD CNG	Low NOx with RNG	14.09	38.66
	HHD CNG	Low NOx with RNG	25.43	
	HHD Diesel	Low NOx	0	
	HHD Diesel	Low NOx with RNG	82.34	
	Urban Bus CNG	Low NOx with RNG	54.58	
NOx	MHD CNG	Low NOx with RNG	0.0170	0.0450
	HHD CNG	Low NOx with RNG	0.0355	
	HHD Diesel	Low NOx	0.0823	
	HHD Diesel	Low NOx with RNG	0.0823	
	Urban Bus CNG	Low NOx with RNG	0.0380	

For Low NOx Engine Incentives, staff are proposing to fund the incremental cost between a conventional vehicle and the low NOx engine. Using quotes from the engine manufacturer on the incremental cost, staff anticipate the incentive cost would be around $10,000 for low NOx engines in conventional CNG vehicles. Staff also anticipate the incremental cost may be more for HHD vehicles with a conventional diesel engine, therefore, staff used $40,000 for the incentive amount for HHD low NOx engines. Applying the technology split to the expected incentive amounts, staff calculated the average incentive cost for Low NOx Engine Incentives, as shown in Table A-43.

Table A-43: Low NOx Engine Incentives Average Incentive Cost

Baseline Vehicle	Supported Technologies	Cost Per Technology	Average
MHD CNG	Low NOx with RNG	$10,000	$16,000
HHD CNG	Low NOx with RNG	$10,000	
HHD Diesel	Low NOx	$40,000	
HHD Diesel	Low NOx with RNG	$40,000	
Urban Bus CNG	Low NOx with RNG	$10,000	

While the budget includes $188 million for Clean Truck and Bus Vouchers, to illustrate the potential magnitude of emission reductions in this Funding Plan, staff assumed that $25 million would be used for Low NOx Engine Incentives. Using the average cost of $16,000 per engine, staff estimate that approximately 1,500 engines can be funded, thus meeting the expected demand. For this analysis, staff used a project life of 3 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 3 years. However, heavy-duty trucks can have a useful life of over 20 years,[23] therefore, staff 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-44.

Table A-44: 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	38.66	1,500	58,000	3	170,000
NOx	0.0450		67.6	15	1,000

Truck Loan Assistance Program

The Truck Loan Assistance Program aids small business truckers affected by CARB's In-Use Truck and Bus Regulation[24] by providing financing assistance for fleet owners to upgrade their vehicles with newer models or with diesel exhaust retrofits. Program data from the 2016 calendar year through June 2017 shows that, on average, funds were directed toward the replacement of 2001 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 2016 calendar year through June 2017, 10 percent of loans went

[23] (link no longer available)
[24] https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation

towards the purchase of MHD vehicles with 2010 model year or newer engines, 15 percent towards the purchase of HHD vehicles with a 2007 to 2009 model year engine, and 75 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 2012 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	2001 Diesel (g/mi)	2008 Diesel (g/mi)	2012 Diesel (g/mi)
MHD	NOx	14.449		1.4050
	PM 2.5	0.4193		0.0620
	ROG	0.9509		0.0422
HHD	NOx	22.737	10.6516	2.6184
	PM 2.5	0.1307	0.0911	0.0418
	ROG	0.3468	0.3170	0.0872

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 based on the average use of a 2001 model year, conventional MHD and HHD diesel truck in EMFAC 2014. The annual usage assumptions for the Truck Loan Assistance Program are shown in Table A-46.

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

Vehicle Class	Usage (mi/yr)
MHD	11,000
HHD	19,000

Using the emission factors, mix of vehicle model years, 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. PM 2.5 emission reductions for the Truck Loan Assistance Program are not quantified because PM emission 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	2012 MY	0.1582	0.3698
	HHD	2008 MY	0.2531	
		2012 MY	0.4214	
ROG	MHD	2012 MY	0.0110	0.0052
	HHD	2008 MY	0.0004	
		2012 MY	0.0054	

In the Truck Loan Assistance Program, the average loan contribution amount has gone down over time and based on program data from 2016 and 2017, staff found that the average cost per loan is approximately $3,100. With the proposed $20 million allocation for the Truck Loan Assistance Program, staff estimate that approximately 6,000 vehicles can be funded. To achieve NOx reductions, the Truck and Bus Regulation requires the replacement of 2001 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 3 years 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	0.3698	6,000	2,220	3	6,700
ROG	0.0052		31.4		94

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.[25]
- "Benefit-cost score" means the reasonably expected or potential criteria pollutant emission reductions achieved per dollar awarded by the Board for the project.[26]
- The state board also may give additional preference based on the following criteria, as applicable, in funding awards to projects:[27]

    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 three projects that will be funded through AQIP: the Trade-Up Pilot Project, the Truck Loan Assistance Program, and the Low NOx Engine Incentives Project.

