EMFAC2014 Volume III - Technical Documentation

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California Environmental Protection Agency

Air Resources Board

Mobile Source Analysis Branch

Air Quality Planning & Science Division

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1 EXECUTIVE SUMMARY

This Technical Document provides technical details on the changes and updates in EMFAC2014 and also provides information regarding the differences between EMFAC2014 and the prior version of the model, EMFAC2011. For more information on how to use EMFAC2014, including how to install the model and how to navigate through the EMFAC2014 user interface, please refer to the EMFAC2014 User's Guide.[1]

Some legacy components, methodologies, data, and logic are carried over into EMFAC2014 from prior versions of EMFAC and are not covered within this document. However, while this document does not provide comprehensive coverage of EMFAC technical details, a summary of where such details can be found is provided in the Comprehensive Table of EMFAC Topics[2].

1.1 OVERVIEW

1.1.1 STRUCTURE OF THIS DOCUMENT

The structure of the Technical Document is laid out as follows:

- In this *Executive Summary* chapter (Chapter 1), readers will find high-level information on the new features/characteristics of EMFAC2014 and graphical plots showing the statewide differences in estimated emissions between the prior version of the model, EMFAC2011, and EMFAC2014.
- An *Introduction* (Chapter 2) provides a more detailed summary of what's new in EMFAC2014 along with specific chapter references where the reader can find more details. It also provides some very basic information on the web-based inventory data tool.
- *Chapter 3* provides details on the model's Methodology Updates, with extensive information on how EMFAC2014 calculates vehicle emission rates and activities.
- *Chapter 4* covers EMFAC2014's Custom Activity mode, with which users can utilize user-specific activity information in EMFAC2014.
- *Chapter 5* provides technical information on EMFAC2014's Project Level Assessment mode, presenting the underlying equations used to calculate emission rates and providing information on how these emission rates should be interpreted. For more information on how to conduct a Project Level Assessment, please refer to the California Air Resources Board's EMFAC2014 PL Handbook.[3]

1.2 OVERVIEW OF MAJOR CHANGES

EMFAC2014 represents the California Air Resources Board's (ARB's) current understanding of how vehicles travel and how much they pollute. An on-road emissions inventory is calculated, at the most basic level, as the product of an emission rate, expressed in grams of a pollutant emitted per some unit of source activity, and a measure of that source's activity. The changes implemented in EMFAC2014 to source activities and emission rates are discussed in detail later in this documentation. The major impacts of these changes to emissions and activity estimates are presented throughout this document. Statewide differences are presented in the sections below.

1.3 UPDATES TO ACTIVITY: METHODS AND ASSUMPTIONS

[1] See http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol1-users-guide-052015.pdf
[2] See http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol4-comp-table-of-emfac-topics-052015.xlsx
[3] See http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol2-pl-handbook-052015.pdf

Multiple Years of Updated DMV Data. Several updates to EMFAC2014 influence its estimates of the total California vehicle population and subpopulations. This is best illustrated by contrasting EMFAC2014 with EMFAC2011. EMFAC2011 used 2009 California Department of Motor Vehicles (DMV) populations and 2010 commercial diesel truck populations along with MPO activity data to forecast/backcast the vehicle populations. In contrast, EMFAC2014 uses actual DMV populations for multiple years spanning from 2000 through 2012; and, to improve the out-of-state diesel truck estimates in EMFAC2014, vehicle model year (MY) distributions based on International Registration Plan (IRP) clearinghouse data were used. These data were not available for EMFAC2011.

Populations for Specific Natural Gas Vehicles (T7 SWCV & UBUS). Changes were also implemented in EMFAC2014 to account for emissions from natural gas powered refuse truck (T7 SWCV) and urban bus (UBUS) vehicles. Populations for these vehicles had been counted as diesel vehicles in EMFAC2011 and were assigned the same emission rates as diesel vehicles. However, air district rules and recent test results call for natural gas specific populations and emission rates for classes with the highest natural gas technology penetrations. In EMFAC2014, emissions from natural gas T7 SWCV and UBUS are calculated separately from diesel and reported as part of the diesel emissions.

Default, Fuel-Use-Based VMT. The manner in which default estimates of vehicle miles traveled (VMT) are derived in EMFAC2014 differs starkly from past versions of EMFAC. In EMFAC2011 and prior versions of EMFAC, default VMT were obtained from local Metropolitan Planning Organizations (MPOs). In contrast, EMFAC2014 default VMT are based upon a relationship between California Board of Equalization (BOE) fuel-sales, vehicle population, and mileage accrual data. Fuel-based regional VMT are also spatially corrected for inter-regional traffic using data from the Highway Performance Monitoring System (HPMS), commercial truck travel surveys, and other vehicle class specific distributions. While default VMT in EMFAC2014 is fuel based and default activity estimates do not take into account SB375, the EMFAC2014 Custom Activity Mode provides users with the option of using MPO activity data in place of the EMFAC2014 default activity. This option is necessary in cases where users are legally required to use MPO activity data, for instance in State Implementation Plan (SIP) and SB375 related work.

Socio-Econometric Forecasting Methods. Another new feature of EMFAC2014 is the use of socio-econometric regression model forecasting methods to predict new vehicle sales and VMT growth trends. These models connect the activity estimates of EMFAC to state and national economic indicators, fuel prices, regional human populations, and regional vehicle ownership characteristics.

The effect of the updates described above on estimated total statewide vehicle population and total statewide VMT are depicted in Figures 1.3-1 and 1.3-2. The plots show that EMFAC2014 and EMFAC2011 predict comparable long-term vehicle population trends. Vehicle populations, between 2010 and 2027, are lower for EMFAC2014; because the revised model incorporates the impact of the recent recession on statewide vehicle populations. With regard to VMT, the estimated long-term statewide VMT growth trend is similar between the two model versions. However, EMFAC2014 estimates lower VMT beyond 2010. This is driven, in part, by the recession which, as seen in Figure 1.3-2, acted to reduce statewide VMT beginning in 2007.

Figure 1.3-1 Comparison of EMFAC2011 and EMFAC2014 Statewide Vehicle Populations

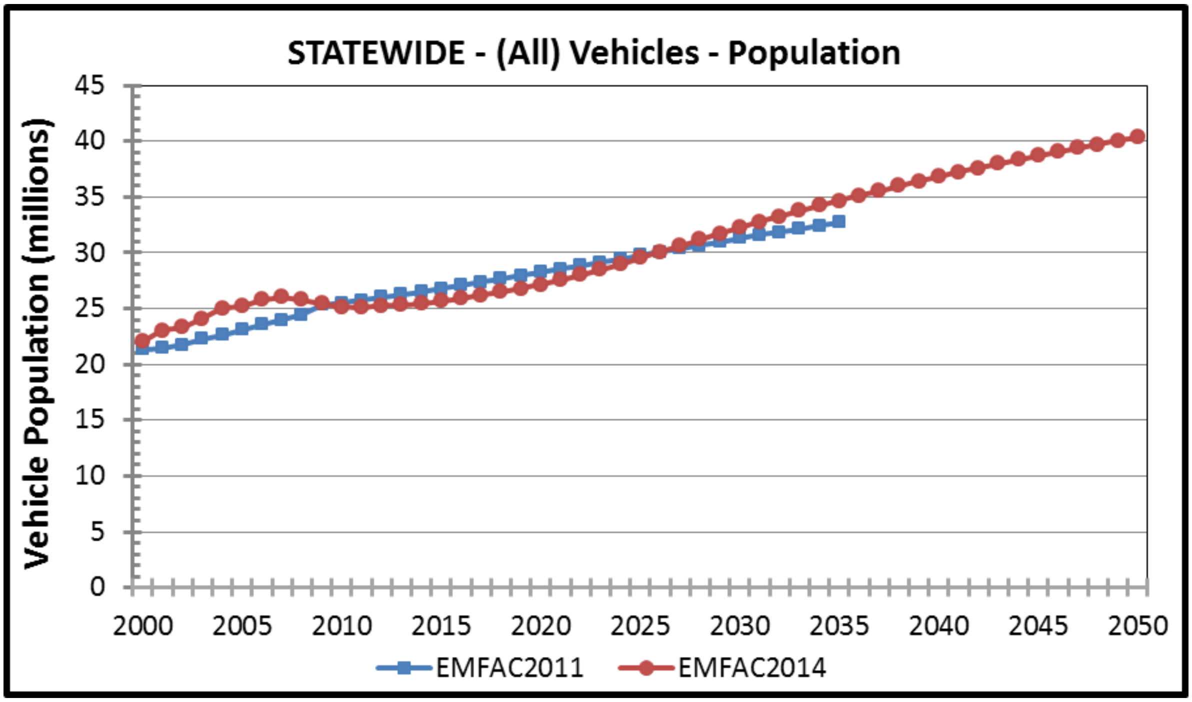
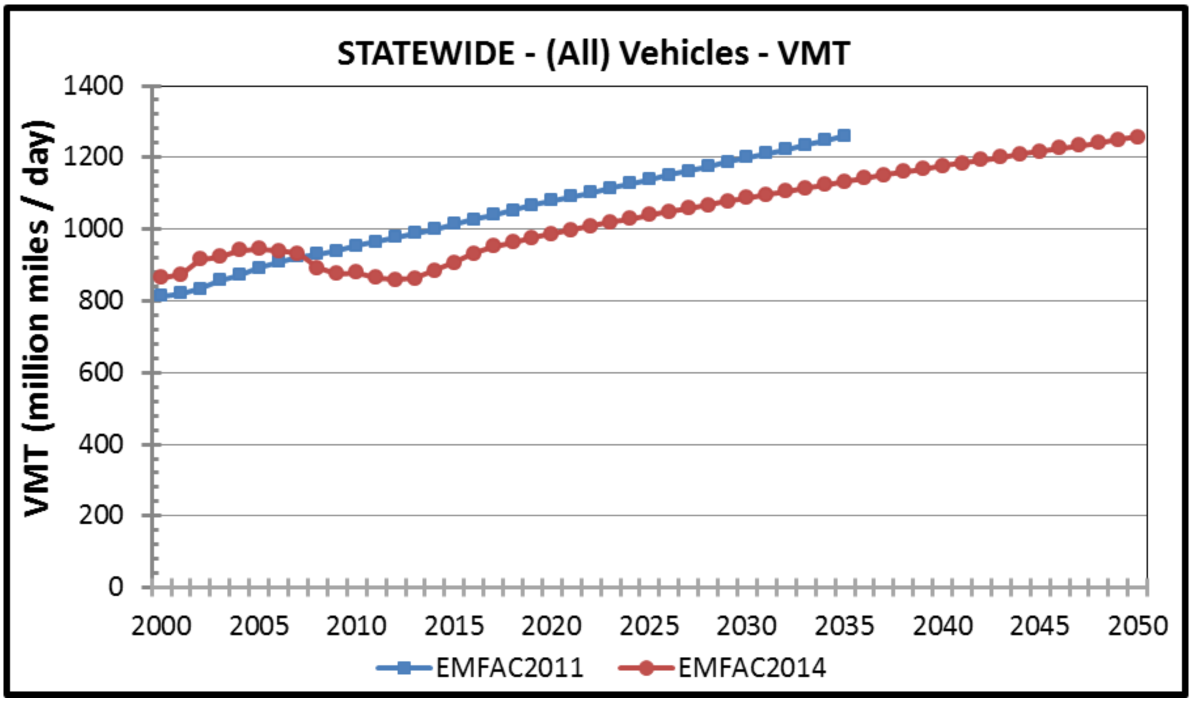


Figure 1.3-2 Comparison of EMFAC2011 and EMFAC2014 Statewide VMT



1.4 UPDATES TO EMISSION FACTORS AND INCORPORATION OF REGULATIONS

Emission factors in EMFAC2014 have been updated based upon new vehicle testing data. In the years since the release of EMFAC2011, ARB and the South Coast Air Quality Management District (AQMD) conducted vehicle testing projects focused on Class 8 diesel trucks certified to 2007 and 2010 engine standards. The results provided much-needed data necessary to update the emission rates for heavy heavy-duty (HHD) diesel trucks. Diesel particulate filters (DPF), required for 2007 and newer engines, were found to be more effective than anticipated in EMFAC2011, at all operation conditions. Selective catalytic reduction (SCR) systems were found to be most effective when the exhaust temperature exceeds around 250 °C. EMFAC2014 emission factors account for higher NOx emissions at lower speeds for 2010 standard engines. NOx emissions from starts, for trips involving engine-off catalyst/exhaust-system cool-down periods of greater than 30 minutes, are also reflected in EMFAC2014. Other updates include the incorporation of crankcase emissions, adjustments for engine and chassis model year (MY) mismatches in heavy-duty (HD) diesel trucks, emission rates for natural gas T7 SWCV and UBUS vehicles, modified emission rates for light heavy-duty (LHD) trucks, new zero-evaporative technology penetration assumptions, and revised chemical speciation profiles.

State and federal regulations and standards, including those that were adopted or amended post-2010 after EMFAC2011 was already released, are reflected in EMFAC2014. The regulations and standards were aimed at lowering fleet average emission rates and were designed to improve air quality and reduce greenhouse gas (GHG) emissions. Some of the updates were in response to regulations enacted through California's Advanced Clean Cars (ACC) Program. The ACC regulations affected light-duty (LD) vehicles of MYs 2017 through 2025 and included controls on precursors of smog, soot, and global warming compounds, as well as mandated requirements for the incorporation of greater numbers of zero-emission vehicles. Another important regulation that is reflected in EMFAC2014 is the state Truck and Bus Regulation, which requires HD vehicles to be retrofit with DPF or replaced with trucks having 2007 or 2010 standard engines. This is in order to accelerate fleet turnover and expedite the penetration of cleaner trucks. EMFAC2014 incorporates the latest, April 2014 amendment to the Truck and Bus Regulation; while the latest amendment in EMFAC2011 was the 2010 rule. Provisions in the now incorporated amendment lead to slightly higher estimated emissions during the phase-in period prior to 2023. Other updates were a result of the Tractor-Trailer Greenhouse Gas (TTGHG) Regulation and federal HD Greenhouse Gas regulations which required lower GHG emissions through retrofit aerodynamic improvements, low rolling resistant tires, and fuel-efficient new engine designs. Note that the Low Carbon Fuel Standard (LCFS) regulation is *excluded* from EMFAC2014 because most of the emissions benefits due to the LCFS come from the production cycle (upstream emissions) of the fuel rather than the combustion cycle (tailpipe). As a result, LCFS is assumed to not have a significant impact on CO2 emissions from EMFAC's tailpipe emission estimates.

Figures 1.4-1 through 1.4-4 compare the statewide criteria pollutant emissions predicted by EMFAC2014 against those predicted by EMFAC2011. In general, EMFAC2014 predicts lower emissions after 2020. Lower EMFAC2014 NOx and PM 2.5 emissions are due to the incorporation of the ACC regulations for LD vehicles and the effectiveness of DPFs and SCR in HD diesel trucks. Lower THC emissions in EMFAC2014 are offset by the incorporation of new speciation data showing higher ROG/THC in gasoline vehicle emissions as compared to EMFAC2011. This results in relatively similar ROG estimates (Figure 1.4-2). For Year 2010 and prior, EMFAC2014 ROG estimates are slightly higher due to inclusion of heavy duty crankcase emissions, a procedure that accounts for engine/chassis MY mismatch, as well as an update to zero-evaporative technology penetration for LD gasoline vehicles. The CO2 estimates, in Figure 1.4-4 illustrate the impact of GHG related regulations and standards.

Figure 1.4-1 Comparison of NOx Emissions between EMFAC2011 and EMFAC2014

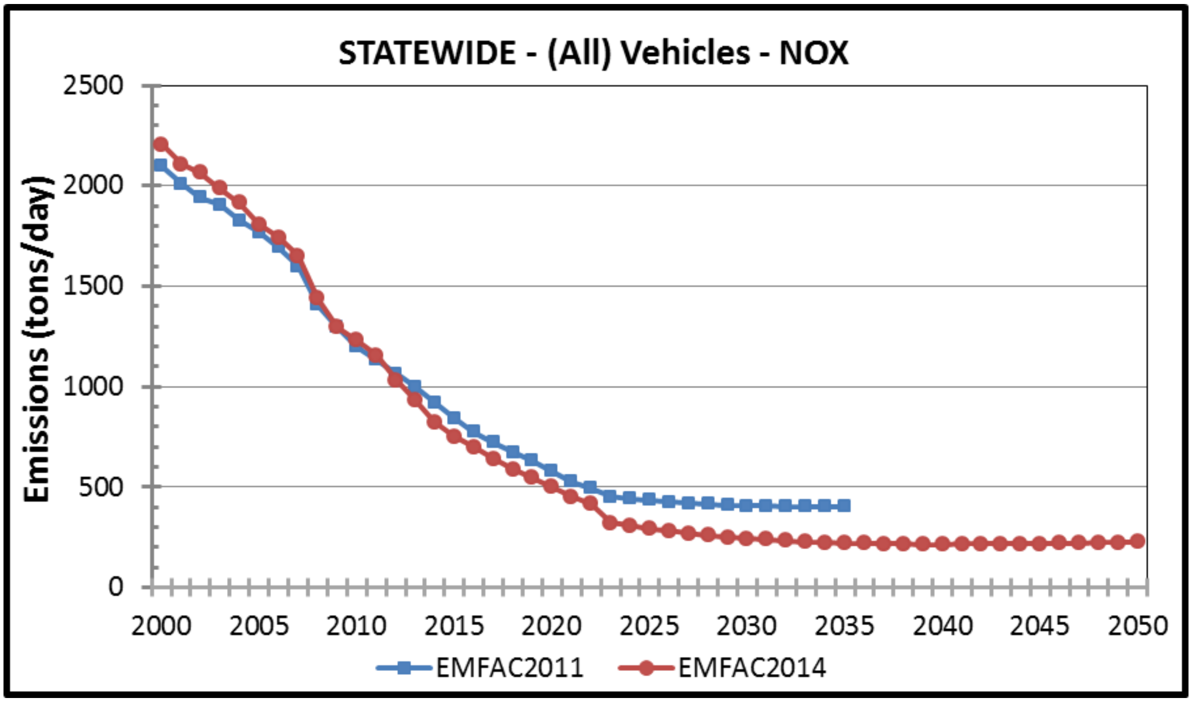


Figure 1.4-2 Comparison of ROG Emissions between EMFAC2011 and EMFAC2014

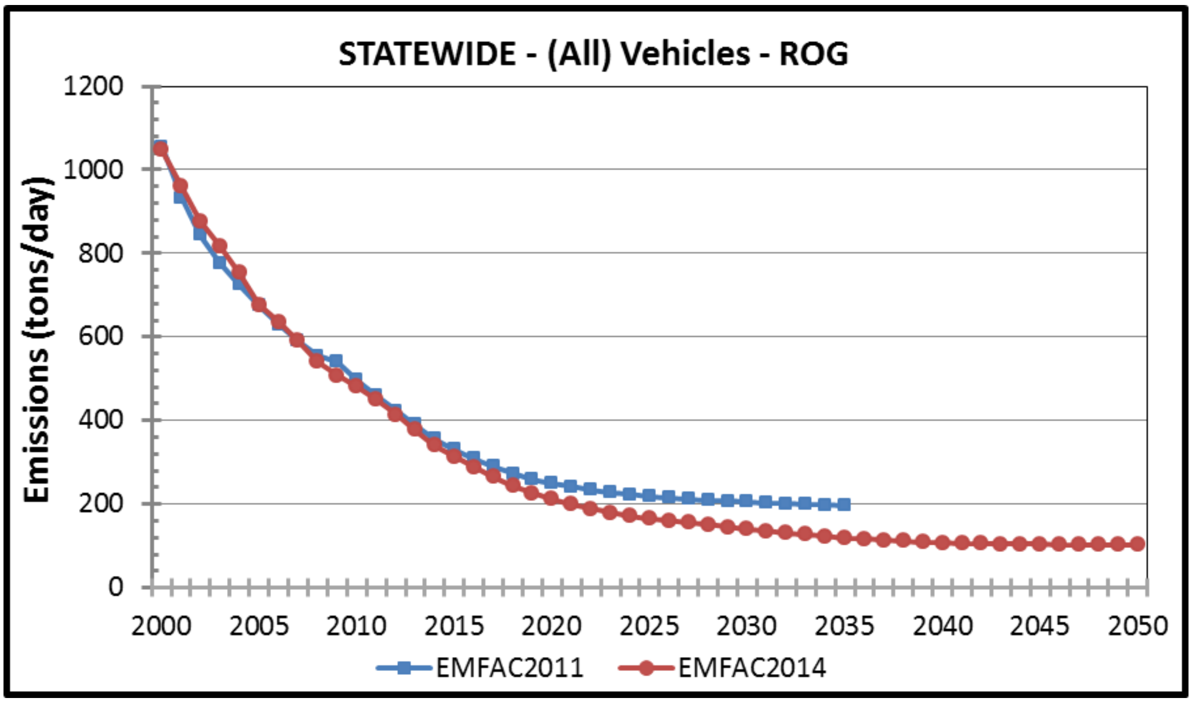


Figure 1.4-3 Comparison of PM2.5 Emissions between EMFAC2011 and EMFAC2014

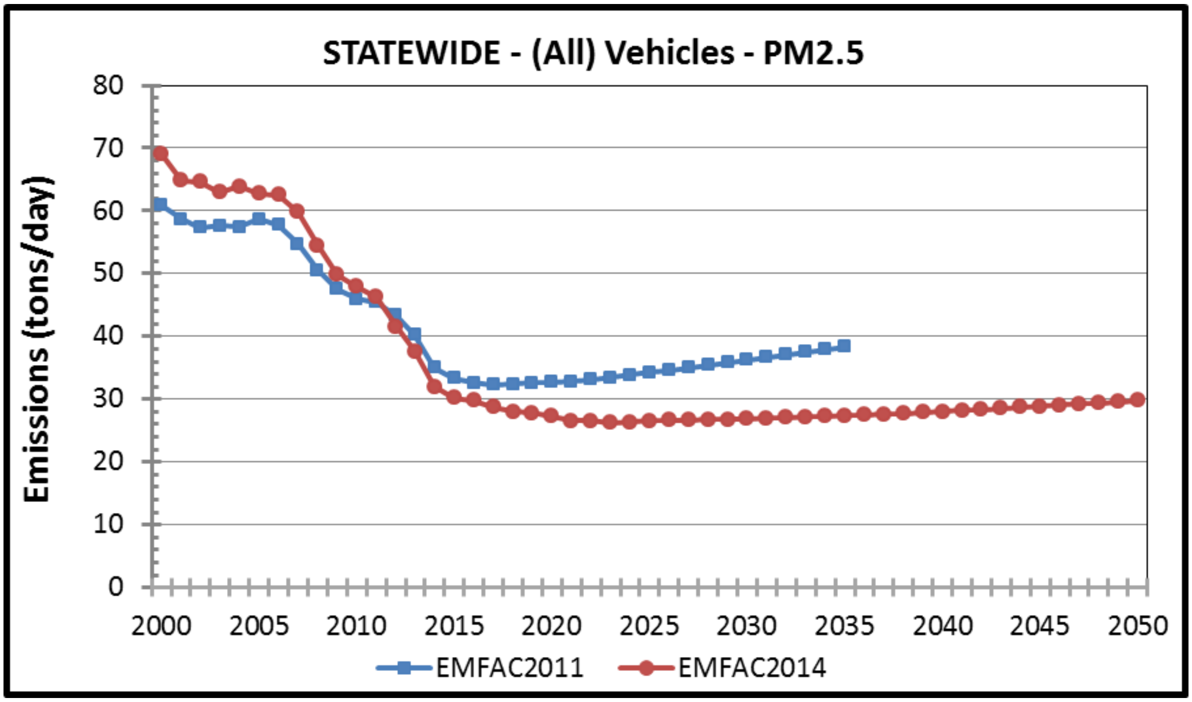
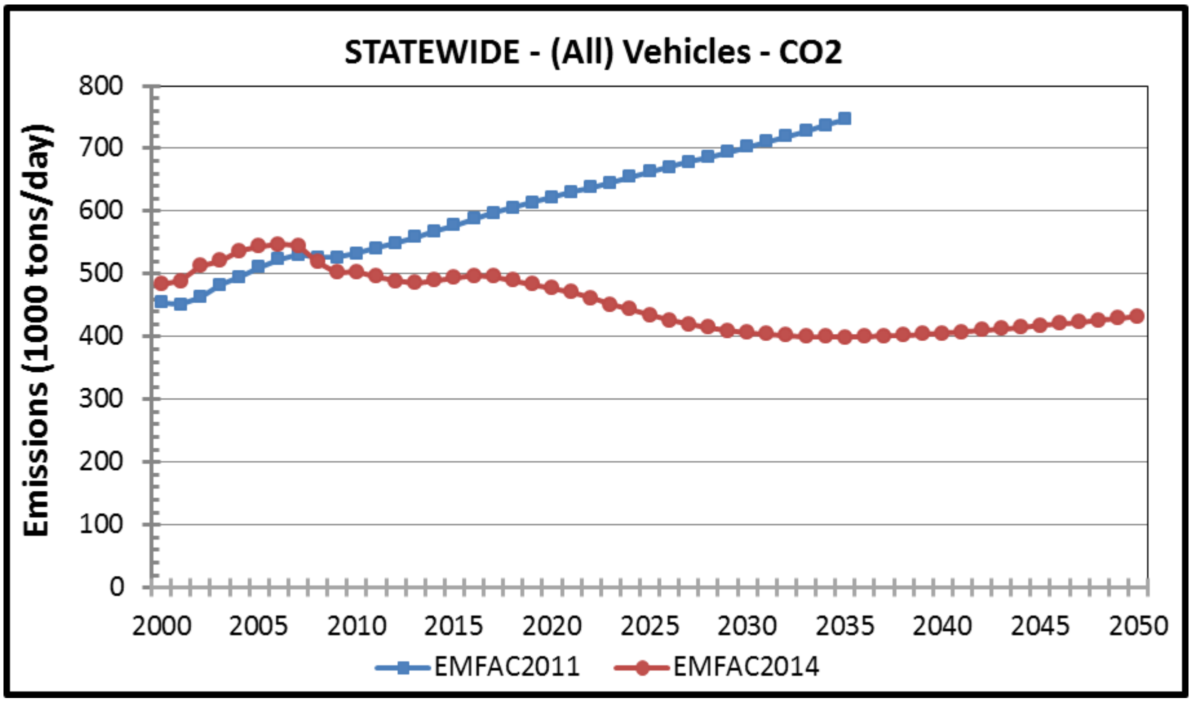


Figure 1.4-4 Comparison of CO2 Emissions between EMFAC2011 and EMFAC2014



1.5 UPDATES TO MODEL STRUCTURE

EMFAC development staff has departed from using FORTRAN (the legacy programming tool used in EMFAC2011-LD vehicle and previous versions of EMFAC) and has rebuilt the model using Python and MySQL software. The main reason for the revision is to make the EMFAC model easier to update, providing greater flexibility to incorporate and assess the impacts of new rules. In EMFAC2014, all the functionalities of the three modules in EMFAC2011 (LD, HD, & SG), as well as the project-level assessment tools, have been integrated into a single package. There are two modes in EMFAC2014 as indicated in Figure 1.5-1. The Emissions Mode can be used to estimate tons of emissions per day by geographic region (as small as GAI, which is equivalent to the common area contained in the intersection of county, air basin, and air district political boundaries) and the Emission Rates Mode can be used to estimate grams of emission per unit of activity for the time, region(s), vehicle type, and pollutant(s) selected through the model's Graphical User Interface. Emissions Mode runs can be carried out using EMFAC2014 default activities or user-defined custom activities.

The Emission Rates Mode can be used for project level assessments. Users can get regional, project specific emission rates for specific vehicle classes, at project specific ambient air temperatures, ambient relative humidity, and vehicle speeds. Both Emission Rate Runs and Emissions runs allow the user to calculate detailed emission inventories using default ARB activity data. Emissions Mode runs can also be performed using custom activity data. User-defined VMT and speed profiles may be input in at the vehicle class level.

Emission Rates runs, Default Activity Emissions runs, and Custom Activity Emissions runs were each designed to serve different purposes. Because of this, there are some differences in the way the data are grouped and processed. Some of the main differences involve the level of detail of the run specifications and the manner in which emissions/emission rates from alternative fuel vehicles are reported out of EMFAC. For instance, in Emission Rate Mode runs, pollutant emission rates for electric and natural gas powered vehicles are reported. Table 1.5-1 provides a summary of this.

Figure 1.5-1 EMFAC2014 Overall Flow

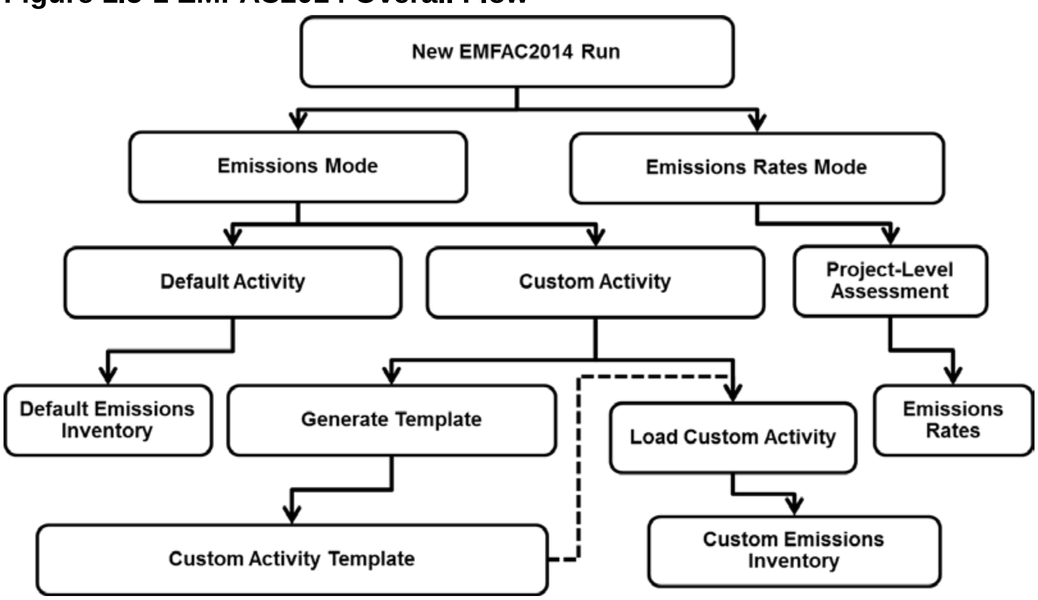


Table 1.5-1 Overview of Modes in EMFAC2014

	Emission Rate Mode	Emission Mode - Default	Emission Mode - Custom
Level of Detail	GAI, Model Year, Vehicle Class (EMFAC2011 & aggregated), Process, Speed, Temp/RH	GAI, Model Year, Vehicle Class (EMFAC2011&EMFAC2007), Process, Speed, Season, Daily/Hourly	GAI, vehicle Class (EMFAC2011&EMFAC2007), Process, Speed, season, Daily/Hourly
Electric (LDA&LDT1)	Reported as Electric	Reported as Electric	Merged with Gasoline
Natural Gas (UBUS&T7 SWCV)	Reported as Natural Gas	Merged with Diesel	Merged with Diesel

1.5.1 CAVEATS

EMFAC2014 is constructed to characterize ARB's understanding of today's inventory, which includes the impacts of adopted regulations and technologies. Staff strives to build the model to meet air quality and climate change planning needs, however,

- *For conformity and State Implementation Plan related runs, VMT from transportation planning agencies need to be used within the Custom Activity Emissions Mode to develop the emission inventories for planning.*
- *EMFAC2014 is not the official Greenhouse Gas (GHG) inventory model. For calculating a GHG emission inventory, users should refer to the GHG Emission Inventory at http://www.arb.ca.gov/cc/ccei.htm*
- *EMFAC2014 contains the latest understanding and interpretation of regulations and standards. Therefore, in Custom Activity Mode, the user is only allowed to change VMT by speed for the various vehicle classes. Other manipulations are not allowed so that the model maintains built-in assumptions of MY distribution and alternative fuel technology penetration.*
- *Users should use VISION tool http://www.arb.ca.gov/planning/vision/vision.htm to perform scenario planning involving accelerated turnover, new emission standards, aggressive ZEV or alternative fuel penetration.*

1.6 UPDATES TO WEB-BASED INVENTORY TOOL

The EMFAC2014 Web-Tool has been updated so that it uses EMFAC2014 default activities and emission rates. In addition, users will now be allowed access to custom emissions data that utilizes the vehicle activities provided by MPOs.

2 INTRODUCTION

This Chapter describes and summarizes the major updates made to the Emission Factors 2014 model (EMFAC2014) and to an additional tool, the web database, which can be used for easy access to inventories. A complete discussion of all the updates and revisions reflected in the Default Activity Mode of EMFAC2014 can be found in Chapter 3. Methodologies for the Custom Activity Mode and Project Level Assessment Mode of EMFAC2014 are presented in Chapters 4 and 5, respectively. For reference purposes, the vehicle class categories referred to within this document have been provided in Appendix 6.1. For other information on other EMFAC2014 topics, please refer to the Comprehensive Table of EMFAC Topics.[4]

2.1 MAJOR UPDATES

This section briefly summarizes the differences between EMFAC2014 and EMFAC2011. The major updates include the following.

- *Re-design of EMFAC with new programming architecture (Section 2.1.1)*
- *Fuel-based default (Sections 3.3.3 and 3.3.4) vs. user-specified custom activities (Chapter 4)*
- *Incorporation of fuel-based statewide activity with new vehicle miles traveled (VMT) spatial allocations (Section 3.3.3)*
- *Socio-econometric modeling of population and VMT (Sections 3.3.3 and 3.3.4)*
- *Revision of heavy-duty diesel (HD Diesel) truck emission rates (Section 3.2.3)*
- *Incorporation of natural gas vehicles for select vehicle classes (Sections 3.2.3 and 3.3.4)*
- *Accounting for Federal and California regulations and standards adopted post-2010 (Section 2.1.8)*

A complete discussion of all the updates can be found in Chapter 3.

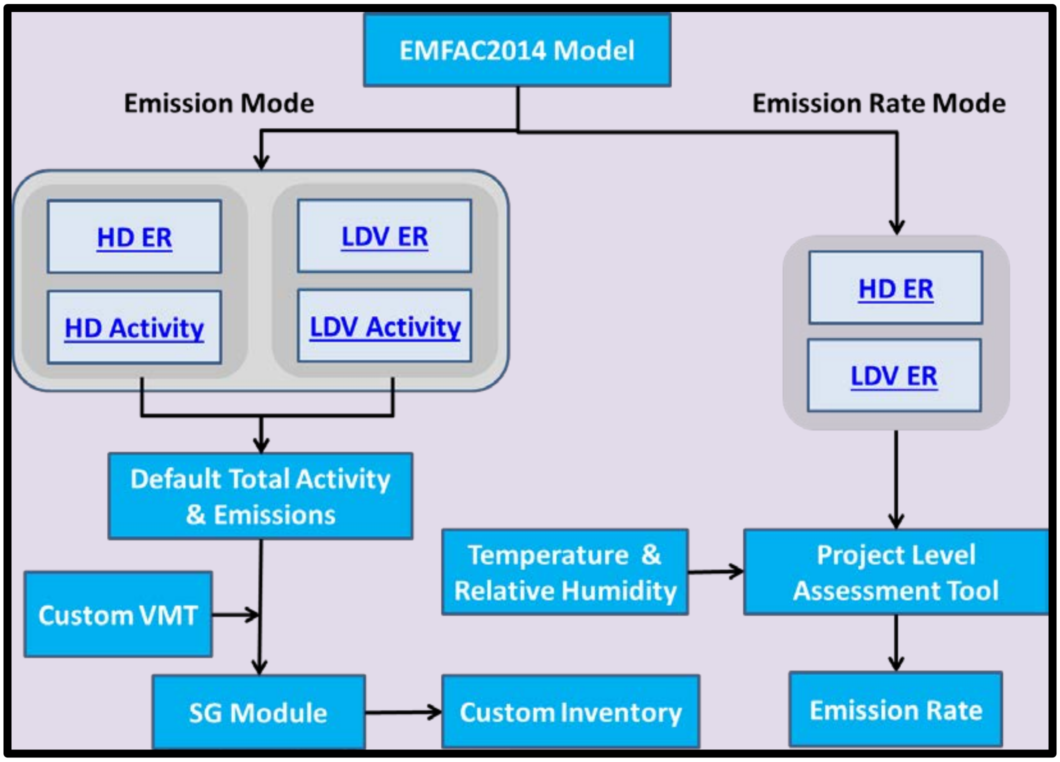
2.1.1 RE-DESIGN OF EMFAC

Since the release of EMFAC2011, EMFAC development has been focused on modifying the model's structure and enabling it to meet increasing data demands associated with regulatory and planning needs. EMFAC2011 is comprised of a suite of three separate modules, HD, LD, and SG. EMFAC2011-HD was written in Visual Basic and MySQL, for which the database architecture facilitated the generation of more detailed information about the truck and bus fleet than had been possible in prior versions. EMFAC2011-LD estimated the emissions of passenger vehicles and used the same algorithms as in EMFAC2007. The third module, EMFAC2011-SG, provided air quality planners, transportation planners, and other EMFAC users a tool for assessing emissions under different future growth scenarios. The modular structure of EMFAC2011 allowed staff to easily accommodate model enhancements that were necessary to support on-going program developments associated with criteria and greenhouse gas (GHG) emissions.

EMFAC2014, written in Python and MySQL, improves upon EMFAC2011's modular structure and combines the three prior modules into one single model. The resulting EMFAC2014 model preserves the advantages of modular structure, while the single entry graphical user interface that accesses all functionalities, makes the model more user friendly for the end user, as well as to ARB's inventory staff. Figure 2.1-1 shows the structure of EMFAC2014. More detailed descriptions of the processes shown here can be found in the EMFAC2014 User's Guide.[5]

[4] See http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol4-comp-table-of-emfac-topics-052015.xlsx
[5] See http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol1-users-guide-052015.pdf

Figure 2.1-1 EMFAC2014 Model Structure



2.1.2 FUEL BASED STATEWIDE ACTIVITY AND NEW SPATIAL ALLOCATIONS

In EMFAC2011, the default statewide VMT per calendar year (CY) is calculated as the summation of the sub-area VMT in sub-areas provided by planning agencies. In contrast, in EMFAC2014 the default statewide VMT estimates per CY are calculated based on fuel consumption rates and historical fuel sales reported by the Board of Equalization (BOE). A similar fuel-based approach is used by the official Air Resources Board (ARB) greenhouse gas (GHG) inventory. While EMFAC2014 does not produce official GHG emission estimates and there are other technical differences with how the GHG inventory is calculated, the fuel-based activity methodology allows for the use of EMFAC2014 to generally support un-official analyses for GHG pollutants. In EMFAC2014, the statewide light-duty (LD) vehicle VMT is distributed at the regional level using spatial allocations derived from Highway Performance Monitoring System (HPMS) data. Using HPMS data in combination with vehicle registration data enables EMFAC2014 to account for inter-regional travel. The detailed methodology can be found in Sections 3.3.3 *Updates to LD Vehicle Activity* and 3.3.4 *Updates to HD Vehicle Activity*.

2.1.3 SOCIO-ECONOMETRIC MODELING OF FUTURE POPULATION AND VMT

In EMFAC2014, VMT growth rates for the majority of vehicle classes are projected using regression models. These growth rates are functions of socio-economic indicators such as human population, fuel price, unemployment rate, and disposable income. For a few vocational specific vehicle classes, such as drayage trucks, activity growth trends of related industries are used as surrogates to predict VMT growth.

Historical vehicle populations are determined based on DMV registration data; while future year populations are projected based on calculated survival rates and new vehicle sales forecasts. Similar to VMT growth rates, new vehicle sales are estimated using combinations of socio-economic regression models and industry-based projections. Section 3.3 has more details on both vehicle population (3.3.3.1 and 3.3.4.1) and VMT (3.3.3.2 and 3.3.4.3) estimation methodologies.

2.1.4 DEFAULT ACTIVITY

In EMFAC2011 and prior versions of EMFAC, Default Mode VMT were provided by metropolitan and regional planning agencies. The planning agencies used transportation models to estimate overall target VMT for one base year and several forecasted years. Prior EMFAC versions employed a VMT matching algorithm[6] to adjust EMFAC default VMT to match the target VMT provided by planning agencies. With the population fixed to vehicle registration, base year VMT necessitated the calculation of updated mileage accrual rates, which were then used in calculating VMT for all future years. In the subsequent VMT matching iterations, population growth rates were calculated so that the future year VMT matched the target VMT from planning agencies based on the updated mileage accrual rates and vehicle attrition rates.

As stated in section 2.1.2, EMFAC2014 estimates default VMT using a relationship with historical fuel sales and regression based growth rates. Planning agency VMT are not incorporated into the Default Activity Mode results but can be input for runs using the Custom Activity Mode in EMFAC2014. The detailed methodologies can be found in Sections 3.3.3 *Updates to LD Vehicle Activity* and 3.3.4 *Updates to HD Vehicle Activity*.

2.1.5 CUSTOM ACTIVITY

For conformity and State Implementation Plan (SIP) work, ARB is required to use VMT from planning agencies. The Custom Activity Mode provides a mechanism to match the target VMT, as in previous versions of EMFAC, with a VMT matching algorithm. ARB will utilize VMT matching through the Custom Activity Mode to generate emission inventories for planning purposes. Details on the Custom Activity Mode methodologies can be found in Chapter 4.

2.1.6 REVISED HD DIESEL TRUCK EMISSION RATES

In EMFAC2011, emission rates for diesel fueled HD trucks were primarily based on emissions data collected from the Coordinating Research Council (CRC) E55/59 testing project. The E55/59 testing project was extensive as well as comprehensive, and greatly improved the quality of the data used in developing the emission factors. However, the newest engine tested in the project was model year (MY) 2003. In the past several years, testing projects have focused on trucks meeting the engine standards for 2007 (equipped with a diesel particulate filter, or DPF) and 2010 (equipped with a DPF and selective catalytic reduction, or SCR). These tests were conducted by ARB and South Coast Air Quality Management District (SCAQMD). Emission rates from these projects have been incorporated into EMFAC2014. Updates were made for base emission rates (BER) (refer to Section 3.2.3.2), idling emission rates (refer to Section 3.2.3.3), speed correction factors (refer to Section 3.2.3.4), and start emission rates (refer to Section 3.2.3.6) for trucks compliant with the 2007 and 2010 engine standards. EMFAC2014 has also been updated to take into account crankcase emissions, and to address mismatches between the engine and chassis MYs in Heavy Duty Trucks (HDTs).

2.1.7 INCORPORATION OF NATURAL GAS VEHICLES

Natural gas (NG) vehicles are often certified to the same emission standard as diesel or gasoline (gas) vehicles. In previous versions of EMFAC, LD natural gas vehicles were grouped into the gasoline population, while HD natural gas trucks and buses were counted as diesel vehicles. In recent years, the use of natural gas vehicles has been allowed as an alternative fuel compliance path to meet several ARB regulations. Additionally, natural gas vehicles were required per air district

[6] EMFAC2002 Technical Memo, "Updated Vehicle Miles Traveled", http://www.arb.ca.gov/msei/onroad/downloads/revisions/web_vmt_071202.doc

rules for some specific applications. According to registration data, the two vehicle classes that have the highest natural gas penetrations are urban buses (UBUS) and T7 solid waste collection vehicles (SWCV), also referred to herein as refuse trucks. Therefore, for EMFAC2014, staff focused on these two classes for deriving and incorporating natural gas specific population and emission rates based on the available test data. The detailed approach and analyses are presented in Sections 3.2.3.9, 3.2.3.11, and 3.3.4.4.

2.1.8 ACCOUNTING FOR ADOPTED REGULATIONS AND STANDARDS

EMFAC2014 incorporates adopted ARB regulations and federal emissions standards to date. The regulations and standards that were accounted for in EMFAC2014, but were not accounted for in EMFAC2011, include:

- *Advanced Clean Cars Program*[7] *(as discussed in Sections 3.2.2.4 and 3.3.3.3)*
- *Heavy-Duty GHG Phase 1 (2013),*[8] *which includes the 2013 Tractor-Trailer Greenhouse Gas Regulation Amendments and Federal Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles and (as discussed in Sections 3.2.3.12 and 3.2.3.13)*
- *Truck and Bus Regulation (2014) Amendments*[9]*(as discussed in Section 3.3.4.2)*

2.2 ACCESSING DATA THROUGH THE WEB DATABASE

The web based inventory data query tool[10] was a feature that was first released with EMFAC2011. For the majority of users, the EMFAC2011 web-based data provided easy access to EMFAC 2011 default emission inventories without the need to actually run the model. EMFAC2014 also provides web-based inventory data sets which utilize the default activity data of EMFAC2014's Default Activity Mode runs. The EMFAC2014 web-based inventory data query tool web page will also be updated with activity data provided by planning agencies to use in place of the EMFAC2014 default activity data.

[7] http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm
[8] http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013.htm
[9] http://www.arb.ca.gov/regact/2014/truckbus14/truckbus14.htm
[10] http://www.arb.ca.gov/emfac/

3 METHODOLOGY UPDATE

3.1 INTRODUCTION

This chapter discusses the updates that have taken place between EMFAC2014 and EMFAC2011. The methodological changes can be broken up into two broad categories, by which the chapter is divided: emission rate updates (Section 3.2) and activity updates (Section 3.3).

Emission rate updates not only include changes in basic emission rates, but also changes to any associated correction factors for those basic emission rates. For example, changes in speed, temperature or relative humidity can all affect the emission rates and thus requires that correction factors be applied to emission rates (as appropriate). Emission rate and associated correction factor updates have been made for exhaust, evaporative and tire wear/brake wear emission processes. For the most part, these emission rate updates are independent of any activity assumptions, with the exception for some processes which exhibit deteriorated emissions as vehicles age. The impetus for these emission rate updates included: new or amended regulations, availability of new data, new methodologies that were developed, or simply a need to fix errors from previous model versions.

Activity updates were made to population, vehicle miles traveled (VMT), speed distributions, idle time duration, mileage accrual rates and other parameter variables which describe how vehicles are utilized. Activity changes can be very dynamic because they are influenced by the economy and human behavior. Section 3.3 documents activity the updates made for both baseline conditions and projections into the future.

3.2 EMISSION RATES

3.2.1 BASICS

This section provides a brief overview of the dominant vehicular emissions sources. Emission rates (also referred to as emission factors) related to these sources are typically measured at standard temperature and humidity using typical vehicle driving and operational patterns. Emission rates are ultimately combined with vehicle activity data (such as vehicle population counts) to estimate vehicle emissions inventories.

3.2.1.1 EXHAUST EMISSION SOURCES

Emissions that emanate from the vehicle's tailpipe are called exhaust emissions. Incomplete combustion of the fuel is the primary cause of hydrocarbon (HC), carbon monoxide (CO), and particulate matter (PM) emissions. These emissions occur at all times, but are more intense when the air-fuel ratio is richer than stoichiometric (14.7-to-1) conditions, such as during a hard acceleration. Oxides of nitrogen (NOx) emissions are produced during combustion at high temperatures and pressures, and can be enhanced under lean air-fuel ratio conditions. Properly working catalysts reduce tailpipe emissions from gasoline vehicles by over 90 percent when combined with electronic systems that monitor the air-fuel ratio. Due to higher combustion temperatures, excess air, and high pressures, a diesel fueled vehicle emits comparatively more NOx than a comparable gasoline-fueled vehicle. The lean overall air-fuel ratios, used by diesel vehicles, preclude the use of conventional reduction catalysts for emissions control systems. Combustion engine vehicles also emit carbon dioxide (CO_2) and are a significant contributor to statewide greenhouse gas (GHG) emissions. It should be noted that EMFAC uses measured CO_2 emissions data to predict CO_2 emissions and emission rates. In contrast, ARB's Official GHG Inventory CO_2 estimates are based upon fuel consumption, and assume complete combustion; that is, fuel is completely converted to CO_2 and H_2O in the combustion process.

There are two vehicle operational modes that contribute to exhaust emissions: the stabilized running mode and the start mode. The stabilized running mode occurs when the engine and/or catalyst are at normal operating temperatures. As defined for modeling purposes, the start mode occurs during the first 100 seconds of operation after the engine has been started. Since the engine and/or catalyst may not have achieved their optimal operating temperature range, the emissions during starts are generally higher. Start emissions may also vary by ambient temperature as well as the length of time that the vehicle has been sitting. Running exhaust emissions may vary by speed, temperature, humidity, and/or air conditioning usage.

Most of the passenger car (LDA), light-duty (LD) truck and medium-duty (MD) truck exhaust data used for modeling purposes have been collected from ARB Surveillance program projects, through which vehicles were tested on a chassis dynamometer. Because heavy-duty (HD) truck engines may be sold independent of the chassis, HD engines are tested on both chassis and engine dynamometers to simulate loads experienced by the engine.

3.2.1.2 EVAPORATIVE EMISSION SOURCES

Gasoline evaporates from the fuel storage and delivery system within vehicles. This occurs whether the vehicle is running or not and whether the ambient temperature is increasing or decreasing. The types of evaporative emissions processes are individually described below.

- *Running loss emissions occur when hot fuel vapors escape from the fuel system or overwhelm the carbon canister while a vehicle is being operated.*
- *Hot soak emissions are evaporative emissions that occur when vapors escape within one hour after the engine has been turned off. These emissions are caused by high under-hood and fuel temperatures. Some of these emissions are also due to permeation.*
- *Diurnal emissions result from evaporation in the fuel system and breakthrough of vapors from the carbon canister, hoses and connectors when the vehicle is not being operated and the ambient temperature is rising. Diurnal emissions also occur as part of the permeation of molecules through rubber and plastic components of the fuel system.*
- *Resting loss emissions are defined as losses when the vehicle has not been operated for at least an hour and the ambient temperature is either constant or decreasing. The primary driving force is no longer considered to be vapor generation because of the declining vapor pressure. The resulting emissions are primarily dominated by permeation of fuel through rubber and plastic components.*

Evaporative emissions are measured using a Sealed Housing Evaporative Determination (SHED) Test. This test is performed by placing a vehicle in an airtight enclosure, also referred to as a SHED, to capture the evaporating gases. The temperature inside the SHED is varied to simulate changes in ambient temperature. A running loss enclosure, which is a dynamometer within a SHED, is used to gather emissions while a vehicle is being driven.

3.2.1.3 TIRE AND BRAKE EMISSIONS SOURCES

Attrition of tire treads and application of vehicle brakes also produce PM emissions, and these are currently uncontrolled. Tire wear and brake wear PM particles tend to be somewhat more coarse than exhaust particles.

3.2.1.4 EMFAC2014 UPDATES

Sections 3.2.2 and 3.2.3 discuss the updates made to emission rates for LD and HD vehicles, respectively, for EMFAC2014. Some of these updates reflect new LD and HD regulations that were not incorporated into EMFAC2011. In addition, some of these updates reflect changes based on new information that was not available for EMFAC2011. To incorporate new technology groups into

EMFAC2014, staff used a ratio-of-standards approach to estimate emission rates if no test data were available. For example, if test data were available for SULEV 30 vehicles (Super Ultra-Low Emissions Vehicles of less than 30 mg/mi combined ROG + NOx), but not for the newly created category SULEV 20, then SULEV 20 vehicles were estimated to have ROG + NOx emission rates of 20/30 or 67% of SULEV 30 vehicles. Section 3.2.2 discusses updates that have been made in EMFAC2014 for LD vehicles and for gasoline fueled HD vehicles (which were included in EMFAC2011 LD vehicle categories). Updates that have been made in EMFAC2014 for diesel and natural gas fueled HD vehicles are discussed in Section 3.2.3.

3.2.2 UPDATES TO EMISSION RATES FOR LD VEHICLES

3.2.2.1 BASE EMISSION RATE (BER) UPDATES

This section describes the updates made in EMFAC2014 to the emission rates for LD vehicle categories and also for the gasoline fueled HD vehicle categories. Updates have been made to:

- *Light heavy-duty (LHD) trucks CO2 and NOx emission rates*
- *Speed correction factors (SCFs) for LD vehicle categories*
- *Tire and brake wear emission rates*
- *LD diesel car and truck emission rates*
- *Urban Transit Bus (UBUS) diesel emission rates*

3.2.2.1.1 LIGHT HEAVY-DUTY (LHD) TRUCKS CO_2 AND NO_X EMISSION RATES

3.2.2.1.1.1 CO_2 BERS AND SCFS

LHD trucks can be described as trucks that drive like cars. The LHD truck category consists of vehicles having a gross vehicle weight rating (GVWR) of 8500-14,000 lbs. LHD1s have a GVWR of 8,500-10,000 lbs. and LHD2s have a GVWR of 10,001-14,000 lbs.

CO_2 BERs are typically derived from tailpipe emissions tests, on the base LA-4 driving cycle; and these BERs are proportional to fuel consumption. CO_2 SCFs are multiplied against CO_2 BERs to determine CO_2 emission rates at different speeds. The LHD BERs and SCFs, used in EMFAC2014, were determined from theoretical energy modeling, rather than emissions tests at different speeds (the approach taken in previous version of the EMFAC model). This is appropriate for CO_2 as it is a direct result of fuel consumption. In the absence of test data, it was more cost effective for ARB staff to theoretically model the energy requirements and fuel consumption for LHD1s and LHD2s on various driving cycles, to derive the BER and SCFs, than to obtain these data through emissions testing.

The energy contributions of aerodynamic drag, tire friction, acceleration/deceleration/ braking, and transmission losses for each second of various driving cycles were all modeled. The LHDs were modeled on the speed correction driving cycles presented in Section 6.2 of the EMFAC2000 Technical Support Document[11] (TSD), and in Gammariello and Long.[12] The cycles modeled included the medium heavy-duty (MHD) truck driving cycles developed under the CRC E-55/59 project. As LHD trucks perform like cars, due to their horsepower-to-weight ratios, but have activities

[11] ARB 2000. Public Meeting to Consider Approval of Revisions to the State's On-Road Motor Vehicle Emissions Inventory: Technical Support Document. California Air Resources Board, Sacramento CA. http://www.arb.ca.gov/msei/onroad/downloads/tsd/Speed_Correction_Factors.pdf

[12] Gammariello, R, and Long, J.. 1996. Development of Unified Correction Cycles. Presentation at 6th CRC On-road Vehicle Emissions Workshop. Coordinating Research Council, Alpharetta, GA.

like trucks (number of trips, speed, etc.), it was important to use both the Gammariello and Long driving cycles developed for cars as well as the E55/59 driving cycles developed for MHD trucks.

ARB's theoretical emission rate and SCF results are shown in Figures 3.2-1 and 3.2-2 for gasoline (gas) and Figures 3.2-4 and 3.2-5 for diesel. Note that the SCFs were normalized so that they would be equal to 1.0 at 16 mph, rather than 19 mph. That is because HD truck BERs are based on the UDDS cycle with an average speed of 19 mph, whereas LHDT BERs are modeled based on FTP Bag 2 cycle which has an average speed of 16 mph.

To use the SCFs and BERs, the BER at 16 mph is multiplied by the SCF and the percent VMT for each speed bin, and the results are summed over all speed bins to derive the emissions. VMTs can vary sharply as a function of speed, as indicated in the examples provided in Figures 3.2-3 and 3.2-6. These contain graphs percent of LHD VMT by speed for Los Angeles County. These originate from the South Coast Association of Governments (SCAG), the largest metropolitan planning organization (MPO) in Southern California. Table 3.2-1 shows the LHD1 emissions results for Los Angeles County in 2025. Please note that the CO_2 emissions, in this table, also include emissions from the starts emissions process.

