

California Air Resources Board

**Greenhouse Gas Quantification Methodology for
California Air Resources Board
Low Carbon Transportation Program
Clean Truck and Bus Vouchers**

**Greenhouse Gas Reduction Fund
Fiscal Year 2017-18**



**FINAL
December 1, 2017**

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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 (CARB) is responsible for providing the quantification methodology to estimate the GHG emission reductions and co-benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). CARB 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>.

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified.

For CARB's Low Carbon Transportation (LCT) Clean Truck and Bus Vouchers, CARB staff developed this Quantification Methodology to provide methods for estimating the GHG emission reductions and air pollutant emission co-benefits (Section B and C), provide instructions for documenting and supporting the estimates (Section D), and outline the process for tracking and reporting GHG and other benefits once a project is funded (Section E).

In an effort to enhance the analysis, provide greater transparency, and assist in project-level reporting, CARB also included guidance for calculating air pollutant emission estimates for select criteria and toxic air pollutants from HVIP and Low NO_x Engine Incentives. Air pollutant emission estimates are calculated using the same methodology as for GHG emissions estimates for the following criteria and toxic air pollutants: reactive organic gases (ROG), nitrogen oxide (NO_x), fine particulate matter less than 2.5 micrometers (PM_{2.5}), and diesel particulate matter (diesel PM). CARB continues to develop methodologies to assess additional social, economic, and environmental co-benefits achieved by CCI.

Project Types

LCT's Clean Truck and Bus Vouchers 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).

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 upfront 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 reduce fossil fuel consumption when used in place of conventional-fueled models. The project is implemented on a first-come, first-served, statewide basis.

Low NO_x Engine Incentives

Low NO_x Engine Incentives provide incentives for the purchase of heavy-duty vehicles with engines certified to the optional low NO_x standards and requires the use of low carbon, renewable fuel to maximize GHG benefits. These vehicles, operating on low carbon, renewable fuel provide GHG benefits because the eligible engines paired with renewable fuel emit less GHGs on a lifecycle basis compared to conventional-fueled models. The project is implemented through HVIP on a first-come, first-served, statewide basis.

Methodology Development

CARB developed this Quantification Methodology consistent with the guiding implementation principles of CCI, including ensuring transparency and accountability.ⁱ CARB developed this Quantification Methodology to be used to estimate the GHG emission reductions and co-benefits 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, and be accessible by all applicants;
- Use existing and proven methods;
- Use project-level data, where available and appropriate; and
- Result in estimates that are conservative and supported by empirical literature.

The emission reduction calculations detailed in this quantification methodology are based on the methods described in the Draft Fiscal Year (FY) 2017-18 Funding Plan for Clean Transportation Incentives, Appendix A - Emission Reductions: Quantification Methodology,ⁱⁱ which CARB developed through a public process. CARB will quantify and report GHG emission reduction estimates and air pollutant emission co-benefits using two approaches:

1. **Awarded Projects:** Estimates will be quantified using the methods described in Section B upon funding allocation. The Estimated Total Project GHG Emission Reductions will be based on the total number of rebates expected to be issued, estimated using the funding amount allocated to Clean Truck and Bus Vouchers.
2. **Implemented Projects:** Estimates will be quantified using the methods described in Section C as projects are implemented. The Estimated Total Project GHG Emission Reductions will be based on the actual number of rebates issued for Clean Truck and Bus Vouchers.

These estimates are calculated using equations listed in Section B and Section C, and CARB-developed emission factors. CARB has established a single repository for emission factors used in quantification methodologies, referred to as the CCI Quantification Methodology Emission Factor Database (Database).ⁱⁱⁱ The Database

Documentation explains how emission factors used in CARB quantification methodologies are developed and updated.

Updates

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the HVIP and Low NO_x Engine Incentives Quantification Methodology from the previous version^{iv} to enhance the analysis and provide additional clarity. The changes include:

- Separation of HVIP and Low NO_x Engine Incentives from other LCT consumer-based heavy-duty project types and renaming as “Clean Truck and Bus Vouchers”;
- Updates of GHG emission factors to reflect the model year of vehicles to be funded through Clean Truck and Bus Vouchers; and
- Addition of guidance and emission factors to estimate air pollutant emission co-benefits using the same methodology used to estimate GHG emissions.

Program Assistance

CARB staff will ensure that the quantification methods described in this document are properly applied to estimate the GHG emission reductions and co-benefits for Clean Truck and Bus Vouchers.

