California Air Resources Board

**Greenhouse Gas Quantification Methodology for the
California State Transportation Agency
Transit and Intercity Rail Capital Program**

Greenhouse Gas Reduction Fund

February 9, 2015

A.   Introduction

The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate greenhouse gas (GHG) emission reductions from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). For the California State Transportation Agency's (CalSTA) Transit and Intercity Rail Capital Program (TIRCP), ARB staff developed the GHG emission reduction quantification methodology to be used by grant applicants to estimate proposed project GHG emission reductions for the first solicitation of TIRCP.

Project applicants will use available project-level data to the extent possible for estimated ridership increases and corresponding vehicle miles traveled (VMT) changes. This methodology relies on applicant provided data, specific components of the "Methods to Find the Cost-Effectiveness of Funding Air Quality Projects for Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement Projects" (CMAQ Methods), on-road vehicle GHG emission factors from the ARB Mobile-Source Emission Factor model (EMFAC2011), as well as ARB developed calculations and emission factors to estimate the GHG emission reductions from proposed TIRCP projects.

Methodology Development

For the first solicitation of the program, ARB and CalSTA staff followed a set of principles to guide the development of the quantification methodology. These principles ensure that the methodology for TIRCP projects would:

- Apply at the project-level
- Align with the project types proposed for funding with TIRCP
- Provide uniform methodologies that can be applied statewide, and be accessible by all applicants
- Use existing and proven tools or methodologies
- Use project-level data when available for estimated ridership increases and corresponding vehicle miles traveled (VMT) reductions

TIRCP Project Types

TIRCP will fund capital improvements and operational investments that will modernize California's transit systems and intercity, commuter, and urban rail systems to reduce GHG emissions; improve/expand service and increase ridership; integrate existing bus and rail operations with each other and with high-speed rail; and improve safety.   For GHG quantification purposes, eligible TIRCP projects fall into the three activity types described in Table 1 below. Some projects may include more than one activity, such as those that provide operational improvements that reduce travel time (generating ridership gains) and also deploy new, lower-emitting vehicles that replace current vehicles.

Table 1: Description of TIRCP GHG Reduction Activities

GHG Reduction Activity	Description
New Service (Bus/Train)	Expansion of bus or train service through new service or additional routes.
Cleaner Vehicles/Technology/Fuels (Bus/Train)	Use of cleaner vehicles, technologies, or fuels that result in GHG emission reductions.
System and Efficiency Improvements that Result in Increased Ridership (Bus/Train)	Any system or efficiency improvements that result in increased ridership for existing routes, including projects that increase service levels, reliability, or decrease travel times.

GHG Emission Reductions

This methodology estimates the GHG emission reductions of a proposed TIRCP project. Applicants will estimate the total GHG emission[1] reductions from the proposed project over the project life, as defined in the methodology.

For TIRCP Program application evaluation purposes, the applicant will report results as:

$$\textit{Metric tons (MT) of CO2 over the project life}$$

$$\textit{GGRF Funds Requested ($)}$$

The following sections describe the calculations needed to estimate the GHG emission reductions for proposed projects under the first solicitation of the TIRCP Program.

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[1] This methodology results in estimated CO_2 reductions only. For the purposes of this quantification methodology and the TIRCP application, the applicant will report CO_2 reductions as GHG reductions.

B.   Quantification Methodology

In consultation with CalSTA, quantification methods are provided for the three activity types described in Table 1.   The following is a summary of the three steps TIRCP applicants will follow to estimate the GHG emission reductions for a proposed project. Detailed instructions for each step are provided on subsequent pages.

Step 1[2]   Calculate trip and VMT reductions, if not available from existing project analyses: The applicant will calculate expected auto and/or bus trip and VMT reductions or use project specific trip or VMT reduction data.

Step 2   Calculate annual GHG emission reductions: The applicant will use the trip data and VMT determined in Step 1, in conjunction with specified CO_2 emission factors from EMFAC 2011 to calculate the initial year and final year GHG emission reductions.[3] Detailed instructions for obtaining the EMFAC 2011 emission factors needed to estimate the GHG emissions are included.

Note: Steps 1 and 2 will each need to be done twice to calculate both the first operational year (Yr1) and the final operational year (YrF) emission reductions of the project. This will require trip and VMT reductions for both the first operational year and the final operational year.

Step 3   Calculate the GHG reductions over the project life: The applicant will calculate the GHG reductions over the project life using results from Steps 1 and 2.

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[2] Step 1 applies only to New Service and System/Efficiency Improvement projects with car displacement.
[3] When using a new vehicle type not contained in EMFAC2011, document the emissions factor recommended for use and submit to the TIRCP program email account for CARB and CalSTA review. See contact instructions at the end of this document.

