

Appendix F:
Cost-Benefit Analysis of Mobile Source Incentive Programs

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Overview

Appendix F (Appendix) provides the cost-benefit values for CARB's Mobile Source incentive programs, including the Low Carbon Transportation (LCT) Program, Air Quality Improvement Program (AQIP), Carl Moyer Memorial Air Quality Standards Attainment (Carl Moyer) Program, Community Air Protection (CAP) Program, and Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program. Assembly Bill (AB) 8 (Perea, Chapter 401, Statutes of 2013) requires CARB to look at benefit-cost scores to provide preference in awarding funding to those projects with higher benefit-cost scores that maximize the purposes and goals of AQIP.

It is important to note at the outset that cost-benefit ratios are an incomplete and partial reflection of the value of these programs. Legislation that governs many of these programs include additional goals that may not be reflected in cost-benefit metrics alone, such as directing funding to disadvantaged and low-income communities. Many of these programs achieve co-benefits and other legislative directives, such as jobs creation and reduction in health risks from near-source exposure to toxic air contaminants. Not all of these benefits can be monetized. Further, one of the roles of public investment, in many instances, is to address needs that may not draw private investment, or in which private investment is lacking - equity, long-term returns, innovation, and distributional benefits are only some of the values not clearly captured in cost-benefit ratios. Thus, the values described in this report, though important, should not be viewed as a full program assessment, or as reflective of all the values these programs serve. They are one metric among many.

The cost-benefit results presented in this appendix are for the date ranges indicated in Table F-1.

Table F-1: Program Data Analysis Time Periods

Program/Project Name	Data Start Date	Data End Date
Clean Vehicle Rebate Project (CVRP)	December 2022	August 2023
Clean Cars 4 All (CC4A)	December 2022	November 2023
Financing Assistance for Lower-Income Consumers	December 2022	November 2023
Clean Mobility Options ¹	December 2020	November 2023
Clean Mobility in Schools	December 2022	November 2023
Rural School Bus Pilot	December 2022	June 2023
Sustainable Transportation Equity Projects (STEP)	December 2020	November 2023
Heavy-Duty Demonstration and Pilot Projects	December 2018	November 2022
Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)	December 2022	November 2023
Clean Off-Road Equipment Voucher Incentive Project (CORE)	December 2022	November 2023
Carl Moyer Program	July 2016	June 2023
CAP Incentives	July 2018	November 2023
FARMER Program	July 2018	March 2024

Cost-benefit is a measure of cost per ton of emissions reduced. The information and tables in this Appendix display greenhouse gas (GHG) and criteria pollutant cost-benefit values of the respective incentive programs or projects over the time periods defined in Table F-1.

GHG cost-benefit value is calculated for each program or project by dividing the total incentive funding by the total GHG emissions reduced over the lifetime of the project, consistent with the methodology used for California Climate Investments, as shown in Formula 1. GHG cost-benefit values are reported in terms of dollars per metric ton of carbon dioxide equivalent (MTCO_{2e}) emission reductions.

¹ As of now, there are no calculated emission reductions for the calendar year 2022 based on the implemented projects. However, emission reductions for ongoing projects will be calculated upon their completion.

Formula 1: GHG Cost-Benefit

$$\text{GHG Cost Benefit (\$/MTCO}_2\text{e)} = \frac{\text{Incentive Funding}}{\text{Lifetime GHG Reductions}}$$

The criteria pollutant cost-benefit value is calculated similarly for each program or project by dividing the total incentive funding by the total lifetime weighted criteria pollutant reductions, as shown in Formula 2. Weighted criteria pollutant emission reductions are calculated by weighting the project's particulate matter (PM) emission reductions by a factor of 20 to account for PM toxicity and then added to the oxides of nitrogen (NOx) and reactive organic gas (ROG) emission reductions.