Figure 3.2-1 LHD1 Gas CO_2 Emission Rate versus Speed

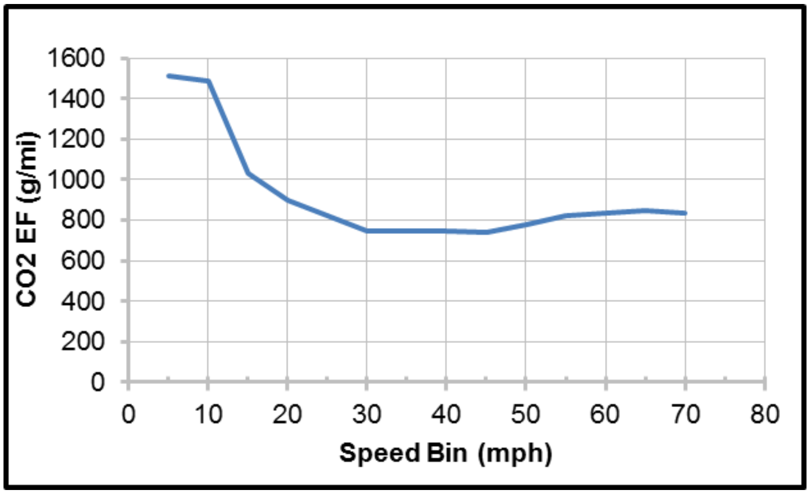


Figure 3.2-2 LHD1 Gas CO_2 SCFs

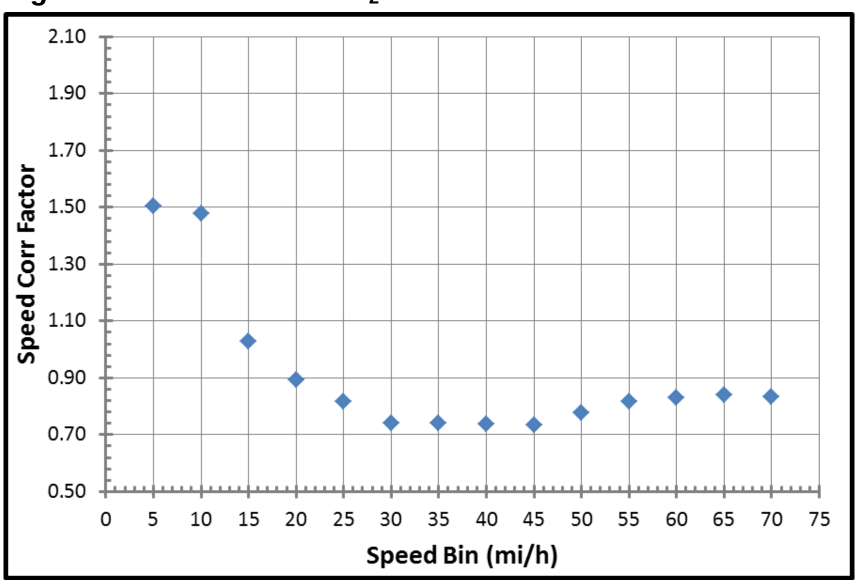


Figure 3.2-3 LHD1 Gas LA VMT Speed Distribution

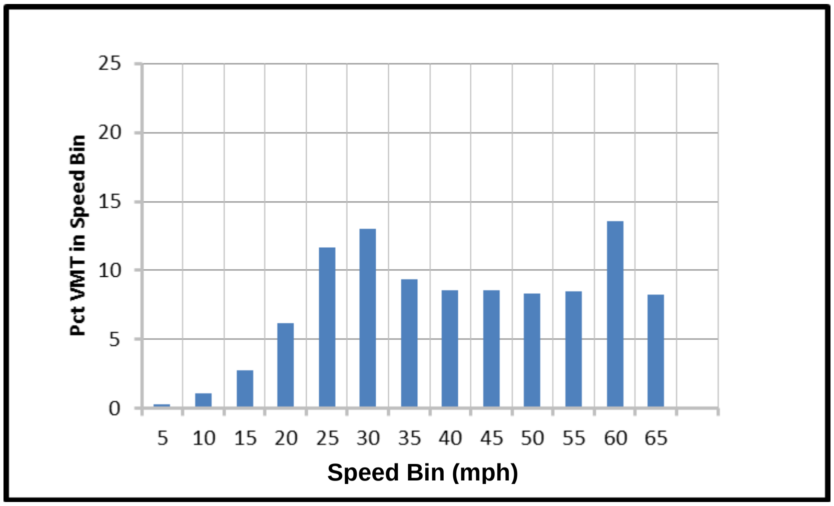


Figure 3.2-4 LHD1 Diesel CO_2 Emission Rate versus Speed

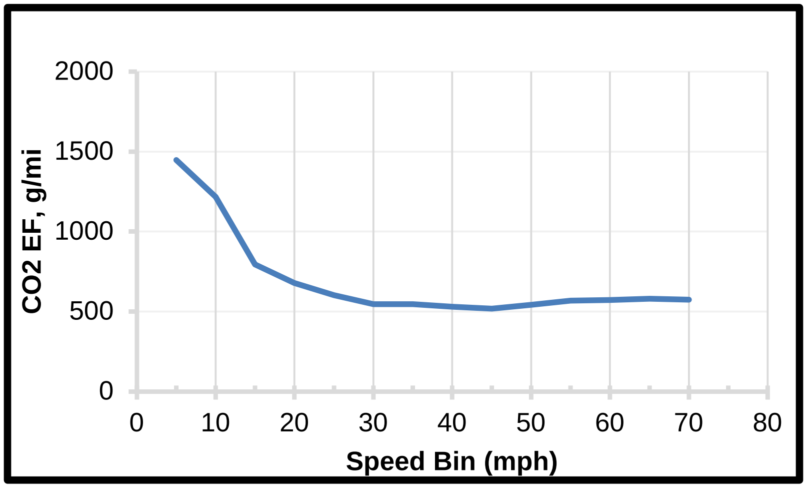


Figure 3.2-5 LHD1 Diesel CO_2 SCFs

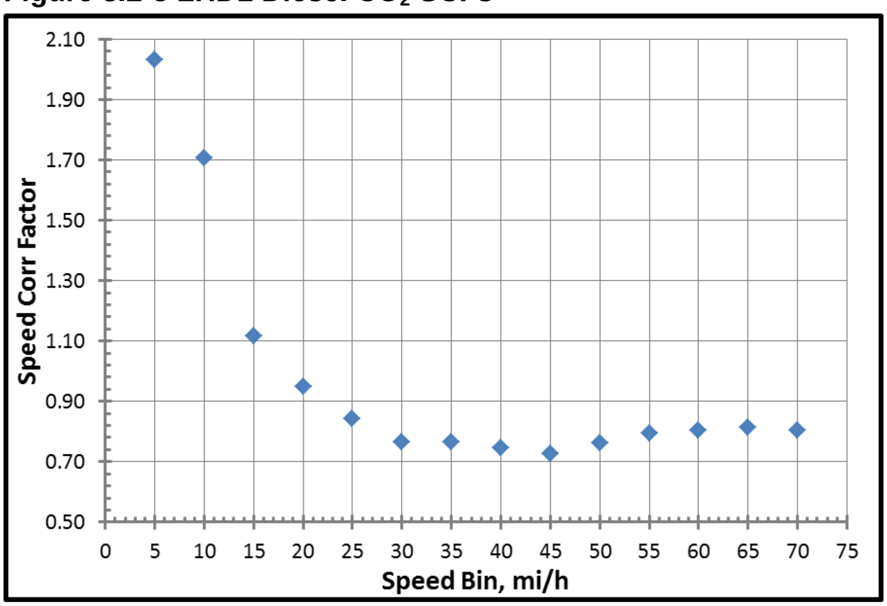


Figure 3.2-6 LHD1 Diesel LA County VMT Speed Distribution

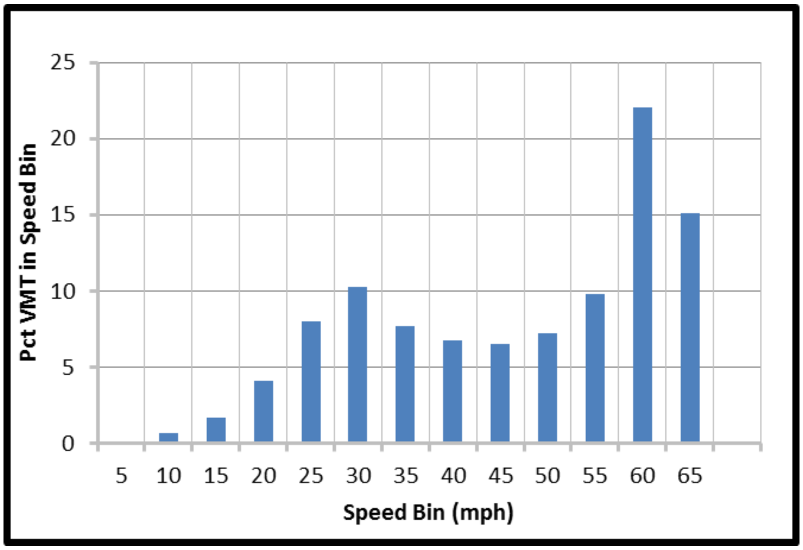


Table 3.2-1 LHD1 LA Emissions Estimation for 2025

Vehicle Class	LA Pop (rounded)	VMT (mi/day)	CO2 BER (g/mi)	Speed Aggregated ER (g/mi)	CO2 (tpd)	VMT Wtd SCF
LHD1 Gas	55,300	1,581,000	898	811	1324	0.90
LHD1 Diesel	58,500	2,097,000	678	576	1097	0.85

Notes: LHD1 are LHD trucks with 8500-10000 lbs. GVWR. TPD stands for tons per day.

In Table 3.2-1, the VMT-weighted SCF and average CO_2 emission rates are listed for gasoline and diesel LHD1s. For both fuels, real-world driving (at speeds above 16 mph) results in lower g/mi CO_2 emissions than at the 16 mph base speed, as the SCFs are less than one at those speeds.

3.2.2.1.1.2 LHD DIESEL NO_X BERS AND SCFS

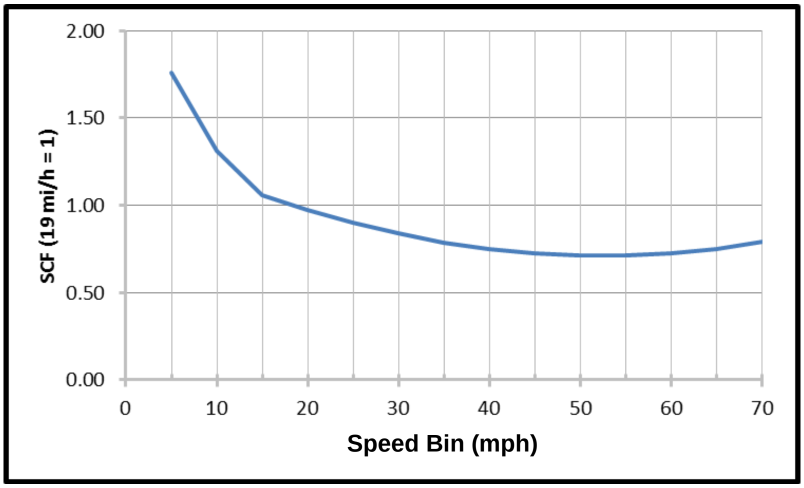
As with CO_2, no chassis-dynamometer emission test data were available that could be used to update the NOx SCFs and BERs for LHD1 and LHD2 trucks. In order to derive updated NOx BERs and SCFs for LHDs meeting the 2007+ EPA standards, it was assumed that the emission performance for HD trucks meeting these standards would be good surrogates. Under the EPA regulations, finalized in 2001,[13] 2007+ HD trucks had to meet a ten-fold NOx reduction from 2004 standards; for LHD Trucks, it was assumed they would also meet these requirements through incorporation of selective catalytic reduction (SCR) devices. Below, EMFAC2011 emissions and speed correction work are presented for HD trucks.

EMFAC2011 NOx SCFs for HD diesel trucks are shown in Figure 3.2-7. The SCF is 1.0 at 19 mph and then levels off to 0.71 at about 50 mph. As described in more detail in an EMFAC 2007 Technical Memo,[14] these SCFs were derived from the results obtained from testing diesel trucks meeting 2004 EPA standards (2.0 g/bhp-hr NOx) with enhanced exhaust gas recirculation (EGR).

Staff expects the diesel trucks that comply with the 0.2 g/bhp-hr NOx standard will use SCR. SCR eliminates almost all NOx emissions after engine operating temperatures warm up sufficiently (> 250 degree C). However, it is important to note that temperatures in the exhaust line can be low during warm up or at low speeds/loads, and under such conditions, the NOx emissions are greater.

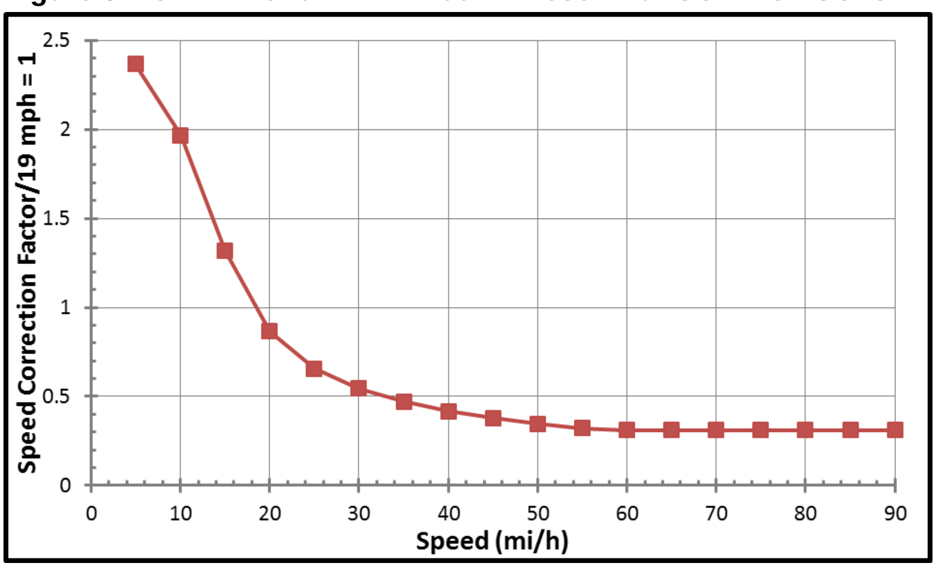
[13] 40 CFR Sect 86.007-11 (a)(1)(i) (2001), 13 CCR 1956.8 (a)(2)(a) (2002)
[14] Zhou, L. 2007. Modification of Heavy Heavy-Duty Diesel Truck Speed Correction Factors. EMFAC2007 Technical Memo.

Figure 3.2-7 NOx SCFs for HD Diesel 2003-2008 EGR Trucks



Most of the work and experimentation on SCR control devices has been conducted on HHD trucks. As there are no direct test data to use for LHD diesel trucks, the NOx SCFs, for diesel LHDs in EMFAC 2014, were chosen based on the SCR work on HD Diesels presented in section 3.2.3 of this document. The SCF curve is shown in Figure 3.2-8. It has a value of 1.0 at 19 mph and levels off to about 0.34 above 55 mph. As discussed above for Figure 3.2-7, for LHDs the SCFs were normalized such that the value of the SCF would be 1.0 at 16 mph, the average speed of FTP cycle's bag 2, rather than 19 mph, the average speed of the UDDS cycle. The SCR incorporation assumption on EMFAC2014 LHD NOx emission rate leads to the prediction that an LHD NOx emission rate, in a place like Los Angeles County, with a VMT-average speed of about 40 mph would be only 40% of the certification test value (the 16-mi/hr value).

Figure 3.2-8 EMFAC2014 LHD 2007+ Diesel with SCR NOx SCFs[15]



In accordance with this change in the SCFs, staff developed new BERs for 2007+ LHD1 diesel vehicles of 200 mg/mi for NOx and 140 mg/mi for ROG (roughly equivalent to the EPA 2007 standards of 200 mg/hp-h and 140 mg/hp-h). The previous LHD NOx BERs, from EMFAC 2011 and earlier versions, did not show compliance with the EPA 2007 standards. The updated LHD NOx BERs, in EMFAC2014 do show compliance with these standards.

[15] Based on HD SCR, presented in Section 3.2.3.

The BERs of LHD2 diesel vehicles were also set to 140 mg/mi for ROG and 200 mg/mi for NOx. For LHD2 gasoline, the BERs were chosen to make the weighted emissions about the same as for EMFAC 2011. Table 3.2-2 lists the resulting BERs and SCFs by speed for LHD1 and LHD2 trucks.

Note that in the actual application of SCFs to determine emission rates, there is only one value of each pollutant's SCF per speed bin. EMFAC2014's speed bins have a resolution of 5 mph since that is the resolution in which VMT are available from the cogs. The SCF used for all speeds within each speed bin is the SCF derived for the midpoint speed of the speed bin. For instance, the SCF used for all emissions determinations, within the 20 mph speed bin (15mph-20mph) is the SCF calculated at 17.5 mph.

Table 3.2-2 LHD1 and LHD2 Emission Rates and SCFs

Emissions Factor Type	2007+ LHD1 Diesel			2008+ LHD1 Gas			2007+ LHD2 Diesel			2008+ LHD2 Gas		
	ROG (mg/mi)	NO_X (mg/mi)	CO_2 (mg/mi)	ROG (mg/mi)	NO_X (mg/mi)	CO_2 (mg/mi)	ROG (mg/mi)	NO_X (mg/mi)	CO_2 (g/mi)	ROG (mg/mi)	NO_X (mg/mi)	CO_2 (g/mi)
Run BER	140	200	640	22	64	870	140	200	730	24	120	1015

Speed Bin (mph)	2007+ LHD1 Diesel			2008+ LHD1 Gas			2007+ LHD2 Diesel			2008+ LHD2 Gas		
	ROG	NO_X	CO_2	ROG	NO_X	CO_2	ROG	NO_X	CO_2	ROG	NO_X	CO_2
	SCFs											
5	4.78	2.37	2.26	3.03	1.40	1.74	4.78	2.37	2.09	3.03	1.40	1.64
10	3.58	1.97	1.90	1.91	1.22	1.71	3.58	1.97	1.86	1.91	1.22	1.70
15	1.75	1.32	1.24	1.27	1.08	1.19	1.75	1.32	1.24	1.27	1.08	1.19
20	0.68	0.86	1.06	0.89	0.97	1.03	0.68	0.86	1.06	0.89	0.97	1.05
25	0.41	0.66	0.94	0.65	0.88	0.95	0.41	0.66	0.94	0.65	0.88	0.95
30	0.31	0.55	0.85	0.51	0.82	0.86	0.31	0.55	0.85	0.51	0.82	0.85
35	0.24	0.47	0.85	0.42	0.77	0.86	0.24	0.47	0.85	0.42	0.77	0.85
40	0.20	0.42	0.83	0.36	0.74	0.86	0.20	0.42	0.82	0.36	0.74	0.84
45	0.17	0.38	0.81	0.33	0.71	0.85	0.17	0.38	0.79	0.33	0.71	0.82
50	0.15	0.35	0.85	0.32	0.71	0.90	0.15	0.35	0.82	0.32	0.71	0.85
55	0.13	0.32	0.89	0.33	0.71	0.95	0.13	0.32	0.84	0.33	0.71	0.89
60	0.12	0.31	0.90	0.35	0.72	0.96	0.12	0.31	0.85	0.35	0.72	0.90
65	0.12	0.31	0.91	0.40	0.75	0.97	0.12	0.31	0.85	0.40	0.75	0.91
70	0.12	0.31	0.90	0.43	0.77	0.96	0.12	0.31	0.84	0.43	0.77	0.89

3.2.2.1.2 UPDATES TO LD SCFS IN EMFAC2014

The SCFs used for LD vehicles, in EMFAC are generally based on a set of 12 cycles referred to as the Unified Correction Cycles (UCC's). The UCC's were designed to be representative of an average trip at a given speed. The mean speeds of the UCC's range from approximately 2.4 mph to 59.1 mph at 5 mph increments. The vehicles used in this analysis were selected from surveillance projects 2S95C1 and 2S97C1, conducted in 1995 and 1997 respectively, and the research projects 2R9513 and 2R9811, which were conducted in 1995 and 1998. The SCFs used in EMFAC were derived from three SCF curves developed based on UCC's for three engine technologies:

a) Carbureted (CARB)

b) Throttle Body Injection / CARB (TBI / CARB)

c) Multiport fuel injection

The equations used to generate the SCFs are second order polynomials for each pollutant / technology group and are normalized to the Unified Cycle (UC) Bag 2 average speed (27.4 mph). The A and B coefficients are listed in Table 3.2-3 by pollutant and technology group. In EMFAC, a technology group is a specific engine technology (such as those listed above) and may vary within a given vehicle class/fuel type/model year (MY) grouping.

$$\boldsymbol{SCF\ (Speed) = \exp\big(A \times (Speed - 27.4)\big) + B \times (Speed - 27.4)^2} \quad \textbf{(3.2.2.1-A)}$$

Since there were fewer SCF technology group equations than technology group designations, SCF equations needed to be mapped to the other technology groups. Staff mapped the available SCF curves[16] to the vehicle category/technology groups as shown in Table 3.2-4.

Table 3.2-3 SCF Coefficients by Pollutant and Technology Group

Pollutants	Technology Group	Technology Group Mapping	A Coefficient	B Coefficient
CO	CARB	1	-0.028971	0.001922
CO	FI	2	-0.016288	0.000054
CO	TBI	3	-0.020787	0.000292
CO_2	CARB	4	-0.025952	0.000309
CO_2	FI	5	-0.026423	0.000744
CO_2	TBI	6	-0.023750	0.001056
THC	CARB	7	-0.031762	0.000908
THC	FI	8	-0.044726	0.001070
THC	TBI	9	-0.036860	0.000664
NO_X	CARB	10	0.008967	-0.000027
NO_X	FI	11	-0.013763	0.000320
NO_X	TBI	12	-0.016610	0.000654

Note that these SCF equations are applicable to the 2.5 mph and 65 mph speed range.

Table 3.2-4 Updates to LD Vehicle SCF Curves

Vehicle Category	Gasoline	Diesel	
	All Model Years	Pre-2007	2007+ (SCR + DPF)[8]
LDA	Unchanged	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
LDT1	Unchanged	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
LDT2	Unchanged	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
MDV	Unchanged	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
LHD1	Use Gasoline SCF [1,2]	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
LHD2	Use Gasoline SCF [1,2]	Use Gasoline SCF [2,4]	Use 2010+ T7 Diesel SCF[5]
T6TS	Use Gasoline SCF [1,2]	T6 Diesel are no longer part of LDV Categories[7]	
T7IS	Use Gasoline SCF [1,2]	T7 Diesel are no longer part of LDV Categories[7]	
OBUS	Use Gasoline SCF [1,2]	OBUS Diesel are no longer part of LDV Categories[7]	
UBUS	Use Gasoline SCF [1,2]	Use T7 Diesel SCF [5,6]	
MCY	Use Gasoline SCF [1,3]	There are no Diesel MCY categories in EMFAC	
SBUS	Use Gasoline SCF [1,2]	SBUS Diesels are no longer part of LDV Categories[7]	
MH	Use Gasoline SCF [1,2]	Use T6 Diesel SCF [5,6]	

[1] Fuel delivery system is considered. Refer to Table 3.2-4 for gasoline SCFs by fuel delivery system.
[2] SCF curve is normalized to 16 mph (FTP Bag 2 average speed) rather than 27.4 mph.
[3] Motorcycle also use UC based emission rates.
[4] Fuel delivery system is assumed as "CARB".
[5] Used aggregated test data - refer to Section 3.2.3.4 for details on HD diesel SCFs.
[6] Model Year Range is considered.
[7] Refer to Section 3.2.3 for details on HD categories.
[8] SCR + DPF refers to selective catalytic reduction plus a diesel particulate filter.

3.2.2.1.3 REVISED TIRE WEAR AND BRAKE WEAR EMISSION RATES

The EMFAC model estimates the direct emissions of total PM for exhaust, tire wear, and brake wear. Since the MVEI7G version of the EMFAC model, ARB has been using the tire wear emissions rate from EPA's PART 5 model.[17] These EPA results used measurements and tire wear mass balance

[16] Refer to section 3.2.3.4 for details on HD diesel speed correction factors.
[17] U.S.EPA. 1995. A Draft User's Guide to PART 5: A Program for Calculating Particle Emissions from Motor Vehicles. EPA-AA-AQAB-94-2. United States Environmental Protection Agency Office of Mobile Sources. Ann Arbor MI. http://www.epa.gov/otaq/models/part5/part5uga.pdf

calculations to determine the emissions rate as 2 mg/mi per wheel.[18] A summary of the tire wear PM emission rates by vehicle type are provided in Table 3.2-5.

For brake wear, the MOBILE6 and earlier EPA model estimates were based on disc-brake cars with asbestos pads. ARB revised these values to account for new brake friction materials, wheel loads (vehicle weight per wheel or axle), and braking frequency and deceleration.[19] Also shown in Table 3.2-5 are the brake wear PM emission rates by vehicle type. Updates to the brake and tire wear emission factors were made in EMFAC2011 based upon published external research.[20] There were errors when staff made assignments for these updated tire and brake wear values in EMFAC2011. These errors corresponded to an underestimation of brake wear total PM by about 2 tpd (2014 statewide) and an underestimation of tire wear total PM of about 0.1 tpd (2014 statewide). The EMFAC2014 brake and tire wear emission factors are displayed in Table 3.2-5. For vehicle types for which there were errors in the emission factors used in EMFAC2011 the errors are indicated.

Table 3.2-5 EMFAC2014 Updated Tire Wear & Brake Wear PM Emission Rates

Exhaust Technology Groups	Vehicle Type	Corrected (EMFAC2014)	Errors (EMFAC2011)	Corrected (EMFAC2014)	Errors (EMFAC2011)
		Brake Wear PM (g/mi)		Tire Wear PM (g/mi)	
1-37	LDAs, LDT1s, LDT2s & MDVs Gas	0.0375		0.008	
40-43	LDAs (Mexican)	0.0375		0.008	
46-57	LHD1 Gas	0.078	0.0375	0.008	
60-71	LHD1 Diesel	0.078		0.012	
76-87	LHD2 Gas	0.091	0.0375	0.008	
90-101	LHD2 Diesel	0.091		0.012	
106-114	T6 Gas	0.133	0.0375	0.012	0.008
120-131	T6 & MH & OBUS Diesel	0.133		0.016	0.012
136-144	T7 Gas	0.063	0.0375	0.020	0.008
170-180	LDAs, LDTs, MDVs Diesel	0.0375	.034/.036	0.008	
216-225	Urban Buses Diesel	0.859		0.012	0.008
228-237	School Buses Gas	0.76	0.0375	0.008	
260-277	Motorcycles	0.012	0.0375	0.004	0.008

Notes: Technology groups reflect specific engine technology (varies by vehicle class/fuel/MY groups).
LHD1 are LHD trucks with 8500-10000 lbs. GVWR, LHD2 are LHD trucks with 10001-14000 lbs. GVWR. T6 are MHD trucks with 14001-33000 lbs. GVWR. MH are mobile homes. OBUS are other buses. T7 are HHD trucks with >33000 lbs. GVWR.

[18] Glover, E L and M Cumberworth. 2003 MOBILE 6.1 Particulate Emission Factor Model. Technical Description. M6.PM.001. EPA420 R-03-001. U. S. Environmental Protection Agency OTAQ, Washington D.C. http://www.epa.gov/otaq/models/mobile6/r03001.pdf

[19] ARB. 2011b. EMFAC 2011 Technical Documentation. Section 9. Appendix: Brake Wear Particulate Matter Emissions Update. California Air Resources Board. Sacramento, CA. http://www.arb.ca.gov/msei/emfac2011-technical-documentation-final-updated-0712-v03.pdf

[20] ARB. 2011b. EMFAC 2011 Technical Documentation. Section 9. Appendix: Brake Wear Particulate Matter Emissions Update. California Air Resources Board. Sacramento, CA. http://www.arb.ca.gov/msei/emfac2011-technical-documentation-final-updated-0712-v03.pdf

3.2.2.1.4 UPDATED LD DIESEL EMISSION RATES

3.2.2.1.4.1 BACKGROUND

The historical treatment of LD diesel vehicles in EMFAC is detailed in this background section. LD diesels followed the emissions standards of HD diesels until the Low Emission Vehicle II (LEVII)[21] program was implemented. Under LEVII, starting with MY2004 engines, trucks up to 8500 lbs. GVWR had to comply with the LDA standards, including diesel trucks. Each manufacturer had to utilize fleet mixture levels for each vehicle type in order to meet the requirements which are based on exhaust hydrocarbon emissions. LEV II created the SULEV category and significantly tightened NOx standards in the LEV and ULEV categories. Under LEV II, the LEVs and ULEVs have the same NOx standard requirements. By 2004, the diesel car engines could easily meet the LEV II HC standards, but required tailpipe control equipment to meet the NOx standards. The manufacturers complied with LEV II by stopping sales of LDV diesels in California. The EMFAC 2007 model therefore assumed no new sales of these vehicles were made after 2004.

Subsequently, with the approach of the EPA HD Diesel NOx standards (a ten-fold reduction from the 2004 standards) for 2008 to 2010 MY vehicles, and with the approach of European and US GHG standards, German auto manufacturers began to offer LEV II-compliant LD diesels with tailpipe control equipment (selective catalytic reduction or NOx storage catalysts) in 2007 or 2008. When LDV diesel sales in California started up again in 2008, 64 diesel LDAs and 83 diesel SUVs (6000-8500 lbs. GVWR) were sold. In the development of EMFAC 2011 which used 2009 California Department of Motor Vehicles (DMV) registration data, it was observed that 4215 diesel LDAs and 1372 diesel SUVs were sold in California. It was decided the sales projections and exhaust emissions technology groups for LD diesels complying with LEV and ULEV requirements would need to be revisited.

After EMFAC 2011 was completed, modeling began for the Advanced Clean Cars (ACC) regulation (refer to Sections 3.2.2.4 and 3.3.3.3). The LEV III[22] portion of this regulation required that the LD fleet reach a SULEV equivalent fleet average of 30 mg/mi NOx + NMOG ER by 2025. And, under LEV III, the standard must be met at 150,000 miles. EMFAC2014 has been updated to reflect the recent LD diesel compliance with the new LEV III provisions.

3.2.2.1.4.2 UPDATED LD DIESEL CERTIFICATION DATA

For EMFAC2011 a ratio-of-standards approach was used to estimate LD diesel emission rates. The approach was a means of dealing with having no data from chassis-dynamometer testing of LEV or ULEV diesels. The ratio-of-standards approach involved calculating new LD diesel emission rates by using the emission rates of older, uncontrolled diesel vehicles, and then multiplying the older emission rates by a ratio of the newer and older standards. For example, emission rates for ULEV diesels were calculated based on the emission rates of a LEV diesel category multiplied by the ratio of ULEV to LEV standard (NOx+ROG standard).

With regard to deterioration, in EMFAC2011, the variation in LD diesel emission rates with odometer mileage was derived from chassis-dynamometer test results on a gasoline advanced technology partial zero-emissions vehicle (AT PZEV).

In general, emission rates obtained from the “ratio-of-standards” approach do not agree with actual certification results, for which vehicles typically show over-compliance with the standards.

Table 3.2-6 shows certification executive order (EO) test results. The emission rates and deterioration rates (DR) used in EMFAC2014 for LD diesel vehicles are based upon these certification results rather than a ratio-of-standards approach. As a result the modeled emission

[21] http://www.arb.ca.gov/msprog/levprog/levii/levii.htm
[22] http://www.arb.ca.gov/msprog/levprog/leviii/leviii.htm

rates for LD diesel vehicles have decreased. There are five entries for the 2009 MY, one for the 2008 MY, and two for the 2010 MY. Results for both LEVs and ULEVs are shown and the NOx standards for LEVs and ULEVs are the same. Comparing the emission rates in Table 3.2-6 against the LD diesel standards in Table 3.2-7 shows that the LD diesel vehicles have test results for HC and CO that are far less than the emissions limits, and thus, these vehicles have no problem with HC or CO compliance. The test results for NOx were closer to, but still safely below, the standards.

Table 3.2-6 Certification EO Test Results for LD Diesel (Sample)

Certification Standard	EO No	Engine Family	At Odometer	HC (mg/mi)	NOx (mg/mi)	CO (mg/mi)
LEV	A-3-341	8MBXT03.0LEV (MY2008)		28	30	100
ULEV	A-3-358	9MBXT03.0U2A (MY2009)	@ 50 kmi	18	30	300
			@ 120 kmi	21		
ULEV	A-3-359	9MBXT03.0U2B (MY2009)	@ 50 kmi	14	40	200
			@ 120 kmi	17		
LEV	A-7-271	9VWXV02.035N (MY2009)	@ 50 kmi	7	40	200
			@ 120 kmi	12	50	400
ULEV	A-7-279	9VWXV02.0U5N (MY2009)	@ 50 kmi	9	30	300
			@ 120 kmi	14	40	500
LEV	A-8-248	9BMXT03.0M57 (MY2009)	@ 50 kmi	18	30	100
			@ 120 kmi	20		
ULEV	A-3-380	AMBXT03.042A (MY2010)	@ 50 kmi	9	20	100
			@ 120 kmi	13		200
ULEV	A-7-285	AVWXV02.0U5N (MY2010)	@ 50 kmi	10	40	300
			@ 120 kmi	15	50	500

Table 3.2-7 Standards for LD Diesel

Certification Standard	50/120 kmi HC (mg/mi)	50/120 kmi NOx (mg/mi)	50/120 kmi CO (mg/mi)
LEV	75/90	50/70	3400/4200
ULEV	40/55	50/70	1700/2100

Table 3.2-8 shows the averages of all of the certification test results for LEV and ULEV vehicles. The table includes the emission rates (ERs) at 50 kmi, and the increases in the emission rate due to deterioration after an additional 70 kmi has been added to the odometer.

Table 3.2-8 Summary of LDV Diesel Certification Test Results

Certification Standard	HC		NO_X		CO	
	ER@50 kmi (mg/mi)	Deterioration between 50 kmi and 120 kmi (mg/mi)	ER@50 kmi (mg/mi)	Deterioration between 50 kmi and 120 kmi (mg/mi)	ER@50 kmi (mg/mi)	Deterioration between 50 kmi and 120 kmi (mg/mi)
LEV	18	2.3	33	3	133	67
ULEV	12	4	32	4	240	100

Note: ER is emissions rate at 50,000 mi odometer.

For CO, the ULEV results were higher than for the LEVs; however, in both cases they were almost an order of magnitude less than the standards. Using the values in Table 3.2-8 for LEV (combined 120 kmi ROG+NOx = 160 mg/mi) staff estimated the diesel SULEV emissions (120 kmi THC+NOx = 30 mg/mi) by applying the "ratio-of-the-standards" approach. SULEVs (under LEV III) have to meet 150 kmi durability requirements. Estimated diesel SULEV emission rates are shown in Table 3.2-9.

The zero-mile emission rates (ZM) reflect when the vehicle is new and no deterioration has yet occurred. The DR reflects the change in emissions per unit change in odometer.

Table 3.2-9 Estimated Diesel SULEV Emission Rates

Emission Level	HC		NOx		CO	
	ZM (mg/mi)	DR (g/mi per 10 kmi)	ZM (mg/mi)	DR (g/mi per 10 kmi)	ZM (mg/mi)	DR (g/mi per 10 kmi)
SULEV	3	0.0003	6	0.0004	85	0.010

DR is deterioration rate vs. odometer.

3.2.2.1.4.3 UPDATED LDV DIESEL EMISSION RATES

The updated emission rates for LD diesels, used in EMFAC 2014, are shown in Table 3.2-10. The LEV and ULEV emission rates were obtained from certification data for diesel LD vehicles. In order to calculate ZM, the deterioration is subtracted from the emissions rate at 50 kmi (the rates are those shown in Table 3.2-8).

$$\mathbf{ZM} = \mathbf{ER}\ (@\mathbf{50\ kmi})\left(\frac{\mathbf{mg}}{\mathbf{mi}}\right) - \frac{\mathbf{50\ kmi}}{\mathbf{70\ kmi}} \times \mathbf{Deterioration}\ (\mathbf{between\ 50-120\ kmi})\left(\frac{\mathbf{mg}}{\mathbf{mi}}\right) \qquad \textbf{(3.2.2.1-B)}$$

SULEV emission rates were calculated, as described above, using LEV deterioration rates.

Table 3.2-10 Updated Diesel LDV Exhaust BERs

Emission Level	HC		NOx		CO	
	ZM (mg/mi)	DR (g/mi per 10 kmi)	ZM (mg/mi)	DR (g/mi per 10 kmi)	ZM (mg/mi)	DR (g/mi per 10 kmi)
LEV	16	0.0003	31	0.0004	85	0.010
ULEV	9	0.0006	29	0.0006	170	0.014
SULEV	3	0.0003	6	0.0004	85	0.010

3.2.2.2 NEW STATEWIDE LD ODOMETER SCHEDULE FOR DETERIORATION

In the EMFAC model, emission rates are a function of the cumulative mileage on the vehicle through an emissions process called deterioration. EMFAC2011 modeled odometer readings or lifetime mileage as a function of both mileage accrual rates and vehicle survival rates. As described later in 3.3.3, both mileage accrual rates and survival rates vary by region. Therefore, the resulting odometer readings used in EMFAC2011, after applying the regional mileage accrual and survival rates, could vary significantly between regions. As the annual mileage accrual rates vary over the lifetime of the vehicles due to changes in the economy and migration between regions, odometer readings are more specific to vehicle classes, rather than to regions. So for purposes of calculating deterioration of LD vehicles, a new statewide odometer schedule has been developed for use in EMFAC2014; regional mileage accrual rates are not used to calculate odometer values for deterioration.

Bureau of Automotive Repair (BAR) Smog Check Data was used to develop an average odometer reading per vehicle age by vehicle class, referred to as an “odometer schedule.” As only gasoline powered vehicles were included in the historical Smog Check program data, it had to be assumed that LD diesel and LD electric-powered vehicles would have the same statewide odometer schedules as gasoline powered vehicles of the same class. The following table lists the applicable vehicle classes included in the Smog Check data set used for this analysis.

Historical BAR Smog Check data for the calendar years (CY) of 2001 through 2011 were available for use in this analysis. This BAR data set included odometer readings that were recorded for 1976 to 2010 MY gas fueled vehicles. Mean odometer readings were computed for each MY by each vehicle age across the eleven CYs. MY2001 and older vehicles each had an average odometer reading computed across eleven ages (one for each CY). Newer MY vehicles had average odometer readings available for less than all of the eleven CYs (MY2010, for example, would only have odometer readings recorded in CY2010 and CY2011).

Table 3.2-11 Smog Check Vehicle Classes

Vehicle Class (also referred to as)	Weight Class
Passenger Cars (LDA or PC)	All
Light-Duty Trucks (LDT1 or T1)	GVWR < 6000 lbs. and ETW <= 3750 lbs.
Light-Duty Trucks (LDT2 or T2)	GVWR < 6000 lbs. and ETW 3751-5750 lbs.
Medium-Duty Trucks (MDV or T3)	GVWR 6000-8500 lbs.
Light-Heavy Duty Trucks (LHD1 or T4)	GVWR 8501-10,000 lbs.
Light-Heavy Duty Trucks (LHD2 or T5)	GVWR 10,001-14,000 lbs.
Motor Homes (MH)	All
GVWR = Gross Vehicle Weight Rating; ETW = Equivalent Test Weight	

After the mean odometer readings per vehicle age were calculated for each vehicle class, the individual MY averages per age were combined into a single data set. However, before proceeding with computing the odometer reading average per age for each vehicle class using this combined data set, adjustments were required. Errors in the odometer readings due to five-digit odometer displays had to be addressed. The majority of vehicles had five-digit displays into the 1990s with most MY1994 and later vehicles having six-digit displays.[23] Unadjusted, the rollover of five-digit odometers from 99,999 to 0 could lead to significant underestimations in the average odometer rates. The following figures demonstrate the level of discontinuity that can be seen in the odometer reading distributions due to this rollover issue. The details in these sample figures are not the primary concern; the differences between the data curves are the focus of this discussion. The top portion of Figure 3.2-9 shows skewed odometer distributions, due to rollover errors for MY1980 vehicles; whereas. In contrast, the bottom of Figure 3.2-9 shows normal odometer distributions curve for MY2000 vehicles, without rollover errors.

To avoid errors related to rollover, average odometer readings per age were computed from newer MY vehicles and then plotted to ensure discontinuities from the five-digit rollover (as seen in the oval section of Figure 3.2-10) were no longer present.

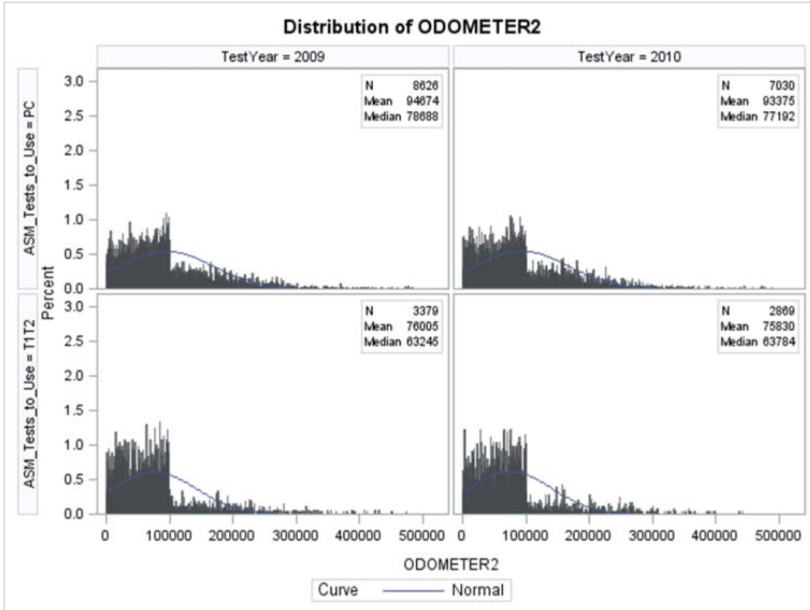
To incorporate average odometer readings for older vehicle ages, MY1977 odometer readings were adjusted to correct for the rollover issue by adding 100,000 to all odometer readings less than 100,000 and over 49,999 and by adding 200,000 to all odometer readings less than 50,000. The eleven CY ages of adjusted MY1977 odometer averages were incorporated into the plotted data, as shown in Figure 3.2-11. The MY1977 odometer readings across the available CYs showed similar results (odometer readings plateaued) indicating the maximum average odometer level to use into the future.

Regression curve formulas were computed at the statewide level, for the average odometer readings by vehicle age, for each vehicle class. Table 3.2-12 provides the results of this regression analysis with the statewide odometer schedule used in EMFAC2014 to compute deterioration (the grams per mile increase in emissions).

[23] Vincent Goh, Paul S. Fischbeck, and David Gerard. *Identifying and Correcting Errors with Odometer Readings from Inspection and Maintenance Data: Rollover Problem for Estimation of Emissions and Technical Change*, Transportation Research Record: Journal of the Transportation Research Board, No. 2011, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 87-97. DOI: 10.3141/2011-10.

Figure 3.2-9 Example Odometer Distributions

MY1980



MY2000

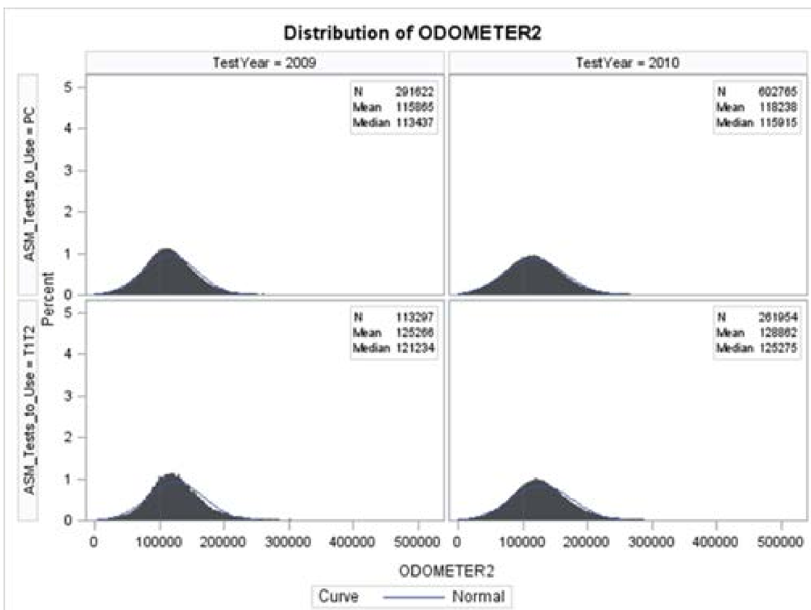


Figure 3.2-10 Odometer Readings versus Age

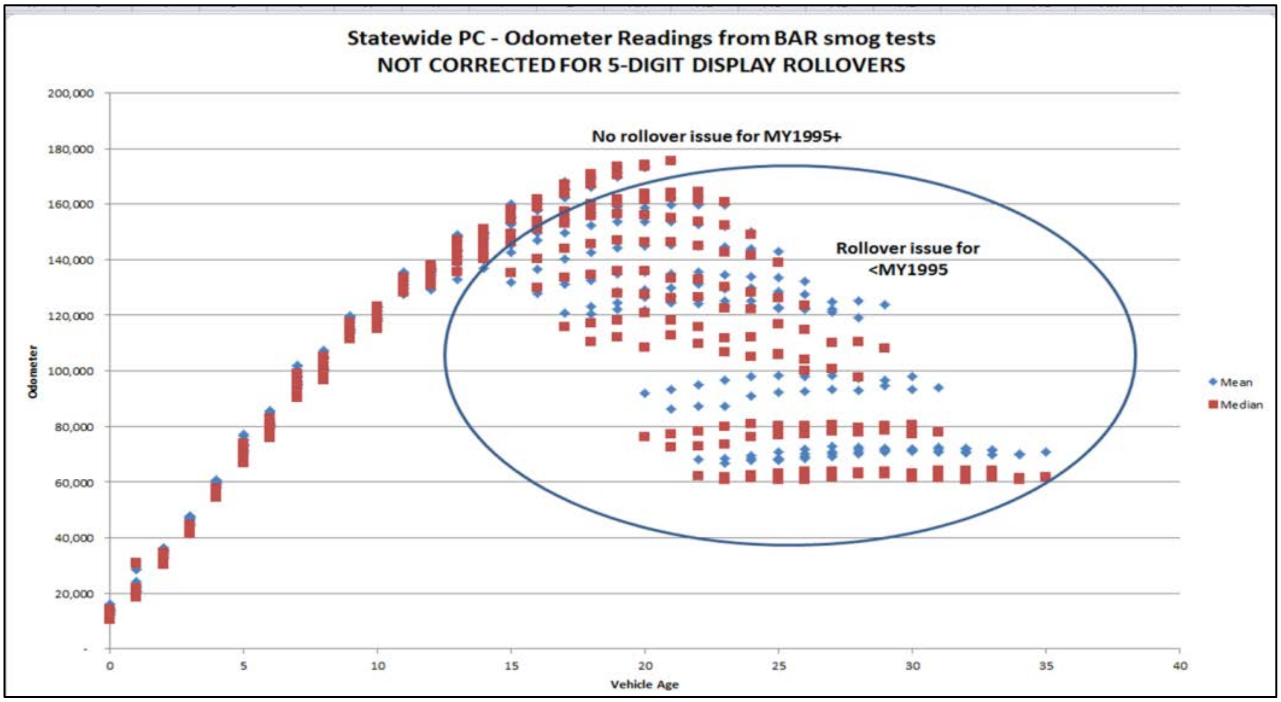


Figure 3.2-11 Sample Odometer Regression Curve

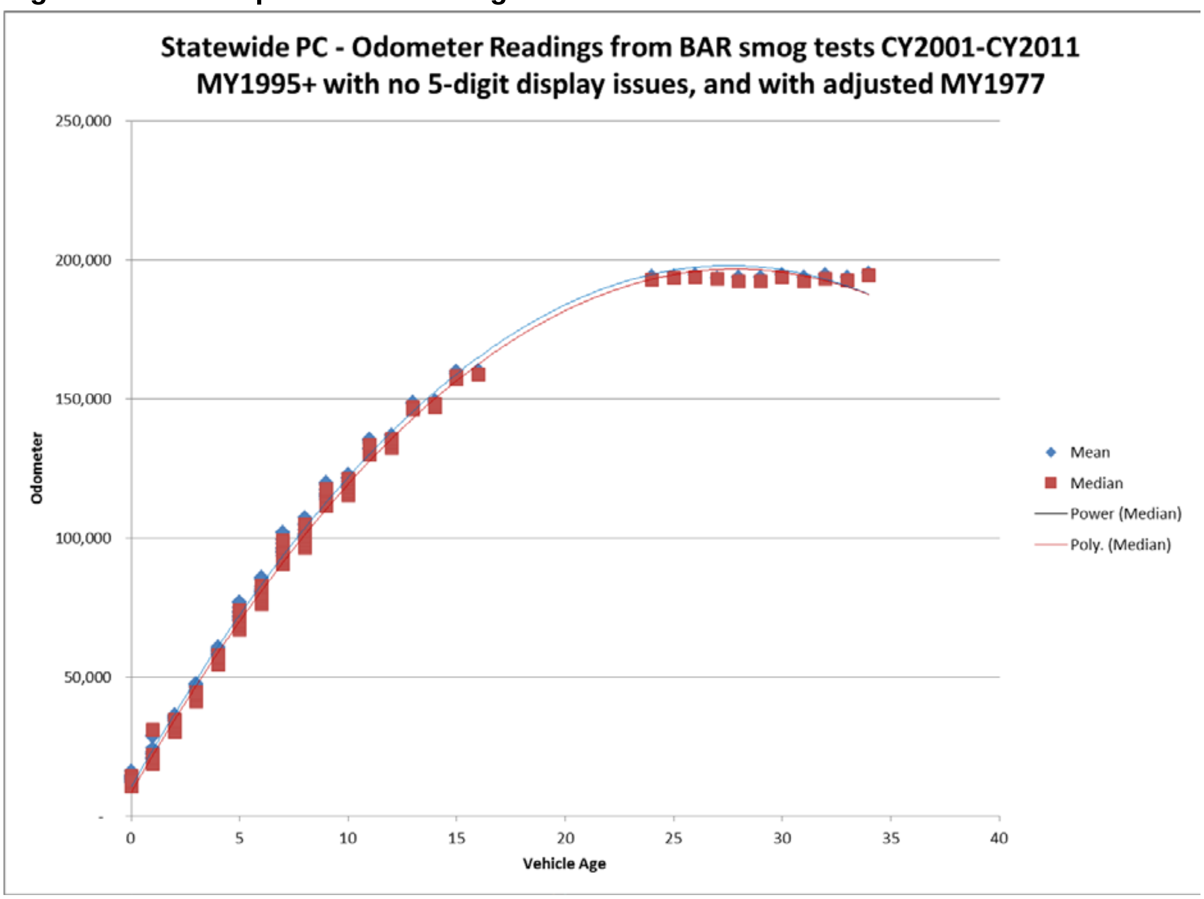


Table 3.2-12 Statewide Odometer Schedule for Deterioration

	ODOMETER BY VEHICLE CLASS GROUPINGS				
Age	PC	T1T2	T3	T4T5	MH
0	10,115	14,569	10,740	14,318	6,846
1	23,583	27,879	26,232	30,135	12,675
2	36,547	40,688	41,091	45,288	18,422
3	49,008	52,997	55,319	59,777	24,085
4	60,964	64,805	68,914	73,602	29,664
5	72,417	76,113	81,876	86,763	35,161
6	83,366	86,920	94,207	99,260	40,574
7	93,810	97,226	105,905	111,093	45,904
8	103,751	107,032	116,970	122,261	51,150
9	113,189	116,338	127,404	132,766	56,313
10	122,122	125,143	137,205	142,607	61,393
11	130,551	133,448	146,374	151,784	66,389
12	138,477	141,252	154,910	160,297	71,303
13	145,899	148,555	162,815	168,145	76,132
14	152,817	155,358	170,087	175,330	80,879
15	159,231	161,661	176,726	181,851	85,542
16	165,141	167,462	182,734	187,707	90,122
17	170,547	172,764	188,109	192,900	94,619
18	175,450	177,565	192,851	197,429	99,032
19	179,848	181,865	196,962	201,293	103,362
20	183,743	185,665	200,440	204,494	107,609
21	187,134	188,964	203,286	207,031	111,772
22	190,021	191,763	205,499	208,903	115,852
23	192,404	194,061	207,081	210,112	119,849
24	194,283	195,859	208,030	210,656	123,762
25	195,659	197,157	208,346	210,656	127,592
26	196,530	197,953	208,346	210,656	131,339
27	196,898	198,249	208,346	210,656	135,002
28	196,898	198,249	208,346	210,656	138,582
29	196,898	198,249	208,346	210,656	142,079
30	196,898	198,249	208,346	210,656	145,493
31	196,898	198,249	208,346	210,656	148,823
32	196,898	198,249	208,346	210,656	152,070
33	196,898	198,249	208,346	210,656	155,233
34	196,898	198,249	208,346	210,656	158,313
35	196,898	198,249	208,346	210,656	161,310
36	196,898	198,249	208,346	210,656	164,224
37	196,898	198,249	208,346	210,656	167,054
38	196,898	198,249	208,346	210,656	169,801
39	196,898	198,249	208,346	210,656	172,465
40	196,898	198,249	208,346	210,656	175,045
41	196,898	198,249	208,346	210,656	177,542
42	196,898	198,249	208,346	210,656	179,956
43	196,898	198,249	208,346	210,656	182,286
44	196,898	198,249	208,346	210,656	184,533

3.2.2.3 UPDATE TO SPECIATION METHODOLOGY

3.2.2.3.1 FACTORS FOR CONVERTING THC EMISSION RATES TO TOG/ROG/CH4

Using new data from speciation testing, EMFAC2014's methodology to estimate the emissions of TOG, ROG and CH4 has been updated. This section describes the factors used in determining the fraction of total hydrocarbons (THC) that are comprised of total organic gases (TOG), reactive organic gases (ROG) and methane (CH4). These factors are based on the speciation profiles developed by ARB for air quality modeling.[24]

Exhaust or evaporative emissions testing using the Federal Test Procedure (FTP) measures total hydrocarbon (THC) using a flame ionization detector (FID). The FID measures total hydrocarbons or compounds with hydrogen and carbon atoms only; carbonyls, and other oxygenated species are not included in THC. TOG includes all organic gases emitted to the atmosphere. ROG is the fraction of TOG that is reactive and does not include compounds that are exempt from regulations (e.g., methane, ethane, and acetone). The fraction of TOG that is either THC or ROG is determined by examination of the speciation profiles. These ARB speciation profiles (refer to above footnote) provide THC conversion factors that can be used to compute TOG and ROG from THC emission rates.

In EMFAC2014, there are three exhaust (running, idle, and start) and four evaporative (hot soak, running loss, resting, and diurnal loss) emissions processes associated with each vehicle category. Ideally, given sufficient speciation data, one could derive THC conversion factors that are vehicle class, emissions process and fuel dependent. However, data was only sufficient for the derivation of THC conversion factors for running, start, hot soak and diurnal processes, by different fuel types, and with/without catalytic converter for the gas fueled vehicles. For example, the THC to TOG conversion factors for running and idling exhaust emissions are assumed to be the same across all vehicle classes. The THC conversion factors used in EMFAC2014 to convert THC to TOG/ROG/CH4 for different emissions processes and fuel types are listed in Tables 3.2-13 through 3.2-15.

Table 3.2-13 THC Conversion Factors for Gasoline Exhaust Emissions in EMFAC2014

Calendar Year	Running and Idle Exhaust						Start Exhaust					
	GAS - CATALYST			GAS - NON-CATALYST			GAS - CATALYST			GAS - NON-CATALYST		
	TOG	ROG	CH4	TOG	ROG	CH4	TOG	ROG	CH4	TOG	ROG	CH4
2000	1.063	0.861	0.189	1.069	0.986	0.060	1.048	0.981	0.055	1.051	0.972	0.069
2001	1.063	0.858	0.192	1.069	0.986	0.060	1.048	0.981	0.055	1.051	0.972	0.069
2002	1.063	0.855	0.196	1.069	0.986	0.060	1.048	0.981	0.055	1.051	0.972	0.069
2003	1.063	0.852	0.199	1.069	0.986	0.060	1.048	0.981	0.055	1.051	0.972	0.069
2004+	1.083	0.742	0.300	1.072	0.986	0.061	1.044	0.953	0.071	1.050	0.968	0.070

Table 3.2-14 THC Conversion Factors for Diesel Exhaust Emissions in EMFAC2014

All Exhaust Processes		
DIESEL		
TOG	ROG	CH4
1.442	1.266	0.059

[24] http://www.arb.ca.gov/ei/speciate/speciate.htm

Table 3.2-15 THC Conversion Factors for Gasoline Evaporative Emissions in EMFAC2014

Calendar Year	Hot Soak and Running Loss		Diurnal and Resting Loss	
	TOG	ROG	TOG	ROG
2000-2003	1.0774	1.0728	1.0948	1.0948
2004-2009	1.0409	1.0409	1.0858	1.0858
2010+	1.0691	1.0691	1.0862	1.0862

3.2.2.3.2 FACTORS FOR CONVERTING PM EMISSION RATES TO PM10/PM2.5

On-road mobile source PM is an important contributor to the total PM emissions. For CY 2010, the statewide annual average PM2.5 emitted from on-road vehicles was 46 tons/day (based on EMFAC2011), which was 5% of the total statewide PM2.5 emissions. Therefore, from a total PM2.5 inventory perspective, it is very important to characterize PM emissions accurately. Exhaust PM emissions testing using the Federal Test Procedure (FTP) involves collecting a small sample of the vehicle's diluted exhaust on a filter media and weighing the filter before and after the test. The difference in the filter weight is the legal definition of PM emissions. The measured PM from this procedure is called PM30.

The size fractions, used in EMFAC2014, to convert PM30 emissions to PM10 and PM2.5 are based on the particle size fraction data developed by ARB for air quality modeling.[25] Table 3.2-16 shows the PM size fractions that are used in EMFAC2014 to convert PM emissions to PM10 and PM2.5.

Table 3.2-16 PM Size Fraction Profiles for Gasoline and Diesel Vehicles in EMFAC2014

Process	PM10			PM2.5		
	GAS - CAT	GAS - NCAT	DIESEL	GAS - CAT	GAS - NCAT	DIESEL
Running Exhaust	0.894	0.961	0.994	0.822	0.917	0.951
Idle Exhaust	0.894	0.961	0.994	0.822	0.917	0.951
Start Exhaust	0.894	0.961	0.994	0.822	0.917	0.951
Brake Wear	1	1	1	0.25	0.25	0.25
Tire Wear	0.98	0.98	0.98	0.42	0.42	0.42

3.2.2.4 ACC REGULATIONS

This section discusses emission rate updates made in EMFAC2014 related to the ACC regulations.[26]

3.2.2.4.1 SCALING FACTORS

Several new certification levels have been defined in the emissions inventory as potential compliance paths for manufacturers meeting the proposed standard or an accelerated scenario. The LEV III program created ULEV (ultra-low emissions vehicles) and SULEV (super ultra-low emissions vehicles) emissions levels in selected vehicle classes for which no testing data were available. To express these new technology groups in EMFAC2014, staff used a ratio-of-standards approach. A ratio-of-standards approach is a technique used to estimate emission rates where no test data are available. For example, if exhaust test data were available for ULEV 50 automobiles but not for SULEV 20 automobiles, UC emission rates in EMFAC for the ULEV 50 category would be multiplied by the ratio-of-standards, in this case 20 mg/mi for SULEV 20 divided by 50 mg/mi for

[25] http://www.arb.ca.gov/ei/speciate/speciate.htm
[26] http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm

ULEV 50, to estimate SULEV 20 emission rates. The technology groups and their emission rates are shown in Tables 3.2-17 through 3.2-19. Table 3.2-20 provides the ratio-of-standards that are used to calculate emission rates for new technology groups (as applied to the listed existing technology groups). More information can be found in the LEV III ISOR Appendix T.[27]

Table 3.2-17 Automobile and Light Truck Technology Groups, NMOG+NOx Emission Rates (FTP Composite)

Category	Emissions Level (mg/mi)
LEV	160
ULEV	125
ULEV 70	70
ULEV 50	50
SULEV	30
SULEV 20	20

Table 3.2-18 LHD-1 (LHD1) Technology Groups, NMOG+NOx Emission Rates (FTP Composite)

Category	Emissions Level (mg/mi)
LEV	395
ULEV	340
ULEV250	250
SULEV170	170

Table 3.2-19 Light Heavy Duty-2 (LHD2) Technology Groups, NMOG+NOx Emission Rates (FTP Composite)

Category	Emissions Level (mg/mi)
LEV	630
ULEV	570
ULEV400	400
SULEV230	230

Table 3.2-20 Standard Ratios for New Technology Groups

Vehicle Categories	New Technology Group	Certification Category	Existing Technology Group	NOx Ratios	PM Ratios	THC Ratios
Gasoline LDA-LDT	2015+, SULEV 20, OBD2	SULEV 20	Gasoline 2004+, PZEV, OBD2	0.667	NA	0.667
Gasoline LDA-LDT	2015+, ULEV 50, OBD2	ULEV 50	Gasoline 2004+, ULEV II, OBD2	0.400	NA	0.400
Gasoline LDA-LDT	2015+, ULEV 70, OBD2	ULEV 70	Gasoline 2004+, ULEV II, OBD2	0.560	NA	0.560
Gasoline LHD1	2016+ LEV III ULEV 250	ULEV 250	Gasoline 2008+, USEPA 2008 stds.	0.735	NA	0.735
Gasoline LHD1	2018+ LEV III SULEV 170	SULEV 170	Gasoline 2008+, USEPA 2008 stds.	0.500	NA	0.500
Diesel LHD1	2016+ LEV III ULEV 250	ULEV 250	Diesel 2007+, USEPA 2007 stds.	0.417	1.000	1.000
Diesel LHD1	2018+ LEV III SULEV 170	SULEV 170	Diesel 2007+, USEPA 2007 stds.	0.283	0.333	1.000
Gasoline LHD2	2016+ LEV III ULEV 400	ULEV 400	Gasoline 2008+, USEPA 2008 stds	0.735	NA	0.735
Gasoline LHD2	2018+ LEV III SULEV 230	SULEV 230	Gasoline 2008+, USEPA 2008 stds.	0.500	NA	0.500
Diesel LHD2	2016+ LEV III ULEV 400	ULEV 400	Diesel 2007+, USEPA 2007 stds.	0.417	1.000	1.000
Diesel LHD2	2018+ LEV III SULEV 230	SULEV 230	Diesel 2007+, USEPA 2007 stds.	0.283	0.500	1.000

[27] ARB. 2011a. LEV III Mobile Source Emissions Inventory. Appendix T to LEV III ISOR. California Air Resources Board, Sacramento, CA. http://www.arb.ca.gov/regact/2012/leviiighg2012/levappt.pdf

3.2.2.4.2 TECHNOLOGY PENETRATION RATES

The penetration rates for new ACC technologies are the same as those shown in tables 2-21 through 2-26 of the LEV III ISOR Appendix T.[28] More information is available in Section 2.7.B of the LEVIII ISOR Appendix T. They are reproduced here in Tables 3.2-21 to 3.2-26.

