California Air Resources Board

Greenhouse Gas Quantification Methodology for

California Air Resources Board

Low Carbon Transportation Program

Clean Vehicle Rebate Project

Greenhouse Gas Reduction Fund
Fiscal Year 2017-18

FINAL
December 1, 2017

Table of Contents

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 the CARB Low Carbon Transportation (LCT) Clean Vehicle Rebate Project (CVRP), 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).

CVRP provides vehicle rebates on a first-come, first-served basis to California residents, businesses, non-profit organizations and government entities that purchase or lease plug-in hybrid vehicles (PHEV), battery-electric vehicles (BEV), fuel cell vehicles (FCV), or zero-emission motorcycles to achieve GHG emission reductions.

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 CVRP. 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), and fine particulate matter less than 2.5 micrometers ($PM_{2.5}$). CARB continues to develop methodologies to assess additional social, economic, and environmental co-benefits achieved by CCI.

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 projects 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.

This methodology uses calculations to estimate the emission reductions of the technology conversion from a current model-year baseline vehicle to a PHEV, BEV, FCV, or zero-emission motorcycle. 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 CVRP.
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 CVRP.

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 CVRP Quantification Methodology from the previous version[iv] to enhance the analysis and provide additional clarity. The changes include:

- Separation of CVRP from other LCT consumer-based light-duty project types;
- Updates of GHG emission factors to reflect the model year of vehicles to be purchased or leased through CVRP and the baseline conventional vehicle;
- Addition of guidance and emission factors to estimate air pollutant emission co-benefits using the same methodology used to estimate GHG emissions; and
- Additional language on reporting after funding.

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 the CVRP.

- 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 CVRP should be sent to:
    Sara Dastoum
    Sara.Dastoum@arb.ca.gov
    (916) 323-1696

Section B. Quantification Methodology for Awarded Projects

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 CVRP. Annual emission reductions are calculated based on the anticipated proportion of each advanced technology vehicles purchased or leased, which is based on data from November 2016 through May 2017. Table 1 shows the proportion of funding for each advanced technology vehicle type and the anticipated incentive amounts for both standard rebates and rebates for low-income applicants.

Table 1: CVRP Assumptions

Rebate Type	Technology Type	Proportion of Funding	Annual Usage[v] (miles/year)	Average Incentive Amount
Standard	PHEV	45%	14,855	$2,250
Standard	BEV	55%	11,059	
Low-Income	PHEV	60%	14,855	$3,900
Low-Income	BEV	40%	11,059	

Note: FCVs accounted for less than 4 percent of rebates during this period, and therefore are not included in the emission estimates for awarded funds.[ii] Similarly, zero-emission motorcycles account for a small percent of rebates and are not included in the emission estimates for awarded projects.

CVRP has a 30 month (2.5 year) ownership requirement, therefore, this will be used as the quantification period of the vehicle in calculating emission estimates.

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., PHEV, BEV) using the emission factors from the Database, annual vehicle miles traveled (VMT) assumptions included above, and Equation 1.

$$ER_{AV} = (EF_B - EF_{AV}) * (VMT) \hspace{3cm} (Eq. 1)$$

Where,

ER_{AV} is the annual emission reductions from the use of one advanced technology vehicle in place of one conventional gasoline vehicle (metric tons (MT)/(year*vehicle) or pounds (lbs)/(year*vehicle));

EF_B is the emission factor for the baseline 2017 conventional gasoline 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 Weighted Average Annual Emission Estimates

The weighted average annual emission reduction is calculated using the proportion of funding that each advanced technology vehicle type received historically and Equation 2.

$$ER_{WtAvg} = (P_{PHEV} * ER_{PHEV}) + (P_{BEV} * ER_{BEV}) \hspace{2cm} (Eq. 2)$$

Where,

ER_{WtAvg} is the weighted average annual emission reductions from the use of one advanced technology vehicle in place of one conventional gasoline vehicle (MT/(year*vehicle) or lbs/(year*vehicle));

P_{PHEV} is the historical proportion of the PHEVs purchased or leased (percent);

ER_{PHEV} is the result from Step 1 for PHEVs (MT/(year*vehicle) or lbs/(year*vehicle));

P_{BEV} is the historical proportion of the BEVs purchased or leased (percent); and

ER_{BEV} is the result from Step 1 for BEVs (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.

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

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 using the weighted annual emission reductions calculated in Step 2 and Equation 4.

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

Where,

ER_{PL}	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 funded through CVRP, which is the vehicle ownership requirement (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 rebates issued.