Overview

Conservative estimates for criteria pollutant, toxic air contaminants, and GHG emission reductions 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 emission reductions reported in this appendix are estimated at the tailpipe. Greenhouse gas emission reductions are tabulated on a WTW basis, as greenhouse gases are a statewide pollutant. Building upon the emission reductions and cost information from the Project Quantification section, this section of the appendix provides information on the following:

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[25] Health & Safety Code Section 44274(b)
[26] Health & Safety Code Section 44270.3(e)(1)
[27] Health & Safety Code Section 44274(b)

- 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.[28] 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

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

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

Formula 9: Annual Weighted Emission Reductions

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

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. The longer project life of 15 years was used for Low NOx Engine Incentives because criteria pollutant and toxic air contaminant reductions occur regardless of whether renewable fuel is used. Additionally, for Low NOx Engines Incentives, staff are proposing to use AQIP funding for HHD diesel replacements only, therefore, staff utilized the NOx emission reduction benefits for a HHD diesel baseline in the AB 8 analysis.

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

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	3	0.340	0.375	$3,100	$2,810
Low NOx Engine Incentives	15	0.072	0.082	$40,000	$34,977

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	$2,810	0.712	5
Low NOx Engine Incentives	$34,977	0.057	1

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-50. 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.

<u>Proposed or Potential Reduction of Criteria or Toxic Air Pollutants</u>

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 receive 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

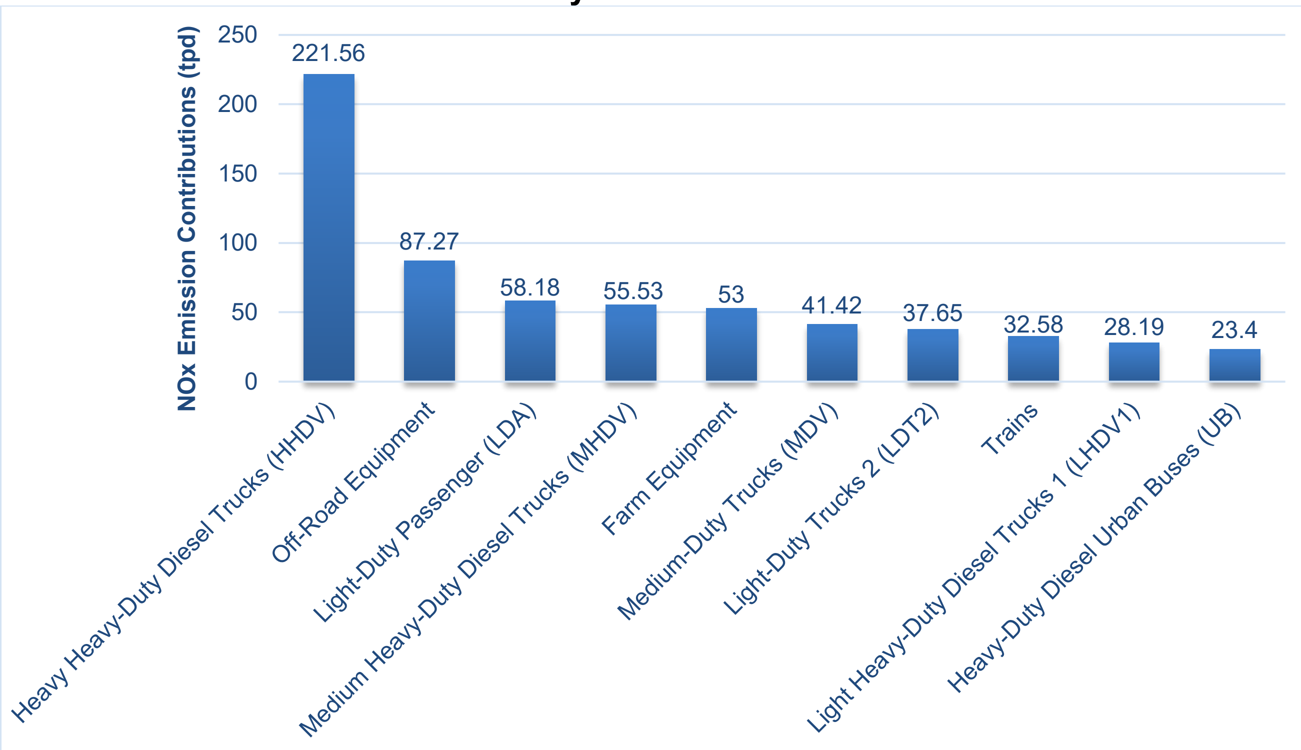
Proposed Project	Annual Per-Vehicle Emission Reductions (tpy)	Project Life (years)	Per-Vehicle Lifetime Emission Reductions (tons)	Score
Truck Loan Assistance	0.375	3	1.13	2
Low NOx Engine Incentives	0.082	15	1.24	2