[28] ARB. 2011a. LEV III Mobile Source Emissions Inventory. Appendix T to LEV III ISOR. California Air Resources Board, Sacramento, CA. http://www.arb.ca.gov/regact/2012/leviiighg2012/levappt.pdf

Table 3.2-21 Technology Group Penetration Rates (LDA) for ACC LEV III

Technology Group:	Ev011	Ev015	Ev016	Ev017	Ex025	Ex028	Ex029	Ex031	Ex038	Ex039	Ex043	Ex044	Ex178	Ex179	Ex180
Model Year	Evaporative				Exhaust										
	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel
2010	0.005	0.784	0.001	0.21	0.001	0.05	0.738	0.21			0.001		0.25	0.75	
2011	0.019	0.771	0.001	0.21	0.001	0.05	0.738	0.21			0.001		0.25	0.75	
2012	0.011	0.777	0.002	0.21	0.01	0.05	0.732	0.207			0.001		0.25	0.75	
2013	0.013	0.775	0.002	0.21	0.01	0.05	0.73	0.209			0.001		0.25	0.75	
2014		0.788	0.002	0.21	0.01	0.05	0.729	0.21			0.001		0.25	0.75	
2015		0.781	0.009	0.21	0.019	0.05	0.632	0.217			0.001	0.081	0.25	0.75	
2016		0.78	0.01	0.21	0.021	0.03	0.504	0.217			0.001	0.228	0.25	0.75	
2017		0.78	0.01	0.21	0.021	0.03	0.378	0.217			0.001	0.354	0.25	0.75	
2018		0.399	0.016	0.585	0.039		0.25	0.244			0.001	0.466	0.25	0.75	
2019		0.4	0.032	0.568	0.06		0.137	0.251			0.001	0.551	0.25	0.75	
2020		0.201	0.047	0.752	0.079		0.02	0.257	0.05		0.001	0.592	0.25	0.75	
2021		0.2	0.061	0.739	0.097			0.265	0.05	0.282	0.001	0.305			1
2022			0.072	0.928	0.114			0.272	0.1	0.453	0.001	0.06			1
2023			0.084	0.916	0.13			0.402	0.1	0.317	0.001	0.05			1
2024			0.094	0.906	0.144			0.404	0.275	0.15	0.001	0.026			1
2025			0.102	0.898	0.157			0.56	0.282		0.001				1
2026			0.102	0.898	0.157			0.56	0.282		0.001				1
2027			0.102	0.898	0.157			0.56	0.282		0.001				1
2028			0.102	0.898	0.157			0.56	0.282		0.001				1
2029			0.102	0.898	0.157			0.56	0.282		0.001				1
2030			0.102	0.898	0.157			0.56	0.282		0.001				1
2031			0.102	0.898	0.157			0.56	0.282		0.001				1
2032			0.102	0.898	0.157			0.56	0.282		0.001				1
2033			0.102	0.898	0.157			0.56	0.282		0.001				1
2034			0.102	0.898	0.157			0.56	0.282		0.001				1
2035			0.102	0.898	0.157			0.56	0.282		0.001				1

Table 3.2-22 Technology Group Penetration Rates (LDT1) for ACC LEV III

Technology Group:	Ev035	Ev036	Ev037	Ex025	Ex028	Ex029	Ex031	Ex038	Ex039	Ex044	Ex178
Model year	Evaporative			Exhaust							
	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Diesel
2010	0.79	0	0.21		0.05	0.74	0.21				1
2011	0.79	0	0.21		0.05	0.74	0.21				1
2012	0.79	0	0.21		0.05	0.74	0.21				1
2013	0.79	0	0.21		0.05	0.74	0.21				1
2014	0.79	0	0.21		0.05	0.74	0.21				1
2015	0.79	0	0.21		0.03	0.691	0.21			0.069	1
2016	0.79	0	0.21		0.03	0.52	0.21			0.24	1
2017	0.79	0	0.21		0	0.44	0.21			0.35	1
2018	0.4	0	0.6		0	0.316	0.21			0.474	1
2019	0.4	0	0.6			0.197	0.21			0.593	1
2020	0.2	0	0.8			0.057	0.21	0.05		0.683	1
2021	0.2	0	0.8				0.21	0.05	0.19	0.55	1
2022			1				0.21	0.1	0.576	0.114	1
2023			1				0.389	0.1	0.511		1
2024			1				0.466	0.2	0.334		1
2025			1				0.8	0.2			1
2026			1				0.8	0.2			1
2027			1				0.8	0.2			1
2028			1				0.8	0.2			1
2029			1				0.8	0.2			1
2030			1				0.8	0.2			1
2031			1				0.8	0.2			1
2032			1				0.8	0.2			1
2033			1				0.8	0.2			1
2034			1				0.8	0.2			1
2035			1				0.8	0.2			1

Table 3.2-23 Technology Group Penetration Rates (LDT2) for ACC LEV III

Technology Group	Ev035	Ev036	Ev037	Ex025	Ex028	Ex029	Ex031	Ex038	Ex039	Ex044	Ex178
	Evaporative			Exhaust							
Model Year	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Diesel
2010	1	0			0.04	0.96					1
2011	1	0			0.04	0.96					1
2012	1	0			0.04	0.96					1
2013	1	0			0.04	0.96					1
2014	1	0			0.04	0.96					1
2015	1	0			0.05	0.812				0.138	1
2016	1	0			0.05	0.76				0.19	1
2017	1	0			0.05	0.529				0.421	1
2018	0.4	0	0.6		0.05	0.528				0.422	1
2019	0.4	0	0.6		0.05	0.423				0.527	1
2020	0.2	0	0.8		0.05	0.364				0.586	1
2021	0.2	0	0.8		0.04	0.241				0.719	1
2022			1		0.04	0.237			0.273	0.45	1
2023			1		0.04	0.05	0.16		0.3	0.45	1
2024			1		0.03		0.266		0.5	0.204	1
2025			1		0.02		0.724		0.256		1
2026			1		0.02		0.724		0.256		1
2027			1		0.02		0.724		0.256		1
2028			1		0.02		0.724		0.256		1
2029			1		0.02		0.724		0.256		1
2030			1		0.02		0.724		0.256		1
2031			1		0.02		0.724		0.256		1
2032			1		0.02		0.724		0.256		1
2033			1		0.02		0.724		0.256		1
2034			1		0.02		0.724		0.256		1
2035			1		0.02		0.724		0.256		1

Table 3.2-24 Technology Group Penetration Rates (MDV) for ACC LEV III

Technology Group	Ev035	Ev036	Ev038	Ex025	Ex028	Ex029	Ex031	Ex039	Ex044	Ex178	Ex179	Ex180
Model Year	Evaporative			Exhaust								
	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel
2010	1				0.15	0.85				0.25	0.75	
2011	1				0.15	0.85				0.25	0.75	
2012	1				0.15	0.85				0.25	0.75	
2013	1				0.15	0.85				0.25	0.75	
2014	1				0.15	0.85				0.25	0.75	
2015	1				0.051	0.81			0.138	0.25	0.75	
2016	1				0.051	0.758			0.191	0.25	0.75	
2017	1				0.051	0.528			0.421	0.25	0.75	
2018	0.4		0.6		0.051	0.527			0.422	0.25	0.75	
2019	0.4		0.6		0.051	0.423			0.526	0.25	0.75	
2020	0.2		0.8		0.051	0.364			0.584	0.25	0.75	
2021	0.2		0.8		0.04	0.241			0.719			1
2022			1		0.04	0.237		0.273	0.45			1
2023			1		0.04	0.05	0.16	0.3	0.45			1
2024			1		0.03		0.266	0.5	0.204			1
2025			1		0.02		0.724	0.256				1
2026			1		0.02		0.724	0.256				1
2027			1		0.02		0.724	0.256				1
2028			1		0.02		0.724	0.256				1
2029			1		0.02		0.724	0.256				1
2030			1		0.02		0.724	0.256				1
2031			1		0.02		0.724	0.256				1
2032			1		0.02		0.724	0.256				1
2033			1		0.02		0.724	0.256				1
2034			1		0.02		0.724	0.256				1
2035			1		0.02		0.724	0.256				1

Table 3.2-25 Technology Group Penetration Rates (LHD1) for ACC LEV III

Technology Group:	Ex054	Ex058	Ex059	Ex071	Ex073	Ex074
	Exhaust					
Model Year	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel
2010	1			1		
2011	1			1		
2012	1			1		
2013	1			1		
2014	1			1		
2015	1			1		
2016	0.8	0.2		0.801	0.199	0
2017	0.599	0.401		0.602	0.398	0
2018	0.401	0.5	0.099	0.398	0.5	0.102
2019	0.3	0.401	0.299	0.3	0.401	0.3
2020	0.2	0.301	0.499	0.199	0.301	0.5
2021	0.099	0.2	0.7	0.102	0.199	0.699
2022		0.1	0.9		0.101	0.899
2023		0.1	0.9		0.101	0.899
2024		0.1	0.9		0.101	0.899
2025		0.1	0.9		0.101	0.899
2026		0.1	0.9		0.101	0.899
2027		0.1	0.9		0.101	0.899
2028		0.1	0.9		0.101	0.899
2029		0.1	0.9		0.101	0.899
2030		0.1	0.9		0.101	0.899
2031		0.1	0.9		0.101	0.899
2032		0.1	0.9		0.101	0.899
2033		0.1	0.9		0.101	0.899
2034		0.1	0.9		0.101	0.899
2035		0.1	0.9		0.101	0.899

Table 3.2-26 Technology Group Penetration Rates (LHD2) for ACC LEV III

Technology Group:	Ex084	Ex086	Ex087	Ex101	Ex104	Ex105
	Exhaust					
Model Year	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel
2010	1			1		
2011	1			1		
2012	1			1		
2013	1			1		
2014	1			1		
2015	1			1		
2016	0.801	0.199		0.801	0.199	
2017	0.599	0.401		0.602	0.398	
2018	0.399	0.5	0.101	0.399	0.5	0.101
2019	0.3	0.401	0.3	0.3	0.4	0.3
2020	0.201	0.302	0.497	0.199	0.302	0.498
2021	0.101	0.201	0.698	0.101	0.199	0.699
2022		0.101	0.899		0.101	0.899
2023		0.101	0.899		0.101	0.899
2024		0.101	0.899		0.101	0.899
2025		0.101	0.899		0.101	0.899
2026		0.1	0.9		0.101	0.899
2027		0.1	0.9		0.101	0.899
2028		0.1	0.9		0.101	0.899
2029		0.1	0.9		0.101	0.899
2030		0.1	0.9		0.101	0.899
2031		0.1	0.9		0.101	0.899
2032		0.1	0.9		0.101	0.899
2033		0.1	0.9		0.101	0.899
2034		0.1	0.9		0.101	0.899
2035		0.1	0.9		0.101	0.899

3.2.2.4.3 GHG REDUCTION ASSUMPTIONS

EMFAC2011-LDV did not account for the benefits of the adopted Pavley Regulations. The EMFAC2014 model does account for the impact of these regulations by applying reduction factors on the CO_2 emission rates. The methodology used is provided below.

3.2.2.4.3.1 PAVLEY

The EMFAC2014 model accounts for the GHG emissions standards in future years that will reduce emissions as cleaner vehicles increase their penetration rates into the fleet. In order for manufacturers to meet the Federal Pavley (Pavley) standard, the fleet average fuel economy of vehicles sold in California should be in compliance with the GHG emissions standards imposed by the Pavley regulation. As a result of this, fleets have been provided with various options for compliance. The penetration of ZEV vehicles is one of many ways in which these standards may be met. Since EMFAC2014 calculates the gasoline and electric VMT separately, staff was able to calculate the GHG benefits for the new fuel economy standards solely for gasoline vehicles apart from the tailpipe emissions benefits of the ZEV program.

The GHG standards are listed in table 3.2-27. By 2025, a 51% reduction in CO_2 emissions (from the baseline emissions) is required for passenger cars.[29] The ZEV program requires specified penetration rates for equivalent electric (no tailpipe emissions) vehicles per year. Thus, the required CO_2 emission rates standards for conventional gasoline can be calculated as:

$$\textbf{Conventional Gasoline CO2 ER}\left(\frac{\mathbf{g}}{\mathbf{mi}}\right) = \frac{\textbf{Fleet Avg Std.} - \%\textbf{ZEV} \times \textbf{ZEV CO}_2\textbf{e}\left(\frac{\mathbf{g}}{\mathbf{mi}}\right)}{1 - \%\textbf{ZEV}} \qquad \textbf{(3.2.2.4-A)}$$

Using these estimated conventional gasoline CO_2 emission rates, staff estimated the percentage of reductions that would need to be applied to gasoline vehicle CO_2 emission rates in the EMFAC2014 model to reflect the impact of these fuel economy standards. These percentage reductions are listed in Table 3.2-27.

[29] Refer to table ES-3 of LEV III ISOR. http://www.arb.ca.gov/regact/2012/leviiighg2012/levisor.pdf

Table 3.2-27 Reductions of Passenger Car CO_2 Emission Rates in EMFAC2014 for Pavley

Model Year	ZEV (gCO2e/mi)	%ZEV Penetration (*See Section 3.3.3.3 for more details*)	Fleet Average CO2 ER (Required by Pavley I and ACC)	Gasoline PC CO2 ER (gCO2/mi)	% Reduction from Baseline
2008	51.6	0.00%	291	291	0%
2012	51.6	0.95%	263	265	9%
2013	51.6	0.97%	256	258	11%
2014	51.6	0.98%	248	249.9	14%
2015	51.6	1.94%	236	239.6	18%
2016	51.6	2.05%	226	229.7	21%
2017	51.6	2.06%	213	216.4	26%
2018	51.6	3.91%	203	209.2	28%
2019	47.3	5.97%	192	201.2	31%
2020	46.4	7.87%	183	194.7	33%
2021	46.2	9.75%	173	186.7	36%
2022	46.8	11.36%	165	180.1	38%
2023	47.2	12.98%	158	174.5	40%
2024	48	14.43%	151	168.4	42%
2025	49.3	15.71%	144	161.6	44%

Since EMFAC2014 assumes that all of the ZEV penetration occurs at the passenger car level, the percentage reduction in light truck (<=8500 lbs. GVWR) CO_2 emission rates, were directly calculated from the fleet average fuel economy standards as is shown in Table 3.2-28.

Table 3.2-28 GHG Standards for New Light Trucks Sold in California

Model Year	Fleet Average CO_2 ER Standards for Light Truck (gCO_2/mi)	% Reduction from Baseline
2008	396	0%
2012	340	14%
2013	330	17%
2014	321	19%
2015	306	23%
2016	292	26%
2017	290	27%
2018	280	29%
2019	273	31%
2020	264	33%
2021	245	38%
2022	233	41%
2023	221	44%
2024	210	47%
2025	200	49%

3.2.2.4.4 PM EMISSION RATE REDUCTIONS

The text in this section is based on text originally presented in the LEVIII Initial Statement of Reasons (ISOR)[30] document. The LEV II standard for PM for LD vehicles is 10 mg/mile. This standard was adopted primarily to provide an upper limit on PM emissions from LD vehicles since test data from

[30] ARB 2011a, LEV III ISOR, http://www.arb.ca.gov/regact/2012/leviiighg2012/levisor.pdf

typical gasoline vehicles at that time showed PM emission levels on the order of 1 to 2 mg/mile. Diesel vehicles meeting this standard were expected to employ particulate filters. This action also aligned California's PM requirements with the federal Tier 2 program.

Since then, California and federal emission requirements to reduce GHG emissions have fostered development of advanced internal combustion technology such as gasoline direct injection engines (GDI). Unlike conventional internal combustion engines using port fuel injection (PFI) where fuel is injected and mixed with air in the intake manifold prior to entering the combustion chamber, as the name implies, GDI engines inject fuel directly into the combustion chamber. Among other advantages, this provides a cooling effect on the air/fuel mixture, allowing for higher compression ratios and, therefore, improved engine efficiency and lower CO_2 emissions.

While test data from early versions of GDI engines have demonstrated compliance with the current 10 mg/mile PM emission standard, some vehicles have tested at measured PM emission levels of up to 8 mg/mile, significantly higher than comparable vehicles with PFI engines that typically test at PM levels at 1 mg/mile. However, later versions of GDI engines have tested at PM levels approaching 1 mg/mile, indicating that significant improvements in PM emissions from GDI engines are achievable.

In order to prevent PM emissions, from passenger vehicles, from increasing with the increasing rate due to incorporation of GDI technologies, LEVIII included new lower PM standards; these rules are applicable to passenger vehicles and light trucks. The LEVIII PM regulations require a phase-in of vehicles meeting a 3 mg/mi PM standard, commencing in 2017, and a phase-in of vehicles meeting a 1 mg/mi PM standard beginning in 2025. To account for the new rules on PM in EMFAC2014, staff has updated future passenger vehicle PM emission factors, from passenger vehicles. These changes reflect the LEVIII PM standard phase-in requirements shown in Table 3.2-29. The phase-in requirements represent the minimum percent of a manufacturer's vehicle sales, in each MY that must comply with the updated LEVIII PM standard.

Table 3.2-29 LEV III Particulate Emission Standard Phase-in for Passenger Cars, LD Trucks, and Medium Duty (MD) Passenger Vehicles

Model Year	% of vehicles certified to a:	
	3 mg/mi standard	1 mg/mi standard
2017	10	0
2018	20	0
2019	40	0
2020	70	0
2021	100	0
2022	100	0
2023	100	0
2024	100	0
2025	75	25
2026	50	50
2027	25	75
2028+	0	100

Due to a lack of data on PM emission rates for vehicles with GDI engines during the inventory development process for ACC,[31] it was decided that gasoline exhaust PM emission rates from the Kansas City Study[32] would be used for GDI vehicles; that is, until 3 mg/mi is required. However, EMFAC2014 does not currently have the capability to differentiate vehicles with GDI or PFI injection systems. Therefore, staff developed fleet average reduction factors (by MY) to reflect the impact of

[31] ARB 2011b. LEV III Mobile Source Emissions Inventory. Appendix T to LEV III ISOR. California Air Resources Board, Sacramento, CA. http://www.arb.ca.gov/regact/2012/leviiighg2012/levappt.pdf

[32] Kansas City PM Characterization Study, EPA420-R-08-009, April 2008

3 mg/mi and 1 mg/mi standards on fleet average PM emission rates in EMFAC2014. In order to develop these reduction factors, a compliance path was assumed for the manufacturers to meet the PM standards. This compliance assumption is shown in Table 3.2-30.

It is assumed that the FTP composite PM emission rates are 0.5 mg/mi for PFI vehicles (based on tests conducted at ARB's laboratory facility[33]), 4 mg/mi for early GDI vehicles, 3 mg/mi for "3 mg/mi GDI certified" vehicles, and 1 mg/mi for "1 mg/mi GDI certified" vehicles. Based on the fleet average PM emission values (by MY) calculated for both a baseline and an ACC scenario, staff estimated reduction factors that would need to be applied to gasoline vehicle PM emission rates in the EMFAC2014 model to reflect the impact of LEVIII PM standards. These reduction factors are shown in Table 3.2-31. It needs to be noted that these reduction factors are applied on both UC Bag 1 and UC Bag 2[34] emission rates as:

$$\mathbf{ACC\ PM\ Emission\ Rate\ (Model\ Year, UC\ Bag\ 1\ or\ 2) =}$$

$$\mathbf{Baseline\ PM\ Emission\ Rate\ (Model\ Year, UC\ Bag1\ or\ 2) \times\ Reduction\ Factor\ (Model\ Year)} \quad \textbf{(3.2.2.4-B)}$$

Table 3.2-30 Assumed Compliance Path for LEV III Particulate Emission Standard

Model Year	% of vehicles sold as:			
	0.5 mg/mi PFI	4 mg/mi GDI	3 mg/mi GDI	1 mg/mi GDI
2016	40%	60%	0%	0%
2017	35%	65%	0%	0%
2018	32%	68%	0%	0%
2019	30%	60%	10%	0%
2020	30%	30%	40%	0%
2021	30%	0%	70%	0%
2022	30%	0%	70%	0%
2023	30%	0%	70%	0%
2024	30%	0%	70%	0%
2025	30%	0%	70%	0%
2026	30%	0%	50%	20%
2027	30%	0%	25%	45%
2028	30%	0%	0%	70%
2029	30%	0%	0%	70%
2030	30%	0%	0%	70%
2031	30%	0%	0%	70%

[33] ARB 2011. EMFAC 2011 Technical Documentation. Section 10. Appendix Gasoline PM Emission Factor Updates. California Air Resources Board. Sacramento, CA. http://www.arb.ca.gov/msei/emfac2011-technical-documentation-final-updated-0712-v03.pdf

[34] FTP and UC cycles consist of three bags representing three operating modes: a cold start (bag 1), a hot stabilized period (bag 2), and a hot start (bag 3); *Code of Federal Regulations*, 40, § 86.137-90, § 86.137-94.

Table 3.2-31 Reduction Factors for LD Vehicle PM Emission Rates in EMFAC2014

Model Year	Baseline FTP Composite (mg/mi)	Reduction Factors in EMFAC2014	Assumed ACC Compliance FTP Composite (mg/mi)
2007	0.5	No Reduction Required	0.5
2008	0.5		0.5
2009	0.6		0.6
2010	0.6		0.6
2011	0.8		0.8
2012	1.0		1.0
2013	1.4		1.4
2014	1.9		1.9
2015	2.3		2.3
2016	2.6		2.6
2017	2.8		2.8
2018	2.9		2.9
2019	3.0	0.97	2.9
2020	3.0	0.86	2.6
2021	3.0	0.76	2.3
2022	3.0	0.76	2.3
2023	3.0	0.76	2.3
2024	3.0	0.76	2.3
2025	3.0	0.76	2.3
2026	3.0	0.63	1.9
2027	3.0	0.46	1.4
2028	3.0	0.29	0.9
2029	3.0	0.29	0.9
2030	3.0	0.29	0.9
2031	3.0	0.29	0.9

3.2.3 UPDATES TO EMISSION RATES FOR HD VEHICLES

This section discusses EMFAC2014 emission rate updates that have been made for diesel and natural gas HD vehicles. Updates for gasoline fueled HD vehicles are discussed in Section 3.2.2.

In EMFAC2011, emission rates (ERs) for diesel heavy duty trucks (HDTs) were primarily based on emissions data collected from the Coordinating Research Council (CRC) E55/59 testing project,[35] in which more than 70 diesel HDTs were tested on a dynamometer. The speed correction factors (SCFs) for diesel HDTs, in EMFAC2011, were also based on the CRC E55/59 data. However, in the CRC E55/59 project, the newest engines tested were 2003 MY, which were used to represent 2003-2006 MYs engines. The ERs and SCFs for 2007+ MY engines were projected from those tested 2003 MY engines.[36] For EMFAC2014 updates, as discussed below, more current test data had become available.

In EMFAC2011, it was assumed that start emissions for diesel HDTs were negligible. Recent emissions testing, however, has revealed that there are excessive NOx emissions during the short

[35] "Heavy-Duty Vehicle Chassis Dynamometer Testing for Emissions Testing, Air Quality Modeling, Source Apportionment, and Air Toxics Emissions Inventory", http://www.crcao.org/publications/emissions/index.html

[36] A detailed description can be found in: Air Resources Board, 2006. *EMFAC Modeling Change Technical Memo: Revision of Heavy Heavy Duty Diesel Truck Emission Factors and Speed Correction Factors*. Available at: http://www.arb.ca.gov/msei/onroad/techmemo/revised_hhddt_emission_factors_and_speed_corr_factors.pdf

period of time following engine start for trucks equipped with Selective Catalytic Reduction (SCR) NOx emissions reduction systems. Thus, it was necessary to account for the start NOx emissions in the EMFAC2014 updates.

Additionally, EMFAC2011 did not separate out emissions for natural gas vehicles. Instead, the natural gas vehicle population was included with the diesel fueled vehicles as there was a lack of natural gas emissions data and these engines were certified to the same standards. However, the population of natural gas heavy duty vehicles (HDVs) has been continuously increasing over the last decade. In several air quality management districts (such as SCAQMD), urban buses and solid waste collection vehicle (SWCV) trucks are primarily fueled by natural gas at the time of this analysis. For EMFAC2014 updates, it was necessary to review how to best model the natural gas vehicle population.

In the last several years, emissions testing data from diesel HDTs and natural gas HDVs have become available from a number of sources. This provided ARB with an opportunity to calculate updated emission rates and SCFs for these HDT and HDV categories for use in EMFAC2014. Two HDT testing projects had recently been carried out by ARB. In the first, Project 2R1110, four trucks were tested at ARB's Depot Park Facility using Portable Emissions Measurement System (PEMS). In the second, Project 2R12PTSD, five trucks were tested on a chassis-dynamometer in ARB's Heavy Duty Emissions Testing Laboratory, as well as using a PEMS at Depot Park. In addition, emissions test data for three diesel trucks, one CNG bus, three diesel refuse trucks, and four LNG refuse truck were obtained from SCAQMD. For CNG buses, emissions data from earlier MYs were also compiled from published reports and journal articles. More detail on these studies will be provided in the sections below.

The emissions data from ARB's 2R12PTSD project and from SCAQMD's work were used in revising the emission rates and SCFs for 2007 and newer MYs for EMFAC2014. The data from the PEMS testing, in both ARB projects, were used to develop NOx start ERs for the 2010 and newer MY diesel heavy heavy-duty (HHD) trucks with SCR systems. The natural gas vehicle test data from SCAQMD and from the published emissions results were used to develop emission rates for natural gas urban buses and refuse trucks.

3.2.3.1 EMISSIONS TESTING

3.2.3.1.1 DYNAMOMETER TESTING OF DIESEL HD TRUCKS FOR 2007-2010 MODEL YEAR ENGINES

In order to develop ERs, five diesel HHD trucks, of MYs 2007 to 2010, were tested on a dynamometer in ARB's HD Laboratory in Project 2R12PTSD. Information about these vehicles is shown in Table 3.2-32.

Table 3.2-32 Test Vehicles for Project 2R12PTSD Dynamometer Testing

Vehicle	Engine	Odometer (mile)	Emissions Control	NOx Cert Std (g/bhp-hr)
2007 Kenworth	2007 Cummins	390,000	EGR, DPF	2.2
2008 Freightliner	2007 DDC	10,700	EGR, DPF	1.2
2011 International	2010 Navistar	70,000	EGR, DPF	0.5
2010 Kenworth	2010 Cummins	13,500	SCR, DPF	0.35
2011 Volvo	2010 Volvo	68,000	SCR, DPF	0.2

All five vehicles were tested over the Urban Dynamometer Driving Schedule (UDDS) cycle. In addition, all vehicles were tested over the Idle, Creep, Transient, and Cruise modes of the ARB 4-Mode Cycle.[37] Each mode characterizes a unique driving phase of a typical truck trip. An additional higher speed

[37] www.dieselnet.com/standards/cycles/hhddt.php

mode, the High Speed Cruise mode, was also used to obtain ERs at 50 mph. Table 3.2-33 lists the parameters of the UDDS, ARB 4-Mode Cycle, and the High Speed Cruise mode.

The UDDS and three of the four modes of the 4-Mode Cycle (excluding the Cruise mode) were repeated two to ten times. Emissions data were collected for all test runs. This ensured that a representative amount of PM accumulated on the DPFs (diesel particulate filters). The test parameters are shown in Table 3.2-33. Results for the individual tests can be found in Appendix 6.2 (Table 6.2-A).

Table 3.2-33 UDDS, ARB 4-Mode Cycle, and High Speed Cruise Mode Parameters

Test Cycle / Mode	Average Speed	Duration (seconds)	Length (miles)	Number of Repeats
UDDS	18.8	1063	5.55	3
Idle	0	600	N/A	3
Creep	1.8	253	0.12	10
Transient	15.4	668	2.85	4
Cruise	39.9	2,083	23.1	1
High Speed Cruise	50.2	757	10.5	2

Emissions test data for three additional diesel HHDTs were obtained from SCAQMD. Vehicle information for these three trucks is shown in Table 3.2-34 and the UDDS emissions results are listed in Appendix 6.2 (Table 6.2-B).

Table 3.2-34 SCAQMD Tested Diesel HD Trucks

Vehicle MY	Engine	Odometer (mile)	Emissions Control	NOx Cert Std (g/bhp-hr)
2010	2009 Navistar	80,400	EGR, DPF	1.2
2011	2011 Navistar	67,300	EGR, DPF	0.5
2011	2011 Mack	36,900	SCR, DPF	0.2

3.2.3.1.2 PEMS TESTING OF DIESEL HD TRUCKS WITH MY2010 ENGINES

In ARB's Project 2R1110, three 2010 MY HDDTs with SCR systems were tested using a PEMS to measure the gaseous pollutant emissions. As mentioned earlier, these data were used to develop NOx start ERs. In addition, a fourth truck equipped with only an EGR system was also tested for comparison purposes. Information on the four test vehicles is summarized in Table 3.2-35. In Project 2R12PTSD, two of the three SCR trucks from Project 2R1110 (2010 Cummins and 2010 Volvo engines) were tested again.

Table 3.2-35 Test Vehicles for Project 2R1110 PEMS Testing

Vehicle	Engine	Odometer (mi)	Emissions Control	NOx Cert Std (g/bhp-h)
2011 International	2010 Navistar	70,000	EGR, DPF	0.5
2010 Kenworth	2010 Cummins	13,500	SCR, DPF	0.35
2010 Freightliner	2010 DDC*	23,000	SCR, DPF	0.2
2011 Volvo	2010 Volvo	68,000	SCR, DPF	0.2

*DDC stands for Detroit Diesel Corporation

In Project 2R1110, PEMS testing was conducted over two prescribed routes in the Sacramento area: one between Depot Park and Placerville and the other between Depot Park and West Sacramento. In Project 2R12PTSD, PEMS tests were conducted only over the Depot Park-West Sacramento route. For each test route, a truck was tested three times at three different vehicle loads: high load at 90%

GVWR, medium load at 70% GVWR, and no load with an empty trailer. For each of the three loads, a truck was tested once in the morning and once in the afternoon, with a rest between the two lasting from 80 to 120 minutes. Each of these tests consisted of an outbound run (starting from Depot Park) and an inbound run (to Depot Park), with a break of approximately 30 minutes between the two runs.[38]

3.2.3.1.3 EMISSIONS TEST DATA OF LNG AND DIESEL SWCV TRUCKS AND CNG UBUS

Test data for three diesel refuse (SWCV) trucks, four LNG refuse trucks, and one CNG urban bus were provided by SCAQMD for use in ER development. Vehicle information on these test vehicles is shown in Table 3.2-36 and the emissions test results are provided in Appendix 6.2 (Table 6.2-C).

Table 3.2-36 SCAQMD Tested CNG Bus and Refuse Trucks

Vehicle	Engine	Fuel	Test Cycle	Emissions Control	NOx Cert Std (g/bhp-h)
Refuse Truck	2004 Cummins	DSL	RTC+C3	EGR	2.4
Refuse Truck	2011 Navistar	DSL	RTC+C3	EGR, DPF	0.5
Refuse Truck	2011 Cummins	DSL	RTC+C3	SCR, DPF	0.2
Refuse Truck	2002 Caterpillar	LNG	RTC+C3	MFI	2.4
Refuse Truck	2004 Mack	LNG	RTC+C3	TBI	1.9
Refuse Truck	2006 Cummins	LNG	RTC+C3	OxCat	1.2
Refuse Truck	2008 Cummins	LNG	RTC+C3	TWC	0.2
Urban Bus	2008 Cummins	CNG	CBD	TWC	0.2

The urban bus was tested over the Central Business District (CBD) cycle,[39] which is a chassis-dynamometer testing procedure for assessing urban bus emissions. All refuse trucks were tested over SCAQMD's Refuse Truck Cycle (RTC) as well as a C3 cycle to simulate the compacting action during the waste pick-up. The RTC cycle is approximately 2,120 seconds long with an average speed of 7.56 mph, and the C3 cycle consists of an 800-second run at a constant speed of 30 mph. The C3 emissions were added to the RTC emissions and then divided by the RTC distance to obtain the emission rates of refuse trucks.

Additional test data for additional CNG buses, of relatively older MYs, were compiled from the literature, and these are tabulated in Appendix 6.2 (Table 6.2-D).

3.2.3.2 HHD DIESEL TRUCK RUNNING EXHAUST EMISSION RATES

For diesel HD trucks of a given MY, running exhaust emissions are characterized by the emission rate at mile zero (ZMR) and the rate of emission deterioration with mileage (DR). In EMFAC, the ZMR and DR are evaluated by applying a model developed by the Radian Corporation.[40] A basic assumption of this model is that the emissions from diesel HDTs remain stable in the absence of tampering and malfunction (T&M).[41] The Radian model identifies a number of specific T&M acts and quantifies their impact on the emissions from trucks using T&M impact rates. For a given pollutant, the T&M impact rate is the percent increase in emissions over the level that vehicles would have produced if they had all been well maintained and free of tampering. Thus, the Radian model calculates the ZMR and DR of

[38] C. Misra, F. C. Collins, J. D. Herner, T. Sax, M. Krishnamurthy, W. Sobieralski, M. Burntizki, and D. Chernich. 2013. In-Use NOx Emissions from Model Year 2010 and 2011 Heavy-Duty Diesel Engines Equipped with Aftertreatment Devices. Environ. Sci. Technol., 2013, 47(14), 7892–7898.

[39] https://www.dieselnet.com/standards/cycles/cbd.php

[40] Radian Corporation. 1988. Heavy-Duty Diesel Inspection and Maintenance Study, prepared for California Air Resources Board, May 16, 1988.

[41] Detailed description can be found in EMFAC2007 technical document: Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors, Appendix C.

a MY group using the pollutant's average ER and the pollutant's T&M impact rate. The following sections describe the average emissions, T&M frequencies, and the ZMRs and DRs for the 2007-09, 2010-12, and 2013+ MY groups.

3.2.3.2.1 AVERAGE EMISSION RATES BY MODEL YEAR GROUPS

Following the methods used in previous EMFAC versions, the ERs of all pollutants measured over the UDDS were used to calculate the HHDT ZMRs and DRs. It should be noted that all tests were conducted using the California No. 2 diesel fuel (CARB No. 2 diesel). As EMFAC2014 has internal fuel correction factors built into the model, based on the clean diesel fuel requirements, all ZMR and DR data were back calculated to reflect the pre-clean diesel fuel basis.

Since the T&M analysis is on a MY group basis (see the next two sections), all test vehicles were grouped into engine MY groups: MY group 2007-2009, MY group 2010-2012, and MY group 2013+. The UDDS ERs, within each group were averaged in order to determine ZMRs and DRs. Because each MY group included engines of different NOx certification levels, the average ER of an engine MY group was determined using weighted averaging by engine sales fractions. The sales fractions were derived from ARB's HD engine certification database, and the results for 2007-2012 engines are shown in Table 3.2-37. All 2013+ engine MYs were assumed to be certified at 0.2 g/bhp-hr.

Table 3.2-37 HD Engine Sales Fractions by NOx Certification Level

Engine MY	2.4 g/bhp-hr	1.2 g/bhp-hr	0.5 g/bhp-hr	0.35 g/bhp-hr	0.2 g/bhp-hr
2007-2009	10.5%	89.7%	0%	0%	0%
2010-2012	0%	0%	4.1%	24.6%	71.3%
2013+	0%	0%	0%	0%	100%

For several test runs over some cycles/modes, the PM emissions were significantly higher than other runs over the same cycles/modes. These were believed to be caused by DPF regeneration events. As regeneration is part of the truck operations, the results of these high PM runs were included when test results were averaged.

Diesel HDTs emit a significant amount of pollutants via crankcase gas venting. Starting with 2007 MY, these emissions, or crankcase emissions, have been controlled by either using a crankcase filter or routing the crankcase gas into engine intake or the exhaust upstream. For a 2007+ MY engine not routing the crankcase gas into the exhaust, EPA 2007 rule requires crankcase emissions to be added to the exhaust emissions when reporting the emission test results.[42] Since all dynamometer tests described earlier were conducted without routing the crankcase gases into the sampling system for measurement, the calculated ERs need to be modified to reflect the effect of the crankcase emissions. The data used for estimating the crankcase emissions were obtained from CRC's Advanced Collaborative Emissions Study (ACES).[43] In ACES Phase 1, four EPA 2007 standard compliant HD engines were tested, with and without crankcase emissions routed for measurement. The with- and without-crankcase emissions of the four engines were respectively averaged, and the ratios between the with and without averages were then used to modify the ERs calculated from the emissions test results. The average with- and without-crankcase emissions and the calculated ratios are shown in Table 3.2-38.

[42] 40 CFR 86.007-11 - Emission standards and supplemental requirements for 2007 and later model year diesel heavy-duty engines and vehicles.
[43] Coordinating Research Council. 2009. Phase 1 of the Advanced Collaborative Emissions Study, June 2009.

Table 3.2-38 Emissions/Ratios from EPA 2007 Standards HD Diesel Engines*

	HC		CO		NOx		PM		CO_2	
	w	w/o	w	w/o	w	w/o	w	w/o	w	w/o
Avg Emissions (g/bhp-h)	0.012	0.004	0.33	0.24	1.08	1.08	0.0011	0.0007	613	621
Ratio (w to w/o)	3.00		1.39		1.00		1.67		0.99	

* w = with crankcase emissions; w/o = without crankcase emissions.

For the 2007-2009 MY group, the ERs were multiplied by the ratios in Table 3.2-38 to obtain the modified ERs (i.e., exhaust emissions plus crankcase emissions). For the pre-2007 MYs, which have no control for crankcase gases, it was assumed that their crankcase emissions would be two times of the crankcase emissions calculated from the ACES data for the 2007-09 MYs. Staff assumed that for all 2010+ MY engines, the crankcase gases would be routed either into the engine intake or into the exhaust upstream and thus no modifications were made to the ERs for 2010+ MYs.

3.2.3.2.2 FREQUENCY OF TAMPERING AND MALFUNCTION OCCURRENCES

For EMFAC2014, emissions DRs have been calculated from the frequencies of T&M and the associated emission impact rates. In EMFAC2007, staff developed the T&M frequency rates and associated emissions impacts that are related to DPF and SCR after-treatment systems and these were also used in EMFAC2011. Staff have reviewed the data available on DPF and SCR performance, on a fleet-wide basis, and found that the T&M frequency rates and emissions impact rates currently used in EMFAC2011 were still reasonable. Thus, staff decided to continue to use the EMFAC2011 T&M frequencies and emission impact rates for calculating DRs and HDTs in EMFAC2014.

3.2.3.2.3 DIESEL HHD TRUCK RUNNING EXHAUST EMISSION RATES

Following the same methodology used in previous EMFAC versions, a sales fraction weighted average ERs were first calculated from the UDDS test data for individual engine MY groups. With the average ERs and T&M impact rates, the HC, CO, NOx, and PM ZMRs and DRs were then calculated for all MY groups. For CO_2, only ZMRs were calculated and a DR of zero was assumed.

The resulting ZMRs and DRs were based on engine MY. However, truck activity data are vehicle MY based. Thus, in order to apply these rates to vehicle activity data for emissions inventory calculations, they had to be adjusted for the mismatch between the vehicle MY and the engine MY.[44] The MY mismatch was adjusted using data from the Drayage Truck Registry (DTR), an ARB administrated database of drayage trucks operating in California. The database includes information on the fractions of different engine MYs within given vehicle MYs. For a given vehicle MY, the ZMR of a pollutant was calculated as the weighted average of the ZMRs of all engine MYs in that vehicle MY, with the fractions of these engine MYs in that vehicle MY used as weighting factors. The fractions of engine MYs, in individual vehicle MYs, derived from the DTR database are given in Appendix 6.2 (Table 6.2-E).

The DRs, for each vehicle MY, were calculated in the same manner. The vehicle MY based ZMRs and DRs of HC, CO, NOx, PM, and CO_2 are shown in Table 3.2-39.

[44] Refer to slide 155 at http://www.arb.ca.gov/msei/msab_oct_workshop_10_07_2013_final.pdf

Table 3.2-39 Revised Zero-Mile Rates (g/mi) and Deterioration Rates (g/mi/10K mi) for Diesel HHD Trucks by Engine Model Year[45]

Vehicle	HC		CO		NOx		PM		CO_2	
MY	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre 1987	1.51	0.034	8.04	0.183	23.0	0.019	1.75	0.0278	2,335	0.0
1987-90	1.18	0.041	6.32	0.218	22.7	0.026	1.90	0.0248	2,262	0.0
1991-93	0.86	0.029	2.90	0.099	19.6	0.039	0.80	0.0145	2,176	0.0
1994-97	0.64	0.034	2.15	0.114	19.3	0.046	0.52	0.0112	2,086	0.0
1998-02	0.65	0.034	2.19	0.113	19.0	0.053	0.57	0.0101	2,135	0.0
2003-06	0.55	0.021	1.20	0.046	13.0	0.052	0.39	0.0060	2,114	0.0
2007	0.51	0.017	1.10	0.036	11.3	0.059	0.29	0.0045	2,169	0.0
2008	0.43	0.008	1.06	0.021	7.46	0.081	0.037	0.0009	2,343	0.0
2009	0.42	0.008	1.06	0.020	7.31	0.082	0.028	0.0008	2,350	0.0
2010	0.38	0.007	1.02	0.020	6.59	0.081	0.024	0.0007	2,307	0.0
2011	0.19	0.004	0.82	0.016	3.26	0.074	0.009	0.0003	2,110	0.0
2012	0.14	0.003	0.76	0.015	2.33	0.073	0.004	0.0001	2,056	0.0
2013	0.14	0.003	0.76	0.014	2.28	0.069	0.004	0.0001	2,056	0.0
2014	0.14	0.002	0.76	0.010	1.97	0.047	0.004	0.0001	2,056	0.0
2015+	0.14	0.002	0.76	0.009	1.89	0.042	0.004	0.0001	2,056	0.0

A comparison of the ZMRs and DRs of EMFAC2014 and EMFAC2011 is shown in Appendix 6.2 (Table 6.2-F).

3.2.3.3 HHD DIESEL TRUCK (HHDT) IDLE EMISSION RATES

As described in Section 3.2.3.1, in ARB Project 2R12PTSD, test data were collected over the Idle Mode for the five diesel HHDTs (for idle test data, refer to Table 6.2A of Appendix 6.2). With the data, staff updated the idle ERs for 2007 and subsequent engine MYs. Since the data were collected at "curb" idle (idling at engine speed ≤ 800 rpm) with no accessory loading, the test results are low idle ERs. Idle emissions from HD trucks are dependent on accessory usage, and engine speed. For extended idling, truck operators sometimes set the engine speed at a high rpm (>800 rpm) to increase the power output and reduce engine wear, and generating high idle emissions.

Low idle ERs for pre-2007 engine MYs remain unchanged. The idle ERs, for 2007+ engine MYs were revised based on idle test data obtained from ARB Project 2R12PTSD. As with running exhaust ERs, low idle ERS were adjusted for the mismatch between engine-vehicle MYs using the fractions presented in Appendix 6.2 (Table 6.2E). Table 3.2-40 shows the updated low idle ERs for diesel HHDTs.

[45] *A detailed description can be found in EMFAC2007 technical document: Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors, Appendix C*

Table 3.2-40 Revised HHD Diesel Truck Low Idle Emission Rates

Vehicle MY	HC (g/h)	CO (g/h)	NOx (g/h)	PM (g/h)	CO_2 (g/h)
Pre-1987	25.9	28.4	45.7	4.76	4,271
1987-90	15.2	23.4	70.2	2.38	4,507
1991-93	12.1	21.5	78.4	1.78	4,610
1994-97	9.68	19.8	85.2	1.34	4,712
1998-02	7.38	17.9	91.7	0.94	4,839
2003-06	6.06	16.6	95.1	0.73	4,924
2007	5.22	14.0	97.7	0.57	5,155
2008	2.00	4.07	73.1	0.021	5,307
2009	1.88	3.71	36.4	0.001	5,318
2010	1.67	3.28	31.2	0.001	5,209
2011	0.68	1.30	16.8	0.001	4,712
2012+	0.41	0.75	12.1	0.001	4,574

Similar to the approach used in EMFAC2011,[46] high idle correction factors were applied to the low idle ERs in Table 3.2-40 to calculate the high idle ERs for HHDDTs for summer months (March through September) and winter months (October through February). The results are shown in Tables 3.2-41 and 3.2-42.

Table 3.2-41 Revised HHD Diesel Truck High Idle Emission Rates for Summer (Mar-Sep)*

Vehicle MY	HC (g/h)	CO (g/h)	NOx (g/h)	PM (g/h)	CO_2 (g/h)
Pre-1987	44.6	88.9	95.0	11.9	9,862
1987-90	26.2	73.2	146	5.96	10,407
1991-93	20.8	67.3	163	4.46	10,645
1994-97	16.7	62.0	177	3.36	10,880
1998-02	12.7	56.0	191	2.36	11,174
2003-06	10.4	52.0	198	1.83	11,370
2007	8.98	43.7	203	1.44	11,904
2008	3.44	12.7	152	0.053	12,254
2009	3.24	11.6	75.6	0.003	12,279
2010	2.87	10.3	64.9	0.003	12,028
2011	1.18	4.06	35.0	0.003	10,881
2012+	0.71	2.34	25.2	0.003	10,562

* Calculated by multiplying the low idle ERs by the high idle correction factors for the summer season.

To calculate the HHD truck idle emission rates for a given month, the low and high idle emission rates are weighted by the fraction of time that trucks operate at the low idle and high idle conditions, which were previously estimated to be 61% and 39%, respectively, based on a study conducted by the University of California at Davis.[47]

[46] A detailed description can be found in EMFAC2007 technical document: Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and SCFs, Appendix C

[47] http://www.arb.ca.gov/msei/onroad/techmemo/revised_hhddt_emission_factors_and_speed_corr_factors.pdf, page 15

Table 3.2-42 Revised HHD Diesel Truck High Idle Emission Rates for Winter (Oct-Feb)*

Vehicle MY	HC (g/h)	CO (g/h)	NOx (g/h)	PM (g/h)	CO_2 (g/h)
Pre-1987	57.0	208	82.7	20.5	7,653
1987-90	33.4	172	127	10.3	8,076
1991-93	26.6	158	142	7.67	8,261
1994-97	21.3	145	154	5.78	8,443
1998-02	16.2	131	166	4.05	8,671
2003-06	13.3	122	172	3.15	8,823
2007	11.5	102	177	2.48	9,238
2008	4.40	29.8	132	0.091	9,509
2009	4.14	27.2	65.8	0.004	9,529
2010	3.67	24.0	56.5	0.004	9,334
2011	1.50	9.51	30.4	0.004	8,444
2012+	0.90	5.47	21.9	0.004	8,196

* Calculated by multiplying the low idle ERs by the high idle correction factors for the winter season.

3.2.3.4 HHD DIESEL TRUCK SPEED CORRECTION FACTORS

EMFAC models vehicle emissions at different speeds using speed correction factors (SCFs). An SCF for a pollutant is developed from the pollutant's average ERs measured over several testing cycles or modes with different average speeds with all ERs then normalized to a particular cycle. For HHDTs, vehicles typically are tested over the UDDS as well as the ARB 4-Mode cycle, and all the ERs are then normalized to the UDDS rates to obtain SCFs. For a pollutant, ERs at various speeds can then be calculated by applying the SCF to that pollutant's ER at the UDDS speed.

In EMFAC2011, the SCFs for the 2003 and all subsequent MYs were based on the emissions data of three 2003 MY trucks. As discussed earlier 2004-2006 MYs belong to the same group as 2003 MY and therefore, these MYs share the same SCFs. Since there were no test data for 2007+ MYs, the SCFs of the 2003-2006 MY group were assumed to also be applicable to the 2007+ MYs. In ARB Project 2R12PTSD, five 2007-2010 MY trucks were tested over the UDDS test cycle, the Creep mode, the Transient mode, the Cruise mode, and the High Speed Cruise mode (refer to Table 3.2-33), generating emissions data at several different speeds. The ERs measured in all individual test runs are provided in Appendix 6.2 (Table 6.2-A). From this data, SCFs were developed for 2007+ MYs. Average ERs, for different MYs, over the UDDS and the four modes of the ARB 4-Mode cycle, are shown in Table 3.2-43.

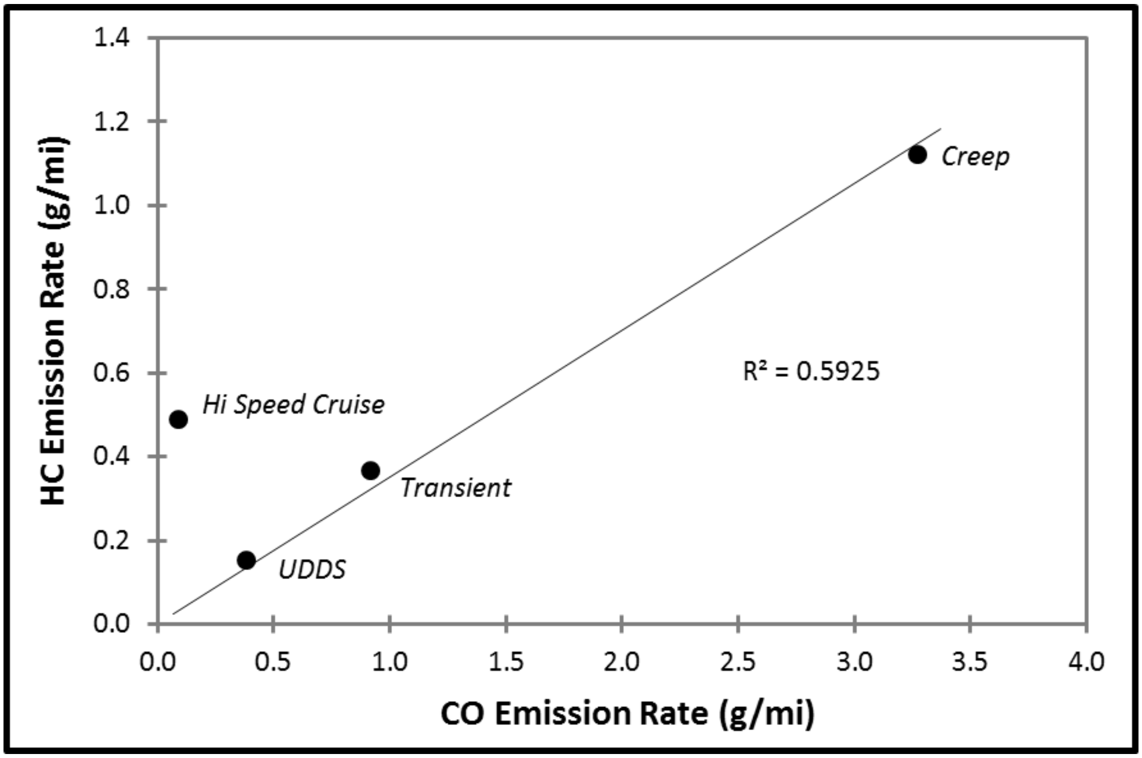
It was found that for CO, only one SCF curve was necessary for 2007+ MYs. For HC, the response signals recorded by the instrument in some test runs were below the pollutant's background level and thus no emissions data were available for two Cruise mode runs and one High Speed Cruise mode run. For the test runs that yielded emissions results, the average HC emissions of the five trucks for UDDS and three modes showed a relatively good correlation with the corresponding CO emissions (Figure 3.2-12), suggesting that the two pollutants may share similar emissions characteristics. Therefore, as an alternative, the CO SCFs will be used for HC.

Table 3.2-43 Average Emission Rates by Test Cycles for Different Model Year Groups

Test Cycle/Mode	CO (g/mi)	NOx (g/mi)			PM (g/mi)	CO_2 (g/mi)	
	2007+	2007-09	2010-12	2013+	2007+	2007-09	2010+
Creep	3.27	21.4	15.0	16.1	0.0103	4,323	4,183
Transient	0.92	9.86	4.79	3.39	0.0077	2,198	2,224
UDDS	0.90	8.86	3.48	1.97	0.0060	2,350	2,056
Cruise	0.069	5.55	1.01	0.19	0.0017	1,257	1,307
High Speed Cruise	0.092	6.68	0.89	0.27	0.0048	1,617	1,589
65 mph*	0.052	6.12	0.63	0.076	--	1,496	1,466

*Estimated from the modal data of the constant 65-mph segment of the Hi Speed Cruise cycle.

Figure 3.2-12 Correlation between HC and CO Emission Rates



NOx SCFs were generated using three curves: 2007-09, 2010-2012, and 2013+ MYs. This reflects the different mix of NOx control technologies (EGR vs. SCR) and the different NOx certification levels for SCR engines between 2007 and 2013 MYs. It should be noted that the impact of SCR performance on NOx emissions at low speeds is well characterized by the SCFs for these three groups, with their NOx SCFs at the speed of Creep mode (1.8 mph) increasing from 2.4 for 2007-09 MY group to 8.2 for 2013+ MY group.

Although all five test vehicles were equipped with a DPF, the PM data showed considerable variation among different test vehicles and sometimes even among the different test runs over the same cycle/mode for the same truck. As a result, when the PM data were analyzed separately for the 2007-09 and 2010+ MY groups, a meaningful emissions-speed relationship could not be found. Combining the data as a single 2007+ MY group resulted in a more reasonable data fit. It should be noted that for one of the test vehicles (a 2008 Freightliner truck with a 2007 DDC engine), the PM emissions from the two test runs over the High Speed Cruise mode differed by a factor of 150. An examination of the data revealed much higher downstream temperature than the engine-out temperature for this high PM test run, suggesting the occurrence of a major DPF regeneration event. This data point may be viewed as unique for the two High Speed Cruise runs since in principle, such a major regeneration event should occur with much less frequency.[48] Therefore, for the purpose of developing SCF, that data point was not included in the calculations.

For CO_2 SCFs, one curve was used for the 2007-2009 MY group and another for the 2010+ MY group.

For each MY group, the pollutant ERs were plotted as a function of speed. Regression curves were then fitted to find the equation best representing the data for each pollutant per MY group. In some cases, a single regression curve was able to be fitted through all points, whereas in other cases, a two-segmented curve had to be used to fit the data points.

For speeds less than 18.8 mph, the SCFs for all pollutants were calculated using Equation 3.2.3.4-A.

$$\boldsymbol{SCF = \frac{a + b \cdot \ln(speed)}{a + b \cdot \ln(18.8)}} \qquad \textbf{(3.2.3.4-A)}$$

For speeds between 18.8 and 55 mph, Equation 3.2.3.4-B was used to calculate the SCFs for CO and HC; Equation 3.2.3.4-C was used for NOx, and CO_2; and Equation 3.2.3.4-D was used for PM.

$$\boldsymbol{SCF = \frac{c \cdot e^{d(speed)}}{c \cdot e^{d(18.8)}}} \qquad \textbf{(3.2.3.4-B)}$$

$$\boldsymbol{SCF = \frac{c \cdot speed^{d}}{c \cdot 18.8^{d}}} \qquad \textbf{(3.2.3.4-C)}$$

$$\boldsymbol{SCF = \frac{c + d \cdot \ln(speed)}{c + d \cdot \ln(18.8)}} \qquad \textbf{(3.2.3.4-D)}$$

In Equations 3.2.3.4-A through 3.2.3.4-D, the “a”, “b”, “c”, and “d” are coefficients for the respective equations. Table 3.2-44 lists the coefficients of the best fit equations for calculating the SCFs of all five pollutants. For speeds greater than 55 mph, the SCFs for all pollutants are set to be constant and equal to the corresponding SCFs at 55 mph.

A comparison between the Revised EMFAC2014 SCFs and the SCFs used in EMFAC2011 is shown in Appendix 6.2 (Figure 6.2-1).

For pre-2007 MYs, the SCFs of EMFAC2011 are used in EMFAC2014 without any changes.

[48] For this same truck, elevated downstream temperatures were also observed for two of the three UDDS runs, but their PM emissions were only about 6-7 times higher than those of the third test run, suggesting the occurrence of relatively moderate regenerations.

Table 3.2-44 Coefficients for Revised Speed Correction Factors

Pollutant	MY Group	5-18.8 mph		18.8-55 mph	
		a	*b*	*c*	*d*
HC, CO	2007+	3.870	-1.034	1.886	-0.06105
NOx	2007-09	24.48	-5.336	20.00	-0.2974
	2010-12	17.92	-4.866	191.4	-1.383
	2013+	19.60	-5.974	2,531	-2.462
PM	2007+	1.198×10^{-2}	-2.122×10^{-3}	1.198×10^{-2}	-2.122×10^{-3}
CO_2	2007-09	4,838	-902.1	6,425	-0.3721
	2010+	4,717	-909.3	4,304	-0.2722

3.2.3.5 HD VEHICLE LOW NOX SOFTWARE UPDATE (CHIP REFLASH) CORRECTION FACTORS

The low NOx software update, or Chip Reflash, is a voluntary program to reduce excess NOx emissions from 1993 - 1998 MY HD diesel engines through software update in electronic control modules.[49]

In the 1990's, engine manufacturers utilized computer-based strategies on engines in trucks and buses that allowed the engines to comply with emission limits under certification conditions, but also allowed increased oxides of nitrogen (NOx) emissions during highway driving. These strategies resulted in off-cycles emissions.

In 1998, several major engine manufacturers signed Consent Decrees with the US EPA, the United States Department of Justice (DOJ), and the ARB, where an October 2002 deadline were set up for meeting 2004 MY standards, in-use testing, and offset and incentive programs. In March 25, 2004, ARB approved the Voluntary Program for Software Upgrade.

In addition to NOx, this program also impact other criteria pollutants and CO_2 emissions. In EMFAC2011HD model, the effect of this program was estimated using control factors specific for a given CY and MY. However, based on E55/59 data (CRC 2007[50]), the impact of the chip reflash program varies by speed bin. Therefore, in EMFAC2014 the effect of chip reflash was modeled as correction factors that were applied to specific speed bins:

$$\boldsymbol{RCF = 1 + ReflashableFraction_{(veh,\ model\,year)} * ReflashRate_{(CY)} * ReflashDiff_{(pol,speed_{bin})}} \tag{3.2.3.5-A}$$

where, RCF is a chip reflash correction factor; ReflashableFraction is the percentage of trucks qualified for the chip reflash program and vary by MY; ReflashRate is the program phase-in rate that vary by CY; ReflashDiff is the ratio of difference in emission rates given the chip reflash program. This variation depends on pollutant and speed bin.

