

California Air Resources Board

**Greenhouse Gas Quantification Methodology for
Air Resources Board
Low Carbon Transportation Program
Consumer-Based Heavy-Duty Projects**

**Greenhouse Gas Reduction Fund
Fiscal Year 2016-17**



January 10, 2017

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Table 1: Quantification and Reporting by Project Phase 8
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Section A. Introduction

The goal of California Climate Investments (CCI) is to reduce greenhouse gas (GHG) emissions and further the purposes of the Global Warming Solutions Act of 2006, known as Assembly Bill (AB) 32. The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate the GHG emission reductions from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). ARB develops these methodologies based on the project types eligible for funding by each administering agency, as reflected in the program Expenditure Records available at:

<https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/expenditurerecords.htm>.

The ARB Low Carbon Transportation (LCT) Program is comprised of 14 different project types, as outlined in the Fiscal Year (FY) 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Projectⁱ (Funding Plan). A subset of these projects, referred to as Consumer-Based Heavy-Duty Projects, provide incentives for the purchase of advanced technology light heavy-duty passenger vans and medium heavy-duty trucks and buses, and have been grouped together for this quantification methodology. ARB staff developed this quantification methodology to estimate GHG emission reductions in metric tons (MT) of carbon dioxide equivalent (CO₂e) from supported advanced vehicle technology types (Sections B and C), provide instructions for documenting and supporting the estimate (Section D), and outline the process for tracking and reporting GHG emission reductions once a project is funded (Section E). The emission reduction calculations detailed in this quantification methodology are based on the methods described in the Funding Plan, Appendix A - Emission Reduction: Quantification Methodologyⁱ, which ARB developed through a public process.

LCT Consumer-Based Heavy-Duty Projects

The LCT Consumer-Based Heavy-Duty Projects reduce GHG emissions by providing incentives for advanced vehicle technology types, such as battery-electric vehicles (BEV), hybrid vehicles, and optional low NO_x standard compressed natural gas (CNG) engines fueled with renewable natural gas (RNG). ARB has identified four LCT Consumer-Based Heavy-Duty Projects:

- 1. Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)**
HVIP provides vouchers, available on a first-come, first-served basis statewide; to help California fleets offset the higher up—front cost of purchasing hybrid and zero-emission trucks and buses. This project provides GHG benefits because the eligible zero-emission and hybrid trucks and buses emit less GHGs on a well-to-wheels basis than conventional diesel-fueled models.
- 2. Rural School Bus Pilot Project**
The Rural School Bus Pilot Project funds cleaner school buses prioritizing applicants in rural air districts. Eligible school buses include near zero-emission

plug-in hybrid school buses and school buses with internal combustion engines operating on renewable fuels, and zero-emission school buses. The project provides GHG benefits because the eligible school buses either operate on renewable fuels or electricity.

3. Low NOx Engine Incentives

Low NOx Engine Incentives provide incentives to truck owners for the purchase of trucks certified to the optional low NOx standards along with a requirement to use low carbon, renewable fuel to maximize GHG benefits. These trucks, operating on low carbon, renewable fuel, provide GHG benefits because the eligible trucks emit less GHG on a lifecycle basis than conventional diesel-fueled models. The project is implemented through HVIP on a first-come, first-served, statewide basis.

4. Agricultural Worker Vanpools

This pilot project is designed to expand access to cleaner, lower GHG-emitting transportation options for agricultural workers in the San Joaquin Valley's disadvantaged communities.

Methodology Development

ARB developed this quantification methodology consistent with the guiding implementation principles of CCI, including ensuring transparency and accountability.ⁱⁱ This quantification methodology will be used to estimate the GHG emission reductions for awarded funds and implemented projects. The implementing principles ensure that the methodology will:

- Apply at the project-level;
- Provide uniform methods to be applied statewide;
- Use existing and proven methods;
- Use project-level data, where available and appropriate; and
- Result in GHG emissions reduction estimates that are conservative and supported by empirical literature.

ARB will quantify and report GHG emission reduction estimates using two approaches:

1. Awarded funds. Estimates will be quantified using the methods described in Section B upon funding allocation.
2. Implemented Projects. Estimates will be quantified using the methods described in Section C as projects are implemented.