Formula 2: Criteria Pollutant Cost-Benefit

$$\text{Criteria Pollutant Cost Benefit (\$/weighted ton)} = \frac{\text{Incentive Funding}}{\text{Lifetime NO}_x + \text{ROG} + (20 * \text{PM})}$$

CARB has historically calculated the cost-effectiveness of each project funded using the cost-effectiveness formula established by the Carl Moyer Program Guidelines and guided by Legislative direction. This formula includes a capital recovery factor to account for the project cost over the life of the project when calculating cost-effectiveness. To provide additional transparency and allow for an equal comparison of cost for emission reduction benefits across programs, CARB is presenting the values in this Appendix using a simplified cost-benefit formula to show the benefits of each program or project proposed to be funded by the Proposed Funding Plan in terms of today's costs.

Low Carbon Transportation Program and Air Quality Improvement Program

The LCT Investments accelerate the transition to low carbon transportation with a priority on providing health and economic benefits to California's most disadvantaged communities. AQIP is a voluntary, mobile source incentive program that focuses on reducing criteria pollutant and diesel particulate emissions with concurrent reductions in greenhouse gas emissions.

Table F-2 presents the GHG and criteria pollutant cost-benefit values of LCT and AQIP projects, based on implemented project data for the time periods specified in Table F-1, as reported in the California Climate Investments Reporting and Tracking System and supplemented with data from projects funded by other sources when applicable. The projects in the following table are grouped by project type: vehicle purchase incentives; clean mobility investments; and heavy-duty vehicle and off-road equipment incentives.

Vehicle purchase incentives include CVRP, Financing Assistance for Lower-Income Consumers (Financing Assistance) and CC4A. CVRP supported increasing the number of zero-emission vehicles (ZEV) on California's roadways to meet deployment goals and achieve large scale transformation of the fleet while also providing support to increase ZEV adoption for lower-income consumers. CVRP has been phased out in 2023 and does not expect future funding. CC4A and Financing Assistance are designed to increase access to cleaner vehicles in disadvantaged communities and lower-income households as prescribed by Senate Bill (SB) 1275 (De León, Chapter 350, Statutes of 2014), and supported by SB 350 (De León, Chapter 547, Statutes of 2015), as well as provide support to the secondary ZEV market.

Clean mobility investments include Clean Mobility Options, Clean Mobility in Schools, the Rural School Bus Pilot Project, and STEP. Clean mobility investment projects support transportation needs of low-income residents and those living in disadvantaged and low-income communities. Mobility needs are not the same in all communities, therefore, various options are provided to be flexible and responsive to the transportation needs of specific communities. These projects provide funding for various clean mobility solutions (other than vehicle ownership) including zero-emission car sharing, vanpools, electric and regular bike sharing, ride-hailing, and other clean mobility options, along with capacity building, outreach, and technical assistance for communities. The Rural School Bus Pilot Project is not expected to receive future funding as it has now transitioned from an initial pilot to a full-scale project implemented through HVIP.

Heavy-duty vehicle and off-road equipment incentives include: Advanced Technology Demonstration and Pilot Projects, Clean Truck and Bus Vouchers through HVIP, and CORE. This category of projects incentivizes technology advancement through Advanced Technology Demonstration and Pilot Projects, and the deployment of commercially available technologies through HVIP and CORE. Because Advanced Technology Demonstration and Pilot Projects accelerate the introduction of a variety of advanced emission reducing technologies on the cusp of commercialization, providing an average cost-benefit value does not accurately represent the projects funded; instead, a range of cost-benefit values are provided, based on projects implemented over the past four years.

Table F-2: Cost-Benefit Values of LCT and AQIP Projects²

Project Name	GHG Cost-Benefit (\$/MTCO _{2e})	Criteria Pollutant Cost-Benefit (\$/weighted ton)
Vehicle Purchase Incentives		
CVRP	\$784	\$575,800
CC4A	\$772	\$435,000
Financing Assistance	\$1,100	\$729,400
Clean Mobility Incentives		
Clean Mobility Options ³	\$2,900	\$2,566,800
Clean Mobility in Schools	\$863	\$286,600
Rural School Bus Pilot	\$1,400	\$97,700
STEP ⁴	\$9,000	\$9,164,900
Heavy-Duty Vehicle and Off-Road Equipment Incentives		
Advanced Technology Demonstration and Pilot Projects	\$105 - \$76,700	\$20,600 - \$38,200,000
HVIP	\$2,300	\$957,800
CORE	\$2,300	\$1,109,400