[49] For more information on Low NOx Software Update program, please visit ARB webpage: http://www.arb.ca.gov/msprog/hdsoftware/hdsoftware.htm

[50] CRC, 2007. Coordinating Research Council Report No. E55/59. Heavy-Duty Vehicle Chassis Dynamometer Testing for Emissions Inventory, Air Quality Modeling, Source Apportionment and Air Toxics Emissions Inventory. August 2007.

3.2.3.6 HHD DIESEL TRUCK START EMISSIONS

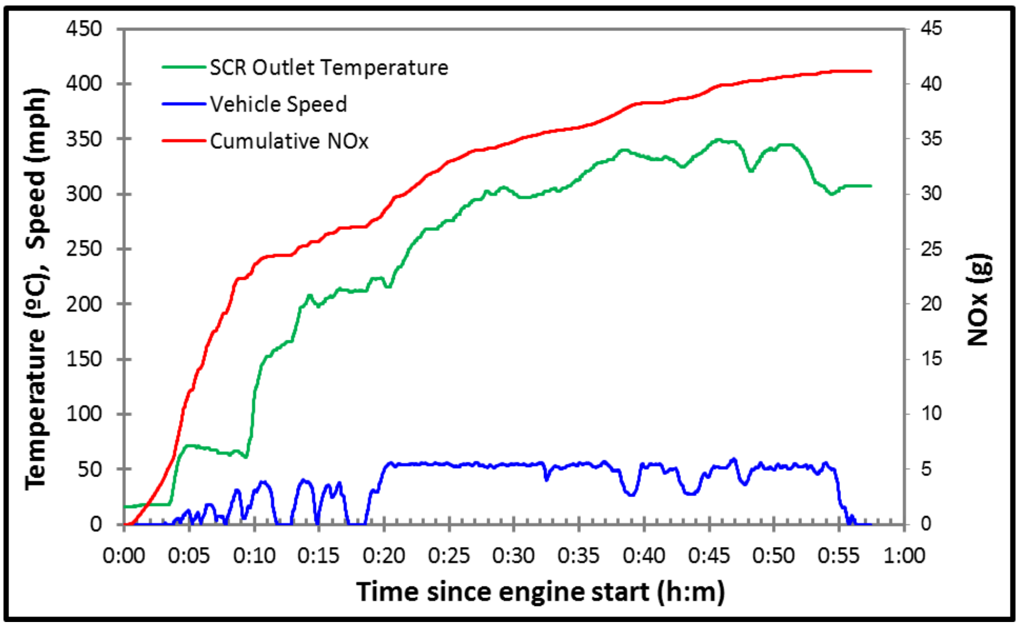
Start emissions from diesel HD trucks were developed based on the emissions data collected from the PEMS testing conducted during ARB projects 2R1110 and 2R12PTSD.

For LD vehicles, start emissions have been determined from lab dynamometer test data and are normally defined as the difference between emissions from a cold start run and a hot start run of the same test cycle. However, calculating start emissions from PEMS data using the LD vehicle method is complicated by the varying testing conditions (such as different test routes, temperatures, traffic conditions, etc.). As a result, a different approach was used to analyze the PEMS data to determine the start emissions.

3.2.3.6.1 NO_X START EMISSIONS TESTING FOR SCR EQUIPPED TRUCKS

Figure 3.2-13 shows the profiles of NOx emissions and SCR temperatures as a function of time elapsed since the engine start for a diesel trucked equipped with SCR. As can be seen from the figure, cumulative emissions of NOx increased rapidly during the first few minutes when the SCR temperature was relatively low. The rate of increase in NOx emissions markedly decreased once the SCR reached high enough temperatures (after about 10 minutes) and essentially maintained that rate for the rest of the test run. In contrast, another diesel truck equipped with an EGR system did not experience higher rate of NOx emissions increase in the first few minutes after the engine start in any of its test runs suggesting that there were no additional start emissions for trucks employing EGR for NOx control.

Figure 3.2-13 SCR temperature and Cumulative NOx emissions as a Function of Time



All three tested trucks equipped with an SCR system exhibited the same pattern in NOx emissions illustrated in Figure 3.2-13. However the durations, of the higher NOx emission periods, and their magnitudes differed between trucks. These characteristics also varied for the same truck when tested on the two different PEMS testing routes. For a test run (such as the one depicted in Figure 3.2-13), the time period from engine start to the point when the cumulative NOx decreases from a very steep rate to a more gradual rate is the starting phase. Following the starting phase is the more stable running phase when the rate of NOx emissions is relatively lower than that of the starting phase. The duration of the starting phase, for a given test run, was estimated by examining the plots of cumulative emissions vs. time (such as the plot shown in Figure 3.2-13).

Staff examined the NOx vs. time plots for all test runs of the three SCR equipped trucks and found that starting phases ranged from 3 to 16 minutes, with the majority lasting 5 to 10 minutes. Table 3.2-45 summarizes the average durations of the starting phases for all morning and afternoon outbound and inbound runs. Note that an outbound run started from Depot Park and an inbound run returned to Depot Park (see Section 3.2.3.1.2).

Table 3.2-45 Average Durations of Starting Phases of Three SCR Equipped Trucks

Test Run Direction	Test Run Time	Duration of Starting Phase (min)			
		High Load[c]	Medium Load[c]	No Load[c]	Average
OUT[a]	AM[b]	9.7	9.8	10.7	10.0
OUT	PM	7.8	9.1	9.5	8.8
IN	AM	5.9	6.8	8.3	7.0
IN	PM	5.8	6.7	7.9	6.8

a. Out = outbound, In = inbound.

b. AM = morning runs, PM = afternoon runs.

c. High Load = 90% GVWR, Medium Load = 70% GVWR, No Load = empty trailer.

As the table shows, on average, the starting phases of the morning outbound runs lasted slightly longer than those of the afternoon outbound runs, reflecting the impact of overnight soaking. The durations of both the starting phases of the morning and afternoon inbound runs were essentially the same. The data in Table 3.2-45 suggest that there were at least two different types of NOx starts for SCR equipped HD trucks: one following overnight soaking and one after a rest of 30 (between outbound and inbound runs) to 150 minutes (between AM and PM runs). An additional type would be starts during which only a negligible amount of excessive NOx emissions would be emitted, but the collected data do not include such starts. In analyzing HD truck start emissions, these three types of starts are referred to as cold start, warm start, and hot start, respectively.

The NOx emissions during the starting phase can be considered as consisting of two parts: 1) running emissions that would otherwise be emitted when the SCR system is at working temperatures, and 2) start emissions that only exist when the SCR system is below its working temperatures. Thus, to calculate the start emissions, the NOx ER (i.e., the slope of the line) of the running phase is first subtracted from the NOx ER of the starting phase and then the difference is multiplied by the duration of the starting phase.

The start emissions for the three equipped trucks were calculated for all test runs with three different test weights and the results are summarized in Table 3.2-46. The start emissions fall into four groups based on whether a test run was conducted in the morning or afternoon and whether a run was outbound or inbound.

Table 3.2-46 Average NOx Start Emissions of Three SCR Equipped Trucks

Test Run Direction	Test Run Time	NOx Start Emissions (g)			
		High Load	Medium Load	No Load	Average
Out	AM	20.0	20.8	21.2	20.7
Out	PM	8.01	9.14	14.7	10.6
In	AM	17.6	17.5	17.4	17.5
In	PM	17.4	19.8	19.3	18.8

As can be seen from Table 3.2-46, the start emissions from a morning outbound run were significantly higher than the emissions from a corresponding afternoon outbound run. For a morning outbound run, there was an overnight soaking for a truck before the test began, whereas for an afternoon outbound run the truck was only rested for around one hour. Therefore, all morning outbound runs experienced a cold start event, but all afternoon outbound runs went through a warm start.

In contrast, since there was only a short period of resting, all the morning and afternoon inbound runs only had a warm start. Thus, for a truck tested with the same test loads, the start emissions of a morning inbound run was similar to the emissions of an afternoon inbound run.

Since cold start testing could not be performed for the inbound runs, and inbound cold start data was needed in order to obtain an equally weighted average from both inbound and outbound runs, staff estimated cold start emissions for inbound runs based on the start emissions of the corresponding outbound runs. As the relative difference in start emissions between two different outbound runs (or two different inbound runs) on a given route are primarily a function of soak times (e.g. overnight vs. an hour, staff assumed that the ratio between the start emissions of morning cold start and afternoon outbound warm start runs would also be applicable to the morning cold start and afternoon warm start inbound runs. Thus, the measured warm start emissions of the morning inbound runs were multiplied by this ratio and the result was used as the estimated cold start emissions for the morning inbound runs.

The measured cold start emissions of outbound runs and the estimated cold start emissions of the inbound runs for each test weight were averaged, and similarly, the warm start emissions of both outbound and inbound runs were also averaged. The cold and warm start emissions of all three test loads were then averaged, respectively, to yield the overall start emissions. Table 3.2-47 shows the calculated cold and warm start emissions.

Table 3.2-47 NOx Start Emission Rates of SCR Equipped HHD Trucks

Start Type	NOx Start Emissions Rate (g/start)			
	High Load	Medium Load	No Load	All Load Avg
Cold Start	31.9	33.0	24.6	29.8
Warm Start	12.7	14.5	17.0	14.7

3.2.3.6.2 EMISSIONS OF HC, CO, PM, AND CO_2 DURING STARTING PHASE

In the two PEMS testing projects, data on HC, CO, and CO_2 were also collected for the three SCR equipped trucks. An examination of the test data shows that there were no discernible excessive emissions of HC, CO, and CO_2 during the first few minutes after the engine start. Therefore, the start ERs for these three pollutants are set to zero in EMFAC2014.

Preliminary PM emissions data, obtained using PEMS, showed that PM levels were mostly near or at the lowest detection limit, even during the starting phase. Therefore, staff assumed that there are no start emissions of PM for diesel trucks of all MYs.

3.2.3.6.3 HHD DIESEL TRUCK START EMISSION RATES

The above analysis showed that only SCR equipped trucks generated NOx start emissions and that there was no evidence of enhanced NOx emissions during the starting phase for trucks with only EGR. As a result, for certain MYs, that include both EGR engines and SCR engines, the NOx start ERs were calculated as weighted averages of the start ERs of SCR and EGR engines using the sales fractions data shown in Table 3.2-37.

As discussed earlier, for HD diesel trucks there is a mismatch between vehicle MYs and engine MYs; and the engine MY based ERs must be adjusted to account for this mismatch. Similar to the running exhaust ERs, DTR data were used to obtain the NOx start ERs for different vehicle MYs. Table 3.2-48 shows the diesel HDT start ERs for HC, CO, NOx, PM, and CO_2 for all vehicle MYs.

Table 3.2-48 Start Emission Rates of Diesel HHD Trucks (in g/start)

Vehicle MY	HC	CO	NOx		PM	CO_2
	Cold/ Warm	Cold/ Warm	Cold	Warm	Cold/ War	Cold/ Warm
Pre-2010	0.0	0.0	0.00	0.00	0.0	0.0
2010	0.0	0.0	4.162	2.053	0.0	0.0
2011	0.0	0.0	23.28	11.48	0.0	0.0
2012	0.0	0.0	28.62	14.12	0.0	0.0
2013	0.0	0.0	28.71	14.16	0.0	0.0
2014	0.0	0.0	29.59	14.60	0.0	0.0
2015+	0.0	0.0	29.80	14.70	0.0	0.0

3.2.3.6.4 NUMBER OF STARTS FOR HD TRUCKS

ARB has recently contracted with the College of Engineering-Center for Environmental Research and Technology (CE-CERT), University of California at Riverside,[51] to conduct a study of start frequencies for HDTs. In this study, the numbers of starts for HDTs were reviewed using truck activity data obtained from two sources. A Telematic data set obtained from HDT fleet management systems provided trip information, including trip start time, trip end time and GPS data. Also, a data set from the PierPass program[52] provided event information for nearly 600 drayage trucks at the Ports of Los Angeles and Long Beach that were instrumented with GPS enabled location devices.

To be consistent with the results from the two ARB PEMS testing projects (as discussed above), only starts with soak times of 30 minutes or longer were counted and any start with a soak time of less than 30 minutes was assumed to be a hot start. Although it is unclear how long a soak time would take to make a subsequent start "hot," a cutoff time of 30 minutes may miss some of the start emissions associated with starts with soaks of less than 30 minutes.[53]

Using a 30-minute soak time as the cutoff, the number of starts for three different service types of HDTs was determined based on the two data sets, as shown in Table 3.2-49.

Table 3.2-49 Number of Estimated Starts per Weekday by Truck Service Type

Truck Service Type	Starts/Day/Vehicle
Long-Haul	2.53
Short-Haul	2.04
Drayage	2.76

For each of the service types, one cold start (a start that follows an overnight soak) per day was assigned for every truck of a service fleet. The number of starts in Table 3.2-49 were then subtracted by 1 (i.e., one cold start) and the results were designated as the number of warm starts. Table 3.2-50 summarizes the numbers of cold and warm starts to be used in start emissions calculations.

As it is likely that there were only an insignificant amount of start emissions during a hot start, the number of hot starts were not estimated and hot start emissions were assumed to be zero for truck emissions calculation purposes.

[51] Barth M., G. Scora and K. Boriboonsomsin, 2012. Review of Heavy-Duty Truck Cold-start Activity for Vehicle Emission Modeling. Final Report submitted to ARB.

[52] http://www.pierpass.org/about-2/

[53] Staff plans to conduct a PEMS study to systematically investigate the relationship between soak times and start emissions of HD trucks.

Table 3.2-50 Number of HD Diesel Truck Starts

Truck Service Type	Type of Start	Starts/Vehicle/Day
Long-Haul	Cold Start	1.00
	Warm Start	1.53
Short-Haul	Cold Start	1.00
	Warm Start	1.04
Drayage	Cold Start	1.00
	Warm Start	1.76

3.2.3.7 MHD DIESEL TRUCK (MHDT) RUNNING EMISSION RATES

The ERs for 2007+ MY diesel MHDT, in EMFAC2011, were estimated from the ERs for the 2003-2006 MYs. No MHDT were tested in either the ARB or SCAQMD truck testing projects described earlier, and therefore MHDT emission rates for 2007+ MYs were estimated by applying scaling factors to the ERs of diesel HHDT.

First, ratios were derived by taking the HHDT average ERs of the 2007-09, 2010-12, and 2012+ MY groups and dividing them by the average ERs of the 2003-06 MY group. The three sets of ratios were multiplied against the MHDT average ERs of the 2003-06 MY group to obtain the scaled MHDT average ERs for the 2007-09, 2010-2012, and 2012+ MY groups. With the scaled average ERs and T&M impact rates (which remain the same as those used in EMFAC2011 – see Section 3.2.3.2), the HC, CO, NOx, and PM ZMRs and DRs for diesel MHDTs of the 2007-09, 2010-12, and 2012+ MY groups were then calculated. For CO_2, only ZMRs were calculated and the DRs were assumed to be zero.

The resulting ZMRs and DRs were based on engine MY. Similar to diesel HHDTs, these rates were then reweighted using the DTR engine-vehicle MY mismatch data to derive the vehicle MY based ZMRs and DRs. The vehicle MY based diesel MHDT ZMRs and DRs are shown in Table 3.2-51.

Table 3.2-51 Revised ZMRs (g/mi) and DRs (g/mi/10K mi) for Diesel Medium Heavy-Duty Trucks

Vehicle MY	HC		CO		NOx		PM		CO_2	
	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre1987	0.98	0.056	2.93	0.167	15.6	0.033	0.99	0.039	1,511	0.0
1987-90	0.77	0.066	2.30	0.198	15.4	0.044	1.08	0.035	1,464	0.0
1991-93	0.41	0.035	1.22	0.104	11.5	0.058	0.59	0.027	1,408	0.0
1994-97	0.30	0.040	0.91	0.120	11.3	0.068	0.34	0.018	1,350	0.0
1998-02	0.31	0.039	0.93	0.119	11.1	0.077	0.37	0.016	1,381	0.0
2003-06	0.26	0.024	0.51	0.049	7.64	0.077	0.25	0.010	1,368	0.0
2007	0.24	0.019	0.47	0.037	6.61	0.081	0.19	0.007	1,404	0.0
2008	0.20	0.008	0.45	0.018	4.37	0.096	0.024	0.001	1,516	0.0
2009	0.18	0.008	0.45	0.017	4.29	0.097	0.017	0.001	1,520	0.0
2010	0.092	0.007	0.43	0.017	3.86	0.095	0.015	0.0009	1,514	0.0
2011	0.067	0.004	0.35	0.013	1.91	0.087	0.006	0.0003	1,487	0.0
2012	0.067	0.003	0.32	0.012	1.37	0.085	0.003	0.0002	1,480	0.0
2013	0.067	0.003	0.32	0.012	1.34	0.081	0.003	0.0002	1,476	0.0
2014	0.067	0.002	0.32	0.009	1.16	0.055	0.003	0.0001	1,447	0.0
2015+	0.067	0.002	0.32	0.008	1.11	0.049	0.003	0.0001	1,440	0.0

3.2.3.8 DIESEL REFUSE TRUCK EMISSION RATES

The ERs for diesel refuse trucks were based on the test data of three refuse trucks: one 2004 MY certified to 2.4 g/bhp-hr NOx; one 2011 MY certified to 0.5 g/bhp-hr NOx; and one 2011 MY certified to 0.2 g/bhp-hr NOx (Table 3.2-36). Since the same engines are used in both diesel refuse trucks and diesel HHDTs, the MY groups for diesel refuse trucks are the same as those for diesel HHDTs, except that some MYs were combined into a single group due to a lack of sufficient test data for individual MY grouping. The ERs of the 2013+ MY group of diesel refuse trucks were calculated from the test data of the 2011 MY refuse truck, with a weighting ratio of 0.825/0.175 based on engine sales fractions of HHD trucks. The ERs of the 2003-2006 MY group were based on the test data of the 2.4 g/bhp-hr 2004 MY diesel refuse truck. The ERs for the pre-2003 MY diesel refuse trucks were estimated. For this estimate, first the ratios between the ERs of pre-2003 MY HHDTs and the ER of 2004 MY HHDTs were obtained, and then the ERs of pre-2003 MY diesel refuse trucks were calculated by applying these ratios to the ER of the 2004 MY diesel refuse trucks.

Very little information was available regarding emissions deterioration of diesel refuse trucks. However, since these trucks are operated primarily by large companies, it seems reasonable to expect these vehicles to be well maintained. Therefore, the DRs for the diesel refuse trucks were assumed to be zero and their ZMRs were set to be the same as the average ERs. The resulting ZMRs for diesel refuse trucks are shown in Table 3.2-52. All ERs are on a combined RTC+C3 basis. The resulting ZMRs for diesel refuse trucks are shown below in Table 3.2-52 by vehicle MY group.

Table 3.2-52 Zero-Mile Emission Rates for Diesel Refuse Trucks

Vehicle MY	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)
Pre-1994	0.01	0.39	37.3	0.48	7,793
1994-97	0.01	0.20	33.9	0.19	7,199
1998-02	0.01	0.20	33.6	0.20	7,376
2003-06	0.01	0.08	23.0	0.12	7,289
2007-09	0.15	0.53	12.1	0.01	6,705
2010-12	0.29	0.97	1.32	0.01	6,122
2013+	0.04	0.17	1.17	0.01	6,572

*Rates are on a RTC+C3 basis.

There are no data available for developing speed correction factors for diesel refuse trucks. As an alternative, the SCFs of HHDTs were used for calculating the emissions of diesel refuse trucks at different speeds. In order to use the HHDT SCFs, which were normalized to the UDDS average speed (18.8 mph), all refuse truck ZMRs were converted to rates at 18.8 mph.

3.2.3.9 LNG SWCV TRUCK EMISSION RATES

The ERs of LNG refuse truckswere based on the testing data from four trucks (Table 3.2-36) and their test data are shown in Appendix 6.2 (Table 6.2-C). Due to limited test data, LNG refuse were grouped into three MY groups on the basis of diesel HD emission standards. For a given group, the RTC and C3 emissions, of each refuse truck, were combined and the combined ERs of all trucks were then averaged to obtain MY groups' average ERs.

Similar to diesel refuse trucks, the DRs for the LNG refuse trucks were assumed to be zero and their ZMRs were set to equal the average ERs. Table 3.2-53 shows the RTC+C based ZMRs of LNG refuse trucks.

No data are available to use in the development of speed correction factors for the LNG refuse trucks. For LNG refuse trucks, with compression ignition engines, their emissions as a function of speed were likely similar to diesel HDTs. For 2010+ MY LNG refuse trucks, with a three way catalyst (TWC) as their primary emissions control, it was assumed that the emissions-speed relationship was similar to a mix of EGR equipped trucks and SCR equipped trucks. Thus, the SCFs for diesel HHDTs were used LNG refuse trucks for corresponding MYs, with the exception that the NOx SCF for 2010-12 MY HHDTs was applied to all 2010+ MY refuse trucks. As with diesel refuse trucks, all LNG refuse truck ZMRs were converted to rates at 18.8 mph.

Table 3.2-53 Zero-Mile Emission Rates for LNG Refuse Trucks

Vehicle MY	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)
Pre-2007	61.1	3.87	53.2	0.091	5,229
2007-2009	22.8	18.5	18.8	0.004	5,404
2010+	10.1	36.6	0.88	0.004	5,077

*Rates are on RTC+C3 basis.

For LNG refuse trucks, there are no fuel correction factors. Other correction factors (such as humidity) are assumed to be the same as diesel refuse trucks. There are no start emissions for LNG refuse trucks. The idle emissions, brake wear, and tire wear emissions of the LNG refuse trucks are assumed to be the same as those from diesel refuse trucks.

The conversion factors used to derive TOG, ROG and CH4 emissions from THC emissions for natural gas vehicles are very different from those for diesel trucks. ARB developed the THC conversion factors for natural gas vehicles based on the most recent speciation studies.[54,55] EMFAC2014 adopted these THC conversion factors for LNG refuse trucks, as shown in Table 3.2-54.

Table 3.2-54 THC Conversion Factors for LNG Refuse Trucks

Model Year	TOG/THC	ROG/THC	CH4/THC
2009 and Prior	1.097	0.16137	0.90921
2010+	0.998	0.013972	0.97788

3.2.3.10 DIESEL URBAN BUS EMISSION RATES

The ERs of diesel UBUS, in EMFAC2011, were based on emissions data collected from 51 pre-1998 MY buses tested over CBD cycle.[56] The ERs for 1998 and later MY diesel UBUS were estimated using the ratios of the standards. For EMFAC2014, staff was not able to obtain test data for newer MY diesel UBUS; however, with the actual test data available for diesel HHDTs, staff used the ratios of the HHDT test data to estimate ERs for late MY diesel UBUS, for which test data were not available.

Table 3.2-55 shows the four 1999+ MY groups for diesel UBUS and their NOx standards; also shown are the same NOx standards for diesel HHDTs and the corresponding average ERs. The reduction factors are the ratios between the HDDT NOx ERs of the other three standard-defined MY groups and the NOx ER of the 4 g/bhp-hr standard MY group. These ratios were then used for scaling the NOx ER of the 1999-2002 MY diesel UBUS to obtain ERs for the 2003, 2004-2006, and 2007+ MY groups.

[54] Wenli Yang, Paul Allen 2014. Organic Gas Speciation Profiles for Buses Running on Compressed Natural Gas (CNG), Available at http://www.arb.ca.gov/ei/speciate/refspec.htm

[55] Wenli Yang, 2014. Organic Gas Speciation Profiles for Running Exhaust of CNG (Compressed Natural Gas) Transit Buses Equipped with TWC (Three-Way Catalysts). http://www.arb.ca.gov/ei/speciate/refspec.htm.

[56] EMFAC2000 Technical Support Document (Emissions Model Methodology): 10.0 HDT Emissions. http://www.arb.ca.gov/msei/onroad/doctable_test.htm

Table 3.2-55 NOx Standards of Diesel UBUS and Diesel HHDTs and Scaling Factors Based on Diesel HHDT NOx Emission Rates

Diesel UBUS		Diesel HHDT (T7)		
MY Group	NOx Standard (g/bhp-hr)	NOx Standard (g/bhp-hr)	NOx ER (g/mi)	Scaling Factor
1999-2002	4	4	18.9	1
2003	2.2	2.2	13.0	0.687
2004-2006	0.5	0.5	3.56	0.188
2007+	0.2	0.2	1.89	0.100

Since the 2003 MY, when the PM standard lowered to 0.01 g/bhp-hr, diesel UBUS have been employing DPF for PM control. With the use of combined DPF and SCR systems, the PM ERs of late MY diesel UBUS have become even lower than the earlier MY buses. Therefore, 2008 MY and 2015 MY HHDTs were selected as surrogates for DPF only diesel UBUS (including 2003-06 MY diesel UBUS) and DPF+SCR UBUS (all 2007+MY diesel UBUS), respectively, and the ratio of PM ERs of 2008 MY and 2015 MY diesel HHDTs was used to calculate PM ERs for 2007+ diesel UBUS. As DPF impacts HC and CO emissions, similar scaling factors were calculated for these two pollutants. Table 3.2-56 shows the PM, HC, and CO scaling factors based on the ERs of the 2008 and 2015 MY diesel HHDTs.

Table 3.2-56 MY Groups of Diesel UBUS and Scaling Factors Based on PM, HC, and CO Emission Rates of 2008 and 2015 MY Diesel HHDTs

Diesel UBUS MY Group	Diesel HHDT MY	PM		HC		CO	
		ER (g/mi)	Reduction	ER (g/mi)	Scaling Factor	ER (g/mi)	Reduction
2004-06	2008	0.0374	1	0.427	1	1.06	1
2007+	2015	0.0045	0.120	0.141	0.331	0.761	0.716

The scaling factors in Table 3.2-55 and Table 3.2-56 were applied to the 1999-2002 diesel UBUS ERs to estimate the NOx, PM, HC, and CO ERs for the 2003 MY, 2004-06 MY, and 2007+ MY UBUS and the results are given in Table 3.2-57.

Table 3.2-57 Zero-Mile Emission Rates of Diesel Urban Buses

Proposed (EMFAC2014) UBUS-Dsl BERs					
Model Year Range	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO2 (g/mi)
1965-1986	2.06	18.2	46.2	1.29	3,053
1987-1990	2.05	16.3	40.2	1.22	2,988
1991-1993	2.02	9.71	25.5	1.16	2,717
1994-1995	1.99	6.50	29.8	1.41	2,525
1996-1998	1.98	5.10	39.2	1.69	2,417
1999-2002	1.98	5.10	20.4	0.579	2,417
2003	0.841	4.05	14.0	0.116	2,417
2004-2006	0.084	3.13	3.83	0.116	2,417
2007+	0.028	2.25	2.04	0.014	2,417

There are no data available on the emissions deterioration of diesel UBUS. Since buses are operated by transit agencies, these vehicles are expected to be free of tampering and well maintained. Therefore, the DRs for the diesel UBUS were assumed to be zero.

No data is available for developing SCFs specific to diesel UBUS. Staff decided to use the SCFs of diesel HHDTs to model the emissions of diesel UBUS at different speeds, with the assumption that the emission patterns of these two types of vehicles, at lower speeds, are similar. Since there is only one MY group for all 2007+ MY diesel UBUS, the three diesel HHDT SCFs for 2007+ MYs were averaged into one SCF to and that SCF was used for the 2007+ MY group of diesel UBUS. To use the diesel HHDT SCFs, all diesel UBUS ERs were converted to rates at the UDDS speed of 18.8 mph.

3.2.3.11 CNG URBAN BUS EMISSION RATES

The ERs of CNG UBUS were on based on a dataset of old MY transit buses compiled from the literature (Appendix 6.2 Table 6.2-D) and the test data of a 2008 MYTWC bus (Table 3.2-36). All test data were based on the CBD cycle. Because of the lack of data for many late MYs, CNG UBUS were divided into three broad MY groups using UBUS emissions standards. The ERs for each group were obtained by averaging the test data of all buses within the group.

No data are available for assessing the emissions deterioration for CNG buses. As with diesel buses, it is believed that most CNG buses operated by transit agencies are well maintained and free of tampering. Thus, the DRs for CNG buses were set to zero and the average ERs calculated for each MY group were used as ZMRs. The HC, CO, NOx, PM, and CO_2 ZMRs for CNG urban buses are shown in Table 3.2-58.

Table 3.2-58 Zero-Mile Emission Rates for CNG Urban Buses

Vehicle MY	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)
Pre-2003	16.6	29.7	21.6	0.043	2,394
2003-06	24.0	43.0	15.4	0.023	2,394
2007+	3.12	14.4	0.65	0.001	2,305

No data are available that can be used to develop speed correction factors for CNG UBUS. Similar to the LNG refuse trucks, the SCFs of diesel UBUS were used for CNG buses. Also, for CNG UBUS, there are no fuel correction factors. Other correction factors, such as humidity, are assumed to be same as diesel UBUS. There are no start emissions for CNG UBUS. The idle emissions, brake wear and tire wear emissions from CNG UBUS are assumed to be same as those from diesel UBUS.

The conversion factors used to derive TOG, ROG and CH4 emissions from THC emissions are the same as those adopted for LNG SWCVs (Table 3.2-54).

Table 3.2-59 THC Conversion Factors for CNG UBUS

Model Year	TOG/THC	ROG/THC	CH4/THC
2006 and Prior	1.097	0.16137	0.90921
2007+	0.998	0.013972	0.97788

3.2.3.12 TRACTOR-TRAILER GREENHOUSE GAS REGULATIONS

3.2.3.12.1 OVERVIEW OF REGULATION

In 2008, ARB adopted a regulation[57] designed to accelerate the use of low rolling resistance tires and aerodynamic fairings to reduce GHG emissions in the heavy-duty truck fleet.

3.2.3.12.1.1 TRACTOR REQUIREMENTS

The regulation applies to owners of Class 7 and 8 heavy-duty tractors (>26,000 pounds GVWR) operating on California highways. The regulation includes the following requirements for tractors:

[57] http://www.arb.ca.gov/cc/hdghg/hdghg.htm

- *2011 and newer MY sleeper-cab tractors that pull affected trailers in California must be SmartWay certified beginning January 1, 2010.*
- *2011 and newer MY day-cab tractors that pull affected trailers in California must use SmartWay verified low rolling resistance tires beginning January 1, 2010.*
- *All 2010 and older MY tractors that pull affected trailers in California must use SmartWay verified low rolling resistance tires beginning January 1, 2013.*

This regulation offers special exemptions for local- and short-haul tractors. A registered local-haul tractor is exempt from the aerodynamic requirements of this regulation, but not from the low rolling resistance tire requirements. An affected short-haul tractor is exempt from all the requirements of this regulation when registered with ARB and updated on an annual basis.

3.2.3.12.1.2 TRAILER REQUIREMENTS

The regulation also applies to owners of 53-foot or longer box-type trailers, including both dry-van and refrigerated-van trailers. The regulation includes the following requirements for trailers:

- *2011 and newer MY 53-foot or longer box-type trailers must, beginning January 1, 2010, be either:*
  - *SmartWay certified or*
  - *Retrofitted with SmartWay verified technologies, as follows:*
    - *Low rolling resistance tires, and*
    - *Aerodynamic devices*
- *2010 and older MY 53-foot or longer box-type trailers (with the exception of certain 2003 to 2009 MY refrigerated-van trailers) must meet the same aerodynamic device requirements as 2011 and newer MY trailers either:*
    - *By January 1, 2013, or*
    - *According to a compliance schedule based on fleet size which allows them to phase-in their compliance over time*
- *2010 and older MY trailers must use SmartWay verified low rolling resistance tires by January 1, 2017*
- *2003 to 2009 MY refrigerated-van trailers equipped with 2003 or newer MY transport refrigeration units have a compliance phase-in between 2017 and 2019*

This regulation offers special compliance options for pre-2011 MY trailers. While all 2011 and newer MY trailers must comply as of January 1, 2010, small fleets (less than 20 trucks) and large fleets can choose to phase-in compliance of their 2010 and older MY trailers for the aerodynamic technology requirements of the regulation.

3.2.3.12.2 EMISSIONS INVENTORY METHODS

Staff used EMFAC2011 and the 2008 staff report as the starting point for this analysis. Based on previous staff analysis and the Tractor-Trailer GHG Reporting database (TRUCRS[58]), staff estimated CO_2 emissions rate reductions under different combinations of CY, MY, tractor cab type, trailer van type, haul type, and trailer phase-in options. Previous staff analysis indicated tire improvements lead to a 1.5% reduction in GHG emissions. This same analysis also indicated that the aerodynamic

[58] California Air Resources Board, Truck Regulation Upload, Compliance, and Reporting System. Available at: https://ssl.arb.ca.gov/ssltrucrs/trucrs_reporting/reporting.php.

improvements lead to 2%, 4%, and 5% reduction in GHG emissions on tractors, refrigerated vans, and dry vans respectively. The detailed documentation for this analysis can be found in Appendix G,[59] of the “Staff Report: *Initial Statement of Reasons for Proposed Rulemaking Proposed Regulation for In-Use On-Road Diesel Vehicles.”*

Lacking more detailed data, staff assumed that each tractor pulls the same MY trailer. With this assumption, staff calculated overall CO_2 reductions for each tractor-trailer combination as a function of CY, MY, tractor cab type, trailer van type, haul type, and trailer phase-in options. Since emissions data from EMFAC2014 does not provide information on haul type, cab type, van type, and options; staff used a variety of data sources to calculate weighted-average reduction factors as a function of CY, MY, and speed.

In order to calculate the population shares among the tractor-trailers that choose short- or long haul exemptions, staff used the registration data from TRUCRS to aggregate the emission reduction factors over different haul types of long-, local-, and short-hauls. Having the total number of tractors and those that are exempt (either local or short haul), staff calculated the population shares of local or short haul by MY. Staff assumed that these shares will remain the same for 2012 MY and newer.

3.2.3.12.2.1 DAY VERSUS SLEEPER CABS

Data from EMFAC2011-HD were used to calculate the splits between sleepers and non-sleeper tractors. Following EMFAC2011-HD, 42% of the affected HD truck vehicle miles travelled VMT are linked to the non-sleepers tractors, while the rest of the 58% are associated with sleeper tractors.

3.2.3.12.2.2 TRAILER TYPE

The trailer production data from 1997 to 2000 Current Industrial Reports[60] (CIR) indicates that 69% of box type trailers are dry-van trailers and the rest (31%) are refrigerated-van trailers. Since this regulation only applies to 53” or longer box type trailers, staff also estimated the percent of VMT in California driven by 53” or longer box type trailers. According to this analysis, 68% of total Tractor-Trailer combinations are affected by this regulation.

3.2.3.12.2.3 REGULATORY OPTIONS

According to the registration data from TRUCRS for small/large fleet options, 58% of pre-2011 MY trailers that are eligible for phase-in option will be fully compliant by 2013, 30% choose option 1, 11% choose option 2, and 1% will take the small fleet option.

3.2.3.12.2.4 IMPROVED AERODYNAMIC BENEFITS AS A FUNCTION OF SPEED

ARB staff estimated the impact that tractor-trailer speed has on the effectiveness of aerodynamic technologies and found out that the use of aerodynamic technologies will reduce the fuel consumption rate of tractor-trailers, even at speeds below 60 miles per hour.

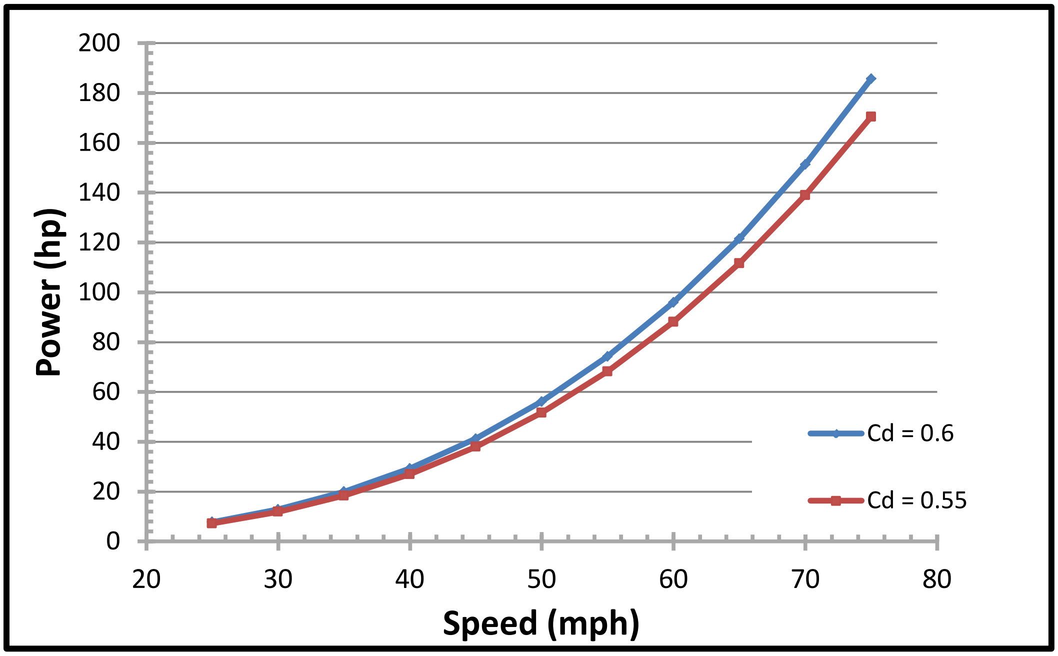
Since data for fuel savings due to improvements in tractor-trailer aerodynamics are available only for test speeds of 60 to 62 mph, staff compared the power needed to overcome aerodynamic drag and tire rolling resistance for two coefficients of drag (C_d), C_d=0.55 and C_d=0.60, and then used the difference in power demand to estimate the fuel savings for speeds lower than 60 mph. The power demand to

[59] California Air Resources Board (2008). Staff Report: Initial Statement of Reasons For Proposed Rulemaking. Proposed Regulation For In-Use On-Road Diesel Vehicles. Appendix G –Emissions Inventory Methodology and Results. Sacramento: October 2008. http://www.arb.ca.gov/regact/2008/truckbus08/appg.pdf

[60] Census, 2000. Bureau of Census. Current Industrial Reports, M336L - Truck Trailers. Available at http://www.census.gov/industry/1/m37l0013.pdf.

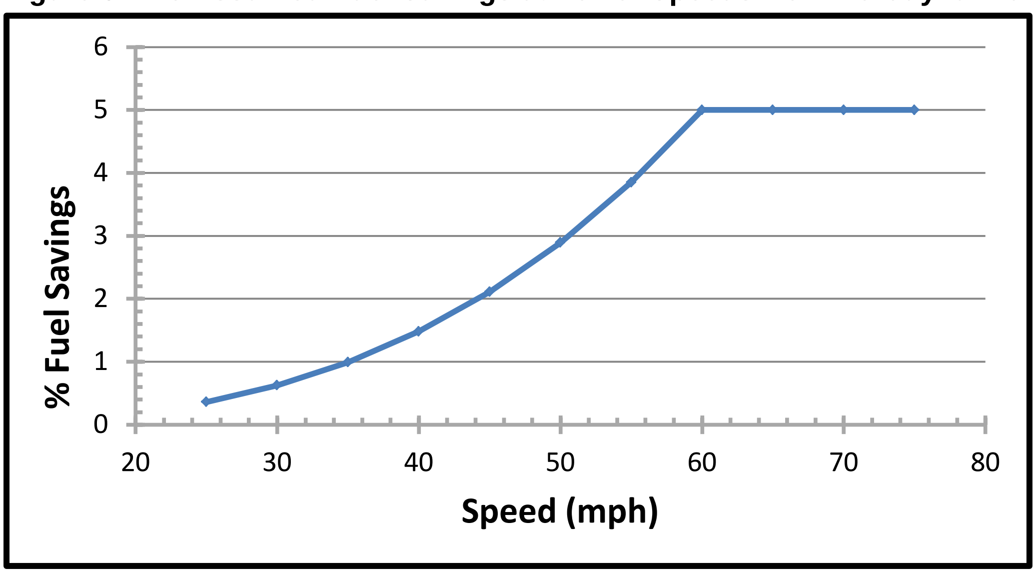
overcome aerodynamic drag and rolling resistance at speeds 60 mph and below for each C_d is depicted in Figure 3.2-14.

Figure 3.2-14 Plot of Power Needed to Overcome Aerodynamic Drag and Tire Rolling Resistance for C_d=0.6 and C_d=0.55.



In calculating the fuel savings for speeds lower than 60mph, staff assumed, for a given speed, the ratio of the fuel savings to the change in power to be equal to the ratio of the fuel savings to the change in power at 60 mph.[61] Using 5% fuel savings at 60 mph, staff calculated the fuel savings at lower speeds, as shown in Figure 3.2-15. For purposes of the emission inventory estimation, staff took the conservative approach and assumed a 5% improvement in fuel consumption for all speeds over 60 mph.

Figure 3.2-15 Assumed Fuel Savings at Lower Speeds from Aerodynamic Technology



[61] This assumes that the brake-specific fuel consumption at different speeds remains constant.

3.2.3.12.2.5 ALIGNMENT WITH CALIFORNIA PHASE 1

To harmonize the tractor requirements of the Tractor-Trailer GHG regulation with the California Phase 1 GHG standards, the amended rule will sunset the requirements of the regulation for 2014 and subsequent MY tractors. Thus, following the amended rule, the 2014 and newer tractors will not provide any emission reductions as a result of aerodynamic or tire improvements.

3.2.3.13 HEAVY-DUTY GHG EMISSIONS STANDARDS (PHASE ONE)

In 2011, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) jointly adopted GHG emission standards and fuel economy standards for MD and HD engines and vehicles, informally known as the "Phase 1" GHG regulations.[62] The proposed California rule will align with federal GHG emission standards and fuel economy standards, and will follow the same structure and stringency levels of the EPA rule, including new engine and vehicle GHG requirements, etc.

3.2.3.13.1 OVERVIEW OF REGULATION

The federal Phase 1 regulation imposed new requirements for newly manufactured compression and spark ignited engines in Class 2b through Class 8 vehicles. Compliance requirements began with MY 2014. The regulation was phased-in such that the regulation takes full effect in 2018. The Rule organizes truck compliance into three groupings:

- *Heavy duty pickups and vans (EPA Class 2b, 3)*
- *Vocational vehicles (VV) (EPA Class 4 through 8)*
- *Combination tractors (EPA Class 7, 8)*

Trucking operations in California differ substantially from the national average. Favorable weather conditions and other factors allow trucks that are operated primarily in California to be retained longer by fleets than the national average. In addition, the California trucking market is segmented, with national, regional and local fleets all competing in different segments of the goods movement economy. This leads to a different vehicle fleet mix, vehicle age, and VMT profiles than the national average. EMFAC2011 reflected these California-specific factors, and was used as the starting point for this analysis. This analysis focuses on the GHG emissions impact of the proposed rule as applied to HD vehicles operated in California.

3.2.3.13.2 CO_2 EMISSION RATES

The Phase-I Regulation sets CO_2 emission standards (gCO_2/ton-mi) for the categories listed below:

- *Vocational Vehicles*
    - *Heavy Heavy (EPA Class 8)*
    - *Medium Heavy (EPA Class 6 & 7-single-unit and Buses)*
    - *Light Heavy (EPA Class 4-5)*
- *Tractors*
    - *EPA Class 7*
    - *EPA Class 8*
        - *Sleeper cab*
        - *Day cab*
- *Pickups and Vans*
        - *Diesel (EPA Class 2b-3)*
        - *Gasoline (EPA Class 2b-3)*
- *Buses*

[62] http://www.arb.ca.gov/msprog/onroad/phaselghg/phaselghg.htm

Since EMFAC2011 vehicle categories were different than the vehicle categories defined by EPA Phase I regulations, staff had made necessary adjustments, as described below, to translate the emission reductions in terms of EMFAC2011 vehicle categories. These adjustments were derived from an analysis of VIUS[63] data and EMFAC 2011 population/VMT data. ARB calculated the population/VMT shares for:

- *T7 trucks (>33,000 lbs. GVWR)*
    - *Vocational (13%)*
    - *Day cabs tractor-trailer (43.5%)*
    - *Sleeper cab tractor-trailer (43.5%)*
- *T6 trucks (14,001-33,000 lbs. GVWR)*
    - *Vocational EPA class 4 and 5 (41%)*
    - *Vocational EPA class 6 and 7 (51%)*
    - *EPA Class 7 tractor-trailer (8%)*
- *LHD trucks (8,501-14,000 lbs. GVWR (8%))*
    - *Vocational (100%)*
    - *Tractor-trailer (0%)*

Using the population/VMT percentages above, staff aggregated the emission rates from the vehicle standards to obtain composite CO_2 emission rates (g/mile) applicable to EMFAC2011 vehicle category.

Staff also applied the Phase I CO_2 Emissions Rate reductions to EMFAC2014. For this update, the vehicle class categories for school buses, UBUS, motor coaches, motor homes, and all other buses were assigned the same reduction level as medium-heavy duty vocational vehicles. The percentage reductions in CO_2 emission rates (with respect to MY 2010) that were incorporated into EMFAC2014 are shown in Table 3.2-60.

Table 3.2-60 Phase I CO_2 Emission Rate (g/mi) Reduction Percentage

Model Year	LHD1/LHD2 Gasoline Reduction	LHD1/LHD2 Diesel Reduction	T6 Composite Reduction	T7 Composite Reduction	Buses
2010	100.0%	100.0%	100.0%	100.0%	100.0%
2014	98.5%	97.7%	94.6%	87.3%	94.7%
2015	98.0%	97.0%	94.6%	87.3%	94.7%
2016	96.0%	94.0%	94.6%	87.3%	94.7%
2017	94.0%	91.0%	91.1%	84.8%	91.1%
2018+	90.0%	85.0%	91.1%	84.8%	91.1%

3.2.3.13.3 REBOUND EFFECT

The Rebound Effect is based on the concept that the demand for driving is a function of the operating costs of the vehicle driven. When operating costs increase, such as when fuel prices increase, driving becomes more expensive and people drive less. Conversely, if fuel prices decrease people may drive more. In the case of the Phase-I regulation, newly manufactured vehicles obtained better fuel economy and are therefore marginally less expensive to operate. As a result, staff expects a marginal increase in the amount of miles driven per vehicle. Following EPA's Final Regulatory Impact Analysis (RIA) of GHG Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and

[63] United States Census Bureau. Vehicle Inventory and Use Survey (2002). Available at: http://www.census.gov/svsd/www/vius/products.html

Vehicles[64] (in Section 5.3.2.2.2), a rebound effect of 1.18% for HD Pickup Vans, 1.33% for vocational vehicles and 0.5% for tractors was assumed for EMFAC2014.

3.3 ACTIVITY

3.3.1 BASICS

Directly after installing the EMFAC2014 model, it can be run in ‘default activity mode’, where it uses readily available, default activity data that are distributed along with the EMFAC system. With regard to the nature of the default activity contained in EMFAC, EMFAC2011 and prior versions of the EMFAC model primarily used adopted regional transportation plan activity data. In contrast to utilizing data from transportation plans for the default activity data, EMFAC2014 uses historical fuel sales to estimate VMT for historical years and includes new forecasting methods to estimate future statewide and regional VMT.

EMFAC can also be run in “custom activity mode”, where users provide their own activity data. That is, while the default data in EMFAC2014 is no longer based on MPO activity data, EMFAC2014 does allow using local MPO-based activity data to estimate emissions.

3.3.2 MPO’S ACTIVITY VERSUS DEFAULT EMFAC ACTIVITY

ARB has committed to using local activity data to develop statewide emissions inventories for air quality planning efforts in support of State Implementation Plan (SIP) development, as well as transportation conformity budget development. In order to ensure that SIPs and motor vehicle emissions budgets are based on the latest local activity data, ARB staff will contact each local planning agency directly to request the latest local activity data assumptions and transportation modeling data used in Regional Transportation Plans (RTPs) or Sustainable Community Strategies (SCS) as needed for transportation conformity budget development.

3.3.3 UPDATES TO LD VEHICLE ACTIVITY

This section discusses the methodology used to estimate the transportation activity from LD vehicles in EMFAC2014. These updates were made to reflect new historical data and the most recent socio-economic indicators used for forecasting. Updates were made to the vehicle populations (both historical and forecasted), the VMT (adjusted to match the statewide base year fuel usage), the vehicle survival and mileage accrual rates, and to incorporate the impacts of the ACC regulations.

Section 3.3.3 discusses updates that have been made in EMFAC2014 for LD vehicles and for gasoline fueled HD vehicles (which were included in EMFAC2011 LDV vehicle categories). Updates that have been made in EMFAC2014 for diesel and natural gas fueled HD vehicles are discussed in Section 3.3.4.

3.3.3.1 LD VEHICLE POPULATION

This section describes the methodology used in developing the LD vehicle population and age distribution matrices used in EMFAC2014. Derivation of accurate vehicle populations is critical to the construction of reliable emissions inventories.

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[64] US EPA (2011). Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles Regulatory Impact Analysis. Available at http://www.epa.gov/otaq/climate/documents/420r11901.pdf

3.3.3.1.1 LDV POPULATION: HISTORICAL DATA

This section discusses how ARB determines vehicle population using data sets obtained from the California DMV. DMV data, along with the BAR Smog Check data, and VIN Decoder data,[65] are used to assign vehicle classes and vehicle populations in EMFAC2014.

The DMV data are provided to the ARB twice per year, in April and October. These are sometimes referred to as the "A" and "B" cuts, respectively. These are snapshots of what DMV has in their database at the time. Each cut has nearly 50 million vehicle records, including on-road vehicles, off-road vehicles, trailers, etc. Most of these vehicles are registered, but DMV also tracks some unregistered vehicles. Prior to including this information in EMFAC, staff must assess which are in-use, active on-road vehicles, and stratify these qualified vehicles into EMFAC categories.

In EMFAC2014, vehicle age distribution matrices were developed for CYs 2000-2012 for the vehicle classes shown in Table 3.3-1. Populations by vehicle classes are further subdivided into Sub-Areas for the 69 Geographical Area Indices (GAI). A GAI is referred to herein as a Sub-Area which are unique combinations of County, Air District, and Air Basin. The population of vehicles have ages ranging from 1 to 45 years (for age one, the MY is equal to the CY). The vehicle classes were differentiated primarily on the basis of gross vehicle weights, as shown in Table 3.3-1. Appendix 6.1 provides a more detailed list of vehicle classes used in EMFAC.

Table 3.3-1 EMFAC 2014 LD Vehicle Classes

Vehicle Class (also referred to as)	Weight
Passenger Cars (LDA or PC)	All
Light-Duty Trucks (LDT1 or T1)	GVWR < 6000 lbs. and ETW <= 3750 lbs.
Light-Duty Trucks (LDT2 or T2)	GVWR < 6000 lbs. and ETW 3751-5750 lbs.
Medium-Duty Trucks (MDV or T3)	GVWR 6000-8500 lbs.
Light-Heavy Duty Trucks (LHD1 or T4)	GVWR 8501-10,000 lbs.
Light-Heavy Duty Trucks (LHD2 or T5)	GVWR 10,001-14,000 lbs.
Motor Homes (MH)	All
School Buses (SBUS)	All
Motorcycles (MCY)	All
Urban Buses (UBUS)	All
GVWR = Gross Vehicle Weight Rating; ETW = Equivalent Test Weight	

The vehicle class/Sub-Area/Age stratified LDV population is further divided by fuel type; and these include gasoline (gas), diesel (dsl), electric, and natural gas (NG). Most vehicle classes only have two fuel types (gasoline and diesel) and a few only have a single fuel type (gasoline or diesel). In EMFAC2014, NG is broken out as a separate fuel type only for UBUS and for SWCV truck counts. The NG population counts for LDV were extremely small and have been included in the gas vehicle counts for LDA, LDT1, LDT2 and MDV. The electric category is only used for passenger car and LD truck counts for LDA and LDT1 (there are none for LDT2 or MDV). EMFAC2014 will output results for gasoline, diesel (which includes natural gas HD trucks), and electric vehicles.

3.3.3.1.1.1 ELIMINATION OF DUPLICATE RECORDS

Records are deemed to be duplicative when more than one record has the same VIN value in a data set. This typically occurs when changes in vehicle ownership and/or changes in the registered owner's address are made during the period of the analysis. When duplication is found, staff removes all but the most recent VIN record in order to best reflect the current distribution by geographic area.

[65] https://help.edmunds.com/entries/23782847-Vehicle-Identification-Numbers-VINs

3.3.3.1.1.2 VEHICLE CLASSIFICATION

EMFAC2014 estimates the emissions inventory for different classes of vehicles; and these are differentiated by vehicle type and weight. Some of these classes are listed in Table 3.3-1.

3.3.3.1.1.3 MATCHING RECORDS WITH PREVIOUS RECORDS

Each DMV record corresponds to one vehicle for which the provided vehicle characteristic information must be verified since this data is not always accurately reflected in the DMV database. To improve the accuracy, for modelling purposes, the DMV records are matched across adjacent time period data sets by VIN. Some vehicle characteristic information fields are updated in the more current data set using the previous time period data set's DMV record assignments. For example, if a vehicle was determined to be a "passenger car" in 2009, it will still be a "passenger car" in 2010. Through this process, a smaller subset of the data is created containing only "new" vehicles that were not previously verified (nearly 3 million vehicles per CY). Using DMV descriptive fields (including VIN, vehicle make and body information, and license types), these "new" vehicles are sorted into five broad bins: Motorcycle, Passenger Car, Truck, Bus, and Other. To further classify vehicles, ARB has developed detailed algorithms using additional vehicle field information including gross vehicle weight code, vehicle series name, engine cubic inch displacement, vehicle motive power, and the license plate patterns. The algorithms are based on data derived from the ARB's Executive Orders issued to manufacturers during the certification process and information from Ward's Automotive Group Data.

3.3.3.1.1.4 ASSIGN TRUCK CLASSES USING BUREAU OF AUTOMOTIVE REPAIR DATA

The declared Gross Vehicle Weight (GVW) is the weight that equals the total unladen weight of the vehicle plus the heaviest load that will be transported on the vehicle. An owner/operator selects a GVW weight level for registration purposes based on the maximum load to be transported by that vehicle. The Gross Vehicle Weight Rating (GVWR) is the maximum operating weight of a vehicle as specified by the manufacturer and a vehicle should never be loaded beyond the manufacturer's listed GVWR. The GVW can change but the GVWR remains constant. The DMV database does not contain extensive vehicle weight data. However, California's Smog Check program requires that the majority of California's vehicles must undergo emissions testing on a dynamometer once every two years. The vehicle's weight must be accurately determined to properly perform the test, and vehicle weight data are recorded and entered into the BAR database. In this phase of the DMV data processing, classification assignments were improved using BAR's weight data.

For EMFAC2014, DMV data were matched by VIN with BAR's 2005 through 2011 data sets. Trucks with a GVWR less than 6,000 lbs. were assigned ranks of LDT1 or LDT2 based on the vehicle test weight. Trucks with a GVWR between 6000 to 8500 lbs. were assigned a MDV rank. Trucks with a GVWR of 8501 lbs. or greater were ranked as LHD1, LHD2 or T6 based on the GVWR. Although vehicles over 14,000 lbs. are not subject to Smog Check, T6 and T7 trucks accounted for 0.2% of the BAR database. Their weights were used to verify MDV's and LHD's that had no GVW values in the DMV datasets. These GVWR-based class assignments are summarized in Table 3.3-2.

Table 3.3-2 Weights Used to Determine Truck Ranking

Vehicle Class (also referred to as)	Weight Class
Passenger Cars (LDA or PC)	All
Light-Duty Trucks (LDT1 or T1)	GVWR < 6000 lbs. and ETW <= 3750 lbs.
Light-Duty Trucks (LDT2 or T2)	GVWR < 6000 lbs. and ETW 3751-5750 lbs.
Medium-Duty Trucks (MDV or T3)	GVWR 6000-8500 lbs.
Light-Heavy Duty Trucks (LHD1 or T4)	GVWR 8501-10,000 lbs.
Light-Heavy Duty Trucks (LHD2 or T5)	GVWR 10,001-14,000 lbs.
Motor Homes (MH)	All
GVWR = Gross Vehicle Weight Rating; ETW = Equivalent Test Weight	

The above process will only rank trucks for which BAR record matches can be found. For unmatched vehicles, there are two software VIN decoders ARB staff have access to for use in determining the vehicle rank. Under standards set by the National Highway Transportation and Safety Administration (NHTSA), every car and light truck MY 1981 or later has a unique 17-digit VIN in a fixed format. VIN decoders decipher the VIN codes based on the fixed formats. ARB applies the VIN Decoder from R. L. Polk & Co. which assesses MYs 1981 to present.

3.3.3.1.1.5 INFER TRUCK CLASSIFICATIONS (VIA BAR RESULTS)

In this step, staff classify, by inference, vehicles that lack specific VIN matches in the BAR database or VIN decoders. These may include both newer vehicles and older vehicles that are exempt from biennial testing.[66] Fields from the DMV database, including vehicle make, model code, series name, and model body type are matched with similar fields in the BAR dataset to infer the correct vehicle class. Additional processing for HD trucks is discussed in the *HDV Vehicle Population* section.

3.3.3.1.1.6 ASSIGNING BUS CATEGORIES

Using the registered owner name and address fields from the DMV database, buses are grouped into three separate classifications: School Bus (SBUS), Urban Bus (UBUS), and Other Bus (OBUS). DMV-based assignments to the School Bus categories, involve matching key words in the registered owner name field such as "school" or "Unified SD". However, DMV data for School Buses are not comprehensive due to exempt license plates (which may exempt them from the normal registration process); and additional processing is required (refer to Section 3.3.4.1 *HDV Population: Base Years*). Urban Buses are assigned by matching key words in the registered owner name field such as "City of" or "Transit Authority". All remaining buses are assigned to the “Other Bus” category (examples include church buses, recreational buses and police buses). Additional processing for buses is discussed in the *HDV Vehicle Population* section.

3.3.3.1.1.7 SPATIAL ALLOCATION OF VEHICLES

The ARB divides California into Sub-Areas using 69 Geographical Area Indices. EMFAC includes only those DMV vehicles that are registered to an address with a California ZIP code (between 90001 and 96162). Using a prepared list that matches known ZIP codes and city names with EMFAC’s geographical area index (GAI), each vehicle is assigned to the appropriate Sub-Area. The ZIP codes and city names of any unassigned vehicles are further examined, as new ZIP codes and city names may have been added and thus need to be incorporated into the known list of ZIP codes and city names. As this methodology depends upon the accuracy of the registered ZIP code of each vehicle, vehicles which have an out of state or out of country ZIP code cannot be verified for inclusion in the in-state vehicle population estimate. Vehicles that have an out-of-state ZIP code or military ZIP code are also excluded. For CY 2011, about 5,800 of over 25 million vehicles were excluded due to military ZIP codes and over one million vehicles were excluded due to out-of-state ZIP codes. For HD vehicles, there are additional processing steps as discussed in Section 3.3.4.1.

