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

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Overview

This appendix provides the cost-benefit values for the suite of CARB's 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) incentives, and Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program.

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 includes 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 2021	November 2022
Clean Cars 4 All (CC4A)	December 2021	December 2022
Financing Assistance for Low-Income Consumers	July 2022	May 2023
Clean Mobility Options[1]	December 2021	May 2022
Clean Mobility in Schools	June 2022	April 2023
Rural School Bus Pilot	December 2021	November 2022
Sustainable Transportation Equity Projects (STEP)	December 2021	November 2022
Heavy-Duty Demonstration and Pilot Projects	January 2018	December 2021
Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)	December 2021	November 2022
Clean Off-Road Equipment Voucher Incentive Project (CORE)	December 2021	November 2022
Truck Loan Assistance Program	December 2021	November 2022
Carl Moyer Program	July 2016	June 2021
CAP Incentives	July 2018	November 2022
FARMER Program	July 2018	September 2022

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 (MTCO2e) emission reductions.

[1] Based on implemented projects from calendar year prior due to lack of calculated emission reductions for ongoing projects.

Formula 1: GHG Cost-Benefit

$$GHG\ Cost\ Benefit\ (\$/MTCO2e) = \frac{Incentive\ Funding}{Lifetime\ GHG\ Reductions}$$

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

$$Criteria\ Pollutant\ Cost\ Benefit\ (\$/weighted\ ton) = \frac{Incentive\ Funding}{Lifetime\ NOx + ROG + (20 * PM)}$$

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 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 for the entire suite 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 Project for Lower-Income Consumers (Financing Assistance), and CC4A. CVRP supports 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 does not expect future funding for the program and will close once funding runs out. 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 and supported by SB 350, 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, CORE, and the Truck Loan Assistance Program. This category of projects incentivizes technology advancement through Advanced Technology Demonstration and Pilot Projects, the deployment of zero-emission heavy-duty vehicles and off-road equipment through HVIP and CORE, and the turnover of the legacy fleet through the Truck Loan Assistance Program. The Truck Loan Assistance Program closed to new loan enrollment applications on July 31, 2023, and no future funding is planned for this program. 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 five years.

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

Project Name	GHG Cost-Benefit ($/MTCO2e)	Criteria Pollutant Cost-Benefit ($/weighted ton)
Vehicle Purchase Incentives		
CVRP (Standard and Increased Rebates)[2]	$337	$348,000
CC4A	$914	$516,000
Financing Assistance	$817	$582,000
Clean Mobility Incentives		
Clean Mobility Options[3]	$2,500	$2,170,000
Clean Mobility in Schools	$860	$287,000
Rural School Bus Pilot	$975	$69,000
STEP[4]	$12,900	$17,400,000
Heavy-Duty Vehicle and Off-Road Equipment Incentives		
Advanced Technology Demonstration and Pilot Projects	$2,500 - $67,000	$10,400 - $39,500,000
HVIP	$676	$267,000
CORE	$2,900	$1,600,000
Truck Loan Assistance Program	N/A	$72,500

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,

[2]In many budget years, standard and increased rebates for lower-income consumers in CVRP did not receive separate budget appropriations, so standard and increased rebates were funded out of the same line-items. Thus, CARB is presenting the overall CVRP cost-benefit values as a single number.

[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.

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.

The Carl Moyer Program has invested a total of $1.6 billion since its inception in 1998. The criteria pollutant cost-benefit values for the program are based on the most recent five years of data from the 2021 Carl Moyer Program Statistics[5] to reflect recent program performance. The data is subject to change, as it reflects reported data through the 2021 reporting cycle as of October 2021.

The cost-benefit values for source category projects are grouped based on similarity, as shown in Table F-3. The off-road agricultural category includes stationary and portable 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 Values

Source Category	Criteria Pollutant Cost-Benefit ($/weighted ton)
Locomotives	$7,900
Marine Vessels	$8,900
Off-Road Agricultural	$7,000
Off-Road Other	$16,100
On-Road	$27,300
Car Scrap	$10,900
Total	$10,400

[5] https://ww2.arb.ca.gov/sites/default/files/2023-02/2021%20Carl%20Moyer%20Program%20Statistics%2002-24-2023.pdf

Community Air Protection Incentives

CAP incentives focus on projects in AB 617 selected communities statewide as well as in AB 1550 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 zero-emission projects. Mobile source projects are funded pursuant to the Carl Moyer Program and the Proposition 1B Goods Movement Emission Reduction Program (Proposition 1B). In addition, the 2019 CAP Incentives Guidelines provide additional funding opportunities for stationary sources and community-identified projects.

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 categories include AB 617 community identified projects as well as air filtration 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 ($/MTCO2e)	Criteria Pollutant Cost-Benefit ($/weighted ton)
Infrastructure	N/A	N/A
Locomotives	$26,500	$12,000
Marine Vessels	N/A	$16,800
Off-Road Agricultural	$1,900	$5,350
Off-Road Other	$1,000	$18,300
On-Road	$750	$54,300
Other CAP Categories	N/A	N/A
Total	$1,900	$12,800

CAP incentives have provided a total of 232,000 MTCO2e 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. Heavy-duty agricultural trucks are not cost-effective under other incentive programs due to the seasonality of the agricultural industry as well as the need for agricultural trucks to be custom built for specialty work, making these trucks more expensive than typical heavy-duty trucks. 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 September 30, 2022. 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 ($/MTCO2e)	Criteria Pollutant Cost-Benefit ($/weighted ton)
Off-Road Agricultural	$2,500	$5,600
On-Road Trucks	$4,600	$100,000
Zero-Emission Agricultural UTVs	$410	$45,900
Total	$1,700	$6,700

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.