Carl Moyer Memorial Air Quality Standards Attainment Program

The Carl Moyer Program provides incentive grants to fund the incremental cost of cleaner than-required engines, equipment, and other technology. The core principle of this program is to achieve cost-effective criteria pollutant emission reductions that are surplus, quantifiable, enforceable, and creditable to the State Implementation Plan. The Carl Moyer Program is implemented as a partnership between CARB and local air districts. Air districts administer the program and select the projects to fund while CARB establishes the guidelines and provides oversight.

² There are newer projects such as Zero-Emission Truck Loan Pilot Project, California E-bike Incentive Project, and Driving Clean Assistance Program, but there are no cost-benefit values as the data is not yet available.

³ CMO also funds projects that facilitate but do not provide direct emission reductions such as other community outreach and engagement efforts. As the statewide program progresses, staff will provide updated cost-benefit values based on recent project data.

⁴ Cost-benefit values for STEP include funding for Planning and Capacity Building Grants and other community outreach and engagement efforts, which facilitate but do not provide direct emission reductions, as well as funding for other project types, such as urban forestry, that provide direct emission reductions that are not quantified here.

The Carl Moyer Program has invested a total of \$1.6 billion from its inception in 1998 to 2021. The criteria pollutant cost-benefit values for the program are based on the most recent seven years of data from the [2021 Carl Moyer Program Statistics](#) supplemented by data from 2022 and 2023. This data is subject to change as staff is developing the current report. While this data is the most recent available for previously funded projects, it is not representative of current or future costs to fund new projects. Current and future projects for most incentive programs will include a higher share of zero-emission projects, shifting from mostly combustion in earlier years. These projects are expected to have higher initial purchase prices, resulting in higher cost-benefit values. For example, current cost-effectiveness limits for the Carl Moyer Program include a maximum of \$522,000 per agricultural pump projects. The off-road other category includes construction, airport ground support, cargo handling, and lawn and garden equipment replacement projects. The Carl Moyer Program focuses on criteria pollutant emission reductions and therefore, does not have quantified GHG emission reductions.

Infrastructure projects enable emission reductions, but do not directly reduce emissions; thus, no cost-benefit value can be calculated for this category.

Table F-3: Carl Moyer Program Cost-Benefit Values⁵

Source Category	Criteria Pollutant Cost-Benefit (\$/weighted ton)
Locomotives	\$10,600
Marine Vessels	\$11,500
Off-Road Agricultural	\$8,400
Off-Road Other	\$18,100
On-Road	\$ 48,900
Car Scrap	\$ 12,200
Total	\$12,100

Community Air Protection Program

The Community Air Protection Program focuses on projects in AB 617 (C. Garcia, Chapter 136, Statutes of 2017), selected communities statewide as well as in AB 1550 (Gomez, Chapter 369, Statutes of 2016), disadvantaged and low-income communities. Air districts administer these incentives and work closely with local community groups to prioritize and select projects according to community needs, with priority on community-guided

⁵ Note that the term “cost benefit value” is not the same as the term “cost-effectiveness value”, where cost-effectiveness values are utilized in the Moyer and FARMER programs and defined by statute.

zero-emission projects. In addition, the CAP Incentives Guidelines provide additional funding opportunities for incentives to reduce exposure to harmful pollutants at sensitive receptors, incentives to reduce emissions of hexavalent chromium from chrome plating and chromic acid anodizing operations, and incentives to address emissions and exposure relating to stationary, and community-identified sources of concern. Additionally, staff recently revised the CAP Incentives Guidelines in March 2024 to add eligibility for a variety of new project categories. These new categories are based on the efforts of air districts and their community partners in developing new kinds of incentives to address the specific community concerns identified during development and implementation of their Community Emissions Reduction Programs, and include incentives for local agency partnerships, dial-a-ride transit vehicle replacements, community greening and vegetative barriers, emergency stationary diesel generator replacements, paving and bike paths, alternatives to open agricultural burning, and low-dust nut harvester replacements.