3.3.3.1.1.8 PENDING VEHICLES

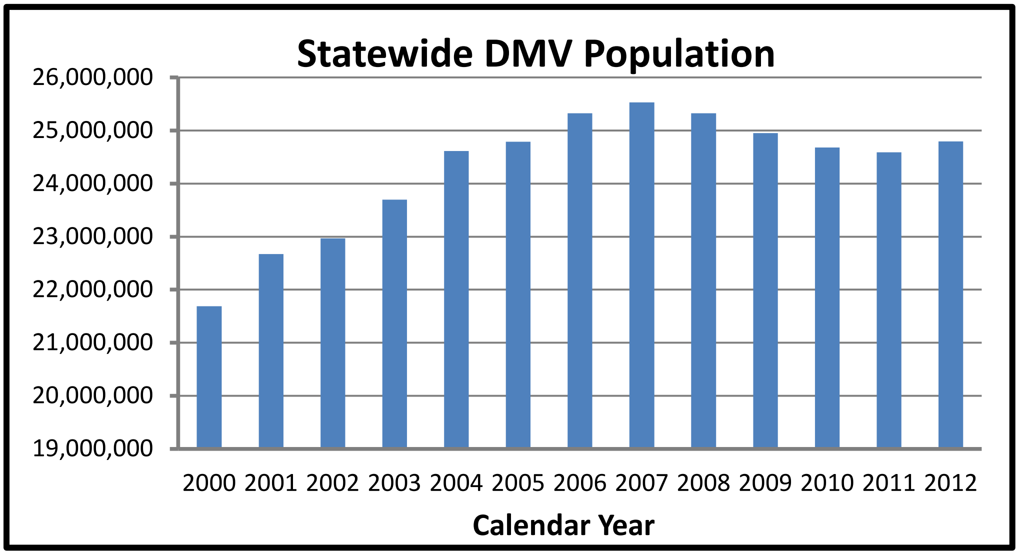
As every effort is made to ensure only vehicles that are on-road are included in the inventory, only vehicles with a valid registration status are considered for inclusion in EMFAC2014’s vehicle populations. Valid registration statuses include vehicles which have a “Current” or “Evidence of Use” value in their registration status. An exception is made for vehicles which have a registration status of “Pending”. Vehicles are placed in the "pending" registration category when the registration renewal

[66] http://www.bar.ca.gov/pdf/Smog_Check_Requirements_by_Vehicle_Type.pdf

process was initiated but, for various reasons, could not be completed. For example, there may be problems with payment of fees, providing proof of insurance, obtaining Smog Check certification, etc. which could delay the registration process. As ARB does not receive instantaneous DMV data, it is possible “Pending” status vehicles may achieve “Current” status between data sets received by ARB. Thus, ARB requires receipt of the subsequent time period data set from DMV in order to complete processing of the prior time period data set (October data is need to complete April’s data process, and the following year’s April data set is needed to complete processing of the October data set). If “Pending” vehicles show up as registered in the subsequent time period’s data set from DMV, the status of the prior data set will be updated as “Current”. “Pending” vehicles whose status remains unchanged after a year are dropped from the vehicle populations used for EMFAC as they are not legally registered vehicles authorized for on-road operations.

Figure 3.3-1 summarizes California’s total registered vehicle population trends between CY 2000 and 2012. There was a steady growth in population from 2000 to 2007, with a subsequent decline in population from 2008 to 2011 due to the economic recession. In 2012, the trend is showing a growth in population once again.

Figure 3.3-1 EMFAC2014 Total Statewide Vehicle Population



3.3.3.1.2 LDV POPULATION: FORECASTED

The LDV population forecasting methodology is described in more detail in the following sub-sections. A future vehicle population is calculated as the existing population plus new vehicle sales minus the number of vehicles that retired or migrated each year. The methodology to estimate new vehicle sales is based on a multivariate regression analysis using actual vehicle sales from 1995-2013. The resulting regression equation is designed to fit these data; and is then used to forecast future new vehicle sales to be added to the existing population in future years based on the historical relationship. Retired vehicle populations to be subtracted from the existing population per region by MY are calculated using retention rates, described in detail in Section 3.3.3.1.3 *LDV Survival Rates*.

3.3.3.1.2.1 FORECASTING LDV RETAINED POPULATION

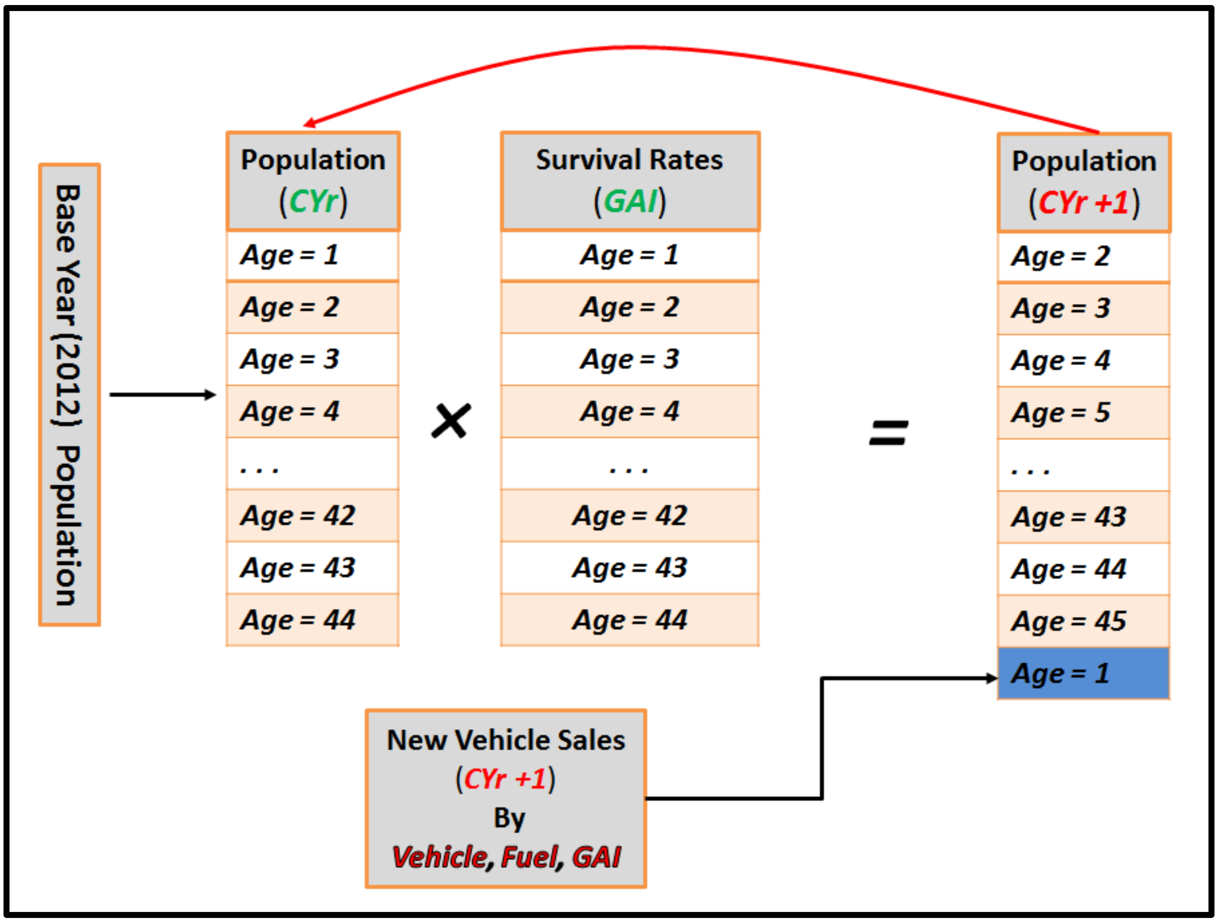
In order to reflect the transition between the economic recessionary period and “Business-As-Usual” (BAU), weighted average retention rates are used across 2012 to 2018.

$$\boldsymbol{Avg\ retention} = \boldsymbol{f} \times \boldsymbol{retention_{rec}} + (\boldsymbol{1} - \boldsymbol{f}) \times \boldsymbol{retention_{BAU}} \quad \textbf{(3.3.3.1-A)}$$

The weighting factor *f* is a linear interpolation between full recession (*f* = *1*) in 2010 and full recovery (*f* = *0*) in 2018.

Starting with the base year, 2012, Sub-Area specific populations from the DMV registration database, the number of new vehicles sold is added and the number of vehicles retired is subtracted to calculate the next year's population. This process is iterated, by using the prior year's population as the base year, for all the CYs of 2013-2050. For 2000-2012, actual DMV population data are used. Figure 3.3-2 shows the steps that EMFAC2014 uses to forecast the vehicle population.

Figure 3.3-2 EMFAC2014 Population Forecasting Methodology



3.3.3.1.2.2 FORECASTING STATEWIDE NEW LDV SALES

In EMFAC2014, the annual vehicle population is comprised of vehicles retained from the prior CY, plus new vehicle sales. The retained vehicles are calculated by applying vehicle survival rates to the prior year's vehicle population. To forecast new vehicle sales, first the statewide new vehicle sales need to be estimated. And then the statewide new vehicle sales need to be disaggregated to regional level new sales, by sub-area. For EMFAC2014, the forecasting equation for statewide new sales of LD vehicles, for all fuel types, was developed using a regression analysis, based on historical time-series data from 1995-2013.

In this econometric modeling process, the selection of variables aimed to be consistent with microeconomic theory which dictates that attention must be paid to the reasonableness of coefficient magnitudes and signs. The goodness of fit and significance criteria (such as t-statistic) from potential models, using different variable combinations, also had to be considered. ARB staff conducted a number of statistical modeling experiments and eventually selected the best available model for forecasting statewide new LD vehicle sales for use in EMFAC2014. The same criteria for statistical modeling were also applied to new vehicle sales, gasoline fuel consumption, and diesel fuel consumption, as discussed in subsequent sections.

The primary data sources used for this analysis included UCLA Anderson Forecast (UCLA), California Department of Finance (DOF), DMV, California Energy Commission (CEC), and U.S. DOE Energy Information Administration (EIA). Below is a more detailed list for the sources used in this regression development, spanning the years 1995-2013, and in the forecasting equations, starting in 2014. All data variables used were for a statewide, annual basis. For more specific descriptions of these data sources, see Appendix 6.3.

Primary data sources included:

- *New vehicle sales (NEW_SALES): DMV and DOF (1995-2013).*
- *Gasoline retail price (GAS_PRICE): CEC (1995-2012), EIA (2013), CEC (2014-2050).*
- *Human population (POP): DOF (1995-2013), DOF (2014-2050, linear interpolation of 5-year increments).*
- *Unemployment rate (UR): DOF (1995-2013), UCLA (2014-2020), Keep constant at 6% (2021+).*
- *Consumer Price Index (CPI): DOF (1995-2013), UCLA (2014-2023).*

The chosen regression model for new LD vehicle sales at the statewide level is as follows.

NEW_SALES_FORECAST = -0.414 - 0.0731*GAS_PRICE - 0.106*UR + 0.0826*POP (3.3.3.1-B)

R^2=0.773; N=19

Where:

NEW_SALES_FORECAST = forecasted statewide new sales of LD vehicles, regardless of fuel type, in millions;

GAS_PRICE = statewide annual average gasoline price, in 2010 dollars per gallon;

UR = statewide unemployment rate, in percentage; and

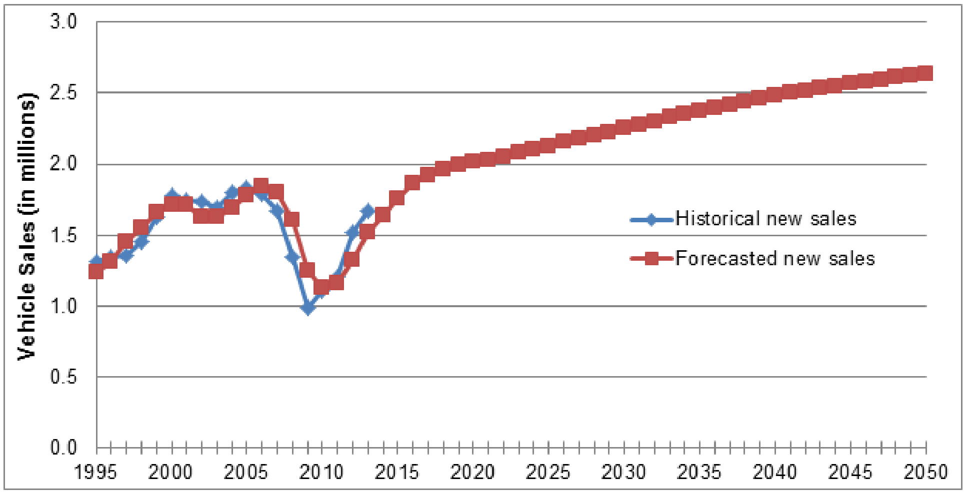
POP = statewide human population, in million persons.

R^2 = the coefficient of determination

N = the number of data points (in this case it is the number of CYs available)

Figure 3.3-3 shows that the forecasted statewide new sales, predicted by the regression model, fit the existing data from 1995-2013 reasonably well, even with the anomaly due to the significant recession during this time period (for which some variance can be seen). The figure below also presents the forecasted statewide sales for years 2014-2050 using the selected regression model.

Figure 3.3-3 The Historical and the Regression-Model Forecasted Statewide New Sales of LD Vehicles, including All Fuel types



3.3.3.1.2.3 DISAGGREGATING STATEWIDE NEW LDV SALES

The forecasted statewide annual new vehicle sales estimates had to be disaggregated into different vehicle types by region. For EMFAC2014, the distribution of new vehicle sales to regions was based on the regional human population proportions using county level data (Sub-Area level data by GAI was not available). It was assumed that regions would maintain their vehicle purchasing power over time. Therefore, the forecasted statewide LD new vehicle sale estimates, for each CY, were disaggregated as follows:

1. *From 2012 DMV data:*

$$\mathbf{C(County)} = \frac{\mathbf{2012\ New\ Vehicle\ Sales\ (County)}}{\mathbf{2012\ Human\ Population(County)}} \qquad \textbf{(3.3.3.1-C)}$$

2. *For future years:*

$$\mathbf{New\ Vehicle\ Sales\ (County) = \ C\ (County) \times Future\ Year\ Human\ Population\ (County)} \qquad \textbf{(3.3.3.1-D)}$$

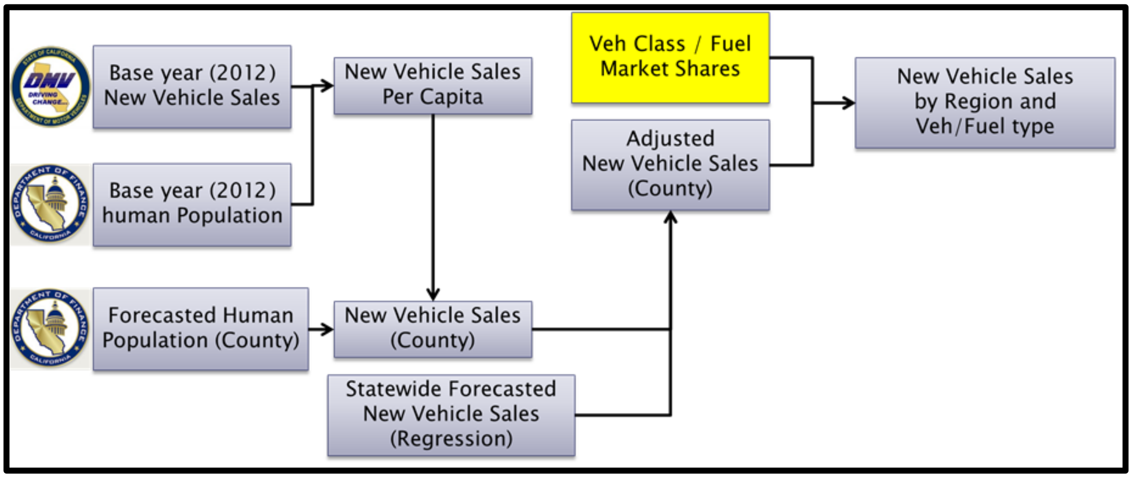
3. *Scale the total New Vehicle Sales summed from step 2 to match the statewide new vehicle sales from the regression equation described in previous sub-section. The scaling factor is calculated as:*

$$\mathbf{Scaling\ factor} = \frac{\mathbf{Statewide\ new\ vehicle\ sales\ from\ the\ regression\ equation}}{\mathbf{\sum County\ Level\ new\ sales\ from\ step\ 2}} \qquad \textbf{(3.3.3.1-E)}$$

Since the statewide new vehicle sales regression equation only provides the number of new LD vehicle sales (GVWR $\leq$ 8500 lbs.), after the regional disaggregation, the resulting regional new LD vehicle sales estimates had to also be disaggregated by vehicle class. The new vehicle sales of other LD categories (such as UBUS, LHDT, etc.) are calculated based on their statewide proportions to LD vehicle sales using the 2009-2012 average vehicle sales ratios for each vehicle class/fuel type from the DMV registration data. These statewide ratios were then applied to each future year's new vehicle sales estimates for all the regions, to estimate the vehicle sales counts by vehicle class/fuel group. For example, if the average ratio of diesel UBUS new sales to LD vehicle new sales is 0.1, within 2009-2012, the same ratio is applied to the projected LD new vehicle sales (obtained from the methodology described above) to calculate the projected new sales of diesel UBUS for all years into the future.

Figure 3.3-4 summarizes the steps taken to disaggregate the statewide new sales by county, by vehicle class and fuel type.

Figure 3.3-4 New Vehicle Sales Forecasting Methodology



3.3.3.1.3 LDV SURVIVAL RATES

In prior EMFAC versions, the survival rates used were computed at the statewide level and not by Sub-Area (GAI) or Regional (groups of similar GAIs) levels. For each vehicle class/fuel group, statewide retention rates were computed using the proportion of vehicles remaining, for a given MY, across each two consecutive CY pair, across all the years of DMV data used in the analysis. These retention rates were then averaged, by vehicle age, to smooth out year-to-year fluctuations in the data. Statewide survival rates, (the proportions of vehicles remaining for a given MY, at each age) were computed from the adjusted retention rates. Statewide survival rates started at a value of one at age zero, and then decreased with vehicle age, in accordance with the average retention rates. Decreasing vehicle retention rates, as vehicle age, are a result of attrition. Migration into and out of the state was unknown, but was reasonably assumed to be at a state of equilibrium and could be excluded from the survival rate computational process.

EMFAC2014 includes necessary changes in the computation of survival rates. There are variations in vehicle survival rates, across the different regions of the state. Some regions tend to buy more new vehicles, while other regions tend to buy more used vehicles; and these patterns were enhanced by the recession. These differences between regions have influence on regional vehicular emissions. In general, regions with higher percentages of older vehicles, on the road, have higher average emission rates per VMT by vehicle class versus regions with higher percentages of newer vehicles. In order to account for this phenomenon in EMFAC2014, survival curves have been computed regionally; instead of only at the statewide level as had been done in prior EMFAC versions.

Survival curves were computed for each vehicle class/fuel grouping in EMFAC2014. If sufficient data were available, the survival curves were computed per Sub-Area. Otherwise, survival curves were computed for regions of grouped Sub-Areas. For some vehicle class/fuel groups, only statewide level survival curves could be computed. And for a few groups, the lack of available DMV data required the adoption of survival curves from another vehicle class/fuel group.

An example of survival rate substitution involves LD diesel vehicles. For a period of time, LD diesel vehicles could not meet California emissions requirements and thus could not be sold or registered in California. So the population for these vehicles dropped until they were able to meet California standards and become certified to be sold and registered in California once again. This type of registration variance, across years, does not allow for computing retention rates that can be used to develop survival curves, so the gasoline survival curves were substituted.

A summary of the geographic levels and substitutions used in the derivation of each of the EMFAC2014 vehicle class/fuel group retention/survival rates is provided in the following table.

Table 3.3-3 Survival Rate Documentation

Description	Gas*	Diesel (Dsl)	Electric
Passenger Cars (LDA or PC)	By Sub-Area (GAI)	Copied** from LDA Gas	Copied** from LDA Gas
Light-Duty Trucks (LDT1 or T1)	Regional (Groups of GAI)	Copied** from LDT1 Gas	Copied** from LDT1 Gas
Light-Duty Trucks (LDT2 or T2)	Regional (Groups of GAI)	Copied** from LDT2 Gas	*No Such Category*
Medium-Duty Trucks (MDV or T3)	Regional (Groups of GAI)	Copied** from MDV Gas	*No Such Category*
Light-Heavy Duty Trucks (LHD1 or T4)	Regional (Groups of GAI)	Regional (Groups of GAI)	*No Such Category*
Light-Heavy Duty Trucks (LHD2 or T5)	Copied** from LHD2 Dsl	Regional (Groups of GAI)	*No Such Category*
Heavy Duty Trucks 14001 - 33000 lbs. (T6)	Copied** from T6 Dsl	Regional (Groups of GAI)	*No Such Category*
Heavy duty Trucks >33000 lbs. (T7)	Copied** from T6 Dsl	Copied** from T6 Dsl	*No Such Category*
Other Buses (OBUS)	Statewide	Statewide	*No Such Category*
Transit/Urban Buses (BT)	Statewide	Statewide	*No Such Category*
Motorcycles (MCY)	Regional (Groups of GAI)	*No Such Category*	*No Such Category*
School Buses (SBUS)	Statewide	Statewide	*No Such Category*
Motor Homes (MH)	Regional (Groups of GAI)	Statewide	*No Such Category*
*For LDV, Gas includes small counts of Natural Gas Vehicles which could not be broken out into a separate fuel group category			
**Sufficient data for this category was not available for this analysis so copied results from another fleet/fuel group as noted			

3.3.3.1.3.1 MIGRATION

In order to develop accurate survival curves by region, migration into and out of each region needs to be taken into account. For EMFAC2014, regional retention rates are actually a combination of attrition (the proportion of a given MY that no longer remain registered within the region from one year to the next) and migration (new vehicle registration movement into the region). As such, the survival curves can exceed a value of 1 when there is migration into regions, at ages with higher rates of used vehicle purchases, that exceeds attrition. For regions that tend to purchase more new vehicles (as shown Figure 3.3-5), the survival rate curves start with a value of 1, at age 0, and then decrease with vehicle age. This is similar to the statewide survival rate curves used in prior EMFAC versions. But for regions that tend to purchase more used vehicles (as shown in Figure 3.3-6), the survival rate curves start with a value of 1 at age 0, then increase above 1 for the ages of high used vehicle migration into the region, and then decrease with increasing vehicle age.

Figure 3.3-5 Sample Survival Curve for Region Where More New Vehicles are Purchased

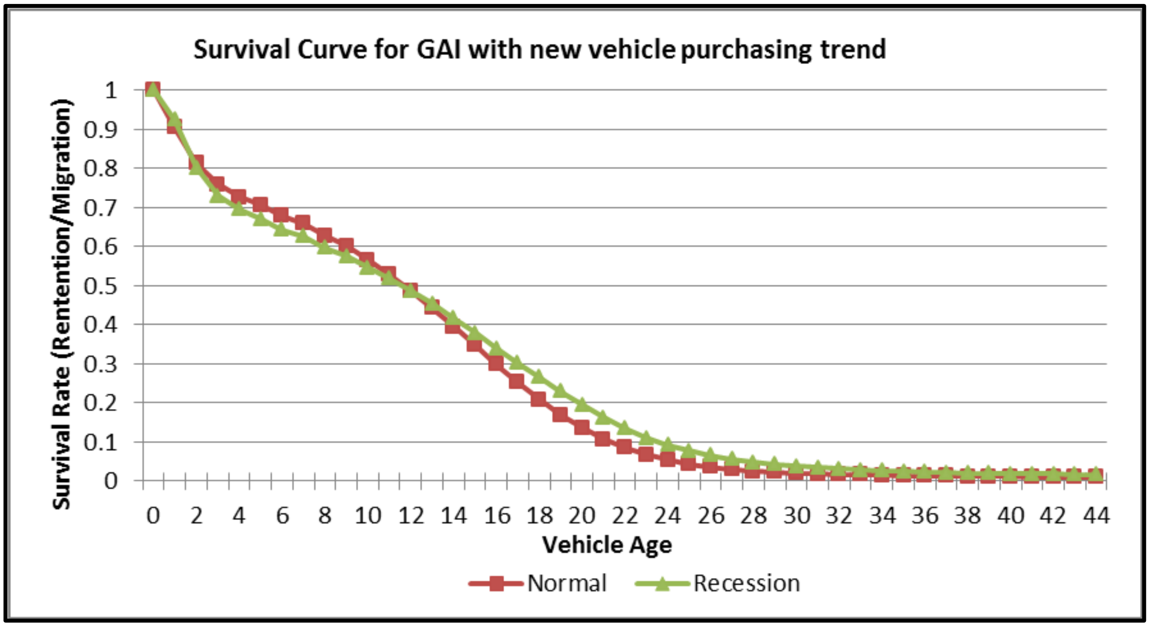
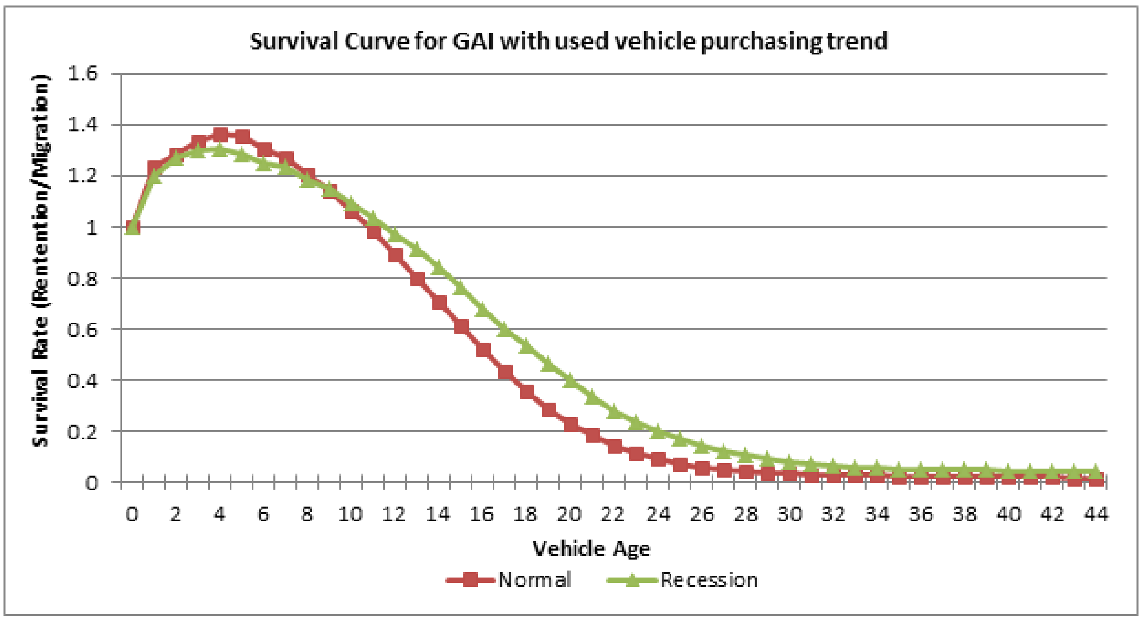


Figure 3.3-6 Sample Survival Curve for a Region Where More Used Vehicles are Purchased



3.3.3.1.3.2 RECESSION AND NON-RECESSION SURVIVAL CURVES

Survival curves also need to account for recessionary changes in vehicle ownership patterns. As a result of the 2007-2009 US recession, the average age of vehicles increased as less new vehicles sales were occurring and older vehicles were being retained longer (decreasing vehicle attrition). To account for this change from pre-recession trends, survival curves for both “recession” and “non-recession” conditions have been computed. For each near future CY, an aggregate survival rate is computed using a weighted average of “recession” and “non-recession” survival curves. Based on economic projections at the time of this analysis, pre-recession economic conditions relative to vehicle sale patterns will occur in CY2018. EMFAC 2014 reverts to using 100% “non-recession” survival curves in CY2018.

3.3.3.1.3.3 CALCULATING RETENTION RATES

At the time of this analysis, the most current processed DMV data available was from CY2011. The CY2012 DMV data later became available for population counts but survival rates were not updated due to time constraints and limited sensitivity testing did not see any significant changes from incorporating CY2012 data. DMV registered vehicle counts, from CY2000 to CY2011, were used to compute retention rates by MY across adjacent CY pairs for each vehicle class/fuel group per Sub-Area, or regions of grouped Sub-Areas, or Statewide (as discussed above). For MY2000 and older, the retention rate was computed per each CY pair: CY2000-to-CY2001, CY2001-to-CY2002, etc. through CY2010-to-CY2011 using the following approach:

$$\textbf{Retention Rate (CY Pair, MY, Sub-Area, Class, Fuel)} = \\ \text{\# of vehicles in } CY_{n+1} \text{ (MY, Sub-Area, Class, Fuel) / \# of vehicles in } CY_n \text{ (MY, Sub-Area, Class, Fuel)} \quad \textbf{(3.3.3.1-F)}$$

The CY pair specific retention rates were then averaged across the CY pairs. For MY2001 and newer, the retention rates were computed in a similar manner, but only incorporating the CY pairs available. Newer MYs only had a few CY pairs available to derive average retention rates. A minimum of two consecutive CYs are needed, so MY=CY will not have a retention rate to calculate.

Calculating Survival Rates

The survival rate can be considered to be the cumulative version of the retention rate and at age zero is always set equal to one. Survival rates per vehicle class/fuel/region are computed by taking the prior age survival rate and multiplying it by the current age average retention rate (from equation 3.3.3.1-F) as shown in the following equation:

$$\text{survival rate of } age_n = \text{survival rate of } age_{n-1} * \text{average retention rate of } age_n \quad \textbf{(3.3.3.1-G)}$$

Thus the retention rate at age one is the age zero survival rate (which is one), multiplied by the average retention rate at age one. The survival rate at age two is the age one survival rate multiplied by the average retention rate at age two, and so on for ages up to 45. By age 45, the counts of vehicles are extremely small; and it is assumed that all vehicles are scrapped or have migrated out-of-state for ages greater than 45.

Both recession and non-recession survival rates were computed. The recession survival curve was based on CY2008 through CY2010 DMV data. The non-recession survival curve was based on all the available years of DMV processed registration vehicle count data at the time of this analysis, including CY2000 through CY2011. All the vehicle class/fuel/region survival curves were reviewed, rates were polynomial curve fitted, and those curve data incorporated into EMFAC2014. It should be noted that DMV data demonstrated no "normal" CY for survival rates due to the variance in vehicle purchasing and attrition trends over time, especially when survival rates are considered at the vehicle class/fuel subgroup level. The DMV analysis was limited by the twelve years of data that were available and the unusual economic events which occurred during those twelve years. Selecting different time periods for these computations produces different results; hence, averaging across all available DMV datasets, rather than using only the most recent DMV datasets, was the best available methodology.

For EMFAC2014, age_n to age_{n+1} retention rates were back calculated from the survival curves and, for reference, these reside in the default "survival rate" table in the EMFAC2014 MySQL tables for the model. This table contains retention rates (Figure 3.3-7) rather than the actual survival rates (Figure 3.3-8).

Figure 3.3-7 Example Retention Rates

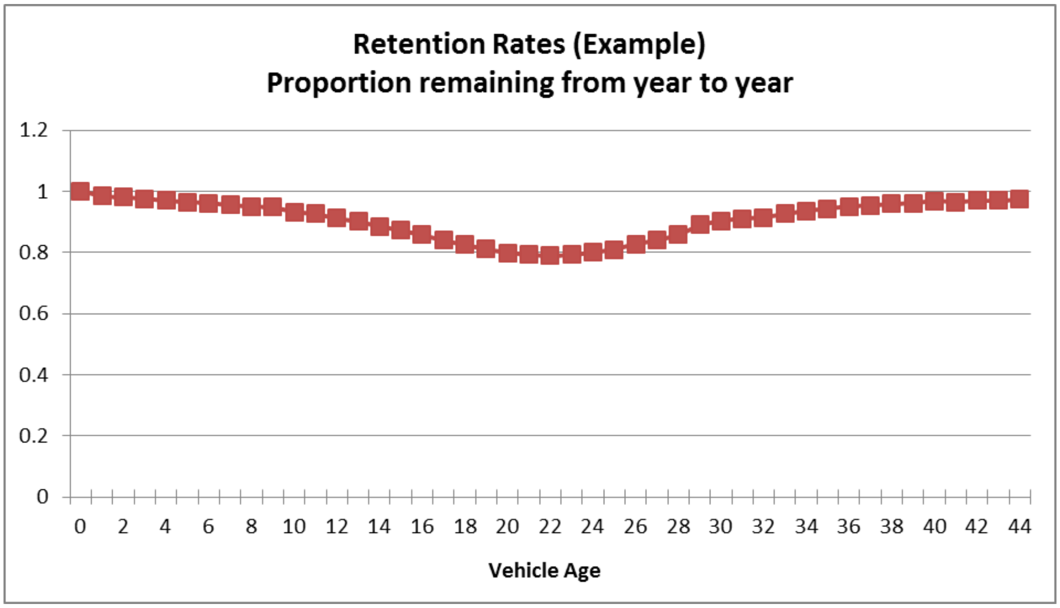
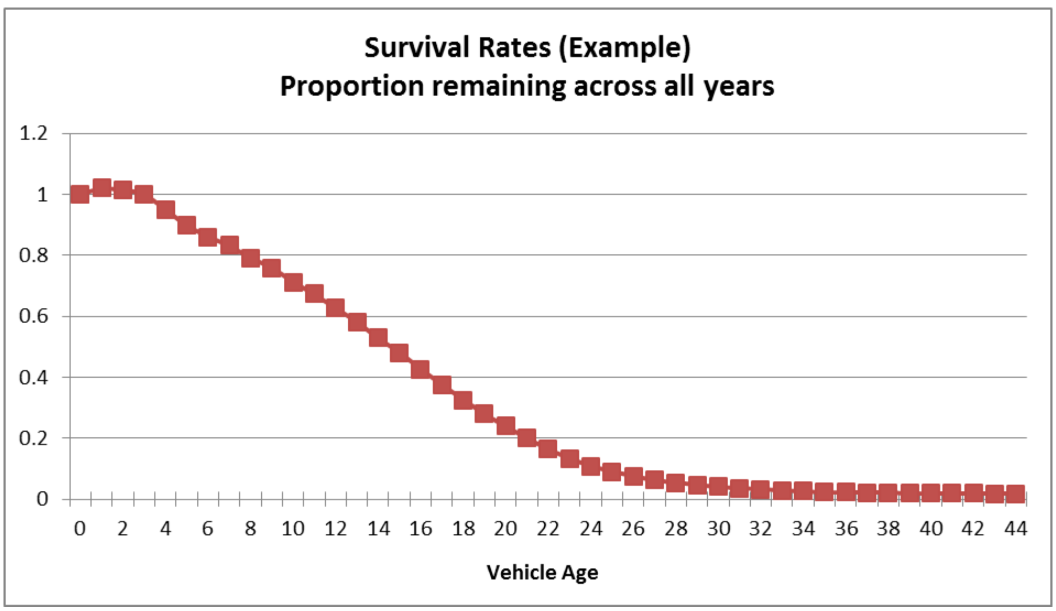


Figure 3.3-8 Example Survival Rates



3.3.3.1.4 LDV POPULATION ADJUSTMENT

After computing the LDV population (forecasting new sales and applying retention/survival rates across CYs as discussed above), the results must also be adjusted to account for VMT that occurs into or out of regions due to inter-regional traffic flow. This is discussed within the LDV VMT section, where more context is provided (refer to *Apportioning Vehicle Population for 2000- 2050*) below.

3.3.3.2 LD Default VMT

For EMFAC, VMT represents the total distance traveled on a typical weekday. Local planning agencies, such as metropolitan planning agencies (MPOs), have developed regional transportation models which output regional VMT for certain planning years. In EMFAC2011, VMT were calculated based on vehicle population and vehicle mileage accrual. Mileage accrual is the total number of miles a vehicle accumulates in a year, and varies by vehicle age, vehicle class, and region forecasted. For EMFAC2011, vehicle population and accrual estimates, for applicable regions, had to be modified to ensure that the results of multiplying the vehicle population by the mileage accrual rates would match the VMT supplied by MPOs. For EMFAC2014, a new methodology has been developed which begins with VMT being derived at both the statewide (based on fuel use) and at regional levels (based on the product of population and mileage accrual). The regional level data gets adjusted for travel across regions, as described in Section 3.3.3.2.2, and then is scaled such that the sum of the VMT across all the regional level matches the statewide VMT. The default EMFAC2014 model does not include MPO VMT (and thus does not adjust to match VMT supplied by these local agencies). By selecting the "Custom Activity (SG)" run type in EMFAC2014, local agencies may import their VMT, either by vehicle class or in aggregated form, to obtain MPO specific results for use in lieu of the default activity results. The new process to develop VMT for the default model will be described in detail below.

EMFAC also contains hourly distributions of VMT by vehicle class. These distributions are based on second-by-second instrumented vehicle activity data collected by the U.S. EPA.[67] And EMFAC uses vehicle adjustment factors to convert annual VMT to weekday VMT.[68]

3.3.3.2.1 LDV MILEAGE ACCRUAL RATES

The mileage accrual rate is an estimate of the miles per year traveled per vehicle. Bureau of Automotive Repair (BAR) Smog Check Data were used to derive regional mileage accrual rates by vehicle age and class for LD vehicles using the same methods employed since EMFAC2007.[69] As only gasoline powered vehicles were included in the Smog Check program data, it was assumed that diesel and electric-powered vehicles would have the same mileage accrual rates as gasoline powered vehicles of the same class. The following table lists the applicable vehicle classes included in the BAR Smog Check data set used for this analysis.

Table 3.3-4 Smog Check Vehicle Classes

Vehicle Class (also referred to as)	Weight Class
Passenger Cars (LDA or PC)	All
Light-Duty Trucks (LDT1 or T1)	GVWR < 6000 lbs. and ETW <= 3750 lbs.
Light-Duty Trucks (LDT2 or T2)	GVWR < 6000 lbs. and ETW 3751-5750 lbs.
Medium-Duty Trucks (MDV or T3)	GVWR 6000-8500 lbs.
Light-Heavy Duty Trucks (LHD1 or T4)	GVWR 8501-10,000 lbs.
Light-Heavy Duty Trucks (LHD2 or T5)	GVWR 10,001-14,000 lbs.
Motor Homes (MH)	All
GVWR = Gross Vehicle Weight Rating; ETW = Equivalent Test Weight	

Historical BAR smog check data for the CYs of 2005 through 2010 were available for use in this analysis for developing updated mileage accrual rates. This data set includes approximately ten million records per CY. All the data were sorted by descending test dates, unique vehicle identifier, region, and vehicle class type. For the same vehicle, for every two adjacent records, the difference in odometer and difference in test dates were computed. To avoid errors due to odometer readings in vehicles with five-digit displays (as discussed in Section 3.2.2 *New Statewide LD Odometer Schedule for Deterioration*), only the positive mileage differences were used for this analysis. The difference of miles per day between consecutive dates was computed and transformed into equivalent annual miles of accrual. To eliminate potential data entry errors, outliers above a reasonable amount were also eliminated (for example, it would be impossible for a vehicle to have annual mileage accrual that

[67] EMFAC 2000, Section 7.6 (http://www.arb.ca.gov/msei/onroad/doctable_test.htm)
[68] EMFAC 2001, Updated Vehicle Miles Traveled document (http://www.arb.ca.gov/msei/emfac2002_docs.htm)
[69] http://www.arb.ca.gov/msei/onroad/techmemo/modified_mileage_accrual_rates.pdf

exceeds maximum operational parameters such as 65 miles per hour for 24 hours per day for all 365 days per year).

For each region and vehicle class, the average mileage accrual by age was computed and regression equations were developed. These updated regression equations were used for the mileage accrual rates in EMFAC2014, replacing the mileage accrual rates that were used in EMFAC2011. If insufficient data were available to compute mileage accrual rates by individual Sub-Areas, similar Sub-Areas were grouped together as a Region. For LHD1, LHD2, and Motor Homes, there were only sufficient data for establishing statewide average mileage accrual rates. Where insufficient data were available to compute mileage accrual rates for individual vehicle classes, some classes were combined into a single grouping (LDT1 and LDT2, LHD1 and LHD2). For ages of one year to five years, the data points available for determining the average mileage accrual by age were limited and no other data sources were available per Sub-Area for comparison purposes. Overall, the regression model results using the average miles per age by group showed reasonable results with high R^2 values (with the majority above 0.80). The newest vehicles accrued the highest mileage and mileage decreased with age. The results were compared to the mileage accrual rates used for EMFAC2011 and were found to be very similar.

The following table summarizes the level of data used to compute the mileage accrual rates, which reside in the default “accrual rate” MySQL table in EMFAC2014. Mileage accrual rates are used to spatially allocate statewide vehicle miles travelled (VMT) as discussed below.

Table 3.3-5 Mileage Accrual Rate Documentation

Description	Grouping
LDA = Passenger Cars	Sub-Area (GAI) or Reginal (groups of similar GAIs)
LDT1 = Light-Duty Trucks (GVWR < 6000 lbs. and ETW <= 3750 lbs)	Sub-Area (GAI) or Reginal (groups of similar GAIs)
& LDT2 = Light-Duty Trucks (GVWR < 6000 lbs. and ETW 3751-5750 lbs)	
MDV = Medium-Duty Trucks (GVWR 6000-8500 lbs.)	Sub-Area (GAI) or Reginal (groups of similar GAIs)
LHD1 & LHD2 = Light-Heavy Duty Trucks (GVWR 8501-14000 lbs.)	Statewide
MH = Motor Homes	Statewide

Note: Comparing the regional accrual rates to the statewide odometer schedule (as discussed in Section 3.2.2 *New Statewide LD Odometer Schedule for Deterioration*) will show significant variation as the data is derived differently. BAR Smog Check gas-fueled vehicle data is used to derive the statewide average odometer values used for deterioration computations. These statewide odometer averages represent an estimated mid-point of the odometer readings for each model year per calendar year (CY), independent of how long a vehicle has actually been operational. For EMFAC purposes, vehicle age is simply the calendar year minus the model year, and not the true operational age. Vehicles of a given model year could be sold in the prior calendar year as well as across different months for the same calendar/model year. The BAR Smog Check odometer readings for a given model year in each calendar year show wide variability, but tend to display a normal distribution curve and the average odometer value reflects the peak of this curve. Comparing across these peak averages across CYs does not take into account the variability of the actual operational vehicle ages.

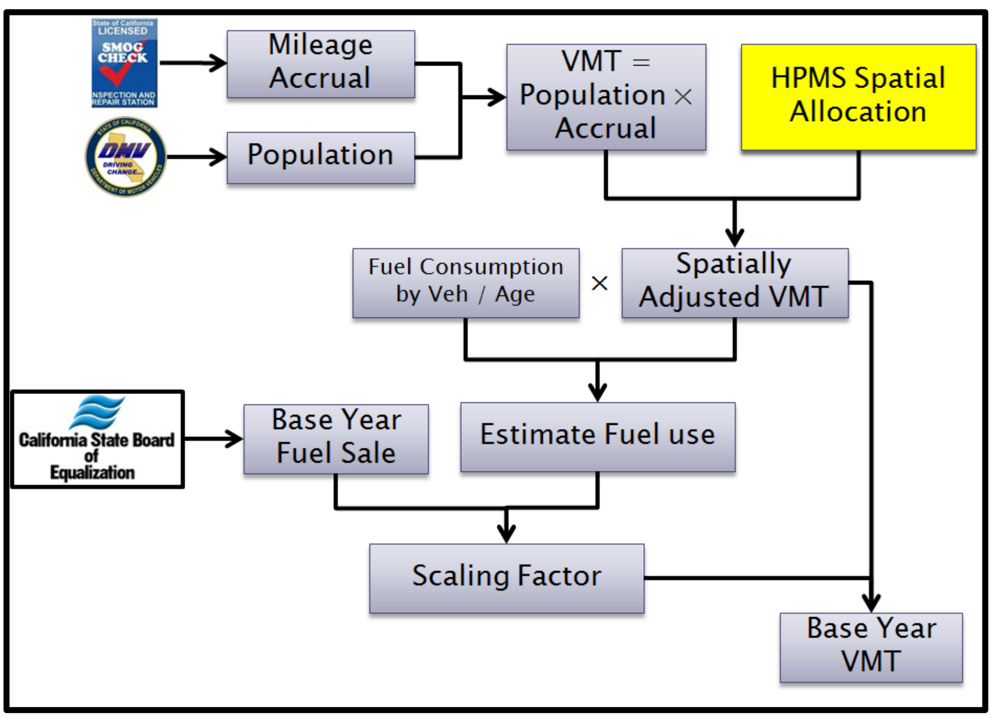
The same BAR Smog Check data is also used to derive regional accrual rates, however, paired vehicle data over time is used to compute distance traveled over time, which is then converted to miles per year accrual rates per region of the state (based on the CY of the most current date per pair to determine the vehicle age). As newer model year vehicles are exempt from biennial review, the smog check data collected for accrual purposes is limited, however, no better data source has been identified. It is possible the Smog Check data might be biased and not as representative of the statewide fleet as is desired (such as if it includes more rental vehicles with higher mileage values) but without other data sets for verification purposes, this cannot be determined. The accrual rates are averaged per vehicle age to develop regional accrual curve models. These models provide the average annual miles travelled per vehicle age by regions. These regional values may vary significantly from the average statewide odometer schedule data differences across CYs.

3.3.3.2.2 DEFAULT LD VMT: BASE YEAR

In the Default Mode of EMFAC2014, future VMT are forecasted from a base year. The base year VMT are first computed and then growth rates (at both statewide and regional level) are applied to the base year VMT to forecast VMT in future years. These initial VMT estimates are later normalized to statewide fuel usage using data provided by the California State Board of Equalization (BOE).

Since the most current, processed DMV data set available was for 2012, year 2012 was selected as the base year for EMFAC2014. Base year VMT were calculated by applying vehicle mileage accrual rates (from the above *LDV Mileage Accrual Rates* Section 3.3.3.2.1) to base year vehicle populations by vehicle class[70] and regional groupings. The resulting base year VMT by vehicle class and region does not, however, account for the inter-regional VMT (across sub-areas). In order to properly account for the inter-sub-area traffic VMT, the VMT were redistributed based on the regional distribution derived from Caltrans Highway Performance Monitoring System (HPMS)[71] data. Once the VMT were redistributed regionally, the statewide fuel use could be estimated using the EMFAC2014 based fuel consumption (gal/mi) values (by MY). Comparing the estimated fuel use and the BOE reported fuel use, for the base year, a single statewide scaling factor was then calculated to apply to the spatially adjusted VMT in order to ensure that the estimated fuel use from the base year VMT were consistent with the BOE reported fuel use. EMFAC2014 uses back calculated annual average statewide fuel consumption rates (gal/mi) to calculate the fuel usage from the VMT and this value is matched to the fuel use data reported by BOE within a margin of 1% (after applying the single statewide scaling factor). An exact match cannot be achieved because of differences in the resolution (temporal and spatial) of fuel consumption rates that are used to scale VMT and the impact of fuel usage in other emission processes such as start or idle emissions which are based on vehicle activity other than VMT. A flowchart describing this process is shown in Figure 3.3-9.

Figure 3.3-9 Base Year VMT Estimation Process



[70] Detail description can be found in Table 3.3-1
[71] GIS based NTAD data was populated by HWA using HPMS link level data.

3.3.3.2.2.1 ALLOCATION OF BASE YEAR (2012) VMT

The calculation of VMT, using vehicle populations x mileage accrual rates (Pop x Accrual) does not account for the inter-regional traffic. Therefore, in order to reflect this in the VMT estimations, HPMS (NTAD2008[72]) based VMT, at the sub-area level, were used to redistribute Pop x Accrual VMT forcing its regional distribution becomes consistent with the HPMS data.

The methodology EMFAC2014 uses to calculate base year VMT consists of 8 steps.

1. *Unadjusted VMT (VMT_U) were calculated, using base year DMV populations and BAR Smog Check or EMFAC2011 mileage accrual rates. Vehicle populations and average mileage accrual rates were determined for each sub-area (SA), vehicle class (Class), age (Age). Fuel type (Fuel) was also included in the population estimates. The matching vehicle populations and mileage accrual rates combined to derive VMT for each SA, Class, Fuel, and Age. The total VMT of each SA (VMT_{SA}) was then determined by summing across Class, Fuel, and Age. The total statewide VMT ($VMT_{Statewide}$) was subsequently determined by summing the VMT_{SA} across the SAs.*

   $$\mathbf{VMT_U(SA,Class,Fuel,Age) = Pop\ (SA,Class,Fuel,Age) \times Accrual\ (SA,Class,Age)} \quad \textbf{(3.3.3.2-A)}$$

   $$\mathbf{VMT_{SA}(SA) = \Sigma_{Class,Fuel,Age} VMT_U(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-B)}$$

   $$\mathbf{VMT_{Statewide} = \Sigma_{SA} VMT_{SA}(SA)} \quad \textbf{(3.3.3.2-C)}$$

2. *The HPMS based VMT, at each SA, were calculated by multiplying $VMT_{Statewide}$ by the HPMS VMT distribution (HPMS $Dist_{SA}$), which is the percent of VMT in each SA.*

   $$\mathbf{HPMS\ VMT_{SA}(SA) = HPMS\ Dist_{SA}(SA) \times VMT_{Statewide}} \quad \textbf{(3.3.3.2-D)}$$

3. *The difference between the HPMS VMT_{SA} and the VMT_{SA} was calculated for each SA.*

   $$\mathbf{\Delta VMT_{SA}(SA) = HPMS\ VMT_{SA}(SA) - VMT_{SA}(SA)} \quad \textbf{(3.3.3.2-E)}$$

4. *For a given SA, there will be vehicles registered in that SA which travel into other SAs, creating an outflow of VMT from the SA. Vehicles registered in other SAs also travel into that SA creating VMT inflow into that SA. To address inflow/outflow VMT, C factors were developed. For outflow VMT from a given SA, the SA specific Class, Fuel, and Age distributions (Equation 3.3.3.2-F) are used. Inflow VMT, however, cannot be mapped to a specific SA as the vehicles are registered in many other SAs. Thus, the inflow vehicles are assumed to have Class, Fuel, and Age distributions equivalent to the statewide averages (Equation 3.3.3.2-G). The C Factors are calculated as follows.*

   $$\mathbf{For\ \Delta VMT_{SA} < 0\ (Net\ Outflow),\ C_{Out}(SA) = \Delta VMT_{SA}(SA)/VMT_{SA}(SA)} \quad \textbf{(3.3.3.2-F)}$$

   $$\mathbf{For\ \Delta VMT_{SA} > 0\ (Net\ Inflow),\ C_{In}(SA) = \Delta VMT_{SA}(SA)/VMT_{Statewide}} \quad \textbf{(3.3.3.2-G)}$$

5. *In order to compute class/fuel/age stratified inflow VMT, statewide VMT had to be calculated using the unadjusted VMT from step 1*

   $$\mathbf{VMT_{Statewide}\ (Class,Fuel,Age) = \Sigma_{SA} VMT_U(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-H)}$$

6. *Inflow and outflow VMT were then calculated as follows.*

[72] https://2bts.rita.dot.gov/pdc/user/products/src/products.xml?p=2795

For Net Outflow

$$\mathbf{VMT_{Out}(SA,Class,Fuel,Age) = C_{Out}(SA)*VMT_{U}(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-I)}$$

For Net Inflow

$$\mathbf{VMT_{In}(SA,Class,Fuel,Age) = C_{In}(SA)*VMT_{Statewide}(Class,Fuel,Age)} \quad \textbf{(3.3.3.2-J)}$$

7. *Depending upon whether the SA has net inflow or net outflow, either VMT_{In} is added to, or VMT_{Out} is subtracted from the unadjusted sub-area VMT.*

   Net Outflow

$$\mathbf{VMT_{HPMS}(SA,Class,Fuel,Age) = VMT_{U}(SA,Class,Fuel,Age) - VMT_{Out}(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-K)}$$

   Net Inflow

$$\mathbf{VMT_{HPMS}(SA,Class,Fuel,Age) = VMT_{U}(SA,Class,Fuel,Age) + VMT_{In}(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-L)}$$

8. *In the last step, the HPMS corrected VMT are normalized to the BOE statewide fuel sales-predicted VMT (VMT_{Fuel}) using a G Factor that is based upon 2012 BOE fuel use data EMFAC2014 fuel consumption rates (**FCR**).*

$$\mathbf{G_{Fuel} = 2012\ BOE\ Fuel\ Use/[\Sigma_{SA,Class,Fuel,Age}VMT_{HPMS}(SA,Class,Fuel,Age)*FCR]} \quad \textbf{(3.3.3.2-M)}$$

$$\mathbf{VMT_{Fuel,HPMS}(SA,Class,Fuel,Age) = G_{Fuel}\ x\ VMT_{HPMS}(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-N)}$$

3.3.3.2.2.2 APPORTIONING VEHICLE POPULATION FOR 2000 - 2050

In the EMFAC model, the spatial allocation of VMT controls where the running exhaust emissions are apportioned to, but not the other processes (such as running loss evaporative emissions, or start exhaust emissions) which are controlled by vehicle population (how many vehicles operate in which Sub-Area). As previously discussed, vehicles do not travel exclusively within their registered Sub-Area. In order to deal with the effect of inter-regional traffic on other emissions processes, the Sub-Area populations need to be adjusted; and this is done using an approach similar to that used for VMT. Using the HPMS proportions that reflect the travel patterns of vehicles across Sub-Areas, the C factors developed above (to allocate VMT) are also used to apportion the vehicle population to reflect these inflow/outflow travel patterns. The process is done in two steps as follow:

1. *Similar to VMT, the Population by age that needs to be apportioned in/out of each Sub-Area is calculated using the C factors (refer to steps 4 to 6 in Allocation of Base Year VMT above but substitute population for VMT).*
2. *The Pop_{In}/Pop_{Out} is added to/subtracted from the forecasted population (refer to step 7 in Allocation of Base Year VMT above but substitute population for VMT).*

3.3.3.2.3 LD VMT: FUTURE STATEWIDE FORECAST

The growth rates used for forecasting VMT in EMFAC2014 are based on regional (county level) human population growth rates with adjustments made to account for projected growth rates in statewide fuel usage (considering no fuel economy improvements) between 2013 - 2017. County level VMT were grown with human population growth rates. Once the VMT for all the counties were calculated, the total statewide VMT sum was verified to be equivalent to the base year VMT multiplied by the statewide fuel sales growth (sources are discussed below). If the total projected statewide VMT sum is higher/lower than the projected VMT (Base Year × Fuel use growth), then the statewide VMT were adjusted by a statewide scaling factor to ensure the results match. This process was used to forecast LD VMT through 2017. However, after 2017, the projected fuel growth rates are more uncertain (due to the uncertainty inherent in the long-term economic forecasts), and it is assumed that VMT per capita stays constant. Therefore, only county level human population trends were used to grow the VMT from 2018 to 2050. Please note that EMFAC2014 default activity estimates do not take into account SB375.

3.3.3.2.3.1 FORECASTING GASOLINE FUEL SALES

Baseline gasoline consumption at the statewide level is forecasted using a regression analysis, based on historical time-series data from 1995-2013. As discussed above in the LD vehicle new sales forecasting section, the selection of variables for EMFAC2014 econometric modeling processes aimed to be consistent with microeconomic theory which dictates that attention must be paid to the reasonableness of coefficient magnitudes and signs. The goodness of fit and significance criteria (such as t-statistic) from potential models, using different variable combinations, also had to be considered. ARB staff conducted a number of statistical modeling experiments and eventually selected the best available model for forecasting statewide gasoline fuel sales for use in EMFAC2014.

The primary data sources used for this analysis included UCLA Anderson Forecast (UCLA), California Department of Finance (DOF), California Board of Equalization (BOE), California Energy Commission (CEC), U.S. DOE Energy Information Administration (EIA), and U.S. Bureau of Economic Analysis (BEA). Below is a more detailed list for the sources used in this regression development, spanning the years 1995-2013, and in the forecasting equations, starting in 2014. All data variables used were for a statewide, annual basis. For more specific descriptions of these data sources, see Appendix 6.3.

- *Motor gasoline sales (GAS): DOF and BOE (1995-2013).*
- *Gasoline retail price (GAS_PRICE): CEC (1995-2012), EIA (2013), CEC (2014-2050).*
- *Disposable personal income (DIS_INC): BEA (1995-2013), UCLA (2014-2023), Linear extrapolation of 1995-2023 (2024+).*
- *Non-farm jobs (NF_JOBS): DOF (1995-2013), UCLA (2014-2023), Linear extrapolation of 1995-2023 (2024+).*
- *Consumer Price Index (CPI): DOF (1995-2013), UCLA (2014-2023).*

The chosen regression model for gasoline consumption at the statewide level is as follows:

$$\mathbf{GAS\_FORECAST=2.509-0.882*GAS\_PRICE+4.969*DIS\_INC+0.564*NF\_JOBS} \qquad \textbf{(3.3.3.2-O)}$$

$R2=0.824$; $F=23.38$; $N=19$

Where:

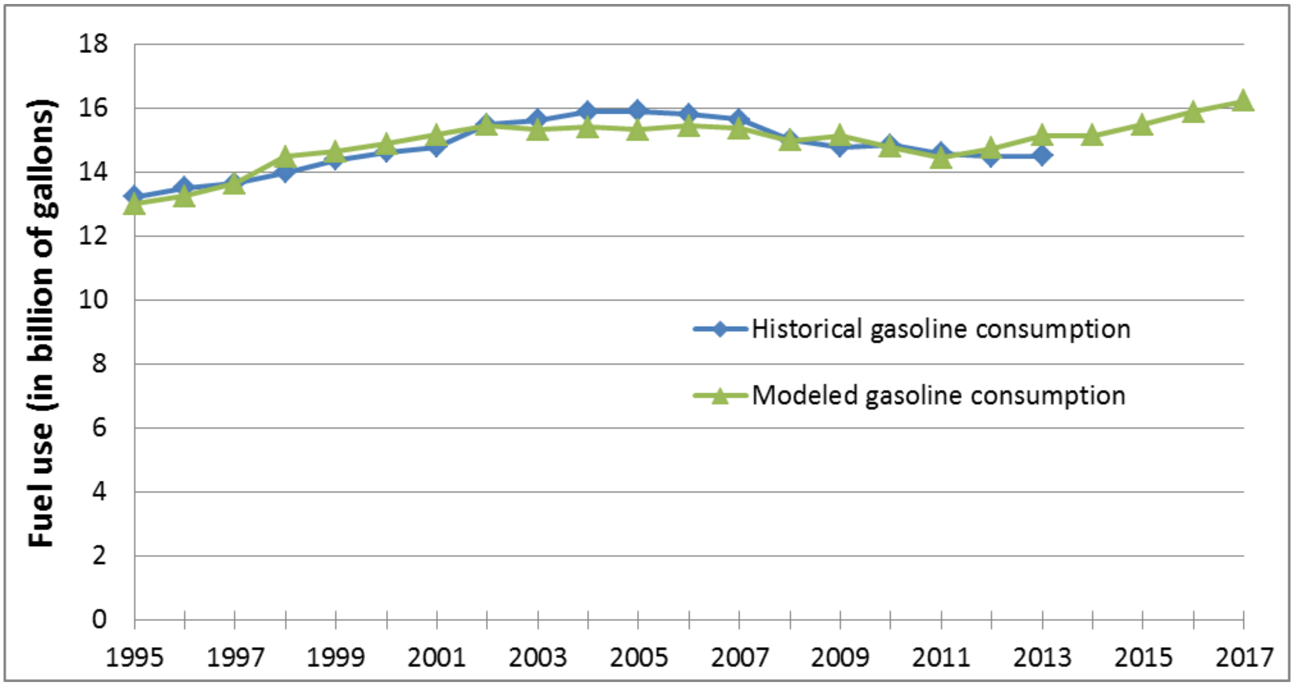
GAS_FORECAST: forecasted statewide annual gasoline consumption, in billions of gallons;

GAS_PRICE: statewide annual average gasoline price, in 2010 dollars per gallon;

DIS_INC: state disposable personal income, in trillions of 2010 dollars; and
NF_JOBS: statewide non-farm jobs, in millions.