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.[29] The ranking scale is based on the emissions inventory shown in Figure A-1.

[29] 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 222 tons per day, to heavy-duty diesel urban buses, at 23 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

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 <u>and</u> clean vehicle technologies
3: Projects that use low carbon alternative fuels <u>or</u> clean vehicle technologies
1: Projects that do not use low carbon alternative fuels nor clean vehicle technologies

<u>Ability to Achieve GHG Reductions</u>

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 minimal or no GHG emission reductions. Because staff are proposing to use AQIP funding for HHD diesel replacements for Low NOx Engine Incentives without requiring the use of renewable fuels, staff found that there were no GHG emission reductions for Low NOx Engine Incentives funded by AQIP. The scoring scale for GHG emission reductions is shown below.

5: Greater than 200 metric tons of CO2e per vehicle
4: 150 to 199 metric tons of CO2e per vehicle
3: 100 to 149 metric tons of CO2e per vehicle
2: 50 to 99 metric tons of CO2e per vehicle
1: Less than 50 metric tons of CO2e per vehicle

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 – 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	3	N/A	1
Low NOx Engine Incentives	N/A	3	N/A	1

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

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

Ability to Leverage Private Capital Investments

Staff is proposing not to include this criterion for FY 2017-18 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-53 summarizes the individual scores and the TBI scores for all of the AQIP projects currently proposed in the FY 2017-18 Funding Plan.

Table A-53: 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	2	5	3	1	0	2.2	5	4.3
Low NOx Engine Incentives	2	5	5	1	5	3.6	1	1.65

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

In the proposed Funding Plan, staff proposes that at least 45 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 10 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 45 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 ½ mile of a disadvantaged community for a total AB 1550 investment of at least 35 percent of California Climate investment funds.

Table A-54 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, HVIP, and EFMP Plus-Up, staff used the historical percent of funds spent in disadvantaged communities as reported in the *2017 Annual Report on California Climate Investments* to project future performance. In the case of HVIP, staff updated these estimates based on vouchers issued through February 2017. In the case of EFMP Plus-Up, staff adjusted the future projection to be more conservative because of the lack of historical data for the potential new air districts expected to start programs. Staff estimated the percent of funds within low-income communities by comparing the most recent project data with the low-income communities identified by CARB and Cal/EPA in April 2017 and the development of guidelines for implementing AB 1550. For EFMP Plus-Up, there are historical data on participants' incomes, so staff estimated the expected percent of funds that would be invested in low-income households.

As shown in Table A-54, several project categories are limited to disadvantaged communities, so staff can say with certainty 100 percent of these funds will be spent in these communities. These include Clean Mobility Options for Disadvantaged Communities, Agricultural Worker Vanpools, and Zero- and Near Zero-Emission Freight Facilities.