CARB generated vehicle usage assumptions for CVRP through literature review for each of the vehicle types evaluated. The annual usage assumptions are 14,855 miles per year for PHEVs and FCVs and 11,059 miles per year for BEVs.**Error! Bookmark n ot defined.** The annual usage assumption for zero-emission motorcycles is 4,476 miles per year.[vi]

CVRP has a 30 month (2.5 year) ownership requirement, therefore, this will be used as the quantification period of the vehicle in calculating emission estimates

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 Estimates for each Advanced Technology Vehicle Type

The total emission reductions is calculated for each advanced technology vehicle type (e.g., PHEV, BEV, FCV, zero-emission motorcycle) using the emission factors from the Database, annual VMT assumptions included above, the number of rebates issued for each advanced technology vehicle type, and Equation 5.

$$\text{ER}_{AV} = (EF_B - EF_{AV}) * (\text{VMT}) * R_{AV} * \text{QP} \qquad (Eq.\,5)$$

Where,
  ER_{AV} is the total emission reductions from an advanced technology vehicle type (MT or lbs);
  EF_B is the emission factor for the baseline 2017 conventional gasoline 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*vehicle));
  R_{AV} is the number of vehicle rebates given out for the advanced technology vehicle type; and
  QP is the quantification period for a vehicle funded through CVRP, which is the vehicle ownership requirement (years).

Step 2. Calculate the Total Project Emission Reductions

The total project emission reductions is calculated by summing the emission reductions from each advanced technology vehicle type (e.g., PHEV, BEV, FCV, zero-emission motorcycle) funded by the project using Equation 6.

$$ER_{PL} = \sum ER_{AV} \qquad\qquad \text{(Eq. 6)}$$

Where,

ER_{PL} is the total project emission reductions (MT or lbs).

Section D. Documentation

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

$$\frac{Total\ Project\ GHG\ Emission\ Reductions\ (MTCO_2e)}{Total\ GGRF\ Funds\ (\$)} \qquad (Eq.7)$$

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 rebates includes:
- Rebate type (standard or low-income);
- Advanced vehicle technology type; and
- Census tract of the rebate recipient.

Up-to-date data on implemented project rebates is available at:
https://cleanvehiclerebate.org/eng/rebate-statistics

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."
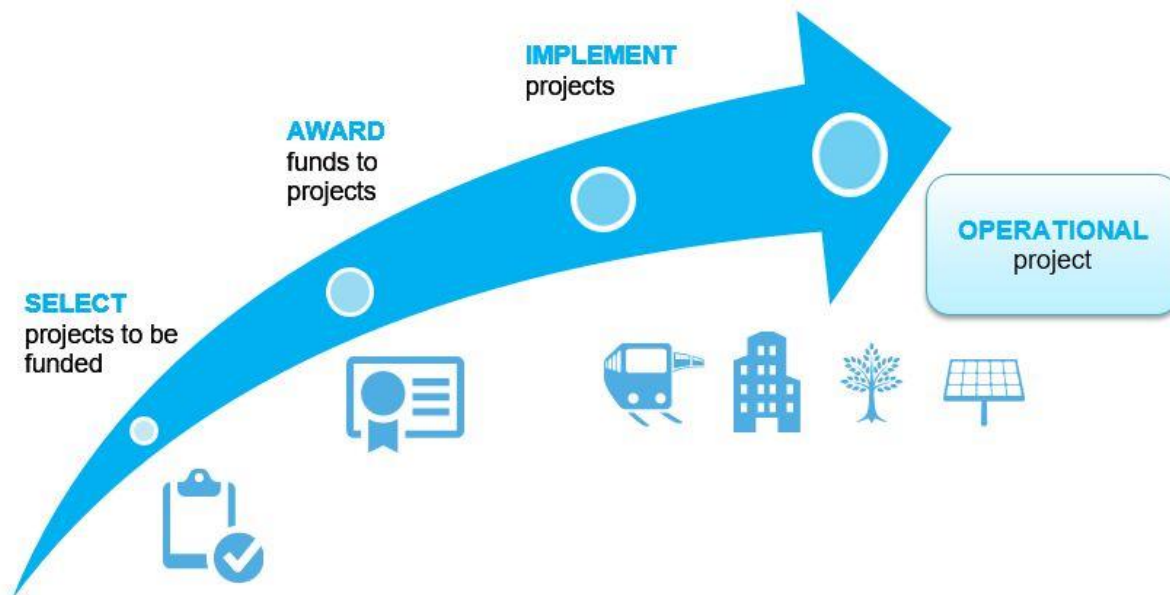
CARB is required to collect and compile project data from funding recipients, including the GHG emission reductions estimated using this Quantification Methodology, co-benefits, and information on benefits to AB 1550[2] Populations. Reported information will be used to demonstrate how the Administration 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 CVRP 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 Light-Duty Projects Quantification Methodology for Fiscal Year 2016-2017. December 16, 2016. Available at: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb_cbld_finalqm_16-17.pdf