- Questions on this document should be sent to GGRFProgram@arb.ca.gov.
- For more information on CARB’s efforts to support implementation of GGRF investments, see: <https://www.arb.ca.gov/auctionproceeds>.
- Questions pertaining to Clean Truck and Bus Vouchers should be sent to:

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(916) 322-2383

Section B. Quantification Methodology for Awarded Funds

The quantification methodology in this section describes how CARB will estimate the GHG emission reductions and air pollutant emission co-benefits based on funds allocated to LCT Clean Truck and Bus Vouchers and assumptions for the proportion of funding that each advanced technology vehicle type is expected to receive.

HVIP Assumptions

CARB staff assume that the HVIP waitlist as of June 2017 represents the voucher demand expected for the 2017-18 fiscal year. Table 1 shows the proportion of funding for each advanced technology vehicle type funded through HVIP and the annual usage assumptions and incentive amounts for each technology type.

Table 1: HVIP Assumptions

Vehicle Class	Technology Type	Proportion of Funding	Annual Usage (miles/year)	Incentive Amount
Medium Heavy-Duty (MHD)	Conventional Hybrid	50%	20,000	\$20,000
	Battery-Electric	5%	12,000	\$90,000
Heavy Heavy-Duty (HHD)	Battery-Electric	5%	12,000	\$150,000
Urban Bus	Battery-Electric	20%	30,000	\$143,750
School Bus	Battery-Electric	20%	12,000	\$225,000

Note: For the urban bus classification, the incentive amount listed in Table 1 is an average based on the voucher amounts for single-decker, double-decker, and 30'-39' buses.

For HVIP, CARB staff generated annual usage assumptions for MHD conventional hybrid vehicles based on the average use of a conventional MHD diesel vehicle in EMFAC 2014. For urban buses, CARB staff used data from previous HVIP voucher recipients to determine annual usage and for all other battery-electric vehicle classifications, the annual usage assumption was based on the California Hybrid, Efficient and Advanced Truck (CalHEAT) Research Center's report on "Battery Electric Parcel Delivery Truck Testing and Demonstration."^v

The baseline vehicle used in calculations is a new 2017 model year, conventional diesel truck or bus. For urban buses, an average of diesel and CNG urban bus emission rates are used since the current California fleet utilizes a mix of the two fuel types. The quantification period for HVIP is 15 years.

Low NO_x Engine Incentive Assumptions

Optional low NO_x standards provide manufacturers the ability to certify engines to NO_x 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 NO_x engines are natural gas engines certified to 90 percent lower than the heavy-duty emission standard. In order to maximize the GHG emission reduction benefits from low NO_x engines, it is required that 100 percent renewable fuel is used for the first 3 years for a vehicle funded through CCI. Table 2 shows the proportion of funding for each advanced technology vehicle type funded through Low NO_x Engine Incentives and the annual usage assumptions and incentive amounts for each technology type.

Table 2: Low-NO_x Engine Incentives Assumptions

Vehicle Class	Baseline Vehicle	Proportion of Funding*	Annual Usage (miles/year)	Incentive Amount
MHD	CNG	6%	20,000	\$10,000
HHD	CNG	34%	25,000	\$10,000
HHD	Diesel	8%	58,000	\$40,000
Urban Bus	CNG	52%	47,000	\$10,000

Note: Air Quality Improvement Program (AQIP) funding is also available for Low NO_x Engine Incentives, which impacts the project's overall proportion of funding across vehicle classes.

For Low NO_x Engine Incentives, staff generated annual usage assumptions based on the average use of a conventional diesel vehicle in EMFAC 2014 for the corresponding vehicle class. The quantification period for Low NO_x Engine Incentives is 3 years for GHG benefits, as that is the amount of time the vehicle is required to be fueled with renewable fuel, and 15 years for co-benefits, the useful life of the vehicle.

Emission factors used in calculations are contained in the Database available at: www.arb.ca.gov/cci-quantification. Documentation on the sources and methods used to develop the emission factors is also provided.