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. 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 Financing Assistance of Lower-Income Consumers pilot project will be limited to consumers with household incomes of less than 400 percent of the federal poverty limit and outreach will be targeted in disadvantaged communities. Thus, staff expects much 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 10 percent in non-overlapping low-income communities for a total of over 45 percent meeting one of the AB 1550 criteria as shown in Table A-54. 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-54: Estimate of the Minimum Proposed FY 2017-18 Low Carbon Transportation Investments in Disadvantaged Communities, Low-Income Communities, and Low-Income Households

Project	**Allocation** (million)	**% in DC**	**$ in DC** (million)	**% in LIC** (non-overlapping)	**$ in LIC** (million)	**%DC/LIC Combined**	**$DC/LIC Combined** (million)	**Data Source for Estimates**
Light-Duty Vehicle and Transportation Equity Projects								
CVRP	$140	7%	$10	11%	$15	18%	$25	• 7% spent in DCs to date from *2017 Annual Report on California Climate Investments.* • Staff estimates 11% in LICs not overlapping with DCs based on 2016 CVRP data.
EFMP Plus-up	$10	50%	$5	25%	$2.5	75%	$8	• 64% spent in DCs to date from *2017 Annual Report on California Climate Investments*. Staff made a more conservative future estimate of 50% because potential new districts have less dense concentration of DC census tracts. • 90% spent to date in low-income households (meeting AB 1550 definition). Staff made a more conservative future estimate of 75% due to lack of historical data for potential new air districts.
Financing Assistance for Lower-Income Consumers	$10	tbd	$-	tbd	$-	tbd	$-	• No data upon which to base estimates, so left as "to be determined" to be most conservative. • Statewide project, but limited to participants with household incomes less than 400% of federal poverty limit with outreach targeted in DCs, so appreciable amount of funds should be spent in DCs, LICs, or low-income households.
Clean Mobility Options	$22	100%	$22	0%	$-	100%	$22	• Project limited to DCs.
Ag Worker Vanpools	$3	100%	$3	0%	$-	100%	$3	• Project limited to DCs.
Rural School Bus Pilot Project	$10	tbd	$-	tbd	$-	tbd	$-	• No data upon which to base estimates, so left as "to be determined" to be most conservative. • Many of the school districts expected to receive funding located in LICs, so appreciable amount of funds should be spent in LICs.
CVRP Rebates for Low-Income Applicants	$25	7%	$2	11%	$3	18%	$5	• Used same data as CVRP standard rebates above. • Low-income rebates limited to consumers earning less than 300% of federal poverty level; very likely a larger percentage of these funds will be spent in DCs, LICs, or AB 1550 low-income households.

Table A-54: Estimate of the Minimum Proposed FY 2017-18 Low Carbon Transportation Investments in Disadvantaged Communities, Low-Income Communities, and Low-Income Households (cont.)

Project	**Allocation** (million)	**% in DC**	**$ in DC** (million)	**% in LIC** (non-overlapping)	**$ in LIC** (million)	**%DC/LIC Combined**	**$DC/LIC Combined** (million)	**Data Source for Estimates**
Allocate Based on Demand	$20	tbd	$-	tbd	$-	tbd	$-	• Will quantify and report based on project implementation.
Heavy-Duty Vehicle and Off-Road Projects								
Zero-Emission Off-Road Freight Voucher Incentives	$40	tbd	$-	tbd	$-	tbd	$-	• No data upon which to base estimates, so left as "to be determined" to be most conservative. • Statewide project, but freight equipment used at facilities predominantly located in DCs. Project design provides extra incentives for equipment in DCs, so appreciable amount of funds should be spent in DCs.
Zero- and Near Zero-Emission Freight Facilities	$100	100%	$100	0%	$-	100%	$100	• Project limited to DCs.
Clean Truck and Bus Vouchers (HVIP + Low NOx Engine Incentives)	$180	30%	$54	25%	$45	55%	$99	• 39% spent in DC and 29% in LICs not overlapping with DCs based on HVIP vouchers reserved or issued through February 2017. Limited data for low NOx engine vouchers upon which to base estimate. • Staff made a more conservative future estimate of 30% spent in DC and 25% in LICs not overlapping with DCs because of limited data on low NOx voucher distribution and no historical data for new technology/vehicle classes that may enter market.
Total	**$560**	**35%**	**$196**	**12%**	**$66**	**47%**	**$261**	

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.
tbd means "to be determined" and reported in future *Annuals Report on California Climate Investments* based on project implementation.