These estimates are calculated using equations listed in Section B and Section C and the emission factors and project data assumptions in Appendix A.

Program Assistance

ARB staff will ensure that the quantification methods described in this document are properly applied to estimate the GHG emission reductions for the project types.

- Questions on this quantification document should be sent to:
GGRFProgram@arb.ca.gov
- For more information on ARB's efforts to support implementation of GGRF investments, see: www.arb.ca.gov/auctionproceeds
- Questions not related to this quantification document, but pertaining to LCT Consumer-Based Heavy-Duty Projects should be sent to:

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Section B. Greenhouse Gas Quantification Methodology for Awarded Funds

The quantification methodology in this section describes how ARB will estimate the GHG emission reductions based on funds allocated to the LCT Consumer-Based Heavy-Duty Projects. This methodology is to be used for each project type separately. Additionally, results for each project type are to be reported separately.

Step 1. Calculate the Annual GHG Emission Reductions for each Advanced Vehicle Technology Type

The annual GHG emission reductions are calculated for each advanced vehicle technology type (e.g., battery-electric urban transit bus, optional low NOx standard CNG engine fueled with RNG, renewable diesel school buses, etc.) using the emission factors and annual vehicle miles traveled (VMT) assumptions included in Appendix A and Equation 1.

$$ER_{AV} = \frac{(EF_C - EF_{AV}) * (VMT)}{1,000,000} \quad (\text{Eq. 1})$$

Where,

ER_{AV}	is the annual GHG emission reductions from the use of one advanced technology vehicle in place of one conventional vehicle (MT CO ₂ e/year);
EF_C	is the emission factor for a conventional vehicle (g CO ₂ e/mile);
EF_{AV}	is the emission factor for the advanced vehicle technology type (g CO ₂ e/mile); and
VMT	is the annual VMT for the vehicle (miles/year).

Step 2. Calculate the Weighted Average Annual GHG Emission Reductions

A weighted average for the project (e.g., HVIP, Rural School Bus Pilot Project, Low NOx Engine Incentives, Agricultural Worker Vanpools) is then calculated using the proportion of funding that each advanced vehicle technology type received historically (Appendix A) and Equation 2.

$$ER_{WtAvg} = \sum_{i=1}^n P_{AV,i} * ER_{AV,i} \quad (\text{Eq. 2})$$

Where,

ER_{WtAvg}	is the weighted average annual GHG emission reductions from the use of one advanced technology vehicle in place of one conventional vehicle (MTCO ₂ e/year);
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$P_{AV,i}$ is the historical proportion of the advanced vehicle technology type (percent); and
 $ER_{AV,i}$ is the annual GHG emission reduction from the use of one advanced technology vehicle in place of one conventional vehicle (MT CO₂e/year).

Step 3. Calculate the Number of Vehicles Funded

The number of vehicles funded is calculated for each project type using Equation 3.

$$N = \frac{\text{Project Allocation Amount (\$)}}{\text{Weighted Average Project Rebate Amount (\$)}} \quad (\text{Eq. 3})$$

Where,
 N is the number of vehicles funded.

Step 4. Calculate the Total Project GHG Emission Reductions

The total GHG emission reductions for each project type (e.g., HVIP, Rural School Bus Pilot Project, Low NOx Engine Incentives, Agricultural Worker Vanpools) is calculated using Equation 4.

$$ER_{PL} = ER_{WtAvg} * N * UL \quad (\text{Eq. 4})$$

Where,
 ER_{PL} is the total project GHG emission reduction (MT CO₂e);
 ER_{WtAvg} is the result from Step 2;
 N is the result from Step 3; and
 UL is the average project life for a vehicle (years).

Section C. Greenhouse Gas Quantification Methodology for Implemented Projects

The quantification methodology in this section describes how ARB will refine the GHG emission reduction estimates from Section B as the grant administrator reports project-specific number for vehicles funded. This methodology is to be used for each project type separately. Additionally, results for each project type are to be reported separately.