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

The annual emission reductions are calculated for each advanced technology vehicle type (e.g., MHD conventional hybrids, HHD battery-electric trucks, battery-electric school buses, etc.) funded by each project type (e.g., HVIP, Low-NO_x Engine Incentives) separately using the emission factors from the Database, annual vehicle miles traveled (VMT) assumptions (see “Annual Usage” in Table 1 or Table 2), and Equation 1.

$$ER_{AV} = (EF_B - EF_{AV}) * (VMT) \quad (\text{Eq. 1})$$

Where,

- ER_{AV} is the annual emission reductions from the use of one advanced technology vehicle in place of one conventional vehicle (metric tons (MT)/(year*vehicle) or pounds (lbs)/(year*vehicle));
- EF_B is the emission factor for the baseline vehicle (grams (g)/mile);
- EF_{AV} is the emission factor for the advanced technology vehicle type (g/mile); and
- VMT is the annual VMT for the vehicle (miles/(year*vehicle)).

Step 2. Calculate the Estimated Weighted Average Annual Emission Reductions

The weighted average annual emission reduction is calculated for each project type separately (e.g., HVIP or Low NO_x Engine Incentives) using the assumed proportion of funding that each advanced technology vehicle type expected to receive 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 emission reductions from the use of one advanced technology vehicle in place of one conventional vehicle (MT/(year*vehicle) or lbs/(year*vehicle));
- P_{AV,i} is the assumed proportion of the advanced vehicle technology type (percent); and
- ER_{AV,i} is the result from step 1 (MT/(year*vehicle) or lbs/(year*vehicle)).

Step 3. Calculate the Estimated Number of Vehicles Funded

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

$$N = \frac{\text{Project Allocation Amount (\$)} * (1 - A)}{\text{Weighted Average Project Rebate Amount (\$)}} \quad (\text{Eq. 3})$$

Where,

N is the estimated number of vehicles funded; and
 A is the adjustment factor used to account for the direct project implementation costs (percent), 7 percent.

Step 4. Calculate the Estimated Total Project Emission Reductions

The estimated total emission reductions is calculated for each project type separately (e.g., HVIP or Low NO_x Engine Incentives) using the weighted annual emission reductions calculated in Step 2 and Equation 4.

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

Where,

ER_{UL} is the total project emission reduction (MT or lbs);
 ER_{WtAvg} is the result from Step 2;
 N is the result from Step 3; and
 QP is the quantification period for a vehicle (years).

Section C. Quantification Methodology for Implemented Projects

The quantification methodology in this section describes how CARB will refine the emission reduction estimates from Section B as the grant administrator reports project-specific numbers for incentives issued.

The VMT assumption used in calculations in this section for each vehicle type are the same as the VMT assumptions listed in Section B.

Emission factors used in calculations are contained in the Database available at: www.arb.ca.gov/cci-quantification. Documentation on the sources and methods used to develop the emission factors is also provided.

Step 1. Calculate the Total Emission Estimate for each Advanced Technology Vehicle

The total emission estimate is calculated for each advanced technology vehicle receiving an incentive through Clean Truck and Bus Vouchers), using the emission factors from the Database, annual VMT assumptions included above, and Equation 5.

$$ER_{AV} = (EF_B - EF_{AV}) * (VMT) * QP \quad (\text{Eq. 5})$$

Where,

ER_{AV}	is the total emission reductions from an advanced technology vehicle (MT or lbs);
EF_B	is the emission factor for the baseline 2017 conventional vehicle (g/mile);
EF_{AV}	is the emission factor for the advanced technology vehicle (g/mile);
VMT	is the annual VMT for the vehicle (miles/year);and
QP	is the quantification period for a vehicle (years).

Section D. Documentation

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

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

Supporting Documentation

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

Documentation collected with issuance of incentives includes:

- Advanced vehicle technology type;
- Census tract of the incentive recipient; and
- Emission reduction estimates.