As shown in Figure 3.3-10, this gasoline consumption regression model provided a good fit between observed and predicted data. The figure below also shows the statewide motor gasoline consumption forecasts for 2014-2017 using the selected regression model. By including socio-economic factors in the model, the impact of the economic downturn was reflected in the forecasted motor gasoline consumption growth rates. EMFAC2014 uses the regression-developed gasoline consumption trend to derive the statewide LD vehicle VMT growth trend for 2014-2017. For 2000-2013, EMFAC2014 used BOE's historical data on motor gasoline sales to assess the statewide VMT trend as discussed in more detail below.

Figure 3.3-10 Statewide Motor Gasoline Consumption Forecasts using Regression Analysis



3.3.3.2.3.2 HUMAN POPULATION GROWTH RATES

As mentioned above, the human population growth rates at the county level were used to forecast VMT. Human population estimates for every five years were obtained from the Department of Finance[73] (DOF) and some example county estimates are shown in Table 3.3-6. Population estimates for the in-between years were interpolated.

Table 3.3-6 Sample of Human Population Estimates from Department of Finance

	2000	2010	2015	2020	2025	2030	2035	2040	2050
Alameda	1,448,768	1,513,251	1,547,734	1,584,797	1,619,555	1,650,596	1,678,473	1,705,642	1,734,695
Fresno	802,224	932,926	1,004,774	1,083,889	1,162,699	1,232,151	1,304,432	1,378,232	1,535,761
Glenn	26,555	28,183	29,320	30,611	31,992	33,318	34,676	36,095	39,475
Humboldt	126,665	134,553	137,276	140,019	142,141	143,811	145,149	145,509	146,120
Imperial	143,151	175,566	187,663	200,521	213,526	228,164	242,759	256,872	285,308
Inyo	18,116	18,624	18,921	19,388	20,049	20,657	21,360	22,091	23,618
Kern	664,373	841,609	933,360	1,041,469	1,162,104	1,276,155	1,399,719	1,529,987	1,823,277

3.3.3.2.4 LD VMT: REGIONAL FORECASTING AND BACKCASTING

In order to project the VMT, the forecasted/backcasted vehicle population (see Section 3.3.3.1) and EMFAC2014 mileage accrual rates, either derived from Smog Check data (see Section 3.3.3.2.1) or taken from EMFAC2011, were used.

The initial estimates of future VMT were calculated by multiplying forecasted/actual vehicle population (by sub-area/class/fuel/age) times mileage accrual rates (by sub-area/class/age). Similar to the base

[73] http://www.dof.ca.gov/research/demographic/reports/projections/view.php

year VMT, HPMS data were used to redistribute the projected VMT regionally. This process provided the spatially adjusted VMT (by sub-area/class/fuel/age), which carries the age distribution from the forecasted/actual population and the regional distribution derived from the HPMS data.

Next, the 2012 base year VMT and VMT growth trend were used to forecast the VMT into the future at both the statewide and regional county levels. As described above, VMT growth rates in EMFAC2014 are based on human population growth rates adjusted to account for projected statewide fuel usage. County level VMT grows with human population growth rates.

After the VMT of all of the counties were calculated, the county VMT were summed to derive the total statewide county-based projected VMT. The statewide county-based projected VMT was verified to be equivalent to the statewide fuel-based VMT (base year statewide VMT multiplied by the statewide fuel sales growth). If the statewide fuel-based VMT was higher/lower than the statewide county-based projected VMT, then the statewide county-based projected VMT (by sub-area/class/fuel/age) was scaled to ensure that the results match. This process continues up to 2017. After 2017, only county level human population trends are used to grow the VMT based on the assumption that VMT per capita stays relatively constant.

The VMT forecasting methodology in EMFAC can be separated into two regimes:

- *VMT forecast between 2013-2017*
- *VMT forecast between 2018-2050*

The major difference between these two regimes is that the county level VMT per capita does not stay constant within 2013-2017 and is controlled by the statewide fuel use growth rates described in previous sections. As mentioned before, during 2018-2050, the county level VMT per capita is assumed to stay constant. These two regimes are described individually below, followed by a summary of the VMT backcasting methodology used for 2000-2011.

3.3.3.2.4.1 FORECASTED VMT FOR YEARS 2013-2017

EMFAC2014 uses the steps shown below calculate VMT for the years of 2013-2017.

1. *Unadjusted VMT (VMT_u) are calculated using SMOG Check database or EMFAC2011 mileage accrual rates (Accrual) forecasted vehicle populations (Pop).*

   $$\mathbf{VMT_U(SA,Class,Fuel,Age) = Pop(SA,Class,Fuel,Age) \times Accrual(SA,Class,Age)} \quad \mathbf{(3.3.3.2\text{-}P)}$$

2. *Since VMT derived in the manner above do not account for inter-regional traffic and commuting, HPMS (NTAD2008) data are used to adjust the VMT regionally.*

   $$\mathbf{VMT_{HPMS}(SA,Class,Fuel,Age) = VMT_U(SA,Class,Fuel,Age) \pm VMT_{In/Out}(SA,Class,Fuel,Age)} \quad \mathbf{(3.3.3.2\text{-}Q)}$$

   where $VMT_{In/Out}$ are calculated in a manner analogous to steps 1-7 of "Allocation of Base Year VMT for 2012." The *C-Factors, used in the calculation of $VMT_{In/Out}$, are based upon 2012 data and are identical to those in the base year calculation. However, $VMT_{Statewide}$ and VMT_{SA}, which are also used in calculating $VMT_{In/Out}$, are based upon forecasted vehicle populations, rather than base year populations.*

3. *The VMT_{HPMS}, calculated in step 2 are normalized to human population growth as follows. First the 2012 HPMS adjusted and fuel sales normalized VMT, from step 8 of Allocation of Base Year (2012) VMT, are summed by across Class, Fuel, and Age for each SA.*

   $$\mathbf{2012\ VMT_{HPMS,Fuel}(SA) = \sum_{Class,Fuel,Age} 2012\ VMT_{HPMS,Fuel}(SA,Class,Fuel,Age)} \quad \mathbf{(3.3.3.2\text{-}R)}$$

The resulting 2012 $VMT_{HPMS,Fuel}$(SA) are then adjusted for human population growth using the ratio of the future CY county-specific human population to the 2012 county-specific human population.

$$VMT_{Target}(SA) = 2012\ VMT_{HPMS,Fuel}(County) \times (HPop_{CY}(SA)/HPop_{2012}(County)) \qquad (3.3.3.2\text{-}S)$$

For each SA, the future year $VMT_{HPMS,}$ from step 2, is summed across all Classes, Fuels, and Ages.

$$VMT_{HPMS}(SA) = \sum_{Class,Fuel,Age} VMT_{HPMS}(SA,Class,Fuel,Age) \qquad (3.3.3.2\text{-}T)$$

A scalar, $F_{HPop,}$ is derived for each SA by dividing the VMT_{Target}(SA) by VMT_{HPMS}(SA)

$$F_{HPop}(SA) = VMT_{Target}(SA)/VMT_{HPMS}(SA) \qquad (3.3.3.2\text{-}U)$$

Finally, the scalars are used adjust the SA, Class, Fuel, and Age stratified future year VMT_{HPMS}, from step 2, for human population growth.

$$VMT_{HPMS,HPop}(SA,Class,Fuel,Age) = F_{HPop}(SA) \times VMT_{HPMS}(SA,Class,Fuel,Age) \qquad (3.3.3.2\text{-}V)$$

4. *Statewide fuel growth rate estimates are then used to normalize the SA, Class, Fuel, and Age specific VMT calculated in the previous step. The process is as follows.*

   First, forecasted statewide VMT is determined by multiplying the 2012 statewide VMT by the fuel sales growth rate (Section 3.3.3.2.3.1)

$$VMT_{Fuel} = 2012\ VMT_{Statewide} \times \text{Fuel Sales Growth} \qquad (3.3.3.2\text{-}W)$$

   where, 2012 $VMT_{Statewide}$ is $\Sigma_{SA,Class,Fuel,Age}VMT_{HPMS,HPop}$(SA,Class,Fuel,Age) from step 8 of the allocation of base year VMT process above; and fuel sales growth is the fuel sales of the future year divided by the fuel sales in 2012.

   A statewide adjustment factor G_{FUEL} is then calculated by dividing VMT_{Fuel} by the integrated version $VMT_{HPMS,HPop}$(SA,Class,Fuel,Age) from step 3.

$$G_{Fuel} = VMT_{Fuel}/\Sigma_{SA,Class,Fuel,Age} VMT_{HPop,HPMS}(SA,Class,Fuel,Age) \qquad (3.3.3.2\text{-}X)$$

   The correction factor from the prior step is then applied to the SA, Class, Fuel, and Age stratified $VMT_{HPop,HPMS}$ from step 3 to derive the final forecasted VMT.

$$VMT_{Fuel,HPop,HPMS}(SA,Class,Fuel,Age) = G_{Fuel} \times VMT_{HPop,HPMS}(SA,Class,Fuel,Age) \qquad (3.3.3.2\text{-}Y)$$

3.3.3.2.4.2 FORECASTED VMT FOR YEARS 2018-2050

EMFAC2014 uses the following steps to forecast the VMT for the years of 2018-2050:

1. *Same as steps 1 and 2 above for* "*Forecasted VMT for Years 2013-2017*"

2. *The VMT at SA levels are calculated using the VMT in CY 2017 and human population growth rates per SA as:*

$$VMT_{HPop}(SA) = 2017VMT(SA) \times (HPop_{CY}(County)/HPop_{2017}(County)) \qquad (3.3.3.2\text{-}Z)$$

where 2017VMT is $\Sigma_{SA,Class,Fuel,Age} VMT_{Fuel,HPop,HPMS}(SA,Class,Fuel,Age)$, for year 2017, from Step 4 above on 2013-2017 forecasting.

3. *The human population adjusted SA VMT from step 2, $VMT_{HPop}(SA)$, is divided by the SA sum of the spatially reallocated VMT from step 1 (VMT_{HPMS}) to compute a scaling adjustment factor (F_{HPop}).*

$$\mathbf{F_{HPop}(SA) = VMT_{HPop}(SA) / \Sigma_{SA,Class,Fuel,Age} VMT_{HPMS}(SA)} \quad \textbf{(3.3.3.2-AA)}$$

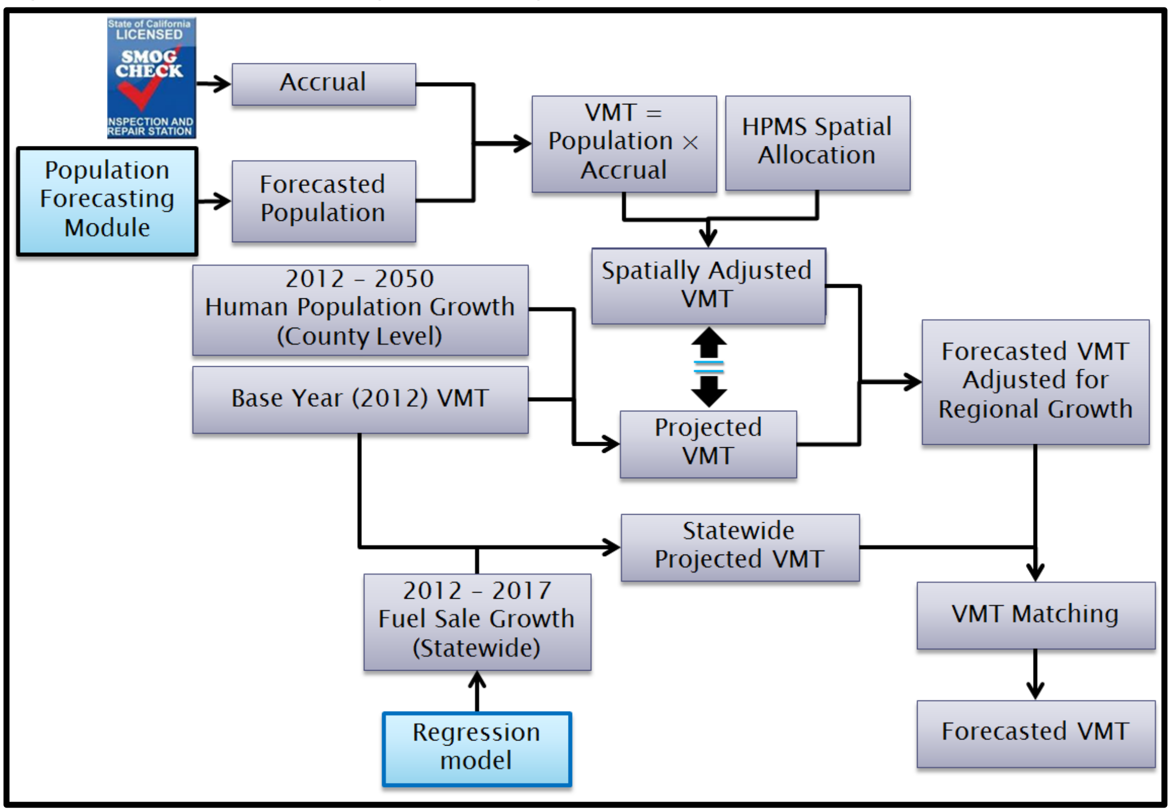
4. *The scaling factors ,developed for each aggregated SA in the prior step (F_{HPop}), are applied to the sub-level VMT class, fuel, and age groupings*

$$\mathbf{VMT_{HPop,HPMS}(SA,Class,Fuel,Age) = F_{HPop} \times VMT_{HPMS}(SA,Class,Fuel,Age)} \quad \textbf{(3.3.3.2-AB)}$$

In contrast to the 2013-2017 forecasted VMT, the 2018-2050 forecasted VMT do not include a direct projected fuel sales growth correction.

After 2017, EMFAC2014 assumes that the county level VMT per capita will stay constant (after recovering from economic recessionary conditions), and SA level VMT follows the human population growth trends. Thus, steps 4 in the 2013-2017 forecasting process are unnecessary for 2018-2050 forecasting. Figure 3.3-11 provides a visual schematic of the VMT forecasting methodology used in the EMFAC2014 model.

Figure 3.3-11 VMT Forecasting Methodology



3.3.3.2.4.3 BACKCASTED VMT FOR YEARS 2000-2011

In order to backcast the VMT for CYs 2000-2011, EMFAC2014 used the statewide growth rates (based on historical fuel use) and calculated the backcasted VMT using the following steps:

1. *Same as Steps 1 and 2 above for "Forecasted VMT for Years 2013-2017."*
2. *Same as Step 4 above for "Forecasted VMT for Years 2013-2017," with the exception that* VMT_{HPMS}(SA,Class,Fuel,Age) is used instead of $VMT_{HPop,HPMS}$(SA,Class,Fuel,Age)

   The backcasted VMT are not adjusted for human population growth because the actual vehicle populations are used in the calculations.

3.3.3.3 IMPACT OF ACC REGULATION

In January 2012, the Air Resources Board approved an emissions-control program for MYs 2017 through 2025. The program combined the control of smog, soot and global warming gases and requirements for greater numbers of zero-emission vehicles into a single package of standards called Advanced Clean Cars.[74]

3.3.3.3.1 ZEV PROGRAM

The ZEV program has required manufacturers to make and sell zero emission vehicles (ZEVs). It was originally envisioned these would be battery-electric vehicles; however, fuel-cell vehicles that qualify have also been developed. Starting in 2004, manufacturers were also allowed to produce very clean gasoline vehicles that could receive PZEV credit towards fulfilling their ZEV requirements. To qualify for PZEV credit, vehicles had to be certified to Super Ultra-Low Emission Vehicle (SULEV) standards with 150,000 mile durability and at zero-evaporative emissions. By 2010, there were few battery-electrics being made. Manufacturers were developing hybrid electric vehicles instead. Manufacturers met their ZEV requirements by making PZEVs rather than true ZEVs, and met their LEV II requirements by making Ultra-Low Emission Vehicles (ULEVs) rather than SULEVs or PZEVs.

In the ACC/ZEV II rulemaking of 2012, the standards were strengthened for MYs 2017 to 2025 and beyond.[75] The required percentages for ZEV sales were aggressively increased. Gasoline vehicles would no longer qualify as ZEVs. The advent of plug-in hybrid electric vehicles created a new class of transitional zero emission vehicles (TZEVs) which approached all-electric usage as their battery capacity (all-electric range) increased. Plug-in hybrid electric vehicles (PHEVs) can run on both electric and gasoline-based energy. PHEVs have electric storage batteries which can operate the electric motors. They also have conventional gasoline engines that are used once the battery is depleted. Battery-electric vehicles (BEVs) and fuel-cell vehicles (FCVs) have no tailpipe CO2 emissions. PHEVs have reduced tailpipe CO2 emissions to the extent that they operate on their batteries alone, and not on the gasoline engine power. Table 3.3-7 shows the compliance strategy that staff assumed for the ACC rule making.

For the ACC rulemaking and EMFAC2014, staff modeled PHEVs as having a 25-mile all-electric range, which equates to a utility factor of 0.40.[76] For the average commuter, this would mean that 40 percent of the VMT could be from all-electric, and 60% would be from gasoline operations. For inventory purposes, 40% of the PHEVs are considered to be pure electric, and 60% of the PHEVs are considered to be SULEV 30 (LEV III Federal Test Procedure certification level) gasoline vehicles. Table 3.3-8

[74] http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm

[75] ARB. 2011. Staff Report. Initial Statement of Reasons. Advanced Clean Cars. 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations. ZEV II ISOR. California State Air Resources Board. Sacramento, CA. http://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf http://www.arb.ca.gov/msprog/clean_cars/clean_cars_ab1085/lev3newsalesrev5.xlsx

[76] ARB. 2012b. California Exhaust and Emission Test Procedures for 2018 and Subsequent Model Zero Emission Vehicles and Hybrid Electric Vehicles, in the Light Duty Automobile, Light Duty Truck, and Medium Duty Vehicle Categories. California State Air Resources Board, Sacramento, CA. Appendix 4 to the ZEV II ISOR. Sect 12.2.3 http://www.arb.ca.gov/regact/2012/zev2012/zevappa4.pdf

shows the market share percentages used in EMFAC2014 to redistribute the LD vehicle population into the electric vehicle (EV) and gasoline vehicle populations as:

$$\textbf{Electric Vehicle Population} = (\textbf{Gas Population} + \textbf{EV Population}) \times \%\ \textbf{EV Market Share} \quad \textit{(3.3.3.3.A)}$$

$$\textbf{Gasoline Vehicle Population} = (\textbf{Gas Population} + \textbf{EV Population}) \times \%\ \textbf{Gas Market} \quad \textit{(3.3.3.3.B)}$$

Table 3.3-7 ZEV Program Required Percentages for New-Car Sales

Model Year	%PHEV	%BEV	%FCV	%Total ZEV
2012	1.80%	0.20%	0.10%	2.00%
2013	1.80%	0.20%	0.10%	2.10%
2014	1.80%	0.20%	0.10%	2.10%
2015	2.50%	0.60%	0.30%	3.50%
2016	2.70%	0.70%	0.30%	3.60%
2017	2.70%	0.70%	0.30%	3.70%
2018	5.70%	1.40%	0.30%	7.30%
2019	6.80%	2.60%	0.60%	10.10%
2020	8.00%	3.60%	1.00%	12.70%
2021	9.20%	4.50%	1.50%	15.30%
2022	10.30%	5.10%	2.10%	17.60%
2023	11.50%	5.70%	2.70%	19.90%
2024	12.60%	6.10%	3.30%	22.00%
2025+	13.70%	6.10%	4.10%	23.90%

Table 3.3-8 Percentage of Market Shares with the ZEV Mandate

Model Year	Market Share of Electric LDA	Market Share of Gasoline LDA
2010	0.08%	99.92%
2011	0.08%	99.92%
2012	0.95%	99.05%
2013	0.97%	99.03%
2014	0.98%	99.02%
2015	1.94%	98.06%
2016	2.05%	97.95%
2017	2.06%	97.94%
2018	3.94%	96.06%
2019	6.01%	93.99%
2020	7.92%	92.08%
2021	9.75%	90.25%
2022	11.36%	88.64%
2023	12.98%	87.02%
2024	14.43%	85.57%
2025	15.71%	84.29%

3.3.3.3.2 REBOUND

The Rebound Effect is based on the idea that the demand for driving is a function of the operating costs of the vehicle being driven. When operating costs increase, such as when fuel prices increase, then driving becomes more expensive and people drive less. Conversely, if fuel prices decrease, then people may drive more. The demand for driving is a function of many factors including income, fuel prices, the distance between one's home and job, desired discretionary driving, transit options and many other factors. Regional transportation planning agencies consider all such factors affecting travel demand when they estimate regional miles traveled. For EMFAC2014, it was assumed that the adopted Pavley federal standard, as well as ACC standards, would decrease vehicle operating costs by increasing vehicle fuel efficiency. A rebound effect of the adopted regulation was not accounted for in EMFAC2011-LDV. The potential magnitude of the rebound effect is the subject of extensive academic research, which is briefly reviewed in Appendix S of the LEV III ISOR.[77] Although the federal agencies are applying a 10 percent rebound to their analysis, California's relatively higher income and congestion levels relative to the national average justify the use of a different rebound assumption. Based on the methodology developed by Hymel et al.[78] using California-specific inputs, future projections of the rebound effect were estimated through CY2030 and the maximum rebound effect ranged between 3 and 6 percent. These results depended upon depending the year and economic scenario utilized. Further details about the methodology and data used to estimate rebound levels are presented in Appendix S of LEV III ISOR.

For EMFAC2014, these rebound effects were translated into the percentage change in VMT by MY and vehicle class for new vehicles sold, based on the estimated percentage decrease in vehicle operating cost. The percentage rebound is applied as:

$$\mathbf{VMT_{with\ Rebound}}\,(\mathbf{CY}, \mathbf{Model\ Year}) = \mathbf{VMT_{before\ rebound}} \times \left(\mathbf{1} + \frac{\mathbf{\%Rebound}}{\mathbf{100}}\right) \qquad \textit{(3.3.3.3.C)}$$

For the California ACC rebound economic scenario, the overall percentage increase in MY specific VMT ranged between one and four percent. VMT increases were applied in the inventory calculation by MY and included in both criteria and GHG emissions inventories.

3.3.4 UPDATES TO HD VEHICLE ACTIVITY

This section discusses the HD vehicle activity updates incorporated into EMFAC2014. These updates were made to incorporate newly available data and account for recently adopted regulations. Updates were made to the vehicle population forecasts (including new vehicle sales and retention rates), VMT, and diesel fleet rule compliance assumptions (including the April 2014 Board approved amendments to the Truck and Bus Regulation). The assumptions that have been made in the model estimate emissions according to regulatory requirements, such as the Truck and Bus Rule, were bounded by modeling and data constraints. For example, there are various options fleets may choose for compliance purposes, and as such, could not be modeled precisely due to not knowing which options would be selected. And in some instances, such options had to be simplified for modeling purposes. Thus, these modeling assumptions, for inventory purposes should not be used in place of the language in the rules to determine regulatory compliance.

3.3.4.1 HD VEHICLE POPULATION

As mentioned in 3.3.3.1 in *LDV Population: Historical Data*, staff processed the DMV data and grouped the vehicle records into vehicle classes based on vehicle type and weight. This classification was used in EMFAC model versions up to 2007 and was sufficient in supporting State Implementation Plans and for regulatory purposes. However, with the increasing complexity of ARB regulations, especially the On-Road HD Diesel Vehicle Regulation, also referred to as the "Truck and Bus Rule" (T&B), finer categorization of the MHD trucks (T6) and HHD trucks (T7) was necessary. During the 2008 and 2010 Truck and Bus Regulation rule making process, staff processed DMV CA registered vehicle data and CA International Registration Plan (IRP)[79] interstate truck data to divide the MHD and HHD trucks into

[77] http://www.arb.ca.gov/regact/2012/leviiighg2012/levapps.pdf
[78] Hymel, Kent M., Kenneth A. Small, and Kurt Van Dender. "Induced demand and rebound effects in road transport." Transportation Research Part B: Methodological 44.10 (2010): 1220-1241.
[79] http://www.irponline.org/

additional new sub-vehicle class categories. The expanded truck categorization was reflected in EMFAC2011. Refer to the vehicle category descriptions in the Appendix 6.1 for additional detail.

3.3.4.1.1.1 HDV POPULATION: BASE YEARS

There are four external population data sources for HD vehicles. DMV registration data (discussed above in LD Vehicle Population) provides vehicle information for all vehicles registered in California; IRP data provides information for vehicles registered in California for fleets that travel interstate; IRP Clearinghouse Recap reports, from the DMV, provide the characteristics of out-of-state registered trucks that travel to California; and, finally, school bus data is provided from the California Highway Patrol (CHP).[80] The school bus data was discussed in the Truck and Bus Regulation, Technical Support Document, Appendix G Emissions Inventory Methodology and Results[81] and will not be covered in this document.

After the vehicle records were grouped into vehicle classes (including T6 = MHD Trucks 14001 - 33000 lbs. and T7 = HHD Trucks >33000 lbs.), further categorization was made based on several DMV descriptive fields to determine the vehicle's body type, ownership, and license type. Since HD vehicles are commercial vehicles and can be owned and operated by non-Californian companies, population counts in HD include CA plated vehicles with out-of-state addresses. The distributions of population and VMT of these CA plated vehicles with out-of-state addresses are assumed to have the same operational spatial distribution as vehicles with CA addresses. In addition, an earlier on-road truck survey indicated that a non-trivial fraction of CA plated trucks in the survey could not be found in DMV dataset; therefore, staff include trucks with pending status to off-set the potential underestimation of truck counts. Using DMV registration and IRP data, staff compiled HD diesel and natural gas HD vehicle populations which include four types of vehicles: intra-state T6 & T7, California registered interstate T6 & T7, out-of state T6 & T7, and buses not operated by transit agencies or school districts.

3.3.4.1.1.1.1 INTRA-STATE FLEETS

The intra-state vehicles are classified according to the following rules:

1. *Agricultural trucks are trucks claiming an Agricultural Vehicle Extension in the Truck Regulation Upload, Compliance and Reporting System (TRUCRS)*[82]
2. *Vehicles with apportioned plates (license type) or in the CA IRP database are considered as California Interstate vehicles and processed following steps in the "California registered interstate" section below*
3. *T7 SWCV are identified as T7's with a garbage body type in DMV*
4. *T6 and T7 public are defined as vehicles with "Exempt" license plates in DMV*
5. *T6 and T7 utility are distinguished based on DMV owners' names and addresses*
6. *Remaining T7 vehicles are divided into two groups: tractor (based on body type in the DMV database) and single (the remaining as single unit, non-tractor)*
7. *Drayage trucks are all tractors and their population is based on the drayage truck rule database and inventory is projected according to drayage truck compliance assumption*
8. *The remaining T6 and T7 records are further divided into "construction" and "regular" T6 instate, T7 single, and T7 tractor, based on the by MY population proportions for these groupings in EMFAC2011*

[80] https://www.chp.ca.gov/programs-services/programs/school-bus-program
[81] http://www.arb.ca.gov/regact/2008/truckbus08/appg.pdf
[82] http://www.arb.ca.gov/msprog/onrdiesel/reportinginfo.htm

3.3.4.1.1.2 CALIFORNIA REGISTERED INTERSTATE

In addition to DMV registration data, ARB also receives California registered interstate (CA IRP) data. The vast majority of the vehicles in the CA IRP dataset can also be found in the DMV registration database with "Apportioned" licenses.[83] Vehicles identified as IRP diesel trucks in either DMV registration data or in the CA IRP dataset are categorized as CA IRP trucks. For the vehicles that can be found in both DMV and CA IRP datasets, the weight class information in DMV are used, otherwise, the weights reported in CA IRP are used to identify T6 and T7 trucks. Similar to the instate fleets, the T7 CA IRP are further divided into "construction" and "regular" vehicles based on EMFAC2011 proportions.

3.3.4.1.1.3 OUT-OF-STATE T6 & T7

There are three vehicle types in the out-of-state truck category, as defined in the Truck and Bus Regulation Technical Support Document, Appendix G:[84] T6 out-of-state (OOS), T7 out-of-state from neighboring states (T7 NOOS) and T7 out-of-state from non-neighboring states (T7 NNOOS). As noted in Appendix G, staff assumed that out-of-state T6 and out-of-state T7 from neighboring states share the same MY distribution as T6 and T7 CA IRP since IRP data indicates that they have similar distributions.

The 2007-2009 US recession affected both CA and out-of-state fleets, slowing down truck turnover. However, non-neighboring IRP trucks engage in long-haul freight transportation operations that result in faster mileage accumulation and higher turn-over rates and thus on average, they are three to four years younger than the CA fleets. The data quality for non-neighboring out-of-state vehicle populations has greatly improved with the availability of monthly IRP Clearinghouse Recap Reports, which are used to supplement the DMV data that are routinely used. DMV has supplied monthly Recap reports (by transaction dates) to ARB staff since 2011, and the reports provide information on all the fleets that travel to California and on all the trucks within those fleets for every IRP jurisdiction that participates in the Clearinghouse. Improvement was also made with regard to where the vehicles originate. Instead of a sample of 12 non-CA jurisdictions, as was available for use in the 2008 Truck and Bus Rule inventory, the latest MY distributions for non-neighboring out-of-state trucks were based on 50 participating jurisdictions (including regions outside of the U.S.).

Out-of-state IRP fleet managers may send many or none of their fleet's individual trucks to travel into California and report such travel information to the Clearinghouse as a fleet, and not per individual truck. To calculate emissions, it is more important to estimate VMT travel in California by MY than to estimate counts of unique out-of-state trucks that travel to California since that cannot be determined accurately. The total VMT accrued by out-of-state trucks has fluctuated over the years,[85] and for this EMFAC revision, staff used the average historical ratios of VMT by out-of-state IRP trucks as compared to VMT by CA IRP trucks. The average ratios are 1.18 and 0.38 for T7 NNOOS and T7 NOOS compared to T7 CA IRP, and 0.57 for T6 OOS compared to T6 CA IRP.

3.3.4.1.1.4 BUSES

There are three bus types in the vehicle classes: urban bus, school bus and other bus. Urban bus and school bus are owned or operated by transit agencies or school districts. As mentioned earlier, discussion in this section is limited to the diesel buses categorized as other bus, not owned or operated by transit agencies or school districts. In EMFAC2011, "other bus" (or OBUS), is further divided into motorcoach and all other buses. Motorcoach are the buses with 40 or more seats and at least 35 feet in length. They are likely to be three axle buses that travel interstate. To simplify the process for EMFAC2014, they are identified in CA IRP and DMV as diesel buses with three axles and with

[83] https://www.dmv.ca.gov/portal/dmv/?1dmy&urile=wcm:path:/dmv_content_en/dmv/pubs/plates/apportioned
[84] http://www.arb.ca.gov/regact/2008/truckbus08/appg.pdf
[85] http://www.arb.ca.gov/regact/2010/truckbus10/truckbusappg.pdf

apportioned license plates. Apportioned license plates[86] are issued for power units under apportioned registration, base plated in California.

3.3.4.1.2 HDV POPULATION: FORECASTED

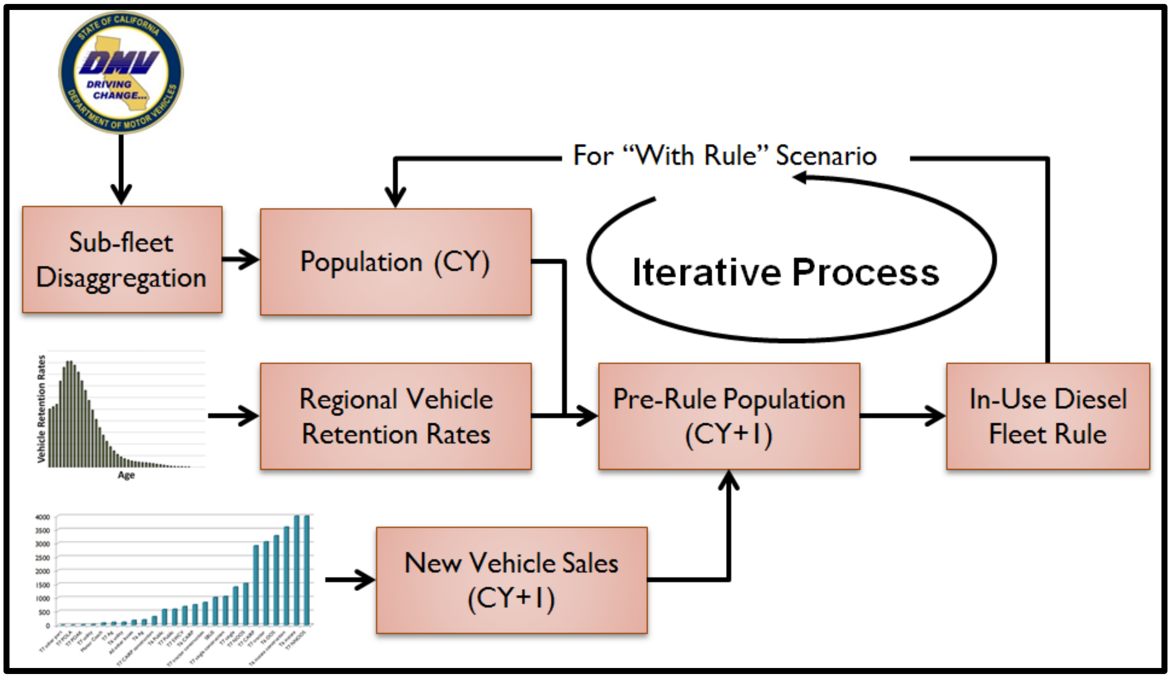
In-Use diesel fleet rules (such as the drayage truck rule, public fleet rule, Truck and Bus Rule, etc.) require fleet owners to replace their HD diesel vehicles with new technology vehicles (2007 or 2010 standard trucks) over time. As a result of these requirements, there is a direct impact on the vehicle age distributions. In order to reflect the impact of these rules realistically, EMFAC2014 forecasts the population of HD trucks by using an iterative approach as explained in this section. This methodology uses the number of new vehicle sales as well as the number of retired vehicles to forecast the population from one year to the next. The methodology that is used to estimate the number of new HD vehicle sales is described below in Figure 3.3-12. Since the Truck and Bus Rule has provisions and compliance options, such as provisions for low or limited mileage or small fleets, these options require finer categorizations than the existing classifications in EMFAC2011. These finer categorizations are called sub-vehicle class. Therefore, it is necessary to forecast the population at the sub-vehicle class level, in order to reflect the impact of Truck and Bus Rule on vehicle population age distribution. The methodology to forecast the population is as follows:

1. *The base year (2012) population (discussed in HDV Population: Base Years above) is disaggregated to the sub-vehicle class level.*[87]
2. *The In-Use diesel fleet rules are applied onto the base year population to determine the number of PM retrofits needed by vehicle age as a result of the in-use diesel fleet rules.*[88]
3. *The weighted average (over recession vs. BAU similar to LD vehicle population forecasting methodology) retention rates*[89] *are applied to the current population to determine the number of retired vehicles.*
4. *The new vehicle sales for the next year are obtained from the new vehicle sale methodology described in Section 3.3.4.1.2.1*
5. *Adding the new vehicle sales and subtracting the number of retired vehicles provides the baseline population for the next year.*
6. *The diesel fleet rules are overlaid on the next year's baseline population in order to reflect the impact of the rules on both fleet turnover and PM retrofits.*
7. *With the estimated next year "with rule" population, it is used as the current population in step 3 to compute the following year, and these steps are iterated to complete the "with rule" population for each year up to CY 2050.*

Figure 3.3-12 provides a flow chart with the steps that EMFAC2014 takes to estimate future populations of HD diesel vehicles.

[86] https://www.dmv.ca.gov/portal/dmv/?1dmy&urile=wcm:path:/dmv_content_en/dmv/pubs/plates/apportioned
[87] More details can be found in section 3.3.4.2
[88] More details on in-use diesel fleet rule implementation can be found in section 3.3.4.2
[89] More details on HD retention rates can be found in below in *HD Vehicle Survival Rates*

Figure 3.3-12 Methodology to Forecast HD Vehicle Population in EMFAC2014



3.3.4.1.2.1 FORECASTING STATEWIDE NEW HDV SALES

Forecasting the vehicle population requires two essential ingredients, 1) the number of new vehicle sales, and 2) the number of retired vehicles. In order to estimate the number of new vehicle sales, new vehicle sales in 2005 (pre-recession new vehicle sales) was used as the starting point. In order to estimate new sales in the future, the national new HD vehicle sales growth trend (obtained from the Annual Energy Outlook[90] (AEO) report of U.S. Energy Information Administration) is translated to California's specific new HD vehicle sales growth trend using the ratio between the national VMT growth (based on AEO) vs. California's VMT growth (Refer to *HD VMT Growth Rates for Forecasting* in Section 3.3.4.3 below). Using this methodology the new vehicle sales were estimated for 2013 to 2050.

The methodology used to forecast new HD vehicles sales is as follows:

1. *The new vehicle sales growth profile is determined as:*

$$\textbf{\textit{California New Sales growth rate}} = \textbf{\textit{AEO New Sales Growth Rate}} \times \frac{\textbf{\textit{California VMT Growth Rate}}}{\textbf{\textit{AEO Nationl VMT Growth rate}}} \quad \textbf{(3.3.4.1-A)}$$

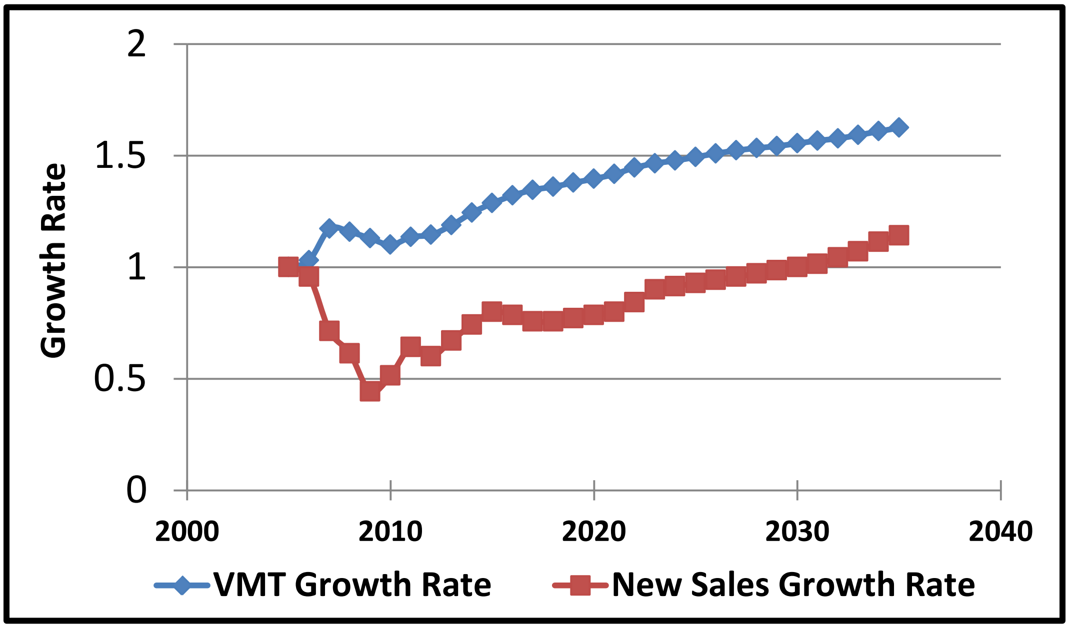
2. *Combining the new vehicle sales in 2005 from DMV with the growth rates per year computed in Step1, new vehicle sales can be forecasted up to 2050.*

$$\textbf{\textit{New Sales}}\ (\textbf{\textit{Year}}, \textbf{\textit{Vehicle type}}) = \textbf{\textit{New Sales}}\ (\textbf{2005}, \textbf{\textit{Vehicle type}}) \times \textbf{\textit{California New Sales growth rate}}\ (\textbf{\textit{Year}}) \quad \textbf{(3.3.4.1-B)}$$

Figure 3.3-13 shows the national VMT and new vehicle sales growth trend used in EMFAC2014.

[90] http://www.eia.gov/forecasts/aeo/

Figure 3.3-13 National VMT and New Sales Growth Trend Reported by AEO (Normalized to New Sales and VMT in 2005)



<u>Exceptions</u>

In order to estimate the new vehicle sales for HD diesel categories, specific assumptions were made for certain vehicle categories

- *Ag Vehicles: Agricultural vehicle exemptions,[91] as defined in the Truck and Bus Rule, include specialty agricultural vehicle provisions (referred to here as "Ag specialty") and expanded low mileage provisions (referred to here as "Ag 15/20/25" for mileage thresholds that vary by engine MY groups and by CYs). Ag vehicles operating less than 10k miles per year are exempted until CY2023 (referred to here as "Ag below 10K"). The new vehicle sales for Ag specialty/Ag 15/20/25 trucks are set to zero, as we assume their population will stay constant before they are required to turnover to 2010 engines. Therefore, for Ag specialty and Ag below 10K, the new vehicle sales are set to zero for CYs < 2023 and for Ag 15/20/25 it is set to zero for CYs<2017. After 2017/2023, it is assumed that they only buy 5 year old (for Ag 15/20/25) and 11 years old (for Ag specialty/below 10K) vehicles. The choice of 5 and 11 years old purchase ages was based on the Truck and Bus Rule which requires these vehicle to become 2010 engine compliant (for which 2012 is the assumed vehicle MY) by 2017 (i.e. 5 years old vehicle) and by 2023 (i.e. 11 years old vehicle). Therefore, instead of adding the new vehicle sales to Age 0, the new vehicle sales are added to their Ages 5 and 11.*
- *Drayage Trucks: Based on analysis conducted during the Drayage truck rulemaking process, it was found that the drayage trucks owners tend to buy used vehicles rather than new ones. Therefore, in order to reflect such purchasing behavior, staff assumed that new sales for drayage trucks occur in ages 0 through 4 rather than only 0. As a result, the new/used vehicle sales for drayage trucks are forecasted by combining the 2005 population of drayage trucks within ages of 0 - 4 (and not just age 0) with the new sales growth rates associated with the drayage truck.*

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[91] http://www.arb.ca.gov/msprog/onrdiesel/documents/fsag.pdf

- *Public/ Utility/SWCV/ Buses/ Motorcoach: Due to difficulties associated with forecasting new sales of Public/ Utility/SWCV/ Buses/ Motorcoach categories (as purchases for these fleets, especially public fleets, relies on government budgets), the new vehicle sales of these categories are calculated differently. The new vehicle sales for these categories are estimated in such a way that the Pop X Accrual from these categories meets the Target VMT determined by Base Year VMT X VMT Growth rates. Therefore, the number of new vehicle sales for these categories was determined based on how much VMT were needed to match the target VMT. This calculation was done in five steps as described below:*

  1. *Calculating the Target VMT as:*

     $$\begin{aligned}&\textbf{Target VMT}(\textbf{Vehicle Class}) = \\ &\textbf{Base year VMT}(\textbf{Vehicle Class}) \times \textbf{VMT Growth Rate}(\textbf{Vehicle Class})\end{aligned} \quad \textbf{(3.3.4.1-C)}$$

  2. *Calculating the VMT of Age 1-44 of the forecasted population:*

     $$\begin{aligned}&\textbf{Forecasted VMT }(\textbf{Vehicle Class}) = \\ &\sum\nolimits_{\textbf{Age}} \textbf{Pop}_{\textbf{forecasted}}(\textbf{Vehicle Class}, \textbf{Age}) \times \textbf{Accrual Rate }(\textbf{Vehicle Class}, \textbf{Age})\end{aligned} \quad \textbf{(3.3.4.1-D)}$$

  3. *Calculating the difference of Step 1 and Step 2 VMT:*

     $$\begin{aligned}&\boldsymbol{\Delta}\textbf{VMT} = \textbf{VMT}_{\textbf{new sales}} = \\ &\textbf{Target VMT }(\textbf{Vehicle Class}) - \textbf{Forecasted VMT}(\textbf{Vehicle Class})\end{aligned} \quad \textbf{(3.3.4.1-E)}$$

  4. *As noted above, new sales are based on VMT growth (how much VMT were needed to match the target VMT) rather than directly estimating purchases for these fleets which are difficult to predict. Statewide new vehicle sales are estimated as:*

     $$\textbf{Statewide New sales} = \frac{\boldsymbol{\Delta}\textbf{VMT }(\textbf{Vehicle Class})}{\textbf{Accrual}(\textbf{Vehicle Class}, \textbf{Age}=\textbf{0})} \quad \textbf{(3.3.4.1-F)}$$

  5. *Scaling the original new sales from the prior methodology steps (above "Exceptions") to match the statewide new sales from Step 4 of this calculation.*

3.3.4.1.2.2 DISAGGREGATING HD POPULATION TO SUB-VEHICLE CLASS LEVEL

In order to reflect the impact of the On-Road HD Diesel Vehicles (In-Use) Regulation[92] on the age distributions and the PM emission rates for the HD diesel vehicles, the HD diesel vehicle population was disaggregated to sub-vehicle class levels based on the compliance schedules defined by the rule. Such disaggregation was done for the purpose of determining the:

1. *Population of vehicles in NOx exempt areas per fleet size (1,2,3,or 4+)[93]*
2. *Population of low use trucks (<5,000 annual miles) [94]*
3. *Population of work/vocational trucks (between 5,000 - 20,000 annual miles)[95]*

[92] http://www.arb.ca.gov/msprog/onrdiesel/regulation.htm
[93] http://www.arb.ca.gov/msprog/onrdiesel/documents/faqnoxexempt.pdf
[94] http://www.arb.ca.gov/msprog/onrdiesel/documents/faqLowuse.pdf
[95] http://www.arb.ca.gov/msprog/onrdiesel/documents/faqamend14.pdf

4. *Population of vehicles for fleets with less than 4 trucks (1,2, or 3)*[96]

In order to calculate the population in each of these sub-vehicle classes, staff analyzed data from the Truck Regulation Upload, Compliance, and Reporting System[97] (TRUCRS), as well as the Vehicle Inventory and Use Survey,[98] and calculated fractions by Vehicle Class and age to disaggregate the HD diesel vehicle population to the above-mentioned sub-Vehicle Class levels.

3.3.4.1.3 HDV SURVIVAL RATES

Updates to the HD diesel vehicle survival rates used the same methodology as for LD vehicles. Refer to 3.3.3.1.3 *LDV Survival Rates* for the detailed retention/survival rate methodology being used in EMFAC2014.

3.3.4.1.3.1 EXCEPTIONS FOR DRAYAGE TRUCKS

As discussed below in Section 3.3.4.2 (refer to Table 3.3-25), the age distribution of drayage trucks was determined using preset age distributions from 2010/2014 to 2023. Since the number of new vehicle sales for this category is very small, the survival rates derived for drayage trucks are showing large values within the first couple of ages. Therefore, applying such survival rates to the population of drayage trucks in 2023 will cause an unrealistic increase in their population. Thus, the survival rates for drayage trucks must be adjusted from flat lines (with survival rate = 1) to curves that reflect their average age distributions. Tables 3.3-9 and 3.3-10 show the drayage truck survival rates from 2024-2029 for ages 0 to 7.

Table 3.3-9 Survival Rate (for Ages 0-7) for Port of Oakland and Other Ports Drayage Trucks

	Port of Oakland and Other ports Drayage Trucks				
Age	CY2024	CY2025	CY2026	CY2027	CY2028
0	1	1	1	1	1
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	8
6	1	1	1.380483	1.380483	1.380483
7	1	1.104957	1.104957	1.104957	1.104957
For 2029+, survival rates are the same as those for base year.					

Table 3.3-10 Survival Rate for Port of Los Angeles Drayage Trucks

	Port of LA Drayage Trucks				
Age	CY2024	CY2025	CY2026	CY2027	CY2028
0	1	1	1	1	1
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1.451846
7	1	1	1	1.18336	1.18336
8	1	1	1.070894	1.070894	1.070894
9	1	1.00682	1.00682	1.00682	1.00682

[96] http://www.arb.ca.gov/msprog/onrdiesel/documents/FAQsmall.pdf
[97] https://ssl.arb.ca.gov/ssltrucrstb/trucrs_reporting/reporting.php
[98] https://www.census.gov/svsd/www/vius/products.html

3.3.4.1.3.2 EXCEPTIONS FOR AGRICULTURAL TRUCKS

With regard to the Truck and Bus Rule requirements for Agricultural trucks,[99] staff assumed that the owners of agricultural trucks, that opted-into the reporting system to use Truck and Bus Rule Ag exemptions, will keep using their vehicles until the rule requires them to turnover. According the Truck and Bus Rule amendments, proposed to the board in 2014, Ag vehicles must stay below the annual mileage limits shown in Table 3.3-11 to be eligible for this Ag exemption. The annual mileage limits, prior to 2017 for this provision (referred to below as “Ag 15/20/25”) are 25,000 miles (2006+ engines), 20,000 miles (1996-2005 engines), and 15,000 miles (1995 and older engines). In addition, the Ag specialty provision allows delayed compliance for applicable vehicles that remain below 10,000 annual miles (referred to as “Ag Specialty”).

Table 3.3-11 Mileage Thresholds for Ag Truck Exemption

Engine Model Year	Annual Mileage Limit		
	2011 to 2016	2017 to 2019	2020 to 2022
2006 or Newer	25,000 miles	15,000 miles	10,000 miles
1996 to 2005	20,000 miles	15,000 miles	10,000 miles
1995 and Older	15,000 miles	15,000 miles	10,000 miles

EMFAC2014 keeps the Ag truck population constant up to 2017 (for Ag 15/20/25) and 2023 (for Ag specialty vehicles and Ag vehicles with less than 10,000 annual miles) by:

1. *Setting the retention rate = 1 for Ag 15/20/25 and for Ag Specialty (below 10K annual miles) between the years of 2010 and 2016/2022 respectively.*
2. *Since EMFAC assumes that vehicles above age 44 are get scrapped, in order to keep the population of Ag trucks constant, the population of all above 44 year old trucks is added to age 44 between 2010 and 2017/2023.*

3.3.4.2 UPDATES FOR DIESEL IN-USE FLEET RULES

EMFAC2011 incorporated regulatory changes for diesel In-Use Fleet Rules.[100] Subsequent amendments to these rules were incorporated into EMFAC2014 as discussed below.

3.3.4.2.1 TRUCK AND BUS RULE COMPLIANCE ASSUMPTIONS

When the Truck and Bus Regulation was first amended in 2010, little information was available regarding the actions that truck fleet operators might take in order to comply with the requirements of the regulation. Therefore, staff made the assumption that the operators would choose to comply with the regulation by following the engine MY compliance schedule and that few operators would use credits for downsizing or early diesel PM filter compliance.

However, vehicle and fleet data collected through TRUCRS shows that as many as 50 percent of the vehicles in some vehicle class categories may delay compliance due to credits and flexibility provisions. In addition, some fleet operators preferred to purchase 2007 standard trucks with originally equipped diesel particulate filter rather than retrofit their existing pre-2007 trucks. The Truck and Bus amendments proposed in April 2014 provided additional flexibility to vehicle owners, ensuring a more successful compliance path, and thereby better protecting the emission benefits of the regulation

[99] Refer to section 3.3.4.2 for more details.
[100] http://www.arb.ca.gov/diesel/mobile.htm

through greater levels of compliance. To reflect these amendments, staff incorporated new assumptions about how trucks in each category would respond to the amended regulatory requirements. These assumptions incorporate updated rule compliance information based on information gathered through TRUCRS.

Please note that in reading the Retrofit/Replace assumptions (Table 3.3-12 through 3.3-26), "Action" means either retrofitting with a diesel particulate filter (DPF), or a replacement of an older vehicle with a newer vehicle (the MY assumption for modeling purposes is given under the action column). For modeling purposes, a single MY vehicle may be used as a replacement assumption. In these tables below, DPF designates a retrofit requirement for pre-2008 trucks that were not equipped with OEM filters; and numbers (e.g. 2008, 2012, 2013, etc.) designate a truck replacement requirement modeled based on the listed MY number. Though some fleets may purchase newer vehicles than the MY assumptions indicate, that would be above and beyond the rule requirements. A one year delay in the engine technology standards has been assumed for modeling purposes (e.g., MY2008 and newer vehicles are assumed to have OEM DPFs, and MY2012 and newer vehicles are assumed to meet 2010 engine standards).

3.3.4.2.1.1 LOW USE VEHICLE[101]

More recent Truck and Bus amendments expanded the existing definition of Low Use Vehicles (of less than 1,000 miles) to include vehicles that travel fewer than 5,000 total miles per compliance year. The 5,000 mile low use exemption sunsets in 2020 and EMFAC assumes all pre-2012 low use vehicles would be replaced with MY 2012 vehicles by January 1, 2020.

3.3.4.2.1.2 WORK TRUCK PHASE-IN OPTION[102]

The April 2014 Board approved Truck and Bus amendments expanded the type of trucks that were eligible for what was formerly referred to as a "construction truck" provision by modifying this provision to reflect a new "work truck" provision. The amendments which changed the existing definition from a "Construction Truck" to a "Work Truck" allowed for the inclusion of more construction related trucks that had not already been included in the existing definition, with the exception of tractor-trailer combinations. In the EMFAC2014 emissions inventory model, staff applied this work truck compliance provision to trucks with annual mileage between 5,000 and 20,000 miles, for trucks that were both HHD single units and tractors in the construction sector, MHD trucks above 26,000 lbs. GVWR, in the construction sector. The compliance assumptions were modeled in the revised inventory as illustrated in Table 3.3-12.

Table 3.3-12 Retrofit/Replacement Assumptions for Work Truck Phase-In Option

By Jan 1	Vehicle Model Year	Fleet Action (Retrofit/Replace)
2014	Pre-2008	33% DPF*
2015	Pre-2008	40% DPF*
2016	Pre-2008	60% 2008**
2017	Pre-2008	80% 2008**
2018	Pre-2008	100% 2012**
2023	DPF Retrofitted	2013**
2023	2008-2011	2013**

*DPF means retrofitting vehicles with diesel particulate filter.

** Replace with a vehicle MY specified (e.g. 2008 means replacement of a pre-2008 truck with a 2008 vehicle MY truck).

101 http://www.arb.ca.gov/msprog/onrdiesel/documents/faqLowuse.pdf

102 http://www.arb.ca.gov/msprog/onrdiesel/documents/faqconstructiontrucks.pdf

3.3.4.2.1.3 LIMITED MILEAGE AGRICULTURAL TRUCK EXTENSION

The agricultural vehicle Truck and Bus Rule extension for vehicles with limited mileage originally was set to expire on January 1, 2017. In April 2014, the Board approved Truck and Bus Rule amendments that extended the provision out over several additional years with step-down mileage limits. The details of the new exemption limits are shown in Table 3.3-13. The mileage limit provision, starting in 2017, was modeled as a phase-in, and the assumptions used are shown in Table 3.3-14.

Table 3.3-13 Truck and Bus Rule Amendments for Ag Truck Mileage Limits

Engine Model Year	Annual Mileage Limit 2011 to 2016	2017 to 2019	2020 to 2022
2006 or Newer	25,000 miles	15,000 miles	10,000 miles
1996 to 2005	20,000 miles	15,000 miles	10,000 miles
1995 and Older	15,000 miles	15,000 miles	10,000 miles

Table 3.3-14 Replacement Assumptions for Limited Mileage Agricultural Trucks

By Jan 1	Vehicle Model Year	Fleet Action (Replace)
2017	Pre-2008	25% 2012*
2020	Pre-2008	50% 2012*
2023	Pre-2012	100% 2012*

* Replace with vehicle MY specified (e.g. 2012 means replacement of a pre-2008/pre-2012 truck with 2012 vehicle MY truck).

Agricultural trucks with approved specialty agricultural vehicle extensions or annual mileage of less than 10,000 miles/year are assumed to be replaced with 2012 MY trucks by January 1, 2023.

3.3.4.2.1.4 SMALL FLEET RULE COMPLIANCE (>26,000 LBS. GVWR)

A small fleet is defined as a fleet with one, two or three trucks that are subject to the Truck and Bus Rule. Amendments to the Truck and Bus Rule provided additional flexibility for small fleets by extending the compliance schedule provisions for the second and third trucks in small fleets, for which updates had to be made in EMFAC2014. In addition, staff assumed that 10 percent of the intra-state small fleets would be eligible for a special provision known as "economic hardship"[103] which delays compliance for owners that cannot comply due to specific economic hardship conditions. For the 10 percent within small fleets that are eligible for this economic hardship provision, no action would be needed until 2018, so in EMFAC2014, all pre-2008 trucks have been assumed to be replaced with 2012 MY trucks in 2018; and 2008-2010 MY trucks have been assumed to be replaced with 2015 MY trucks in 2023 to meet the rule requirements. Tables 3.3-15 through 3.3-17 present the compliance assumptions that were made in EMFAC2014, for the other 90% of small fleets (not eligible for the economic hardship provisions).

[103] www.arb.ca.gov/msprog/onrdiesel/documents/faqhardship.pdf

Table 3.3-15 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Single-Unit Trucks (Small Fleets)

By Jan 1	Vehicle Model Year	1st truck	2nd truck	3rd truck
2014	1996-2007	2/3 DPF, 1/3 2008	N/A	N/A
2015	1996-2007	N/A	N/A	N/A
2015	Pre-1994	2012	N/A	N/A
2016	Pre-1996	2012	N/A	N/A
2017	Pre-1996	N/A	2012	N/A
2017	1996-2007	N/A	50% 2008, 50% 2012	N/A
2018	Pre-2008	N/A	N/A	2012
2023	1996-2007	2015	N/A	N/A
2023	2008-2011	2015	2015	2015

Note: N/A = No action is required (e.g. by January 1, 2014, only the first truck of the two/three truck fleets needed to be either retrofitted with DPF or replaced. It is assumed that 2/3 will be DPF retrofitted and 1/3 will be replaced.)