Step 1. Calculate the Total GHG Emission Reduction for each Advanced Vehicle Technology Type

The total GHG emission reductions is calculated for each advanced vehicle technology type (e.g., battery-electric urban transit bus, optional low NOx standard CNG engine fueled with RNG, renewable diesel school buses, etc.) using the emission factors and project assumptions in Appendix A, the number of vehicles funded for each advanced vehicle technology type, and Equation 5.

$$ER_{AV_PL} = \frac{(EF_C - EF_{AV}) * (VMT) * N_{AV} * UL}{1,000,000} \quad (\text{Eq. 5})$$

Where,

ER_{AV_PL}	is the total GHG emission reductions from an advanced vehicle technology type (MT CO ₂ e);
EF_C	is the emission factor for a conventional vehicle (g CO ₂ e/mile);
EF_{AV}	is the emission factor for the advanced vehicle technology type (g CO ₂ e/mile);
VMT	is the annual VMT for the vehicle (miles/year);
N_{AV}	is the number of vehicles funded for the advanced vehicle technology type; and
UL	is the project life for the vehicle (years).

Step 2. Calculate the Total Project GHG Emission Reductions

The total project (e.g., HVIP, Rural School Bus Pilot Project, Low NOx Engine Incentives, Agricultural Worker Vanpools) GHG emission reductions is calculated by summing the emission reductions from each advanced vehicle technology type funded by the project, using Equation 6.

$$ER_{PL} = \sum ER_{AV_PL} \quad (\text{Eq. 6})$$

Where,

ER_{PL}	is the total project GHG emission reductions (MT CO ₂ e); and
ER_{AV_PL}	is the result from Step 1.

Section D. Documentation

ARB reports Total Project GHG Emission Reductions by project type for both awarded funds and implemented projects. Total Project GHG Emission Reductions per dollar of GGRF funds can be calculated using Equation 7.

$$\frac{\textit{Total Project GHG Emission Reduction (MTCO}_2\textit{e)}}{\textit{Total GGRF Funds (\$)}} \quad (\text{Eq. 7})$$

Supporting Documentation

ARB is required to retain documentation that is sufficient to allow all quantification calculations to be reviewed and replicated.

Documentation collected with issuance of vehicle funding includes:

- Project specific equipment specifications and certifications; and
- Summary page with, at a minimum, the following information:
 - Number of advanced vehicles by technology type; and
 - GGRF funds requested for the project.

Section E. Reporting after Funding Award

Accountability and transparency are essential elements for all GGRF CCI projects. As described in Volume 3 of ARB’s Funding Guidelinesⁱⁱ, each administering agency is required to track and report on the benefits of the CCI funded under their program(s). Each project funded by the GGRF is expected to provide quantifiable GHG emission reductions. The previous sections of this document provide the methods used to estimate the GHG emission reductions for each project type. This section explains ARB’s reporting requirements for awarded funds and implemented projects.

LCT Consumer-Based Heavy-Duty Project grant administrators have the obligation to provide, or provide access to, data and information on project outcomes to ARB.

It is the responsibility of ARB to collect and compile data from the grant administrators, including information needed to refine GHG emission reduction estimates and information on benefits to disadvantaged communities.

Table 1: Quantification and Reporting by Project Phase

	Timeframe	Quantification Methods
Funding Allocation	Upon allocation of funding from the legislature, when ARB can estimate the number of vehicles that can be funded from funding allocation.	ARB uses methods in Section B to estimate GHG reductions based on funding allocations and historical project data.
Phase 1	Period from funding allocation through implementation of all allocated project funds, when the grant administrator has provided project-specific information.	ARB uses methods in Section C to calculate GHG reductions based on the actual number of vehicles funded.

During the funding allocation phase, ARB estimates the GHG emission reductions anticipated by allocated funds and reports these estimates in the funding plan for the Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program.

During Phase 1, ARB will collect information characterizing the vehicle. Refined emission reduction estimates will be quantified as projects are implemented and data becomes available.

ⁱ California Air Resources Board. Proposed Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and The Air Quality Improvement Program. May 20,2016. https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_full.pdf

ⁱⁱ California Air Resources Board. Funding Guidelines for Agencies Administering California Climate Investments. December 21, 2015. <http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb-funding-guidelines-for-ca-climate-investments.pdf>.