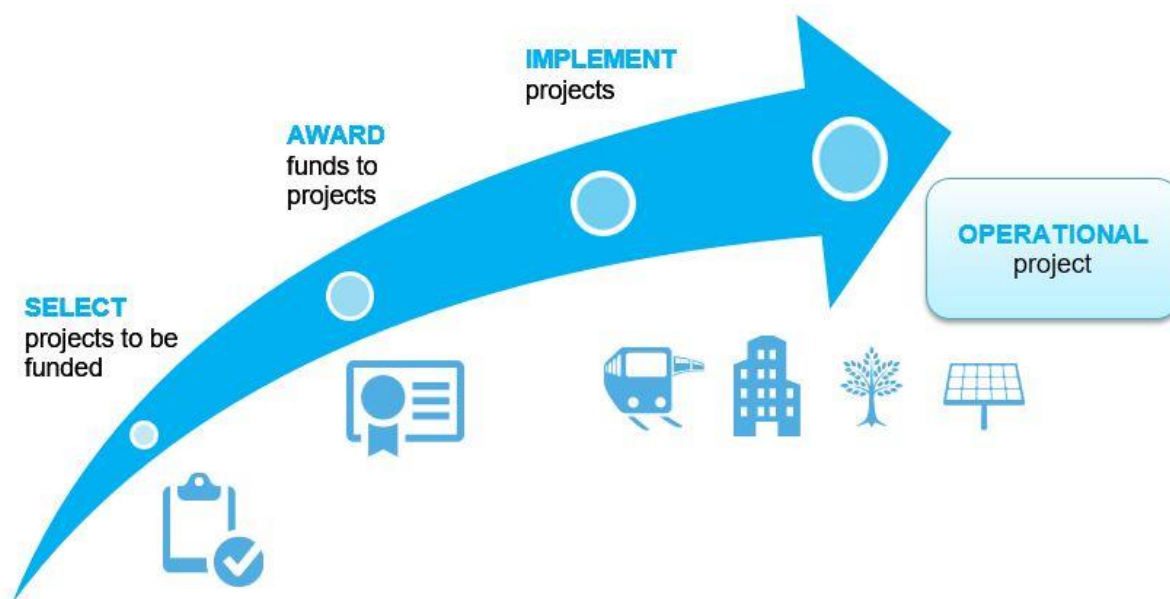
Up-to-date data on implemented project rebates is available at:

<https://www.californiahvip.org/tools-results/>

Section E. Reporting after Funding Award

Accountability and transparency are essential elements for all CCI. All administering agencies are required to track project implementation and report on the benefits of those investments. CARB develops tracking and reporting guidance for CCI. The reporting process and requirements are found in Volume 3 of the draft Funding Guidelines.¹ Draft Funding Guidelines Appendices 3.A and 3.B contain detailed reporting requirements that are specific to each project type or administering agency and cover all stages of reporting.

The specific data that need to be reported depend on the project type and the stage of project implementation at the time of reporting. Initially, administering agencies must report basic project information and expected benefits. As projects are implemented, administering agencies provide additional information on project status, benefits, and results. When projects are completed, administering agencies submit project closeout reports. A subset of projects, selected by CARB, will report on project outcomes upon reaching a specified milestone and being considered “operational.”



CARB is required to collect and compile project data from funding recipients, including the GHG emission reductions estimated using this Quantification Methodology, co-benefits, and information on benefits to AB 1550² Populations. Reported information will be used to demonstrate how the Administration is achieving or exceeding the

¹ CARB released updated draft Funding Guidelines in August 2017. These draft Funding Guidelines are subject to change based on public input and Board direction. While the draft provides an indication of what is currently required, administering agencies must incorporate all provisions reflected in the draft Funding Guidelines and subsequent Board approved Funding Guidelines.

² AB 1550, Gomez, Chapter 369, Statutes of 2016; amending Health and Safety Code Section 39713. Detailed information on AB 1550 requirements is provided in Volume 2 of the draft Funding Guidelines.

statutory objectives for CCI. Funding recipients have the obligation to provide, or provide access to, data and information on project outcomes to CARB. Applicants should familiarize themselves with the requirements within the HVIP and Low NO_x Engine Incentives Program Guidelines and grant agreement, as well as the CARB Funding Guidelines.

ⁱ California Air Resources Board (2017). Available at:

www.arb.ca.gov/cci-fundingguidelines

ⁱⁱ California Air Resources Board (2017). Discussion Draft Funding Plan. Available at:

https://www.arb.ca.gov/msprog/aqip/fundplan/1718_draft_funding_plan_workshop_100417.pdf

ⁱⁱⁱ California Air Resources Board (2017). California Climate Investments Quantification Methodology Emission Factor Database. Available at: www.arb.ca.gov/cci-quantification.

^{iv} California Air Resources Board Low Carbon Transportation Program Consumer-Based Heavy-Duty Projects Quantification Methodology for Fiscal Year 2016-2017. January 10, 2016. Available at:

https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb_cbhd_finalqm_16-17.pdf

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

Appendix A. Example Project

Introduction

The following is a hypothetical project³ to demonstrate how the FY 2017-18 Clean Truck and Bus Vouchers Quantification Methodology would be applied. This hypothetical project does not provide examples of the supporting documentation that is required of actual project applicants.

Overview of the Proposed Project

In the awarded phase, CARB plans to allocate \$161,000,000 for incentives through HVIP. Once the project is implemented, reporting is done on a per vehicle funded basis. Calculations will be for a conventional hybrid MHD vehicle.