Table 3.3-16 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Tractor Trucks (Small Fleets)

By Jan 1	Vehicle Model Year	1st truck	2nd truck	3rd truck
2014	1996-2007	1/3 DPF, 2/3 2008	N/A	N/A
2015	1996-2007	N/A	N/A	N/A
2015	Pre-1994	2012	N/A	N/A
2016	Pre-1996	2012	N/A	N/A
2017	Pre-1996	N/A	2012	N/A
2017	1996-2007	N/A	50% 2008, 50% 2012	N/A
2018	Pre-2008	N/A	N/A	2012
2023	1996-2007	2015	N/A	N/A
2023	2008-2011	2015	2015	2015

Note: N/A = No action is required

Table 3.3-17 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Interstate Trucks (Small Fleets)

By Jan 1	Vehicle Model Year	1st truck	2nd truck	3rd truck
2014	1996-2007	60% 2008, 40% 2012	N/A	N/A
2015	Pre-1994	2012	N/A	N/A
2016	Pre-1996	2012	N/A	N/A
2017	Pre-1996	N/A	2012	N/A
2017	1996-2007	N/A	40% 2008, 60% 2012	N/A
2018	Pre-2008	N/A	N/A	2012
2023	2008-2011	2015	2015	2015

Note: N/A = No action is required

3.3.4.2.1.5 LARGE FLEET RULE COMPLIANCE (>26,000 LBS. GVWR)

A large fleet is defined as one with more than three trucks subject to the Truck & Bus Rule. Although the Truck and Bus amendments did not specifically target large fleets, there are credits/provisions that large fleets can utilize for compliance.[104] Credits include those given for fleet downsizing compared to 2006, adding PM filters before rules mandate their installation, and adding cleaner vehicles to their fleets. Provisions include those for economic hardship, low mileage work trucks, agricultural vehicles, vehicles operated in areas with cleaner air, and low use vehicles. For modeling, staff assumed that

[104] For more information, please refer to http://www.arb.ca.gov/msprog/truckstop/tb/truckbus.htm.

20% of the large fleets currently using credits/provisions will be able to further delay actions by another two years. Table’s 3.3-18 to 20 show EMFAC2014’s modeling assumptions for large fleets.

Table 3.3-18 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Out of State Trucks

By Jan 1	Vehicle Model Year	Action (Retrofit/Replace)
2012	1996-1999	2008
2013	2000-2004	50%DPF + 50% 2012
2014	2005-2007	50%DPF + 50% 2012
2015	Pre-1994	2012
2016	1994-1995	2012
2020	1996-1999	2015
2021	2000-2004	2016
2022	2005-2007	2017
2023	2008-2011	2017

Table 3.3-19 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Tractor Trucks

<table>
<tr><th colspan="2"></th><th>No provision</th><th>Early PM credit</th><th>Economic Hardship</th></tr>
<tr><td colspan="2">% of population:</td><td>80%</td><td>10%</td><td>10%</td></tr>
<tr><td>By Jan 1</td><td>Vehicle Model Year</td><td></td><td></td><td></td></tr>
<tr><td>2012</td><td>1996-1999</td><td>2008</td><td rowspan="6">No Action</td><td rowspan="5">No Action</td></tr>
<tr><td>2013</td><td>2000-2004</td><td>50%DPF + 50% 2012</td></tr>
<tr><td>2014</td><td>2005-2007</td><td>50%DPF + 50% 2012</td></tr>
<tr><td>2015</td><td>Pre-1994</td><td>2012</td></tr>
<tr><td>2016</td><td>1994-1995</td><td>2012</td></tr>
<tr><td>2017</td><td></td><td></td><td rowspan="6">Pre-2008 turnover to 50% 2012, 50% 2008</td></tr>
<tr><td>2018</td><td></td><td></td><td rowspan="5">Pre-1998--> 2008
1998-2007-->2012</td></tr>
<tr><td>2020</td><td>1996-1999</td><td>2015</td></tr>
<tr><td>2021</td><td>2000-004</td><td>2016</td></tr>
<tr><td>2022</td><td>2005-2007</td><td>2017</td></tr>
<tr><td>2023</td><td>2008-2011</td><td>2017</td><td>2017</td><td>2017</td></tr>
</table>

Table 3.3-20 Retrofit/Replacement Assumptions for >26,000 lbs. GVWR Single Unit Trucks

<table>
<tr><th colspan="2"></th><th>No provision</th><th>Early PM credit</th><th>Economic Hardship</th></tr>
<tr><td colspan="2">% of population:</td><td>80%</td><td>10%</td><td>10%</td></tr>
<tr><td>By Jan 1</td><td>Vehicle Model Year</td><td></td><td></td><td></td></tr>
<tr><td>2012</td><td>1996-1999</td><td>50%DPF + 50% 2008</td><td rowspan="6">No Action</td><td rowspan="5">No Action</td></tr>
<tr><td>2013</td><td>2000-2004</td><td>50%DPF + 50% 2008</td></tr>
<tr><td>2014</td><td>2005-2007</td><td>50%DPF + 50% 2008</td></tr>
<tr><td>2015</td><td>Pre-1994</td><td>2012</td></tr>
<tr><td>2016</td><td>1994-1995</td><td>2012</td></tr>
<tr><td>2017</td><td></td><td></td><td rowspan="6">Pre-2008 turnover to 2012</td></tr>
<tr><td>2018</td><td></td><td></td><td rowspan="5">Pre-1998--> 2008
1998-2007-->2012</td></tr>
<tr><td>2020</td><td>1996-1999</td><td>2013</td></tr>
<tr><td>2021</td><td>2000-2004</td><td>2014</td></tr>
<tr><td>2022</td><td>2005-2007</td><td>2015</td></tr>
<tr><td>2023</td><td>2008-2011</td><td>2015</td><td>2015</td><td>2015</td></tr>
</table>

3.3.4.2.1.6 NO_X EXEMPT AREAS[105]

The April 2014 Board approved Truck and Bus amendments expanded the regions in the NOx exempt provision. The provision only applies to vehicles that travel exclusively within these specified NOx exempt areas. Staff assumed that 25% of the activity within the NOx exempt regions (after spatial allocations) will be impacted by the "NOx Exempt" provisions as described in Table 3.3-21.

The rest of the rule compliance assumptions have not been changed and are briefly described in this document.

Table 3.3-21 Retrofit Assumption for Trucks in the NOx Exempt Areas

NOx Exempt Areas (only >26000 lbs GVWR)	Applicable	Large Fleets	Small Fleet Trucks to be Retrofit		
By Jan 1	Vehicle Model Years	*Fleets with more than three trucks*	*One Truck Fleet*	*Two Truck Fleet*	*Three Truck Fleet*
2015	Pre-2008	25% must have DPF	N/A	1st DPF	1st DPF
2016	Pre-2008	40% must have DPF	N/A	N/A	N/A
2017	Pre-2008	55% must have DPF	1st DPF	N/A	2nd DPF
2018	Pre-2008	70% must have DPF	N/A	N/A	N/A
2019	Pre-2008	85% must have DPF	N/A	2nd DPF	3rd DPF
2020	Pre-2008	100% must have DPF	N/A	N/A	N/A

NOx Exempt Areas (only ≤26000 lbs GVWR) By Jan. 1	Applicable Vehicle Model Years	≤26k Trucks to be Retrofit Regardless of Fleet size)
2015	pre-1996	All of these MYs must have DPF
2016	1996	All of these MYs must have DPF
2017	1997	All of these MYs must have DPF
2018	1998	All of these MYs must have DPF
2019	1999	All of these MYs must have DPF
2020	2000-2003	All of these MYs must have DPF
2021	2004-2007	All of these MYs must have DPF

3.3.4.2.1.7 ASSUMPTIONS FOR TRUCK ≤26,000 LBS. GVWR

According to the Truck and Bus Rule, lighter trucks and buses with a GVWR of 14,001 to 26,000 pounds would not have any compliance requirements until 2015. The Engine Model Year Schedule for Lighter Trucks table lists the compliance dates that would apply by truck MY for lighter trucks. Starting January 1, 2015, lighter trucks, with engines that are 20 years or older, would need to be replaced with newer trucks. Starting January 1, 2020, all remaining trucks and buses would need to be replaced so that they would all have 2010 MY engines or equivalent emissions by 2023. Table 3.3-22 shows the assumptions for these trucks.

105 http://www.arb.ca.gov/msprog/onrdiesel/documents/faqnoxexempt.pdf

Table 3.3-22 Replacement Assumptions for ≤ 26,000 lbs. GVWR Trucks

Below 26k lbs Regardless of Fleet Size		
By Jan 1	Vehicle Model Year	Action (Replace)
2015	pre-1996	2012
2016	1996	2012
2017	1997	2012
2018	1998	2013
2019	1999	2014
2020	2000-2003	2015
2021	2004-2007	2016
2023	2008-2011	2017

3.3.4.2.1.8 SCHOOL BUS PROVISION

Diesel-fueled school buses with a Gross Vehicle Weight Rating over 14,000 pounds are subject to the Truck and Bus Regulation. Owners needed to retire school buses manufactured before April 1 1977, by January 1, 2012. School buses manufactured on or after April 1, 1977, must have particulate filters (DPF that reduce diesel PM emissions by 85 percent) installed according to the schedule shown below in Table 3.3-23.

Table 3.3-23 Retrofit/Replacement Schedule for School Buses

By Jan 1	Vehicle Model Year	Action (Retrofit/Replace)
2012	Pre-1977	Needed to be replaced with MY2008 or newer*
2012	n/a	33% of whole fleet needed to have DPF (excluding 1988-1993 & 2-stroke)
2013	n/a	66% of whole fleet needed to have DPF (excluding 1988-1993 & 2-stroke)
2014	n/a	100% of whole fleet needed to have DPF (excluding 1988-1993 & 2-stroke)
2014	n/a	1988-1993 (excluding 2 stroke) needed to have DPF
2018	n/a	2 stroke engines will need to be replaced with MY2008 or newer*

*MY2008 or newer with OEM installed DPF

3.3.4.2.1.9 PUBLIC/UTILITY/SOLID WASTE COLLECTION VEHICLES

California's solid waste collection vehicle (SWCV) Rule was passed in September 2003 and required owners to use ARB verified control technology that best reduces emissions, following a phased-in schedule from 2004 through 2010. On December 8, 2005, the California Air Resources Board approved a regulation to reduce diesel particulate matter (PM) emissions from fleets operated by public agencies and utilities (PAU). EMFAC2014 assumes the compliance assumptions listed in table 3.3-24 to reflect the combined impact of PAU, SWCV and Truck and Bus rules on these fleets.

Table 3.3-24 Retrofit/Replacement Assumptions for Public/Utility/Solid Waste Collection Vehicles

Public			
By Jan 1	Vehicle Model Year	Sub-Area Type	Action (Retrofit)
2013	Pre-2008	High Population Sub-Area	DPF
2018	Pre-2008	Low Population Sub-Area	DPF

SWCV		
By Jan 1	Vehicle Model Year	Action (Retrofit)
2012	Pre-2008	DPF

Utility		
By Jan 1	Vehicle Model Year	Action (Retrofit/Replace)
2008	20% Pre-2002*	50% DPF; 50% 2008
2010	60% Pre-1987	2008
2014	Pre1998	2012
2014	1998-2007	50% 2013 , 50% DPF
2017	Pre-2012	2013
*20% of pre-2002 pop need to have DPF or be replaced by 2008 CY		

3.3.4.2.1.10 DRAYAGE TRUCKS

According to the staff analysis, the age distribution of drayage trucks affected by the drayage truck regulation is assumed to follow the distribution characterized in Table 3.3-25. Using this table, staff interpolated the age distribution of drayage trucks from 2010 – 2023 for the Port of LA (left panel) and from 2014-2023 for the Port of Oakland and Other Port trucks (right panel). Once the population was redistributed according to pre-set age distributions, the retrofit requirements were applied according to the schedule Table 3.3-26.

Table 3.3-25 Drayage Truck Age Distributions

Port of LA Trucks					
Calendar Year	Engine Model Years				
	1994-2003	2004	2005-2006	2007-2009	2010+
2010	4%	10%	21%	58%	7%
2011	4%	10%	21%	58%	7%
2012	4%	6%	11%	70%	9%
2013	4%	6%	9%	72%	9%
2014	0%	0%	0%	72%	28%
2015	0%	0%	0%	69%	31%
2016	0%	0%	0%	66%	34%
2017	0%	0%	0%	63%	37%
2018	0%	0%	0%	60%	40%
2019	0%	0%	0%	57%	43%
2020	0%	0%	0%	54%	46%
2021	0%	0%	0%	51%	49%
2022	0%	0%	0%	48%	52%
2023	0%	0%	0%	0%	100%

Port of Oakland and Other Ports Trucks					
Calendar Year	Engine Model Years				
	1994-2003	2004	2005-2006	2007-2009	2010+
2014	0%	0%	0%	72%	28%
2015	0%	0%	0%	69%	31%
2016	0%	0%	0%	66%	34%
2017	0%	0%	0%	63%	37%
2018	0%	0%	0%	60%	40%
2019	0%	0%	0%	57%	43%
2020	0%	0%	0%	54%	46%
2021	0%	0%	0%	51%	49%
2022	0%	0%	0%	48%	52%
2023	0%	0%	0%	0%	100%

Table 3.3-26 Retrofit Assumptions for Drayage Trucks

Drayage Trucks	Vehicle Model Year	Action (Retrofit)
2009	Pre-1994	DPF
2010	Pre-2004	DPF
2012	2004	DPF
2013	2005 -2007	DPF

3.3.4.3 HD VMT

EMFAC2014 first computes the base year VMT and then applies growth rates at the statewide level to forecast future year VMT. The growth rates in EMFAC2014 were updated based upon newly available information. EMFAC2014 HD base year VMT is then normalized using BOE statewide diesel fuel usage data.

3.3.4.3.1 HDV MILEAGE ACCRUAL RATES

HDV mileage accrual rates in EMFAC2014 are similar to those in EMFAC2011, with the exception of Ag trucks and low-mileage work trucks. HDV mileage accrual rates, in EMFAC2011, were primarily based on data from the Vehicle Inventory and Use Survey (VIUS)[106] which were supplemented with ARB survey data, as documented in the 2008 Truck and Bus (T&B) Technical Appendix.[107] However, Ag trucks in EMFAC2014 are more specifically defined than in EMFAC2011. Only those trucks, reported in TRUCRS as having the Ag truck designation are eligible for the T&B Ag provision. The mileage accrual rates, for these Ag trucks are based on their mileage reported in TRUCRS. To incorporate the low-mileage work truck provisions, VIUS/ARB survey data were used to compute mileage accrual rates for each mileage threshold sub-vehicle class grouping.

3.3.4.3.2 HD VMT: BASE YEAR

The first step to estimate future HD diesel VMT for EMFAC2014 is to calculate the base year (2012) VMT using the diesel fuel use data from the California Board of Equalization (BOE), the vehicle population data from DMV, and mileage accrual rates obtained from the VIUS. Calculating the HD diesel base year VMT in EMFAC2014 model is done through four steps as follows:

1. *VMT are first calculated using population and mileage accrual rates as:*

$$\boldsymbol{VMT}(\boldsymbol{SA},\boldsymbol{Class},\boldsymbol{Fuel},\boldsymbol{Age}) = \boldsymbol{Population}(\boldsymbol{SA},\boldsymbol{Class},\boldsymbol{Fuel},\boldsymbol{Age}) \times \boldsymbol{Accrual}(\boldsymbol{SA},\boldsymbol{Class},\boldsymbol{Age}) \quad \textbf{(3.3.4.3-A)}$$

2. *The VMT calculated from step one is multiplied by EMFAC2014-calculated statewide average fuel consumption rates (gallons/mile) to estimate the fuel use:*

$$\boldsymbol{Fuel\ use}\left(\frac{\boldsymbol{Gallons}}{\boldsymbol{year}}\right) = \boldsymbol{VMT}\left(\frac{\boldsymbol{miles}}{\boldsymbol{year}}\right) \times \boldsymbol{Fuel\ Consumption\ Rate}\left(\frac{\boldsymbol{Gallons}}{\boldsymbol{mile}}\right) \quad \textbf{(3.3.4.3-B)}$$

3. *A scaling factor is calculated based on the estimated fuel use from step 2 and the diesel fuel use from BOE. Since BOE only provides taxable diesel fuel use, the fuel consumption rates for diesel school buses and UBUS are assumed to be zero in step 2.*

106 https://www.census.gov/svsd/www/vius/products.html

107 Table 1 in http://www.arb.ca.gov/regact/2008/truckbus08/appg.pdf cites sources used to derive mileage accrual rates.

$$Scaling\ Factor = \frac{BOE\ Fuel\ Use\ (Gallons/\ year)}{Estimate\ Fuel\ Use(Gallons/year)} \quad \textbf{(3.3.4.3-C)}$$

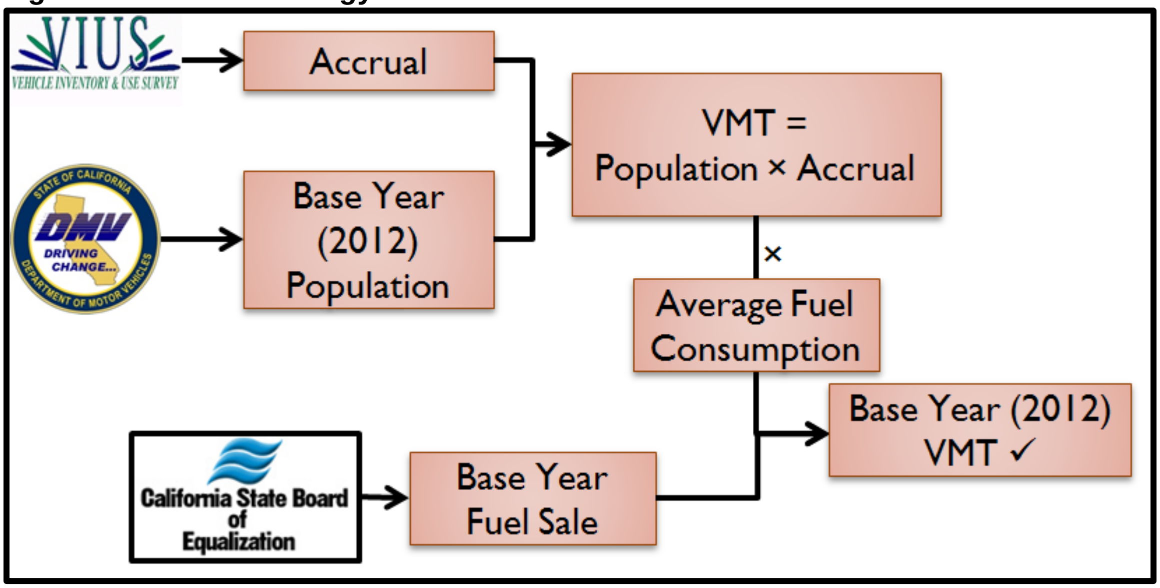
Since mileage accrual rates vary year to year, this scaling factor is used to scale accrual rates for the base year, so that the product of population, mileage accrual, and fuel consumption rates matches the fuel use reported by BOE. Please note that BOE diesel fuel use, used in the HD model is adjusted for diesel use by vehicles in the LD categories.

4. *The VMT estimate from step one (VMT by region, vehicle type, and age) is adjusted using the scaling factor from step 3 as:*

$$Base\ Year\ VMT = Population \times Accrual \times Scaling\ Factor \quad \textbf{(3.3.4.3-D)}$$

The scaling procedure ensures that when the base year diesel VMT, as calculated above, is converted to fuel use (using the fuel consumption rates), it matches the BOE reported taxable diesel fuel use. Figure 3.3-14 illustrates the steps taken to calculate the base year VMT for the heavy duty diesel vehicles in EMFAC2014.

Figure 3.3-14 Methodology to Calculate Base Year VMT for HD Diesel Vehicles



3.3.4.3.3 HD VMT: FORECASTING

The methodology used to forecast VMT for HD diesel vehicles is similar to the methodology used to forecast VMT for the LDV vehicles, described in Section 3.3.3.2 With the main difference being that the VMT, for each HD vehicle category, is scaled separately.

HD vehicle class specific "initial" VMT are first calculated, using the forecasted vehicle population; by Sub-Area, vehicle class, fuel type, and age; and by mileage accrual rates (by Sub-Area, vehicle class, fuel type, and age, as discussed in Section 3.3.4.3.1). Vehicle class specific target VMT are then calculated, using the base year VMT (by vehicle class) and VMT growth trends (by vehicle class) as described below.

Using the "initial" estimated VMT and Target VMT vehicle class specific scaling factors are calculated. The scaling factors are applied to the estimated VMT to calculate the forecasted VMT by sub-area, vehicle class, fuel and age.

The process, described above, scales the mileage accrual rates and vehicle population for each vehicle class so that the product of the population and mileage accrual rates matches the target VMT. Since the Truck and Bus Rule provides exemptions, for some low mileage vehicles,[108] in EMFAC2014, we do not scale the population and mileage accrual for the vehicles within this exemption, as these vehicles are bound to specific annual mileage thresholds and their population depends on whether they have reported their vehicles to ARB or not. Therefore, the VMT forecasting methodology in EMFAC2014 is adjusted to account for this. The process is described in the following five steps:

1. $$\boldsymbol{Low\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age}) = \boldsymbol{Low\ Mileage\ Population}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \times \boldsymbol{Low\ Mileage\ Accrual\ rates}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \tag{3.3.4.3-E}$$

2. $$\boldsymbol{High\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age}) = \boldsymbol{High\ Mileage\ Population}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \times \boldsymbol{High\ Mileage\ Accrual\ rates}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \tag{3.3.4.3-F}$$

3. $$\boldsymbol{Target\ High\ Mileage\ VMT}(\mathbf{Sub-Area, Class, Fuel, Age}) = (\boldsymbol{Base\ Year\ VMT} \times \boldsymbol{VMT\ Growth\ Rate})(\mathbf{Sub-Area, Class, Fuel, Age}) - \boldsymbol{Low\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \tag{3.3.4.3-G}$$

4. $$\boldsymbol{Scaling\ Factor}\ (\mathbf{Sub-Area, Class, Fuel, Age}) = \frac{\boldsymbol{Target\ High\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age})}{\boldsymbol{High\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age})} \tag{3.3.4.3-H}$$

5. $$\boldsymbol{Forecasted\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age}) = (\boldsymbol{High\ Mileage\ VMT} \times \boldsymbol{Scaling\ Factor})(\mathbf{Sub-Area, Class, Fuel, Age}) + \boldsymbol{Low\ Mileage\ VMT}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \tag{3.3.4.3-I}$$

For LD vehicle activity, EMFAC2014 only scales the mileage accrual rates to match the target VMT. The population is not scaled. For the HD diesel fleet, the square root of a scaling factor is applied to both the population and the mileage accrual rates.

The main reason, for this difference, is that the HD sector is driven by the freight transportation industry, whereas the light-duty sector is driven primarily by personal vehicle usage. In EMFAC2014, staff assumed that due to the high cost of newer technology vehicles, fleet owners may scrap more vehicles than the number of new vehicles they buy, so they can better absorb the financial impacts to their business. However, since their businesses generally require a certain amount of VMT being driven each year, their new vehicles should be more likely to accrue higher mileage than the older vehicles. That is because newer trucks are more reliable to drive longer distance/more hours.

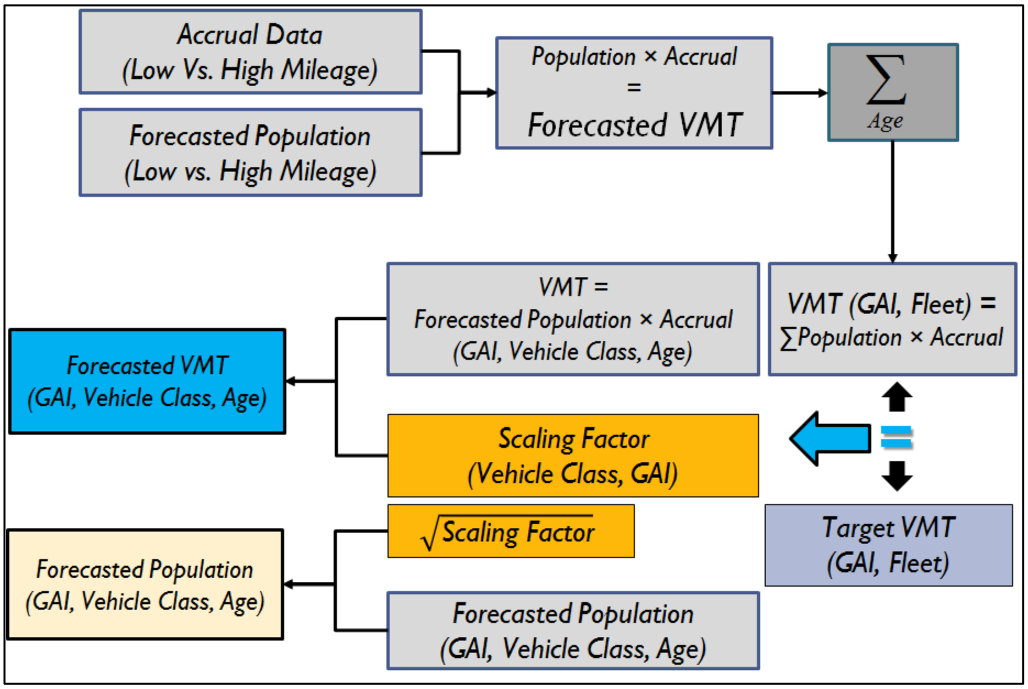
Therefore, in forecasting the VMT, for the HD diesel sector, EMFAC2014 applies the square root of a scaling factor (calculated in step 4) to both the mileage accrual and the population to account for the mileage shifting from older vehicles, with lower mileage accrual that are being retired (but not replaced), onto the newer vehicles that could be driven additional miles per year. As a result of this methodology (called the "Square Root" approach), the final population is calculated as:

[108] Refer to amended regulatory requirements as listed on http://www.arb.ca.gov/msprog/truckstop/tb/truckbus.htm

$$\textit{Final Forecasted Population}\ (\mathbf{Sub-Area, Class, Fuel, Age}) =$$
$$\textit{Forecasted Population}\ (\mathbf{Sub-Area, Class, Fuel, Age}) \times \sqrt{\textit{Scaling Factor}} \qquad \textbf{(3.3.4.3-J)}$$

It should be noted that this approach (i.e. "square root") was only applied to the forecasted populations (2013-2050). For backcasted populations (2000-2012), the actual population from the DMV registration database was available. Thus the scaling factor was only applied to mileage accrual rates and not the population. Figure 3.3-15 provides a flow chart on the steps that EMFAC2014 takes to forecast the VMT of the HD diesel fleet.

Figure 3.3-15 Methodology to Forecast HD Vehicle VMT in EMFAC2014



Note: GAI=Sub-Area

3.3.4.3.3.1 FORECASTING DIESEL FUEL SALES

Similar to gasoline consumption forecasting, on-road diesel consumption, at the statewide level, is forecasted using a regression model that is based on historical time-series data from 1995-2013. The regression model's statewide diesel fuel growth rates are used in EMFAC2014 to forecast the statewide diesel VMT as discussed in more detail below.

ARB staff conducted a number of statistical modeling experiments and eventually selected the best available variables, to represent forecasted statewide diesel fuel sales, for use in EMFAC2014, based upon the model's ability to simulate historical data. The regression model, for statewide diesel fuel consumption is characterized by the following equation:

DSL_FORECAST=0.697+1.863*DIS_INC-0.0670*UR **(3.3.4.3-K)**

R2=0.926; F=99.58; N=19

Where:

DSL_FORECAST = forecasted statewide annual diesel consumption, in billions of gallons;
DIS_INC = state disposable personal income, in trillions of 2010 dollars; and
UR = statewide unemployment rate, in percentage.

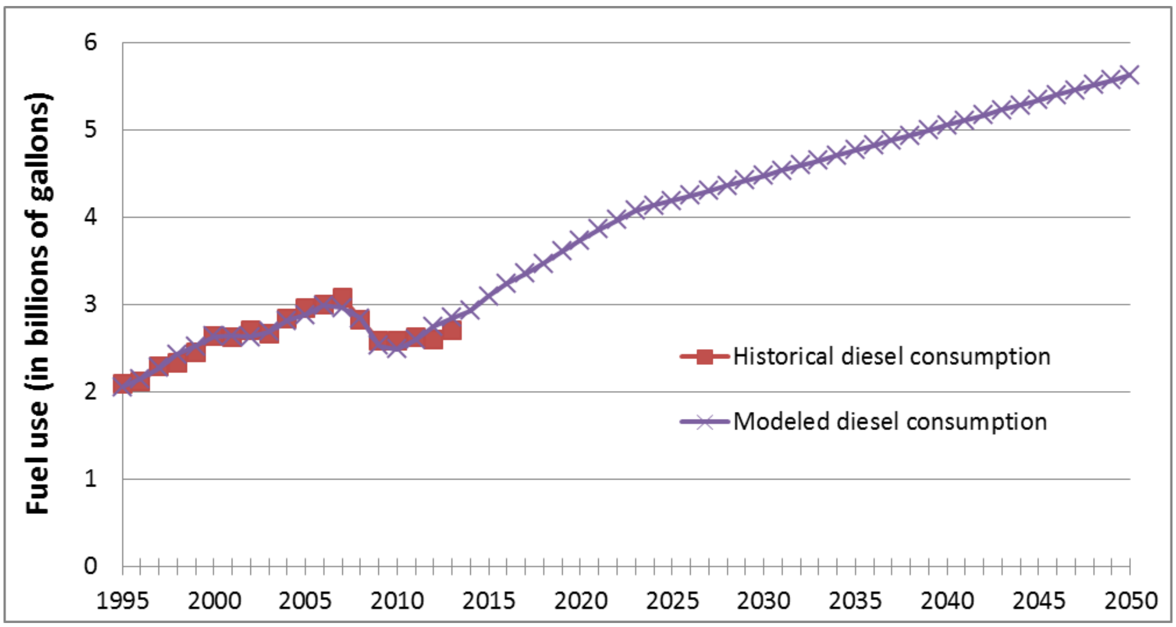
The primary data sources included UCLA Anderson Forecast (UCLA), California Department of Finance (DOF), California Board of Equalization (BOE), and U.S. Bureau of Economic Analysis (BEA).

Below is a more detailed list of the sources used. All data variables used were on a statewide, annual basis. For more specific descriptions of these data sources, see Appendix 6.3.

- Motor diesel sales (DSL): DOF and BOE (1995-2013).
- Disposable personal income (DIS_INC): BEA (1995-2013), UCLA (2014-2023), Linear extrapolation of 1995-2023 (2024+).
- Unemployment rate (UR): DOF (1995-2013), UCLA (2014-2020), Keep constant @ 6% (2021+).
- Consumer Price Index (CPI): DOF (1995-2013), UCLA (2014-2023).

As shown in Figure 3.3-16, this diesel consumption regression model provided a good fit between observed and predicted data. The figure below also shows the statewide diesel consumption forecasts, for 2014-2050, using the selected regression model. By including socio-economic factors in the model, the impact of the historical economic downturn was reflected in the forecasted diesel consumption growth rates.

Figure 3.3-16 Statewide Diesel Consumption Forecasts Using Regression Analysis



3.3.4.3.3.2 HD VMT GROWTH RATES FOR FORECASTING

EMFAC2014 uses the resulting diesel consumption trend discussed above to derive the statewide VMT HD vehicle growth rates for years 2014-2050. For years 2000-2013, EMFAC2014 uses BOE's historical data on taxable diesel fuel sales to normalize the statewide VMT rates.

EMFAC2014 uses category specific VMT growth rates to forecast the VMT for HD diesel vehicles. Applicable growth rates are then applied to specific HD vehicle categories (refer to the vehicle category definitions in Appendix 6.1). The HD VMT growth rates applied in EMFAC2014 are described below.

<u>Ag Trucks</u>

For HD diesel trucks that opt to use the agricultural truck provision specified by the Truck and Bus rule,[109] EMFAC2014 assumes that their total VMT will stay constant over time. This assumption is

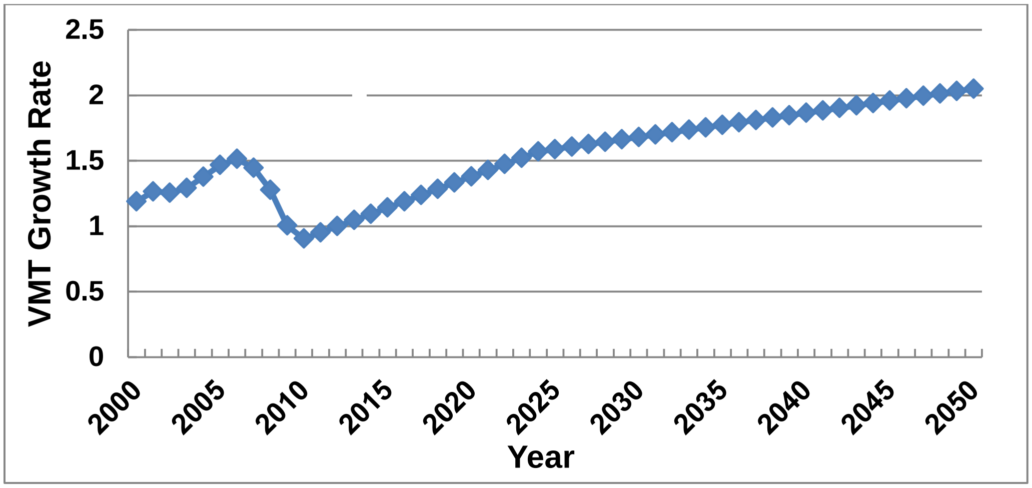
[109] http://www.arb.ca.gov/msprog/onrdiesel/documents/fsag.pdf

supported by the fact that these trucks are exempt from the rule requirements up to 2017/2023 as long as they were reported to the ARB by January 31, 2014.

Construction Trucks

The VMT of construction trucks in EMFAC2014 is assumed to follow the same activity growth trend as of off-road construction equipment under the In-Use Off-Road Equipment inventory model.[110] According to the In-Use Off-Road Equipment inventory model, the California construction and mining equipment growth rates were based on California construction sector employment data from the Bureau of Labor Statistics (BLS).[111] Figure 3.3-17 shows the VMT growth rates used in EMFAC2014 for construction trucks.

Figure 3.3-17 VMT Growth trend for Construction Trucks



Public, Utility and Solid Waste Collection Vehicles (SWCV)

EMFAC2014 assumes that the activity of public, utility, and SWCV is correlated to the statewide growth of human population. Therefore, EMFAC2014 uses the DOF[112] based statewide human population projections as a surrogate to forecast the VMT for these specific vehicle classes. Figure 3.3-18 shows the VMT growth rates used in EMFAC2014 for public, utility, and SWCV.

Drayage Trucks

EMFAC2014 uses the activity growth rates from ARB's Ocean-Going Vessel (OGV) model[113] as a surrogate for future drayage truck VMT growth. It is assumed that the growth in drayage truck activity is directly correlated to the activity growth in OGV's activity. The OGV growth trend is based on the 2013 Federal Highway Administration (FHWA) Freight Analysis Framework (FAF) forecast which provides freight tonnage, by commodity type, for various port regions in California out to 2040. For historical years of 2000-2012, EMFAC2014 uses the container counts (in TEUs[114]) from the ports of Los Angeles, Long Beach and Oakland.

For the "Other Ports" drayage truck category, EMFAC2014 assumes that VMT grows similar to the diesel fuel use trend, with the assumption that every 1% growth in diesel fuel use is equivalent to 1.5%

110 http://www.arb.ca.gov/regact/2010/offroadlsi10/offroadappd.pdf
111 http://www.bls.gov/sae/
112 http://www.dof.ca.gov/research/demographic/reports/projections/view.php
113 http://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf
114 Twenty-foot equivalent units

growth in "Other Ports" drayage trucks VMT. Figure 3.3-19 shows the VMT growth rates used in EMFAC2014 for drayage trucks.

Figure 3.3-18 VMT Growth Trend for Public/Utility/SWCV

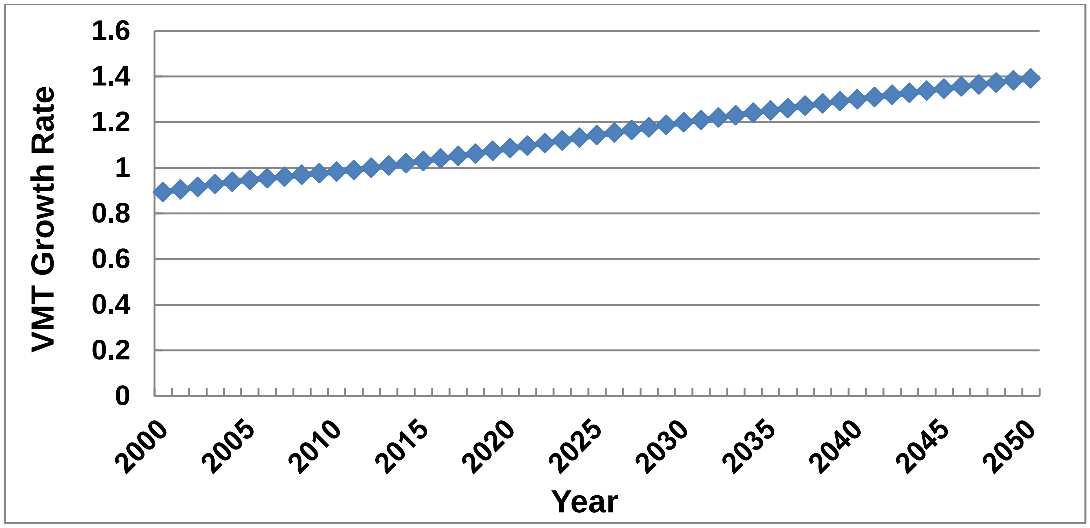
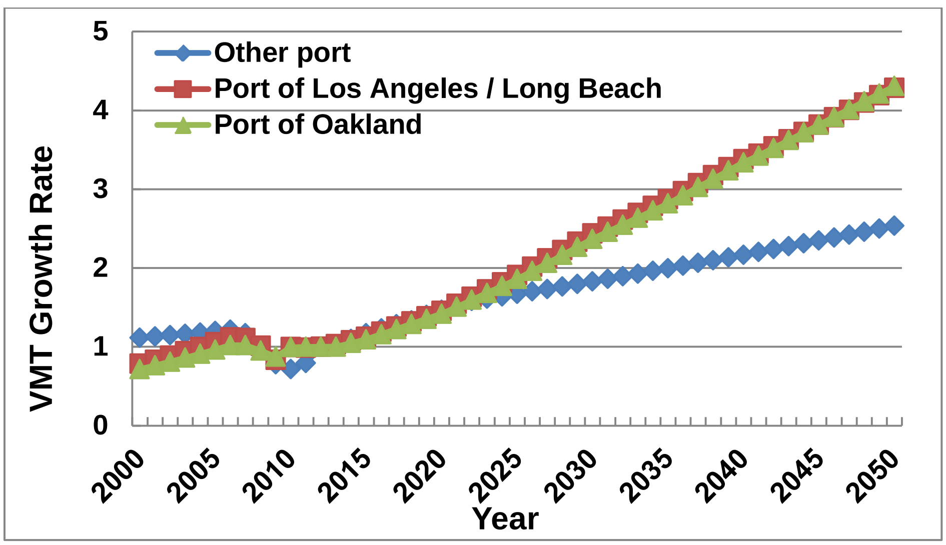


Figure 3.3-19 VMT Growth Trend for Drayage Trucks

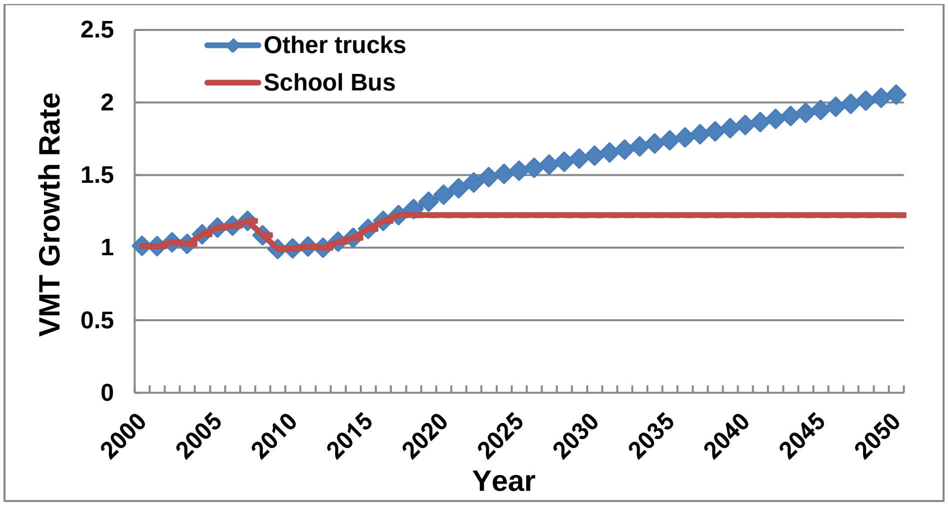


<u>Other Vehicle Categories</u>

The VMT growth rates for all other vehicle categories, not listed above, follow the diesel fuel use trend estimated by the regression model, described in Section 3.3.4.3.3.1.

Among these vehicle categories, School Buses follow the diesel fuel trend up to 2017,then VMT stays constant after 2017 (because it was assumed that after the recession school bus VMT would remain constant). Figure 3.3-20 shows the VMT growth rates used in EMFAC2014 for the School Bus and Other Trucks categories.

Figure 3.3-20 VMT Growth Trend for School Bus and Other Trucks Categories



3.3.4.4 FORECASTING NG UBUS AND SWCV TRUCK PENETRATION RATES

This section describes the methodology used to estimate the penetration of CNG UBUS and natural gas powered SWCV trucks into California's motor vehicle fleet. CNG vehicles have been introduced into a wide variety of vehicle classifications commercial applications, such as: LD trucks and sedans, like taxi cabs; medium-duty trucks, like UPS delivery vans and postal vehicles; and HD vehicles, like transit buses, street sweepers and school buses. In California, transit agency buses and refuse trucks are some of the most visible CNG vehicles.

3.3.4.4.1 MODELING CNG UBUS NEW SALES PENETRATION

According to the Public Transit (PT) Regulation adopted in 2000, transit agencies are required to choose a fuel path: Diesel or Alternative fuel. Fuel path choice affects Urban Bus (UB) purchases and dictates emissions reduction deadlines. In the event that transit agencies choose the alternative fuel path, they are required to have at least 85% of their annual UB purchases be fueled by alternative fuel. Alternative fuel includes compressed natural gas (CNG), liquid propane gas (LPG), ethanol, methanol, gasoline/electric hybrid, hydrogen, electricity, fuel cells, or advanced technologies that do not rely on diesel fuel. According to the PT rule, transit agencies must report every January 31st, from 2003 through 2016, the UBs owned, operated, or under contract to the transit agency as of January 1 of that year. All these reports are maintained in ARB's transit bus registry database.

In order to estimate the penetration of CNG UBs across different regions of California, both DMV data and Bus registry data (as reported to ARB annually per the Fleet Rule for Transit Agencies[115]) were used. DMV data were available from 2000 to 2012. Staff used the DMV information on body type model, registered owner name and fuel to extract the number of CNG buses operating in California. The DMV data includes all registered buses from all transit agencies. Although some urban buses may have valid registrations, some might not be actively operating, and identifying these urban buses is not feasible from DMV data. In order to determine more accurate counts of CNG UBs, at regional levels in California, staff used the Bus registry information. The Bus Registry has more up-to-date information on the actively operated buses in most of the transit agencies. The registry counts are thus used to estimate future penetration of CNG buses into transit fleets.

115 http://www.arb.ca.gov/msprog/bus/bus.htm

Based on a point in time snap shot of the Bus Registry database in 2013, there were 203 active transit agencies over the state, of which 49 were operating in the South Coast, 35 were operating in the San Joaquin Valley, and 28 were operating in the Bay Area Air District. Since the EMFAC model assigns a single vehicle category for both urban and transit buses, total counts of transit (TFV) and UB buses were used in this analysis. The Bus Registry database indicates that almost 100%, of 2006 and newer MY of UB/TFV, purchased in the South Coast, Antelope Valley and Mojave Desert were CNG. t It also indicates, that within the Ventura, San Diego, and Sacramento air districts, almost 90% of their total UB/TV purchases (2006+ MYs) were CNG.

In order to estimate the future penetration of CNG buses into the transit fleets using the Bus Registry data, staff reviewed the fuel path that each agency appears to be taking. In order to determine whether an agency is taking a Diesel path or an Alternative Fuel path, staff looked into the percentage of their CNG purchases from 2006 and on. If the percentage of CNG purchases were above 85%, then that agency was assumed to be following the alternative fuel path; otherwise, the agency was assumed to be following a diesel path. Table 3.3-27 provides a list of air districts and the number of agencies within each district that follow either the diesel or alternative fuel path based on their 2006+ purchases. The total number of agencies reported in this table is 112, as compared to 203 that reported for all MYs. The 112 agencies are a subset of the 203 reporting agencies, for only those agencies which have purchased 2006 or newer CNG/DSL buses.

As shown in the Table 3.3-27

- *Ventura has five transit agencies, three of them following a CNG path and two of them following a Diesel path. However, Gold Coast Transit, which is the largest transit agency in this district, is following a CNG path. Therefore, we are assuming that in the future the Ventura Air District will have 100% CNG purchases.*

- *San Diego has total of three transit agencies (Chula Vista Transit, North County San Diego Transit, San Diego Metropolitan Transit System) and all three of them are following a CNG path. Therefore, we are assuming a 100% CNG path penetration rate in the future.*

- *Sacramento has three main transit agencies (e-tran, Folsom and the Sacramento Regional Transit District) and all except Folsom (which has a relatively small fleet) are following a CNG path. From 2006 to 2012, Folsom had only 5 purchases of Diesel buses, whereas e-tran and Sacramento Regional Transit District had a total of 129 purchases. Therefore, we are assuming a 100% CNG path penetration rate in the future.*

- *San Joaquin Valley Unified has total of 17 transit agencies and 13 of them are taking a CNG path while four of them (Clovis Transit, Modesto - Transit Division, San Joaquin Regional Transit District, YARTS) are taking a Diesel path. Therefore, an estimate of 82% in the future for the CNG path penetration rate was assumed to be fairly realistic. This estimated rate was derived using the number of 2006+ CNG vs. Diesel purchases.*

- *Yolo Solano has two transit agencies (with similar number of purchases) and one of them is taking a Diesel path and the other is taking a CNG path. Based on the data, an estimate of a 76% CNG path penetration rate was assumed to be reasonable.*

- *Butte air district has only one transit agency that has bought 2006+ CNG/Diesel buses. Data shows that Butte was buying only CNG buses in 2006 and 2008 while in 2011 they only bought Diesel. Since in 2011 they had 100% Diesel purchases, we cannot assume that this transit agency is following the alternative fuel path. Therefore, a 67% average CNG path penetration rate will be used for the future, in EMFAC2014 (There is a possibility that data were entered into the ARB database incorrectly).*

- *Monterey Bay Unified has three similar sized transit agencies and two of them are following a Diesel Path (100% Diesel) and one of them is following a CNG path (100% CNG).*

Therefore, a 64% CNG path penetration rate was assumed to be reasonable for their future penetration.

- *In Placer, Bay Area, North Coast Unified, Kern, Santa Barbara, there are a mixture of agencies that follow either a CNG or a Diesel path; however, the number of Diesel purchases are higher than CNG, and thus we cannot expect a growth of CNG into their fleets in the future. Therefore, the average of 2006+ purchases CNG vs. diesel is used for their future CNG penetration rate.*
- *The rest of the air districts (shown in Gray) are all Diesel and we cannot assume any CNG penetration in the future for those areas.*

Table 3.3-27 Number of Agencies Following Diesel or Alternative Path in California Air Districts

Air Districts	CNG Path	Dsl
Antelope Valley	1	/
Bay Area	2	15
Butte	/	1
Calaveras	/	1
El Dorado	/	1
Feather River	/	1
Glenn	/	1
Great Basin Unified	/	1
Imperial	/	2
Kern	/	3
Lassen	/	1
Mendocino	/	1
Modoc	/	1
Mojave Desert	3	/
Monterey Bay Unified	1	2
North Coast Unified	/	3
Northern Sierra	/	2
Placer	2	2
Sacramento	2	1
San Diego	3	/
San Joaquin Valley Unified	13	4
San Luis Obispo	/	3
Santa Barbara	/	4
Shasta	/	1
Siskiyou	/	1
South Coast	22	2
Tehama	/	1
Tuolumne	/	1
Ventura	3	2
Yolo-Solano	1	1

”/” indicates no 2006+ CNG/DSL bus purchases

According to this analysis, the estimated future penetration rates for CNG buses into the California fleet are shown in Table 3.3-28.

Table 3.3-28 Future Penetration of CNG Buses into the California Fleet

Air District	Future Penetration	Air District	Future Penetration
Calaveras	0%	Mariposa	0%
El Dorado	0%	Northern Sonoma	0%
Feather River	0%	Placer	22%
Glenn	0%	Bay Area	29%
Great Basin Unified	0%	North Coast Unified	36%
Imperial	0%	Kern	36%
Lassen	0%	Santa Barbara	38%
Mendocino	0%	Monterey Bay Unified	64%
Modoc	0%	Butte	67%
Northern Sierra	0%	Yolo-Solano	76%
San Luis Obispo	0%	San Joaquin Valley Unified	80%
Shasta	0%	Ventura	100%
Siskiyou	0%	San Diego	100%
Tehama	0%	Sacramento	100%
Tuolumne	0%	South Coast	100%
Amador	0%	Antelope Valley	100%
Colusa	0%	Mojave Desert	100%
Lake	0%		

3.3.4.4.2 SWCV PENETRATION RATES

After urban and transit buses, SWCVs have the second highest number of trucks powered by natural gas in California. An alternative-fuel engine, such as one that runs on natural gas, was one of the BACT (Best Available Control Technology) options for fleet owners to comply with the Waste Collection Vehicle Regulation adopted in 2003. In addition, South Coast AQMD's Rule 1193 requires fleet operators to acquire alternative-fuel SWCV HD trucks when procuring these vehicles for use to provide services to a government agency within the district's jurisdiction. These state and local regulations help promote the penetration of natural gas SWCV.

To estimate the penetration of natural gas SWCVs, staff used DMV registration data from 2006 to 2012 and examined the ratios of the natural gas SWCV population as compared to the combined natural gas and diesel SWCV population, by MY in each air district. The average ratios across 2006 to 2012 were used as the historical natural gas truck penetration rate for the specific MY and air district. Table 3.3-29 shows the CNG penetration rates for air districts that have MY 2005+ SWCVs. Blanks indicate that no new natural gas or diesel SWCVs were purchased.

The historical DMV registration (2000-2012) vehicle counts are used in the inventory, and the penetration rates in Table 3.3-29 are used for pre-2013 models in future years. However, staff must project future CNG penetration rates starting from MY 2013. For the air districts which show statistically valid growth trends, linear regression models were used. Averages of historical penetration were used for other districts. Table 3.3-30 shows the future penetration rates for natural gas fueled SWCVs used in EMFAC2014 for each air district in California.

Table 3.3-29 CNG Penetration Rates for Air Districts with MY2005+ Model SWCV

Air District	Penetration Rates by Vehicle Model Year Average Natural Gas/(Natural Gas + Diesel)							
	2005	2006	2007	2008	2009	2010	2011	2012
Antelope Valley	50%	/	0%	100%	60%	/	/	/
Bay Area	16%	1%	4%	10%	11%	25%	53%	79%
Imperial	0%	0%	0%	0%	100%	0%	/	/
Kern County	0%	0%	100%	0%	0%	0%	0%	/
Mojave Desert	0%	0%	/	/	/	/	100%	/
Monterey Bay	0%	0%	0%	0%	13%	0%	68%	67%
Northern Sierra	0%	0%	0%	/	0%	/	/	100%
Sacramento Metro	11%	3%	21%	9%	68%	67%	20%	63%
San Diego	7%	0%	0%	1%	2%	80%	79%	76%
San Joaquin Valley	27%	5%	19%	18%	14%	16%	0%	27%
San Luis Obispo	0%	/	0%	43%	89%	100%	75%	0%
Santa Barbara	0%	0%	0%	25%	48%	83%	77%	100%
South Coast	16%	8%	43%	68%	90%	94%	94%	99%
Ventura	0%	0%	44%	29%	52%	63%	75%	/

"/" indicates no new natural gas or diesel SWCVs were purchased

Table 3.3-30 Future Penetration Rates of NG Powered SWCVs

Vehicle Model Year Penetration, Natural Gas/(Natural Gas + Diesel)			
Air District	2013	2014	2015
Antelope Valley	42%	42%	42%
Bay Area	90%	100%	100%
Imperial	20%	20%	20%
Kern County	20%	20%	20%
Monterey Bay	30%	30%	30%
Mojave Desert	20%	20%	20%
Northern Sierra	20%	20%	20%
Sacramento Metro	45%	45%	45%
San Joaquin Valley	15%	15%	15%
San Luis Obispo	61%	61%	61%
Santa Barbara	100%	100%	100%
South Coast	100%	100%	100%
San Diego	100%	100%	100%
Ventura	91%	100%	100%

3.3.4.5 UBUS, SWCV, AND DRAYAGE TRUCK SPEED DISTRIBUTIONS

Urban buses mainly operate in urban surface streets with a small fraction of activity occurring on freeways. Based on the population reported to the Transit Fleet Rule Online Reporting Website in 2013,[116] 85% of the buses are engaged in urban transportation while 15% of the buses are engaged in longer-distance transit service. Thus, the speed distribution for urban buses was developed as a weighted result of using 15% of EMFAC's MHDT speed distribution plus 85% of the Central Business District (CBD) cycle speed profile.

The CBD cycle is a test procedure developed for HD vehicles by the US Department of Transportation and the Urban Mass Transit Association for assessing bus performance. Following the MHDT speed distribution convention in EMFAC, CBD cycle speeds were first grouped into 5-mph speed bins (i.e., the

[116] ARB Transit Fleet Rule Online Reporting Website, http://www.arb.ca.gov/msprog/bus/bus.htm

5-mph bin including speeds from 0 to <5 mph, the 10-mph bin for all speeds from ≥5 to <10 mph, and so on) and the fractions of VMT by speed bin were then calculated from the speed-time trace.

The MHDT speed distributions vary by geographic region, CY, and period of the day. As a result, the composite 85% MHDT +15% speed distribution of urban buses also varies by geographic region, CY and period of the day. Thus, the MHDT and the composite speed distributions are not shown here due to the large number of data combinations. However, Table 3.3-31 shows the CBD Cycle speed distribution, which represents the largest contribution to the composite results of CBD (85%) and MHDT (15%).

Table 3.3-31 Urban Bus CBD Cycle Speed Distribution

Speed Bin	Fraction of VMT
5-mph	0.016
10-mph	0.051
15-mph	0.089
20-mph	0.844
>25-mph	0.000

The speed distribution for SWCV trucks (also referred to herein as refuse trucks) were calculated from the AQMD Refuse Truck Cycle (RTC),[117] developed for South Coast Air Quality Management District (SCAQMD). This cycle is based on the William H. Martin Cycle. It includes highway operation (to represent driving between the pickup area and dump site) and curbside refuse pickup operation. Figure 3.3-21 is a graphic representation of RTC. As with CBD, the fractions of VMT for all speed bins were calculated from speed-time trace and the results are shown in Table 3.3-32.

For the speed distribution of drayage trucks, three different test cycles were combined to model the driving of these trucks Near Dock, Local, and Regional. Near Dock, Local, and Regional cycles simulate, the travel between terminals and near-dock rails (distance of 5 miles or less), between terminals and off-dock rails (average distance of 20 miles), and between terminals and local transloading (average distance of 33.2 miles). The speed-time traces, for these three cycles, are shown below in figures 3.3-22 through 3.3-24.

The speed distributions of the Near Dock, Local, and Regional drayage truck cycles were first calculated. For each speed bin, the fraction of VMT was obtained by weighted averaging the three fractions of VMT for each speed bin, using as weights the estimated VMT splits between near dock, local, and regional activity assumed in the Drayage Truck Regulation. The VMT weights of Near Dock, Local, and Regional cycles were 0.06, 0.34, and 0.60, respectively.[118] The final results are shown in Table 3.3-33.

[117] http://www.afdc.energy.gov/pdfs/35115.pdf

[118] California Air Resources Board, Drayage Truck Regulation, 2007.