The cost-benefit values for source category projects are compiled from program staff and grouped based on similarity, as shown in Table F-4. As with the Carl Moyer Program, infrastructure projects enable emission reductions, but do not directly reduce emissions; thus, no cost-benefit value can be calculated for this category. The on-road category includes Proposition 1B projects, which are not subject to the Carl Moyer Program’s traditional cost-effectiveness limits. Additionally, the other CAP incentives categories include AB 617 community identified projects as well as air filtration and other projects at schools. These projects may not have quantified emission reductions and therefore, do not have calculated cost-benefit values.

Table F-4: Cost-Benefit Values of CAP Incentives

Source Category	GHG Cost-Benefit (\$/MTCO _{2e})	Criteria Pollutant Cost-Benefit (\$/weighted ton)
Infrastructure	N/A	N/A
Locomotives	\$21,000	\$13,300
Marine Vessels	N/A	\$7,200
Off-Road Agricultural	\$2,700	\$5,400
Off-Road Other	\$1,000	\$10,900
On-Road	\$900	\$71,600
Other CAP Categories	N/A	N/A

CAP incentives have provided a total of 250,800 MTCO_{2e} GHG reductions. However, some projects may result in no GHG reductions or even slight increases. For example, when looked at separately, marine vessel projects resulted in a slight increase in GHG emissions. Marine vessel projects are primarily diesel-to-diesel engine replacements and although the two engines do the same work, the new engine may have a slightly higher horsepower

rating than the old engine. On a per-horsepower basis, there would be no change in GHG emissions from the old diesel engine to the new one, but under the existing quantification methodology, these projects result in a slight increase in GHG emissions due to the increase in horsepower. Therefore, no cost-benefit value was calculated for this category.

Funding Agricultural Replacement Measures for Emission Reductions Program

The FARMER Program provides funding to replace high-emitting diesel agricultural vehicles and equipment with the cleanest, commercially available vehicles, equipment, or engines to achieve cost-effective emission reductions. Consistent with Legislative direction, the FARMER Program also provides funding to replace heavy-duty trucks used in agriculture. In addition, the FARMER Program provides opportunities to support market transformation in the agricultural sector by providing funding for zero-emission equipment used in agriculture, such as zero-emission agricultural utility terrain vehicles (UTV) and tractors under the zero-emission agricultural equipment category.

The cost-benefit values for FARMER projects are compiled from the latest semi-annual reports from districts, based on data from program inception through March 31, 2024. Like the Carl Moyer Program and CAP incentives, projects are grouped based on similarity, as shown in Table F-5. The off-road agricultural category includes agricultural trade-up projects, zero-emission agricultural equipment projects, used agricultural equipment projects for small producers, and stationary agricultural irrigation pump projects.

Table F-5: FARMER Program Cost-Benefit Values

Project Category	GHG Cost-Benefit (\$/MTCO _{2e})	Criteria Pollutant Cost-Benefit (\$/weighted ton)
Off-Road Agricultural	\$1,500	\$7,000
On-Road Trucks	\$5,500	\$100,500
Zero-Emission Agricultural UTVs	\$470	\$54,300
Total	\$1,300	\$8,000

More Information

This document provides the cost-benefit values for the suite of CARB’s incentive programs. These values are based on program parameters imposed by each project or project category. To learn more about the LCT Program, please visit the [Low Carbon Transportation Investments and AQIP Funding Plans](#) website. To learn more about the Carl Moyer Program and their annual reports, please visit the [Carl Moyer Memorial Air Quality Standards Attainment Program](#) page. To learn more about CAP incentives, please visit the [Community](#)

Air Protection Incentives page. To learn more about the FARMER Program, please visit the *FARMER Program* page.