Example Calculations using Method in Section B

Emission factors used in example calculations were taken from the Database available at: www.arb.ca.gov/cci-quantification.

GHG Calculations

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

$$ER_{AV} = (EF_B - EF_{AV}) * (VMT)$$

$$\begin{aligned} ER_{CH_MHD} &= \left(1,540 \frac{gCO_2e}{mile} - 1,232 \frac{gCO_2e}{mile} \right) * \left(20,000 \frac{miles}{year * vehicle} \right) \\ &= 6.16 \frac{MT CO_2e}{year * vehicle} \end{aligned}$$

$$\begin{aligned} ER_{BE_MHD} &= \left(1,540 \frac{gCO_2e}{mile} - 289 \frac{gCO_2e}{mile} \right) * \left(12,000 \frac{miles}{year * vehicle} \right) \\ &= 15.01 \frac{MT CO_2e}{year * vehicle} \end{aligned}$$

$$\begin{aligned} ER_{HHD} &= \left(2,223 \frac{gCO_2e}{mile} - 417 \frac{gCO_2e}{mile} \right) * \left(12,000 \frac{miles}{year * vehicle} \right) \\ &= 21.67 \frac{MT CO_2e}{year * vehicle} \end{aligned}$$

³ The hypothetical project has not undergone verification of any LCT Program requirements; all assumptions about location type and features are for quantification methodology demonstration purposes only.

$$ER_{UBUS} = \left(2,309 \frac{gCO_2e}{mile} - 476 \frac{gCO_2e}{mile} \right) * \left(30,000 \frac{miles}{year * vehicle} \right)$$

$$= 54.99 \frac{MT CO_2e}{year * vehicle}$$

$$ER_{SBUS} = \left(1,786 \frac{gCO_2e}{mile} - 335 \frac{gCO_2e}{mile} \right) * \left(12,000 \frac{miles}{year * vehicle} \right)$$

$$= 17.41 \frac{MT CO_2e}{year * vehicle}$$

Step 2. Calculate the Weighted Average Annual Emission Estimates

$$ER_{WtAvg} = \sum_{i=1}^n P_{AV,i} * ER_{AV,i}$$

$$ER_{WtAvg} = \left(0.50 * 6.16 \frac{MT CO_2e}{year * vehicle} \right) + \left(0.05 * 15.01 \frac{MT CO_2e}{year * vehicle} \right)$$

$$+ \left(0.05 * 21.67 \frac{MT CO_2e}{year * vehicle} \right) + \left(0.20 * 54.99 \frac{MT CO_2e}{year * vehicle} \right)$$

$$+ \left(0.20 * 17.41 \frac{MT CO_2e}{year * vehicle} \right) = 19.39 \frac{MT CO_2e}{year * vehicle}$$

Step 3. Calculate the Estimated Number of Vehicles Funded

$$N = \frac{Project\ Allocation\ Amount\ (\$) * (1 - A)}{Weighted\ Average\ Project\ Rebate\ Amount\ (\$)}$$

$$N = \frac{\$161,000,000 * (1 - 0.07)}{\$95,750} = 1,564\ vehicles$$

Step 4. Calculate the Estimated Total Project Emission Reductions

$$ER_{UL} = ER_{WtAvg} * N * QP$$

$$ER_{UL} = 19.39 \frac{MT CO_2e}{year * vehicle} * 1,564\ vehicles * 15\ years = 454,889\ MT\ CO_2e$$

The same calculations are done for ROG, NO_x, PM_{2.5}, and diesel PM using the corresponding emission factors from the Database and the quantification period.

Example Calculations using Method in Section C

Emission factors used in example calculations were taken from the Database available at: www.arb.ca.gov/cci-quantification.

GHG Calculations

Step 1. Calculate the Total Emission Estimates for each Advanced Technology Vehicle

$$ER_{AV} = (EF_B - EF_{AV}) * (VMT) * QP$$

$$\begin{aligned} ER_{CH_MHD} &= \left(1,540 \frac{gCO_2e}{mile} - 1,232 \frac{gCO_2e}{mile} \right) * \left(20,000 \frac{miles}{year} \right) * 15 \text{ years} \\ &= 92.40 \text{ MT } CO_2e \end{aligned}$$

The same calculation is done for ROG, NO_x, PM_{2.5}, and diesel PM using the corresponding emission factors from the Database and the quantification period.