Appendix A. Emission Factors and Project Data Assumptions

ARB developed a set of emissions factors using fuel consumption rates from the ARB Mobile Source Emission Factor Model (EMFAC 2014ⁱ) and carbon intensity values for different fuel types from the ARB Low Carbon Fuel Standards (LCFSⁱⁱ) Program. Table A-1 through Table A-5 provide an overview of the emission factors for GHG emissions for the advanced technology and conventional vehicles included for each project type.

Table A- 1. Well-to-Wheel GHG Emission Factors for 2016 Model Year Advanced Technology Medium Heavy-Duty Vehiclesⁱⁱⁱ (HVIP)

	2016 Diesel	Conventional Hybrid	BEV
GHG (gCO ₂ e/mi)	1,596	1,277	609

Table A- 2. Well-to-Wheel GHG Emission Factors for Urban Busesⁱⁱⁱ (HVIP)

	2016 Diesel	CNG	BEV	Fuel Cell
GHG (gCO ₂ e/mi)	2,640	2,254	648	1,203

Table A- 3. Well-to-Wheel GHG Emission Factors for School Busesⁱⁱⁱ (Rural School Bus Pilot Project)

	2016 Diesel	Renewable Diesel	BEV
GHG (gCO ₂ e/mi)	1,859	761	456

Table A- 4. Well-to-Wheel GHG Emission Factors for CNG Trucksⁱⁱⁱ (Low NOx Engine Incentives)

	2016 CNG Baseline	Optional Low NOx Standard CNG Engine Fueled with RNG
GHG (gCO ₂ e/mi)	1,363	315

Table A- 5. Well-to-Wheel GHG Emission Factors for 2016 Model Year Advanced Technology Light Heavy-Duty Vehiclesⁱⁱⁱ (Agricultural Worker Vanpools)

	2016 Gasoline	Conventional Hybrid
GHG (gCO ₂ e/mi)	1,060	848

Vehicle usage assumptions (annual VMT) were generated through a literature review for each of the vehicle technology types. Table A-6 summarizes the annual mileage assumptions, usage life, and average rebate amount used for GHG emission reductions analysis.

Table A- 6. Annual Usage Assumptions and Usage Life by Project Typeⁱⁱⁱ

Project	Vehicle Technology Type	Annual VMT Assumptions (miles per year)	Usage Life (Years)	Average Rebate Amount
HVIP	BEV	12,000	15	\$35,665
	Conventional Hybrid	22,000	15	
Rural School Bus Pilot	BEV/Renewable Fuels	13,500	15	\$237,500
Low NOx Engines	Optional Low NOx Standard, CNG Engines	25,000	3	\$18,000
Agricultural Worker Vanpools	Hybrid Light Heavy-Duty Passenger Vans	25,000	6	\$45,000

The proportion of each advanced vehicle technology type funded for each project type is based on historical project data, when available. Table A-7 shows the proportion of each advanced vehicle technology type funded by project type.

Table A- 7. Proportion of Advanced Vehicle Technology Types Fundedⁱⁱⁱ

Project	BEV	Conventional Hybrid	Battery-Electric Bus	Renewable Fuels	Optional Low NOx Standard CNG Engines
HVIP	81%	14%	5%	-	-
Rural School Bus Pilot	-	-	50%	50%	-
Low NOx Engines	-	-	-	-	100%
Agricultural Worker Vanpools	-	100%	-	-	-

Note: The Low NOx Engines Incentives only fund trucks certified to the optional low NOx standards that use renewable, low carbon fuels, such as RNG.

ⁱ California Air Resources Board. EMFAC2014 Web Database V1.0.7. <http://www.arb.ca.gov/emfac/2014/>

ⁱⁱ California Air Resources Board. Low Carbon Fuel Standard. December 28, 2016.
<http://www.arb.ca.gov/fuels/lcfs/lcfs.htm>

ⁱⁱⁱ California Air Resources Board. Proposed Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and The Air Quality Improvement Program. May 20, 2016.
https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_full.pdf