Step 1: Calculate trip and VMT reductions

AutoTrips = *Annual Auto Trips Reduced* (*in trips per year*) =

$$[(D) * (R) * (A)] * [1 - (AA)]$$

or

Annual auto trip reduction value determined by applicant's method[4]

AutoVMT = *Annual Auto VMT Reduced* (*in miles per year*) =

$$[(D) * (R) * (A)] * [(L) - (AA) * (LL)]$$

or

Annual auto VMT reduction value determined by applicant's method[4]

Where:
D =   Days of operation per year
R =   Average daily ridership.
           Use: expected average daily increased ridership based on project data.
A =   Adjustment factor to account for transit dependency
           Use: documented project specific data or system average developed from a
           recent, statistically valid survey.
L =   Length (miles) of average auto trip reduced.
           Use: value based on specific project or system average reported to the National
           Transit Database.
AA =   Adjustment factor to account for auto trips used to access transit service.
           Use value based on project specific data or system average developed from a
           recent, statistically valid survey.
LL =   Length (miles) of average trip for auto access to transit.
           Use: value based on specific project data.

Note: Applicant must provide detailed supporting documentation for calculations and variables used in Step 1. ARB has developed recommended default values[5] for certain service types that may be used if project specific data does not exist, which include:
A =   Adjustment factor to account for transit dependency
           Use: 0.5 for local bus service or 0.83 for long distance commuter service
AA =   Adjustment factor to account for auto trips used to access transit service.
           Use: 0.1 for local bus service or 0.8 for long distance commuter service
LL =   Length of average trip for auto access to transit.
           Use: 2 miles for local bus or 5 miles for long distance commuter service.

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[4] Applicant specified methods are subject to CalSTA and ARB approval. The applicant must provide supporting documenting demonstrating how the auto trip and VMT reduction values were derived.
[5] "Methods to Find the Cost-Effectiveness of Funding Air Quality Projects for Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement Projects"

Step 2: Calculate GHG emission reductions

Table 2 below lists the specific calculations applicants will use to estimate the GHG emission reductions based on their project type.

Table 2: TIRCP Project GHG Emission Reduction Calculations

Activity		GHG Emission Reduction Calculations (in MTCO$_2$ / year)
New Service	Bus	GHGs of Displaced Autos – GHGs of New Bus
	Train	[GHGs of Displaced Autos + GHGs of Displaced Buses] – GHGs of New Train
Cleaner Vehicles/ Technology/ Fuels	Bus	GHGs of Old Bus – GHGs of New Bus
	Train	GHGs of Old Train – GHGs of New Train
System and Efficiency Improvements (that result in increased ridership)	Bus	GHGs of Displaced Autos
	Train	GHGs of Displaced Autos + GHGs Displaced Bus

Where:

GHGs of Displaced Autos

$$= \frac{[(AutoTrips) * (ATSEF) + (AutoVMT) * (AREF)]}{1,000,000}$$

GHG Bus (Displaced, New, or Old)

$$= \frac{[(BusVMT) * (BREF)]}{1,000,000}$$

GHG Train (New or Old)

$$= \frac{[(TrainVMT) * (TREF)]}{1,000,000}$$

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Where:
AutoTrips   = Annual Auto Trips Reduced from Step 1
AutoVMT   = Annual Auto VMT Reduced value from Step 1
Bus VMT   = Annual Bus VMT based on project data
TrainVMT   = Annual Train VMT based on project data
ATSEF   = Auto Trip Start Emission Factor in grams/trip from EMFAC2011
AREF   = Auto Running Emission Factor in grams/mile from EMFAC2011
BREF   = Bus Running Emission Factor in grams/mile from EMFAC2011, specific to old or new engine
TREF (Diesel)= 19,600 grams CO_2/mile[6]

Note: The current methodology calculates only tailpipe emissions. For projects that incorporate zero emission technologies or zero emission miles (i.e. electric train), the new technology emission factor is 0 grams CO_2/mile.

Reminder: each GHG emission reduction calculation will need to be done two times to calculate both the first year (Yr1) and the final year (YrF) emission reductions of the project. Yr1 is the first operational year of the project and YrF is the final operational year of the project, as determined by the Project Life[7] in Step Three. Once the Yr1 and YrF GHG reductions have been calculated, the Total GHG Reductions over the Project Life can be calculated according to Step Three.

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[6] This train emission factor (TREF) represents the average CO_2 emission rate of 124 diesel powered passenger trains in California over the course of a full year (2010) incorporating total fuel usage and miles traveled based on best available data.
[7] Project Life, or PL, is the reported lifetime of the equipment, the useful lifetime of the equipment, 20 years, or 2035, whichever comes first.

EMFAC2011 Emission Factors

CO_2 emission factors must be obtained from EMFAC2011. ARB provides a web-based EMFAC2011 tool (available at http://www.arb.ca.gov/emfac/) to determine vehicle emission factors based on region, calendar year, season, vehicle category, model year, speed, and fuel. The tool provides specified emission factor data in a comma separated values (CSV) output file that can be opened in most spreadsheet software.