[v] Based on 40.7 miles per day for PHEV and 30.3 miles per day for BEV. FCVs are assumed to be used at the same rate as PHEVs. Smart, J. and Schaey, S. "Battery Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project." SAE Int. J. Alt. Power. 1(1):23-33, 2012, doi: 10.4271/2012-01-0199. (http://papers.sae.org/2012-01-0199/)

[vi] California Air Resources Board. Emission Factor (EMFAC 2014) Web Database. Available at: https://www.arb.ca.gov/emfac/2014/

Appendix A. Example Project

Introduction

The following is a hypothetical project[3] to demonstrate how the FY 2017-18 CVRP 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 $140,000,000 for standard rebates through CVRP. Once the project was implemented, standard rebates for 21,584 PHEVs, 33,968 BEVs, 2,198 FCEVs, and 174 battery-electric motorcycles were issued.

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.

<u>GHG Calculations</u>

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

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

$$ER_{PHEV} = \left(360 \frac{gCO_2e}{mile} - 218 \frac{gCO_2e}{mile}\right) * \left(14{,}855 \frac{miles}{year * vehicle}\right) * \left(\frac{1\ MT}{1{,}000{,}000\ g}\right)$$
$$= 2.11 \frac{MT\ CO_2e}{year * vehicle}$$

$$ER_{BEV} = \left(360 \frac{gCO_2e}{mile} - 113 \frac{gCO_2e}{mile}\right) * \left(11{,}059 \frac{miles}{year * vehicle}\right) * \left(\frac{1\ MT}{1{,}000{,}000\ g}\right)$$
$$= 2.73 \frac{MT\ CO_2e}{year * vehicle}$$

---

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

Step 2. Calculate the Weighted Average Annual Emission Estimates

$$ER_{WtAvg} = (P_{PHEV} * ER_{PHEV}) + (P_{BEV} * ER_{BEV})$$

$$ER_{WtAvg} = \left(0.45 * 2.11 \frac{MT\ CO_2e}{year * vehicle}\right) + \left(0.55 * 2.73 \frac{MT\ CO_2e}{year * vehicle}\right)$$
$$= 2.45 \frac{MT\ CO_2e}{year * vehicle}$$

Step 3. Calculate the Estimated Number of Vehicles Funded

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

$$N = \frac{\$140,000,000 * (1 - 0.07)}{\$2,250} = 57,867\ vehicles$$

Step 4. Calculate the Estimated Total Project Emission Reductions

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

$$ER_{UL} = 2.45 \frac{MT\ CO_2e}{year * vehicle} * 57,867\ vehicles * 2.5\ years = 354,435\ MT\ CO_2e$$

The same calculations are done for ROG, NOₓ, and PM2.5 using the corresponding emission factors from the Database.

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 Type

$$\text{ER}_{AV} = (EF_B - EF_{AV}) * (\text{VMT}) * R_{AV} * \text{QP}$$

$$\text{ER}_{PHEV} = \left(360\frac{gCO_2e}{mile} - 218\frac{gCO_2e}{mile}\right) * \left(14,855\frac{miles}{year * vehicle}\right) * 21,584\ vehicles$$
$$* 2.5\ years * \left(\frac{1\ MT}{1,000,000\ g}\right) = 113,824\ \text{MT}\ CO_2e$$

$$\text{ER}_{BEV} = \left(360\frac{gCO_2e}{mile} - 113\frac{gCO_2e}{mile}\right) * \left(11,059\frac{miles}{year * vehicle}\right) * 33,968\ vehicles$$
$$* 2.5\ years * \left(\frac{1\ MT}{1,000,000\ g}\right) = 231,965\ \text{MT}\ CO_2e$$

$$\text{ER}_{FCV} = \left(360\frac{gCO_2e}{mile} - 129\frac{gCO_2e}{mile}\right) * \left(14,855\frac{miles}{year * vehicle}\right) * 2,198\ vehicles$$
$$* 2.5\ years * \left(\frac{1\ MT}{1,000,000\ g}\right) = 18,856\ \text{MT}\ CO_2e$$

$$\text{ER}_{BE\ Motorcycle} = \left(303\frac{gCO_2e}{mile} - 95\frac{gCO_2e}{mile}\right) * \left(4,476\frac{miles}{year * vehicle}\right)$$
$$* 174\ vehicles * 2.5\ years * \left(\frac{1\ MT}{1,000,000\ g}\right) = 405\ \text{MT}\ CO_2e$$

Step 2. Calculate the Total Project Emission Reductions

$$ER_{PL} = \sum ER_{AV}$$

$$ER_{PL} = 113,824\ \text{MT}\ CO_2e + 231,965\ \text{MT}\ CO_2e + 18,856\ \text{MT}\ CO_2e + 405\ \text{MT}\ CO_2e$$
$$= 365,050\ \text{MT}\ CO_2e$$

The same calculations are done for ROG, NOx, and PM2.5 using the corresponding emission factors from the Database.