Complete the following steps for both calendar years: Yr1 and YrF[8].

Step 2a. Generate the Output File

Figure 1. EMFAC Emissions Database

On the EMFAC Emissions Database screen, select the following parameters:

Data Type:	Emission Rates
Region:	County
Calendar year:	Obtain output files for both Yr1 and YrF
Season:	Annual Average
Vehicle category:	EMFAC2011 Categories
	Autos: LDA, LDT1, LDT2, and MDV
	Bus: UBUS or project specific vehicle category
Model year:	Aggregated for autos or existing buses
	Model year specific for new bus projects
Speed:	Aggregated
Fuel:	Gas for autos; Diesel for buses

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[8] EMAC2011 emission factors are only available through 2035. Use 2035 as a proxy for any final year beyond 2035.

For the remaining steps, you will <u>only</u> need the following columns from the output file:

- VMT
- CO2_RUNEX (Pavley I+LCFS)
- CO2_STREX (Pavley I+LCFS)

Step 2b. Calculate VMT-weighted Auto Trip Start and Running Emission Factors

Auto Trip Start Emission Factor (ATSEF)

Auto fleet average Start Factor in grams/vehicle/day divided by trips per vehicle per day)

$$= \frac{\begin{array}{c}(\text{VMT} * \text{CO2\_STREX(Pavley I} + \text{LCFS)})_{LDA} + (\text{VMT} * \text{CO2\_STREX(Pavley I} + \text{LCFS)})_{LDT1} \\ +(\text{VMT} * \text{CO2\_STREX(Pavley I} + \text{LCFS)})_{LDT2} + (\text{VMT} * \text{CO2\_STREX(Pavley I} + \text{LCFS)})_{MDV}\end{array}}{Sum\ (VMT)}$$

The Auto Trip Start Factor in grams/trip is calculated by dividing the Auto Start Factor by 6 trips/vehicle/day[9] as follows:

$$\text{ATSEF} = \left(\frac{Auto\ Start\ Factor}{6}\right)$$

Auto Running Emission Factor (AREF)

Auto fleet average Running Factor in grams/vehicle/day

$$= \frac{\begin{array}{c}(\text{VMT} * \text{CO2\_RUNEX(Pavley I} + \text{LCFS)})_{LDA} + (\text{VMT} * \text{CO2\_RUNEX(Pavley I} + \text{LCFS)})_{LDT1} \\ +(\text{VMT} * \text{CO2\_RUNEX(Pavley I} + \text{LCFS)})_{LDT2} + (\text{VMT} * \text{CO2\_RUNEX(Pavley I} + \text{LCFS)})_{MDV}\end{array}}{Sum\ (VMT)}$$

Bus Running Emission Factor (BREF)

For each calendar year, the Running Factor can be taken directly from the CSV file:

$$Running\ Factor = \text{CO2\_RUNEX(Pavley I} + \text{LCFS)}$$

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[9] The number of trips per vehicle per day was estimated by dividing the average number of trips per day by the number of vehicles for each vehicle category (LDA, LDT1, LDT2, and MDV) from the EMFAC web-based tool.

Step 3: Calculate the GHG Reductions Over the Project Life

Project Life (GHG Reductions) =

$$\left(\frac{Yr1\ GHG\ Reductions\ +\ YrF\ GHG\ Reductions}{2}\right) * PL$$

Where:
PL   = Project Life, or the reported lifetime of the equipment, the useful lifetime of the equipment, 20 years, or 2035, whichever comes first.

C.   Reporting and Documentation

For TIRCP application evaluation purposes, the applicant will report results as:

$$\frac{\textit{Metric tons (MT) of CO2 over the project life}}{\textit{GGRF Funds Requested ($)}}$$

Applicants are required to provide electronic documentation that is complete, and sufficient enough to allow the quantification calculations to be reviewed and replicated. Paper copies of any materials must be available upon request by CalSTA or ARB staff.

Documentation will include such things as:

- Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations
- Project description, including excerpts or specific references to the location in the main TIRCP application of the project information necessary to complete the applicable portions of the quantification methodology
- Project data support, including:
    - Documentation of the project specific data used in Section B
    - References to public documents that are the source of the project specific data used in Section B.
    - Documentation of calculations (spreadsheets, EMFAC2011 reports, etc.)
- Summary page with, at minimum, the following information
    - The Activity Types from Table 2 that are applicable to the GHG estimates identified.
    - GHG emission reductions for Yr1, YrF, and Total over the project life
    - GGRF funds requested for the project
    - Total Project GHG emission reductions per GGRF funds requested

For more information on ARB's efforts to support implementation of GGRF investments, see: www.arb.ca.gov/auctionproceeds. Questions on this document should be forwarded to GGRFProgram@arb.ca.gov. Questions on the TIRCP program should be forwarded to tircpcomments@dot.ca.gov.