Figure 3.3-21 Speed-Time Trace of Refuse Truck Cycle

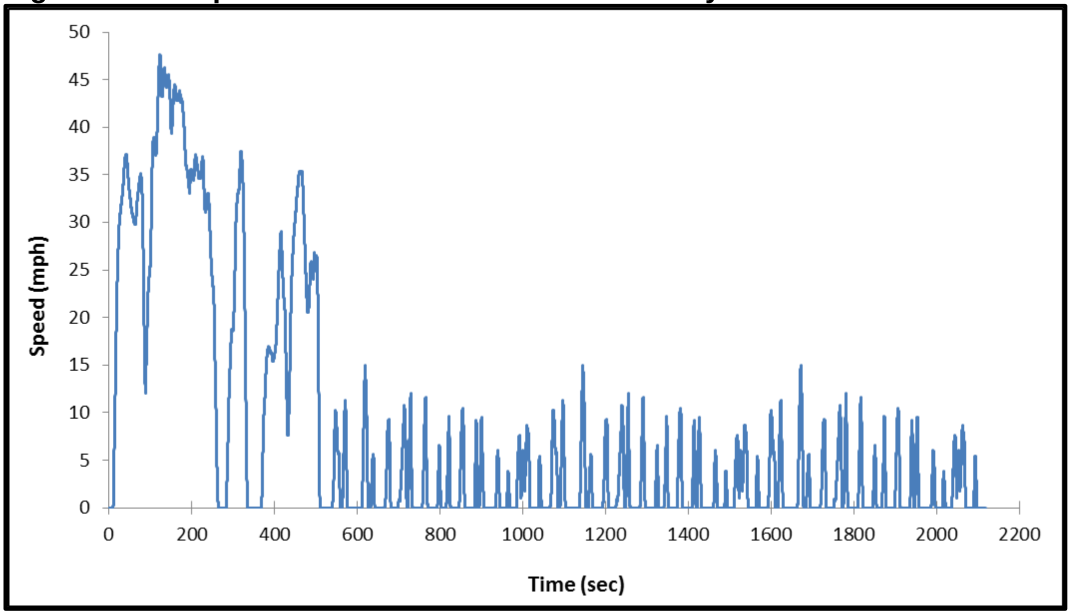


Table 3.3-32 Refuse Truck Speed Distribution

Speed	Fraction
5-mph	0.0533
10-mph	0.1280
15-mph	0.0585
20-mph	0.0538
25-mph	0.0777
30-mph	0.0873
35-mph	0.2156
40-mph	0.1552
45-mph	0.1266
50-mph	0.0441
>55-mph	0.0000

Figure 3.3-22 Speed-Time Trace for Near Dock Cycle

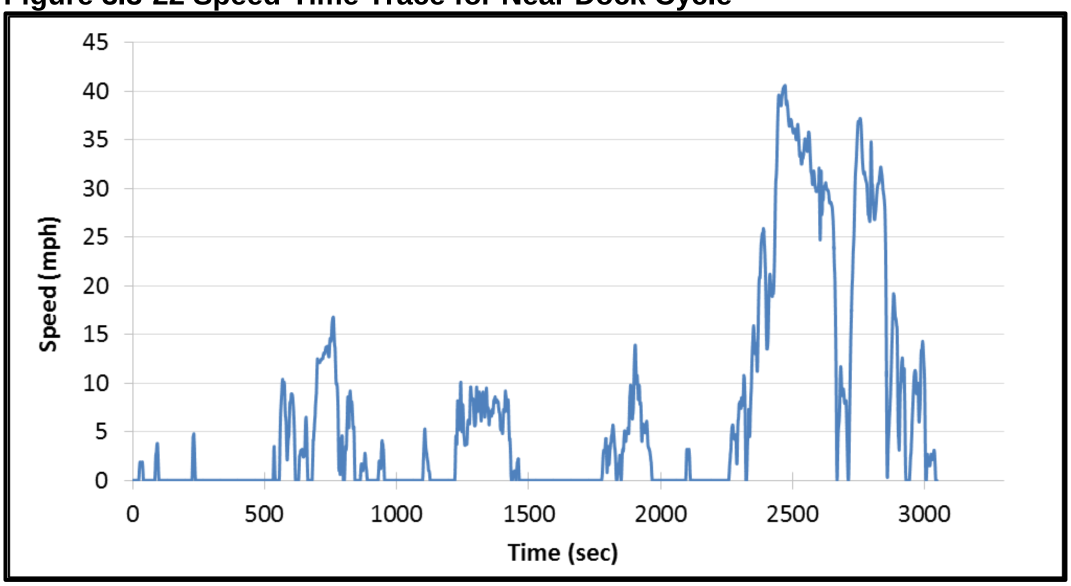


Figure 3.3-23 Speed-Time Trace for Local Cycle

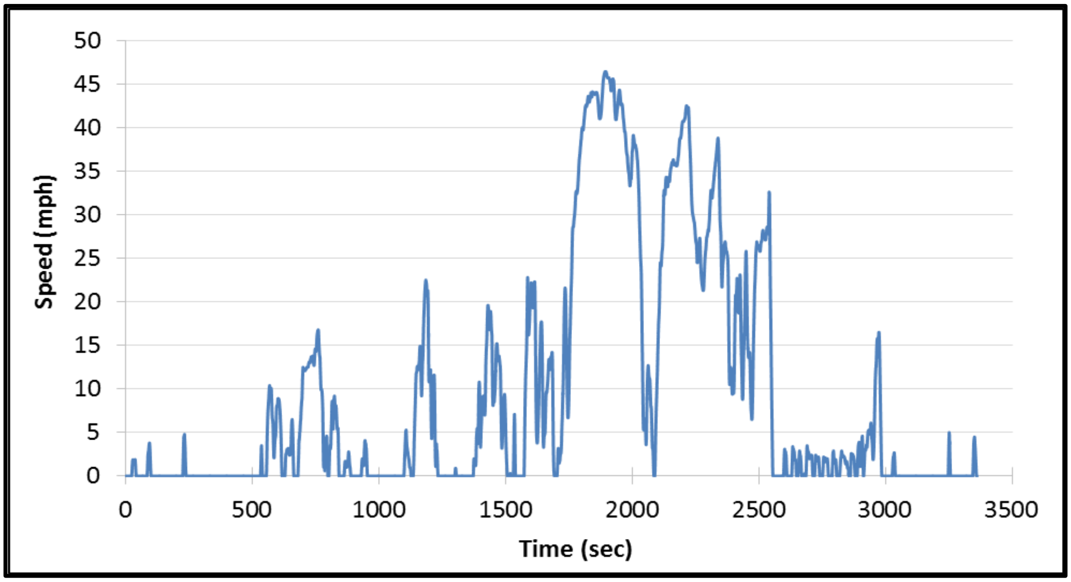
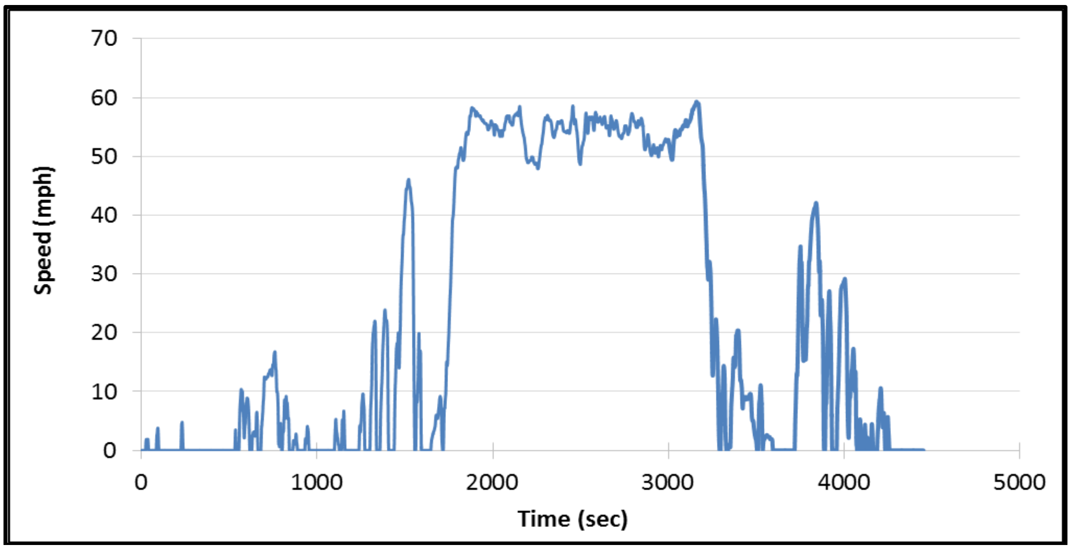


Figure 3.3-24 Speed-Time Trace for Regional Cycle



The drayage truck speed distribution is applied to HHD drayage trucks traveling in regions near major ports or terminals, namely, in Alameda, Los Angeles and San Bernardino Counties. In other regions, drayage trucks behave like regular HHDTs and the generic HHDT speed profile is applied.

Table 3.3-33 Drayage Truck Speed Distribution

Speed Bin	Fraction of VMT
5-mph	0.027
10-mph	0.048
15-mph	0.056
20-mph	0.041
25-mph	0.045
30-mph	0.065
35-mph	0.061
40-mph	0.075
45-mph	0.090
50-mph	0.066
55-mph	0.200
60-mph	0.226
>65-mph	0.000

3.4 IMPACT OF UPDATES

As described earlier in this document, EMFAC2014 retains some of the EMFAC2011 updates but also has some unique additions. For example, amendments to the Truck and Bus Rule approved by the Board in April 2014 have been incorporated into EMFAC2014. Also, both the diesel and gasoline fuel usage, as determined by EMFAC2014's default VMT and mpg assumptions, are consistent with the BOE taxable fuel sales data. Although EMFAC is not used to generate the official GHG inventory, ensuring consistency with BOE fuel usage supports the use of both criteria and GHG emissions results from EMFAC for project level analyses. In addition to these major changes,

1. *EMFAC2014 uses socio-economic modeling techniques to estimate future new vehicle sales and VMT growth rates;*
2. *Diesel emission rates in EMFAC2014 have been updated based on HD truck dynamometer testing of 2007 and 2010 standard trucks by the ARB and the SCAQMD ; and*
3. *EMFAC2014 incorporates emissions from natural gas UBUS as well as SWCV trucks.*

To examine the impact of these EMFAC2014 updates (which were described in detail in Sections 3.2 and 3.3), this section presents plots of emissions, vehicle populations, and VMT. A comparison is made between that which is predicted by EMFAC2011 and that which is predicted using EMFAC2014, at the statewide level. In order to better explain the differences, separate comparisons are made for LD and HD vehicles. The EMFAC2014 results presented in this section were generated using the default activity run type which does not incorporate MPO VMT data. The EMFAC2011 results presented were generated using EMFAC2011 default activity data (based on latest available MPO's VMT at the time of release).[119] Even if using the same default input activity data, the output activity results may differ due to the methodologies used in each EMFAC version, such as for spatial reallocation (as described in prior sections).

Similar comparisons have been performed for the South Coast and San Joaquin Valley Sub-Areas; and, the explanations provided for the statewide results also apply to these regions. The charts, for these intra-regional comparisons are not presented in this section, but are provided in Appendix 6.4.

This section compares the statewide results of EMFAC2014 with EMFAC2011 for vehicle populations (in millions), VMT (in million miles per day) and Emissions (in tons per day). Differences in the results between the two model versions are discussed below.

[119] Please refer to http://www.arb.ca.gov/msei/emfac2011-documentation-final.pdf

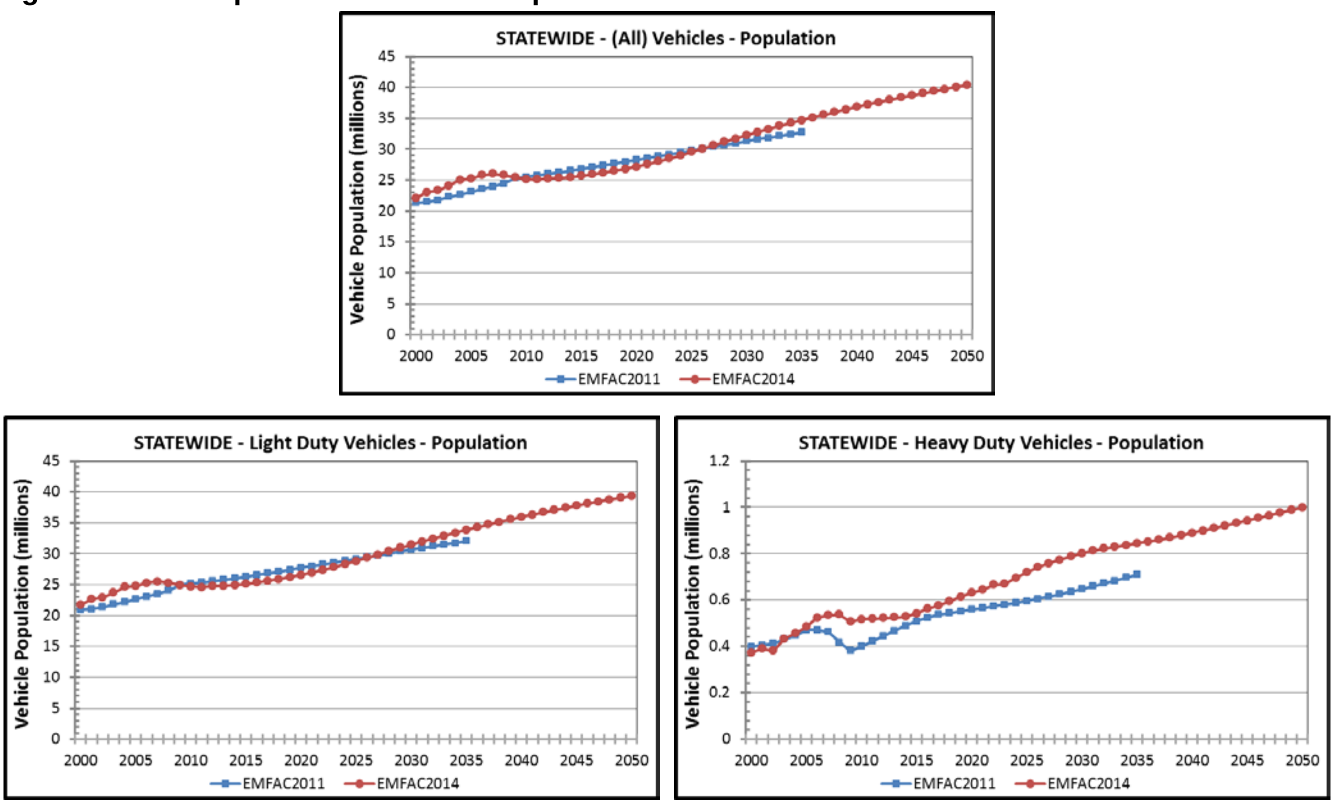
3.4.1 VEHICLE POPULATION

The panels of Figure 3.4-1 compare EMFAC2011 and EMFAC2014 total, HD, and LD vehicle populations. The EMFAC2014 total vehicle population, which is dominated by LD vehicles, is higher than the EMFAC2011 population for the years spanning 2000-2009. For CY 2010-2026, the EMFAC2014 total vehicle population was lower and then surpassed the EMFAC2011 total vehicle population for CY 2027 through 2035.

EMFAC2014 and EMFAC2011 vehicle populations were computed differently and these differences led to the divergences apparent in Figure 3.4-1. In EMFAC2014, historical vehicle populations (2000-2012) are based upon real vehicle populations recorded in the DMV registration database. For years 2013-2050, EMFAC2014 uses the 2012 DMV vehicle population along with estimations of new vehicle sales and vehicle attrition to forecast future CY vehicle populations. In contrast, EMFAC2011 historical and future vehicle populations were based upon only a single year of DMV data, 2009. The 2009 vehicle populations were combined with MPO VMT estimates to predict vehicle populations prior and subsequent to 2009.[120]

Note that the EMFAC2014vehicle population reflects the impact of the recession on vehicle sales and retention, as the total vehicle population decreases from 2007 until 2012, and then with the economic recovery, grows after 2012. Similar effects are observed in the LD and HD vehicle populations.

Figure 3.4-1 Comparison of Vehicle Population between EMFAC2011 and EMFAC2014



3.4.2 VMT

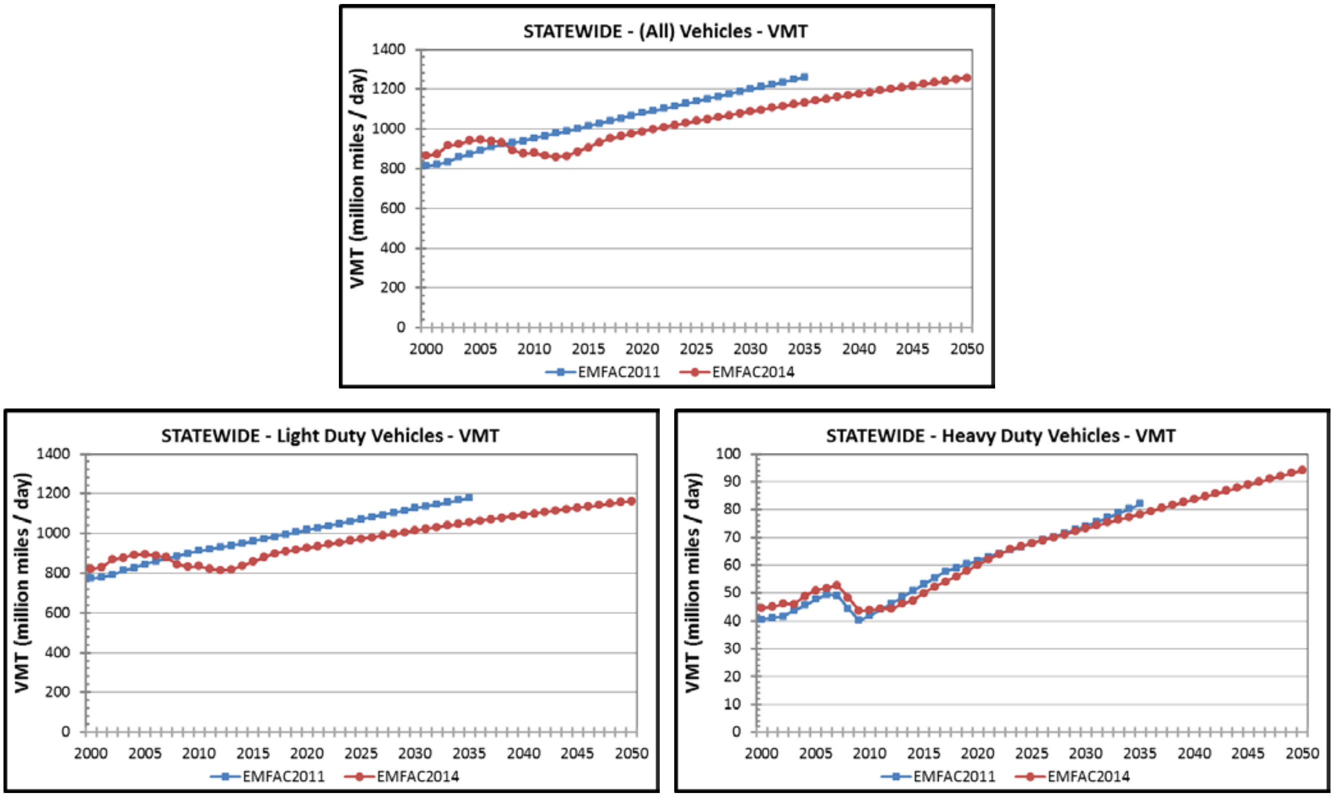
Figure 3.4-2 shows a comparison of statewide VMT from EMFAC2011 and EMFAC2014 in million miles per day. EMFAC2014 outputs VMT slightly higher than EMFAC2011 in years 2000-2007; but this trend

120 Please refer to http://www.arb.ca.gov/msei/onroad/downloads/revisions/web_vmtscag2.doc

reverses and EMFAC2014 outputs lower VMT for years beyond 2007. Both models show similar long term VMT growth trends.

The bottom left panel of Figure 3.4-2 shows the EMFAC2011 vs. EMFAC2014 LD VMT comparison. EMFAC2014 outputs higher VMT from 2000-2007 and lower VMT after 2007. The reason for the higher VMT is that EMFAC2011 underestimated the fuel usage for the earlier years. And the lower VMT after 2007 are because EMFAC2014 was updated to account for the lower taxable fuel use during the recessionary period. The bottom right panel of Figure 3.4-2 shows a similar comparison of the EMFAC2014 and EMFAC2011 HD VMT. Since EMFAC2014 uses an updated vehicle population which is higher than that used by EMFAC2011, and because EMFAC2014 matches the fuel use from BOE (using updated average fuel economy rates), the VMT from EMFAC2014 are slightly higher for years 2000-2010. EMFAC2014 VMT become more similar to EMFAC2011 after 2010.

Figure 3.4-2 Comparison of VMT between EMFAC2011 and EMFAC2014



3.4.3 EMISSIONS

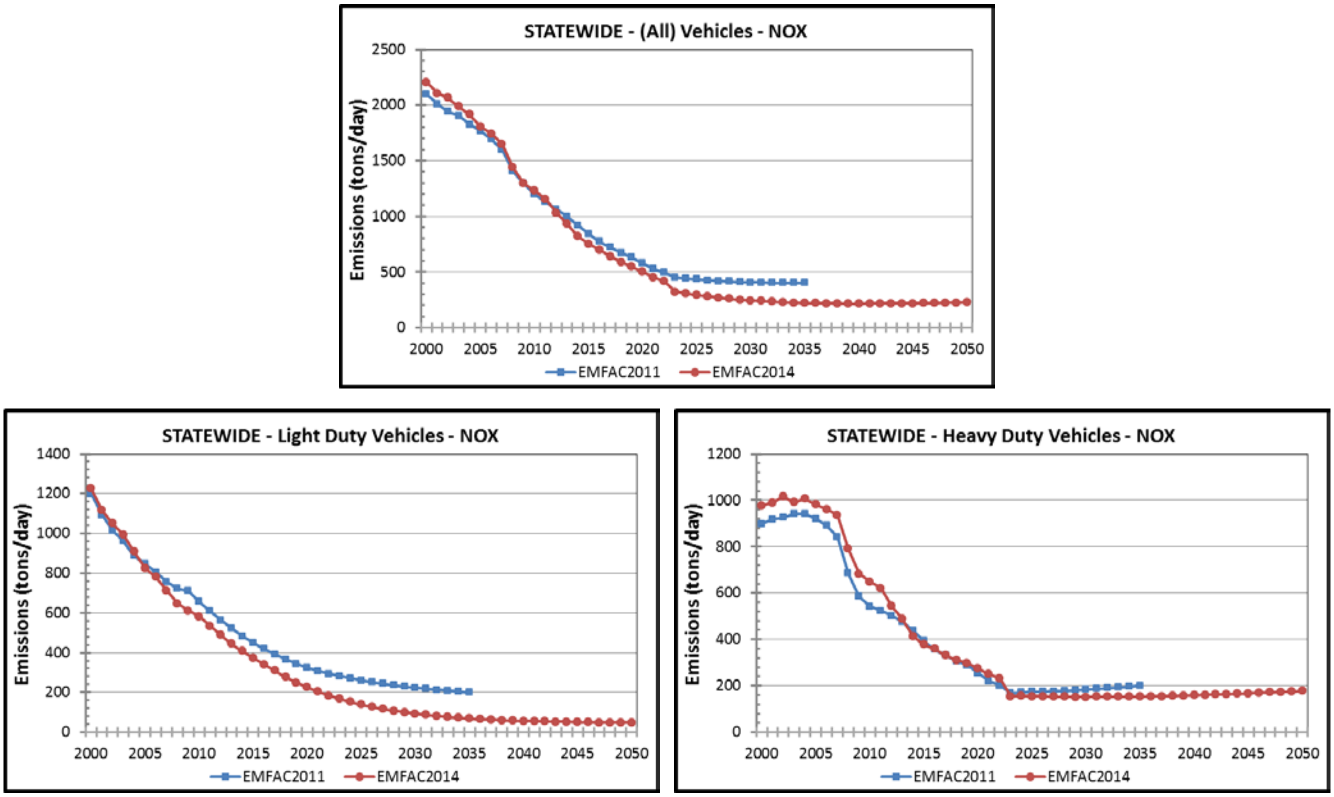
In general, EMFAC2014 shows higher emissions, in years 2000-2008, as a result of the utilization of higher VMT in the emissions calculations. Enhancing this emissions increase is the inclusion of crankcase emissions (an EMFAC2014 update). After 2022, the emissions predicted by EMFAC2014 become lower than EMFAC2011 as a result of lower VMT, updates made for new and more stringent LDV emissions standards from the ACC rule, and from updates made to the diesel HD emission rates.

3.4.3.1 NOX

Figure 3.4-3 shows the comparison of estimates of statewide NOx emissions between EMFAC2011 and EMFAC2014, in tons per day. As can be seen in the charts, EMFAC2014 results show slightly higher NOx emissions in years 2000 through 2008 and lower emissions thereafter.

In terms of LD vehicles, EMFAC2014 reports slightly higher NOx emissions in years 2000-2007, due to the higher VMT in EMFAC2014; and EMFAC2014 reports lower emissions in 2008+ due to lower VMT (as discussed above in section 3.4.2) as well as the impact of the ACC Rule. In terms of HD vehicles, EMFAC2014 gives slightly higher NOx emissions in years 2000 through 2013. Updates for this time period include higher VMT, updated HD diesel emission rates, incorporation of diesel start emissions, and procedures to account for chassis MY/engine MY mismatch. Beyond 2023, EMFAC2014 predicts lower NOx emissions than EMFAC2011, as a result of updated 2010+ engine MY diesel truck NOx emission rates in EMFAC2014.

Figure 3.4-3 Comparison of NOx Emissions between EMFAC2011 and EMFAC2014



3.4.3.2 ROG

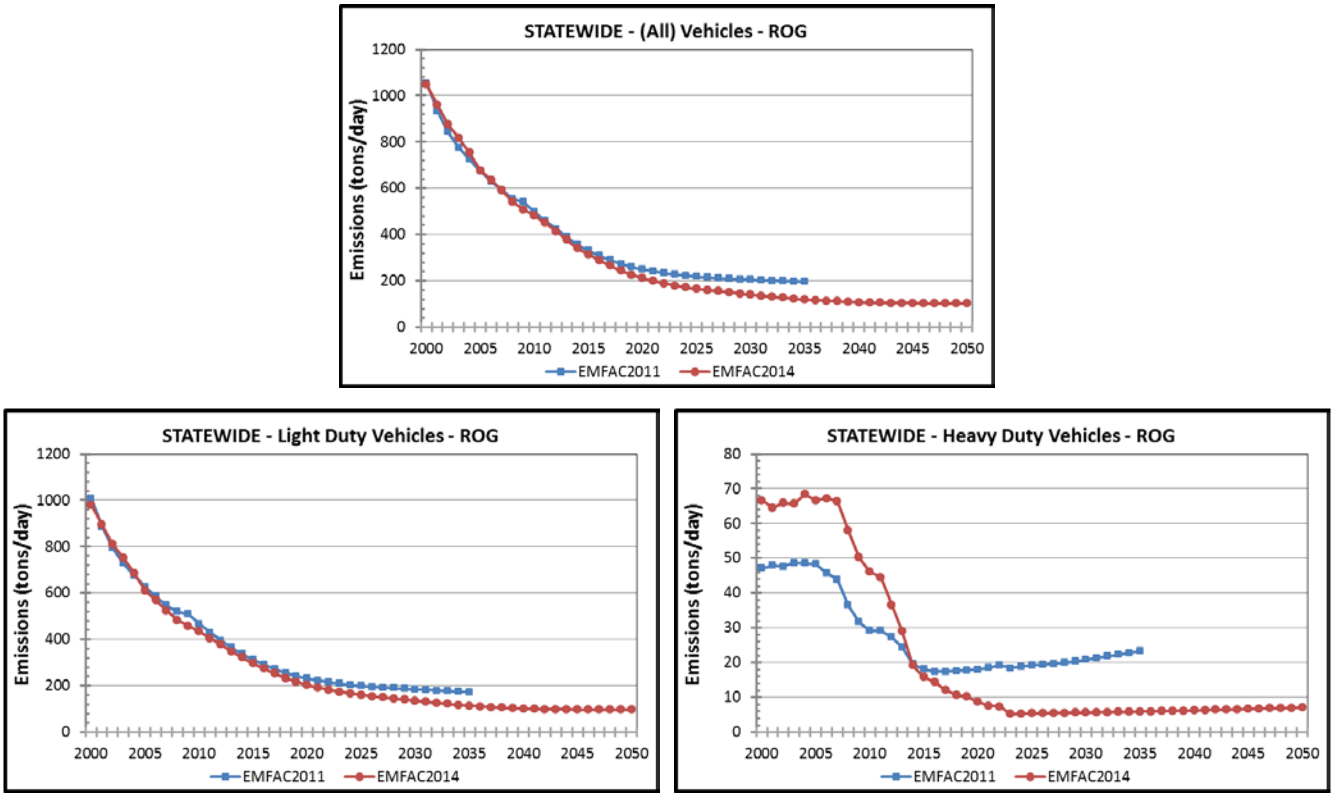
Figure 3.4-4 shows a comparison of EMFAC2011 and EMFAC2014 estimates of statewide ROG emissions. As shown in the charts, EMFAC2014 ROG results are similar to those of EMFAC2011 during 2000-2015, and are lower than those of EMFAC2011 during 2016-2035.

For LD vehicles, ROG emissions by EMFAC2014 and EMFAC2011 are similar from 2000-2020, despite the lower LD VMT, used by EMFAC2014 within this timeframe. This is primarily due to updates to the zero-evaporative technology penetration assumptions discussed in Section 2.4.A.1 of the LEV III ISOR Appendix T.[121] EMFAC2014 LDV ROG emissions become lower than EMFAC2011 from 2030 through 2035 as a result of the ACC and ZEV regulations. The impacts of the inclusion of these new LDV regulations were partially offset by an update to the hydrocarbon speciation methodology, which was based on new speciation test data (refer to Section 3.2). The speciation update is one of the primary reasons that the ROG differences between EMFAC2011 and EMFAC2014 (at 2035) are not as significant as those seen for NOx. In terms of HD ROG emissions, EMFAC2014 outputs higher ROG emissions from 2000 through 2015, as a result of the inclusion of crankcase emissions for pre-2010

[121] ARB. 2011a. LEV III Mobile Source Emissions Inventory. Appendix T to LEV III ISOR. California Air Resources Board, Sacramento, CA. http://www.arb.ca.gov/regact/2012/leviiighg2012/levappt.pdf

trucks. EMFAC2014 HD ROG emissions become lower from 2015 through 2035, as a result of revised HC emission rates for 2010+ MY trucks and improved crankcase emissions controls on these trucks.

Figure 3.4-4 Comparison of ROG Emissions between EMFAC2011 and EMFAC2014



3.4.3.3 PM2.5

Figure 3.4-5 shows the comparison of estimates of statewide total (exhaust and tire/brake wear) PM2.5 emissions between EMFAC2011 and EMFAC2014. EMFAC2014 has higher emissions in years 2000-2015. EMFAC2014 shows much lower PM2.5 emissions than EMFAC2011 in years 2020- 2035 and the reasons for this will be discussed below.

Regarding LD PM2.5 emission, EMFAC2014 has higher emissions in years 2000-2007 as a result of higher LD VMT. LD PM emission estimates, from EMFAC2014, become lower than those of EMFAC2011 for years 2008-2014 as a result of lower light-duty VMT in those years. In years 2020 through 2035, EMFAC2014 shows lower PM emissions than EMFAC2011, as a result of more stringent PM standards imposed by the ACC regulations. In terms of HD PM2.5 emission, EMFAC2014 shows higher emissions in years 2000-2015 as a result of higher estimated VMT in 2000-2010 (as discussed above in Section 3.4.1.2), the inclusion of crankcase emissions for pre-2007 trucks (as discussed in Section 3.2.3), the revision to diesel PM emission rates (as discussed in section 3.2.3) and from updates made to reflect the 2014 Truck and Bus rule amendments (as discussed in Section 3.3.4). During years 2016 through 2035, EMFAC2014 estimates much lower PM emissions than EMFAC2011 as a result of updates to diesel PM emission rates. As described in Section 3.2, according to new diesel truck test data, diesel PM filters are much more effective than previously projected.

Figure 3.4-5 Comparison of PM2.5 between EMFAC2011 and EMFAC2014

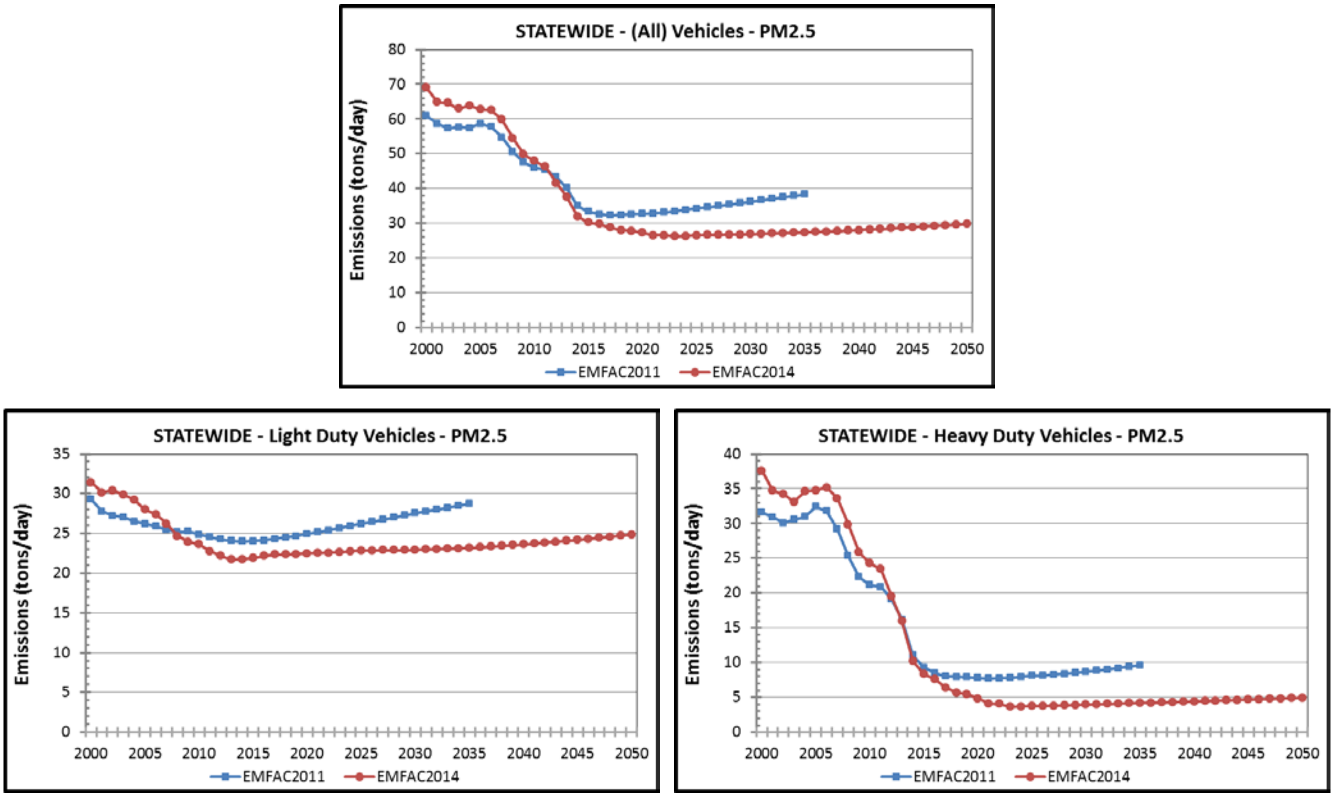
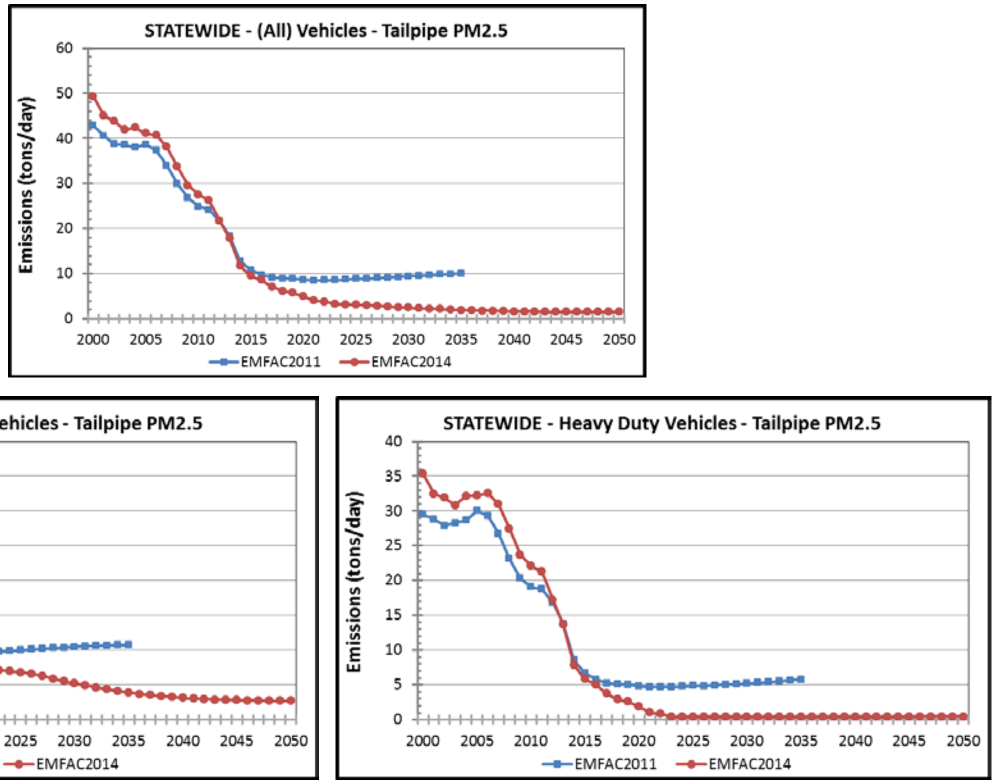


Figure 3.4-6 shows the comparison of estimates of statewide total tailpipe (exhaust only) PM2.5 emissions between EMFAC2011 and EMFAC2014. Similar to Figure 3.4-5, EMFAC2014 has higher emissions in years 2000-2015. EMFAC2014 shows much lower PM2.5 emissions than EMFAC2011 in years 2020-2035 for the reasons discussed above.

The tailpipe PM2.5 emission differences between EMFAC2011 and EMFAC2014 can be explained with the same reasons provided for total PM2.5 emission differences. On the light-duty side, EMFAC2014 has higher emissions in years 2000-2006 and lower emissions than those of EMFAC2011 for years 2007-2014 as a result of VMT differences. In years 2020 through 2035, EMFAC2014 shows lower tailpipe PM emissions than EMFAC2011 as a result of more stringent PM standards imposed by the ACC regulations (one and three mg/mi standards). In terms of HD tailpipe PM2.5 emission, EMFAC2014 shows higher emissions in years 2000-2012 as a result of differences in VMT and updates made to Truck and Bus Rule compliance assumptions, and updates to diesel emission rates (more detail are provided earlier in this section). During years 2017 through 2035, EMFAC2014 estimates much lower PM emissions than EMFAC2011 as a result of updates to diesel PM emission rates.

Figure 3.4-6 Comparison of Tailpipe PM2.5 between EMFAC2011 and EMFAC2014

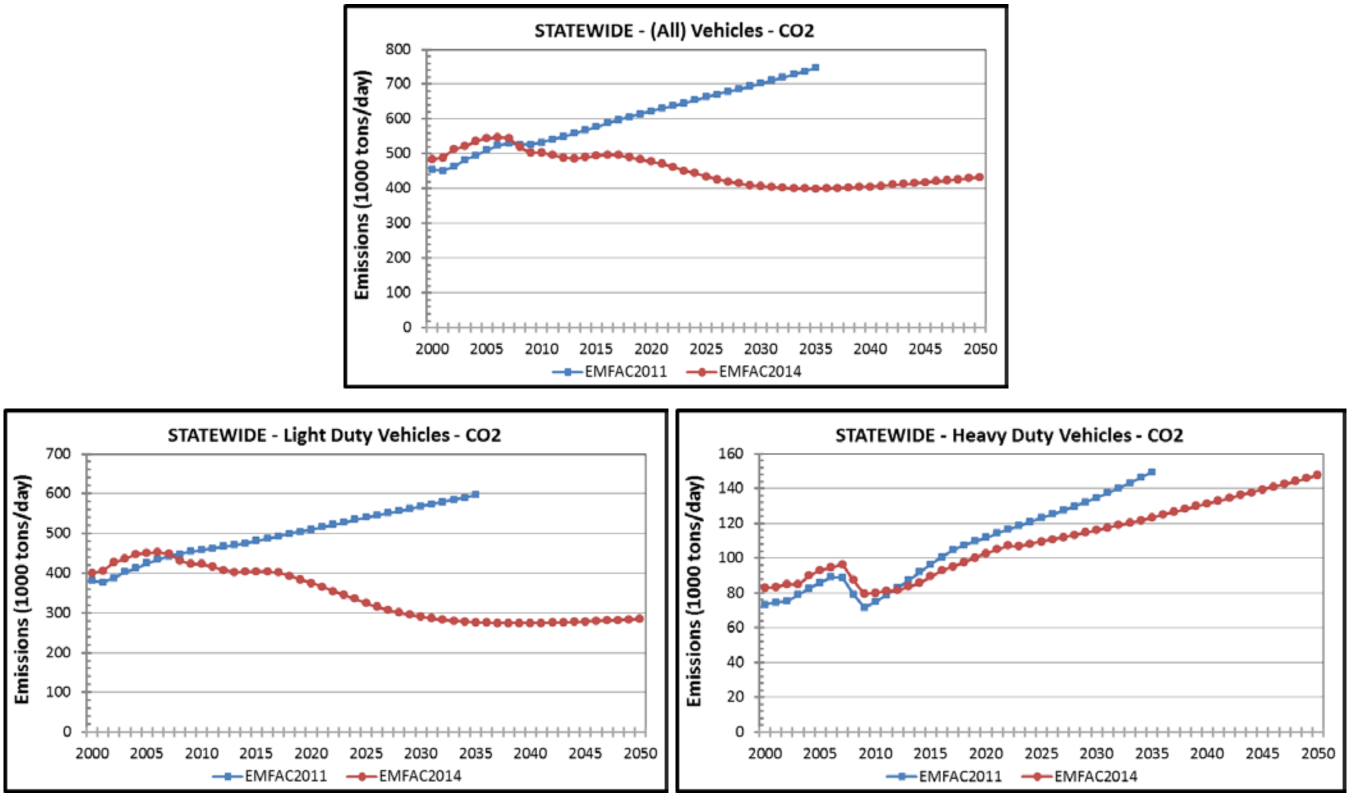


3.4.3.4 CO_2

Figure 3.4-7 shows the statewide CO_2 emissions comparison between EMFAC2011 and EMFAC2014. EMFAC2014 produces slightly higher estimates for CO_2 during 2000-2007 as a result of higher VMT; however, with the reflection of the recession on VMT, and the incorporation of new GHG regulations, the CO_2 emissions from EMFAC2014 decrease from 2008 to 2035. In contrast, EMFAC2011 CO_2 emissions continued to grow.

In terms of the LD CO_2 emissions, the incorporation of the Federal Pavley and ACC standards, as well as ZEV requirements (described in Section 3.2.2), leads EMFAC2014 to predict much lower tailpipe CO_2 emissions by 2035. In terms of the HD CO_2 emissions, the incorporation of the ARB's Tractor-Trailer GHG regulation as well as the U.S. EPA's Phase 1 GHG regulations (described in Section 3.2.3) drives EMFAC2014 to predict much lower tailpipe CO_2 emissions by 2035.

Figure 3.4-7 Comparison of CO_2 Emissions between EMFAC2011 and EMFAC2014



4 CUSTOM ACTIVITY MODE

This chapter covers the custom activity processing system in EMFAC2014. In basic terms, custom inputs for vehicle miles traveled (VMT) and speeds can be provided by the user for use in EMFAC. These custom input data are ingested into the model using a prescribed Microsoft Excel input file structure that is referred to in this chapter as a "custom activity template." EMFAC utilizes the input data from the templates to calculate custom-to-default activity ratios (i.e. scalars) that are then used to scale default emissions to reflect the emission inventory impact of the user-provided custom activity.

4.1 BACKGROUND

The capability for using custom activity inputs in EMFAC is linked to the requirement that SIP inventory development and Conformity assessments be conducted using local transportation activity data (more details are provided below). USEPA specifically approves EMFAC for these purposes.

State and federal laws require regional planning agencies to prepare both a transportation plan (Regional Transportation Plan or RTP), to benefit public mobility, and an air quality plan (State Implementation Plan or SIP), to protect public health. Under the Federal Clean Air Act, transportation activities that receive federal funding or approval must be found to be fully consistent with the SIP. The requirement that these federally funded transportation plans and projects help communities attain federal air quality standards is known as conformity.

Conformity applies to federal transportation decisions in all areas that are designated "nonattainment" for specific pollutants (ozone, carbon monoxide, particulate matter) by the United States Environmental Protection Agency. These are areas that have recorded violations of the National Ambient Air Quality Standards. "Attainment" areas that have adopted air quality maintenance plans are also subject to conformity. Areas that have exceeded the more stringent California air quality standards, but are within national standards, are not subject to conformity (however, the California Environmental Quality Act applies to all projects in the state).

Adoption by a metropolitan planning organization (MPO) of a 20-year RTP, or a short-term federal transportation improvement program (TIP), must include a conformity analysis prepared by the MPO. In addition, sponsors of transportation projects that require a federal approval are responsible for assessing project conformity. Final determinations of conformity for RTPs, TIPs, and projects are made by the Federal Highway Administration and the Federal Transit Administration.

Conformity assessments are part of a broader regional transportation planning process carried out by transportation agencies. Because joint transportation and air quality planning assists both conformity assessments and air pollution reduction efforts, local air districts and transportation planning agencies regularly consult with each other and with involved state and federal agencies. Local transportation and air quality planning processes are also open to interested organizations and members of the public.

For RTP and TIP demonstrations, conformity first involves an emissions estimate. The air quality plan (SIP) forecasts levels of pollutant emissions that will enable steady progress toward attainment of air quality standards by Clean Air Act deadlines, backed up by control strategies that will enable these levels to be reached. Such forecasts are stratified by emissions source. The on-road mobile source portion of the forecast is known as a motor vehicle emissions budget. To be found in conformity with the SIP, a region's transportation plan and program must be found to result in emissions that are within each emission's budget.

In addition to conformity assessments, California's SB 375 requires each MPO to include a "Sustainable Communities Strategy" in their RTP that demonstrates how the region will meet California's greenhouse gas emission targets. If the Sustainable Communities Strategy falls short of meeting the targets, the region must prepare an "Alternative Planning Strategy" that, if implemented, would meet the targets.

Based upon the background provided above, EMFAC2014 can be used to produce emissions inventories for two specific types of assessments: conformity assessments and SB375 assessments.

Conformity assessments. For SIP conformity assessments, emissions are estimated with all current controls active, except Low Carbon Fuel Standards (LCFS). The reason for excluding LCFS is that most of the emissions benefits due to the LCFS come from the production cycle (upstream emissions) of the fuel rather than the combustion cycle (tailpipe). As a result, LCFS is assumed to not have a significant impact on CO_2 emissions from EMFAC's tailpipe emission estimates.

SB375 assessments. For SB375, the Advanced Clean Cars (ACC)/Pavley and LCFS rules are deactivated.

IMPORTANT! – Because the ACC regulation has certain assumptions about vehicle usage built into it, default data in custom activity templates produced for conformity assessments will not match the default data in templates for SB375 assessments.

IMPORTANT! – EMFAC2014 does not produce official GHG emissions.

4.2 METHODOLOGY

As mentioned above, EMFAC2014 uses custom activity data (VMT data only or VMT and speed profile data together) to calculate custom-to-default activity ratios (i.e. scalars) that are then used to scale default data (emissions, population, and VMT as well as light-duty (LD) vehicle trips). This section describes the methodology used for this process in four parts:

1. *A brief summary of the Custom Activity default emissions calculation is provided first;*
2. *A description of the necessary custom activity input data formats and variables that must be provided by the user;*
3. *An explanation of how the custom activity input data are used in the calculation of scalar ratios by EMFAC; and,*
4. *Discussion as to how EMFAC scales default emissions, population, and VMT.*

Part 1 - Default Emissions Calculation. EMFAC2014 uses the following equations to calculate the default running emissions and other (non-running) emissions by vehicle class (VC) and fuel:

$$\mathbf{Run\ Emiss}_{\mathbf{VC,Fuel,Speed}} = \mathbf{VMT}_{\mathbf{VC,Fuel}} \times \mathbf{Speed\ Frac}_{\mathbf{Speed\ \ VC,Fuel}} \times \mathbf{Run\ Emiss\ Fact}_{\mathbf{Speed,VC,Fuel}} \quad \textbf{(4.2-A)}$$

$$\mathbf{Strt\ Emiss}_{\mathbf{VC,Fuel}} = \mathbf{Trips}_{\mathbf{VC,Fuel}} \times \mathbf{Strt\ Emiss\ Fact}_{\mathbf{VC,Fuel}} \quad \textbf{(4.2-B)}$$

$$\mathbf{Idle\ Emiss}_{\mathbf{VC,Fuel}} = \mathbf{Idle\ hours}_{\mathbf{VC,Fuel}} \times \mathbf{Idle\ Emiss\ Fact}_{\mathbf{VC,Fuel}} \quad \textbf{(4.2-C)}$$

$$\mathbf{Htsk/RunL\ Emiss}_{\mathbf{VC,Fuel}} = \mathbf{Trips}_{\mathbf{VC,Fuel}} \times \mathbf{Htsk/RunL\ Emiss\ Fact}_{\mathbf{VC,Fuel}} \quad \textbf{(4.2-D)}$$

$$\mathbf{Diurn/RestL\ Emiss}_{\mathbf{VC,Fuel}} = \mathbf{Vehicle\ Population}_{\mathbf{VC,Fuel}} \times \mathbf{Diurn/RestL\ Emiss\ Fact}_{\mathbf{VC,Fuel}} \quad \textbf{(4.2-E)}$$

$$\mathbf{BW/TW\ Emiss}_{\mathbf{VC,Fuel}} = \mathbf{VMT}_{\mathbf{VC,Fuel}} \times \mathbf{BW/TW\ Emiss\ Fact}_{\mathbf{VC,Fuel}} \quad \textbf{(4.2-F)}$$

where:

$$\mathbf{Speed\ Frac}_{\mathbf{Speed,VC,Fuel}} = \frac{\mathbf{VMT}_{\mathbf{Speed,VC,Fuel}}}{\mathbf{Total\ VMT}_{\mathbf{VC,Fuel}}} \quad \textbf{(4.2-G)}$$

Note that in the above equations the following abbreviations are used: running (Run), start (Strt), hot soak (Htsk), running loss (RunL), diurnal (Diurn), resting loss (RestL), brake-wear (BW), tire-wear (TW), emission (emiss), factor (Fact), fraction (Frac), vehicle class (VC). Also, to be clear, there is no division in any of the equations above (i.e. "/"); rather, the "/" indicates "or". For example, equation 4.2-D can be used for hot soak (Htsk) or running loss (RunL) emissions.

It's important to note that, in order to facilitate scaling default emissions, using MPO or other custom activity data, there are slight default emissions processing differences between EMFAC's Custom Activity and Default Emissions modes. First, for LD vehicle default outputs under Custom Activity Mode, electric vehicles are combined with gasoline vehicles; while, in Default Emissions Mode, electric vehicle activity and emissions are reported separately. Second, in Custom Activity Mode, any vehicle population and hence VMT activity data, that would otherwise be zero, are set to a very small non-zero number to facilitate avoiding a divide by zero calculation error during scalar calculations. A zero VMT value might occur when there are no vehicles of that type in the GAI and calendar year of interest under default conditions. Similarly, any zero fraction of VMT in speed profiles is replaced with a very small non-zero number to avoid a zero VMT by speed. Because of this, the second processing difference is necessary for calculating a Custom Activity scaling factor for scenarios where a user is interested in introducing activity for vehicle types that may not yet exist in a region or their speed profiles have zero fractions of VMT in different speed bins. Otherwise, if left as a missing or zero value, the scalar could not be calculated. This is described more in Part 3 and evident in Equations 4.2-H to L)

Part 2 - Custom Activity Input Data (File Formats & Data Fields). EMFAC2014 accepts custom VMT activity input data based on Microsoft Excel files (referred to as "templates") in one of two forms, either: 1) daily total VMT; or 2) daily total VMT by vehicle class and fuel. Speed fraction profiles are optional.

Template files must be created specific to each geographic (GAI) region, since GAI-specific scalars corresponding to the default data for each GAI region are calculated in Step 3 (Note that a geographic area of index, GAI, corresponds to the intersection of three sets of political boundaries -- county, air basin, and air district – and is also used in other parts of ARB's emissions inventory, often synonymously referred to as CO-AB-DIS).

In Custom Activity mode, EMFAC generates GAI-specific templates for users to populate with custom activity data (the 'raw' templates contain default data from Part 1, which the user can edit with custom inputs). Below, the custom activity file format types and data structures of the required Excel templates are described first, followed by a description of the mechanism to generate region-specific Excel templates in EMFAC. EMFAC2014 produces an Excel 2007 format template (suffix is "*.xlsx") containing the default VMT and the optional hourly speed fraction profile data. The EMFAC2014 custom activity data format is similar to that of EMFAC2011-SG, except the scenario number and title columns are removed.

Template File Format Types and Data Structure. Microsoft Excel calls an entire spreadsheet file a "workbook"; and an individual tab within the workbook is known as a "worksheet." Custom activity input data can only be entered via one of two very specifically formatted Excel workbook "template" formats created by EMFAC (the template creation process is described in the next sub-section). The two options are either: 1) the EMFAC2011-SG template format; or 2) the EMFAC2014 template format (NOTE: The EMFAC2011-SG format must be in the Excel 2003 format where the file name suffix is "*.xls"; so, if an existing EMFAC2011-SG file has been edited and saved in another version of Excel, e.g. where the suffix is *.xlsx, it must be re-saved in the Excel 2003 format in order for EMFAC2014 to read it).

Table 4.2-1, below, shows a list of the possible Excel worksheet names for each of the two acceptable Excel workbook template formats as well as the types of data (data fields) contained in each of them. Again, note that this is a list of all tabs that are possible in each worksheet (see table footnote). Worksheet names should not be modified, since the specific names are used to identify what type of data is present. Worksheets with any other names will be ignored by EMFAC2014. EMFAC2014 can import multiple sets of activity data at one time; however, they must be the same template format, i.e. either EMFAC2011-SG or EMFAC2014.

Table 4.2-1 Activity Template Worksheets (EMFAC2011-SG and EMFAC2014 formats)

Template File Format Type	Worksheet Name	Worksheet Data Fields
EMFAC2011-SG (*.xls)	regional_scenarios	Contains run parameters: area type, area, calendar year, and season
	scenario_base_inputs	Whether default or user input will be used and total daily VMT
	scenario_vmt_by_vehcat*	VMT by vehicle type and fuel
	scenario_speed_profiles*	Daily speed profile
EMFAC2014 (*.xlsx)	settings	Season/month and whether it is a SB375 template
	daily_total_vmt**	Daily total VMT
	daily_vmt_by_veh_tech**	Daily VMT by vehicle type and fuel
	hourly_fraction_veh_tech_speed*	Hourly speed profile calculated using default VMT by hour by speed

*Optional – may or may not be created based on user input; **One, not both, will exist (See Table .4.2-3b)

More detail on the specific data fields within each worksheet is provided in the discussion below. With regard to using EMFAC2011-SG template formats in EMFAC2014 and for clarify, please note that "default" in the "Scenario_Base_Inputs" tab means that the model will use EMFAC2014 default data, not EMFAC2011 default data (i.e. EMFAC2014 default data is used in all cases for scaling with EMFAC2014 for both template file formats).

Using Existing EMFAC2011-SG Custom Activity Input Data Templates in EMFAC2014.

As illustrated in the top half of Table 4.2-1, the "scenario_base_inputs" worksheet that is contained within the EMFAC2011-SG input format workbook describes which type of data are contained in the template workbook (i.e. "default "or custom "user" inputs). Below, Table 4.2-2a shows the specific data fields in this worksheet. The data in the field labeled "VMT Profile," "VMT By Vehicle Category," and "Speed Profile" determine whether the data in the other worksheets (i.e. Scenario_Base_Inputs, Scenario_VMT_by_VehCat, and Scenario_Speed_Profiles) contain "default" data or "user" data (i.e. where "user" = custom data). More specifically, Table 4.2-2b summarizes the possible combinations of "default" or "user" options in the "scenario_base_inputs" worksheet fields and, given the combination of options selected by the user in this worksheet, whether and how EMFAC will perform scaling based on VMT or both VMT and speed (depending on last two columns in Table 4.2-2b).

Table 4.2-2a EMFAC2011-SG Template: Worksheets and Data Field Descriptions

EMFAC2011-SG Template Format (*.xls Excel Workbook)		
Worksheet	**Data Field Name**	**Description**
Regional Scenario	Group	EMFAC2011-SG Processing Group ID
	Area Type	Type of Area: Air Basin, Air District, County, or Sub-Area
	Area	Area Name
	CalYr	Calendar Year
	Season	Season or Month: Summer, Winter, Annual, or a Month Name
Scenario Base Inputs	Group	EMFAC2011-SG Processing Group ID
	Area	Area Name
	Scenario	Scenario Number
	Sub-Area	Sub-Area Name
	CalYr	Calendar Year
	Season	Season or Month: Summer, Winter, Annual, or a Month Name
	Title	Title of Report that is Generated
	VMT Profile	"Default" or "User"
	VMT by Vehicle Category	"Default" or "User"
	Speed Profile	"Default" or "User"
	New Total VMT	New Total VMT for given Sub-Area within given Area
Scenario_VMT_by_VehCat	Group	EMFAC2011-SG Processing Group ID
	Area	Area Name
	Scenario	Scenario Number
	Sub-Area	Sub-Area Name
	CalYr	Calendar Year
	Season	Season or Month: Summer, Winter, Annual, or a Month name
	Title	Title of Report that is Generated
	Veh & Tech	Vehicle Class and Fuel Type
	New VMT	New Total VMT for given Vehicle Class, Fuel, Sub-Area and Area.
Scenario_Speed_Profiles	Group	EMFAC2011-SG Processing Group ID
	Area	Area Name
	Scenario	Scenario Number
	Sub-Area	Sub-Area Name
	CalYr	Calendar Year
	Season	Season or Month: Summer, Winter, Annual, or a Month Name
	Title	Title of Report that is Generated
	Veh & Tech	Vehicle Class and Fuel Type
	EMFAC2007 Veh & Tech	EMFAC2007 Vehicle Class and Fuel
	5MPH, 10MPH, etc.	Percent of VMT Travelling at Given Speed

Referring to Table 4.2-2b, for scaling to take place, one or more of the two columns, “VMT Profile” or “VMT by Vehicle Category”, should contain the “user” designation; otherwise, EMFAC2014 will treat it as a default activity run and neither VMT nor speeds will be scaled. If the combination of options corresponds to a “No Scaling” determination in the VMT column, then EMFAC2014 will post a message to this effect. This means that the user is, essentially, selecting a combination of options that can be generated using a default EMFAC run. Note also that, if both the “VMT Profile” and the “VMT by Vehicle Category” are marked as “user”, priority is given to the “VMT by Vehicle Category” scalars contained in the scenario_vmt_by_vehcat worksheet. (IMPORTANT: Again, with regard to the terminology in this section, “user” means user-provided custom activity, where the user has changed the data values in a template originally containing “default” data. The difference between the “user” data and default data will be the basis for scalars calculated with equations 4.2-H through L in Part 3 below. Use of default data only would result in scalars of unity, 1.0).

Table 4.2-2b EMFAC2011-SG Template: VMT or Speed Scaling Dependencies (Based on user inputs contained in Scenario_Base_Inputs Worksheet)

User-Selected Data Field Options			*Scaling Based on*	
VMT Profile	VMT by Vehicle Category	Speed Profile	VMT	Speed Profile
Default	Default	Default	No Scaling*	No
User	Default	Default	Scaling by VMT Total	No
Default	User	Default	Scaling by VMT-Veh Tech	No
User	User	Default	Priority Scaling by VMT-VehTech	No
Default	Default	User	No Scaling*	No
User	Default	User	Scaling by VMT Total	Yes
Default	User	User	Scaling by VMT-Veh Tech	Yes
User	User	User	Priority Scaling by VMT-VehTech	Yes

*This means that the user is, essentially, selecting a combination of options that can be generated using a default EMFAC run

Using EMFAC2014 Custom Activity Input Data Templates.

This section mirrors the discussion above, but is focused on using EMFAC2014 templates, which are different than EMFAC2011-SG templates.

Default templates created with EMFAC2014 are precisely formatted spreadsheets that are populated with the default activity data and user options selected. Once a default template is created, the user can edit the default activity data in the template to meet their needs as long as the worksheet names are not changed and as long as the column order and column position are not changed. Additional columns, comments, or worksheets with names other than the ones used to by EMFAC will be ignored. Note again that the default Custom Activity Templates generated by EMFAC contains activity data that are slightly different from that used in the Default Emissions mode of EMFAC2014. As mentioned previously in the Part 1 discussion, gasoline LD vehicles are represented in the Custom Activity Mode as a combination of electric vehicles and gasoline vehicles and any VMT activity data that would otherwise be zero are set to a very small, non-zero number to avoid a divide by zero calculation error when calculation scalar ratios (see the denominator in equations 4.2-H through L in Part 3, below).

As illustrated in the lower half of Table 4.2-1, above, the "Settings" worksheet contained in the EMFAC2014 template workbook is used for two purposes: to specify the season/month value for the desired emissions run, and to indicate whether or not the template is for a SB375 assessment run. Again, this is very important because SB375 requires the ACC/Pavley to be turned off in the calculations made for the emissions inventory that will be generated. As mentioned earlier, the ACC program assumes a different fleet mix and VMT, so the data in templates produced for SB375 runs will not match data in templates produced for non-SB375 purposes.

Below, Table 4.2-3a shows all of the worksheets contain in the EMFAC2014 workbook template as well as the data fields contained in each worksheet.

Table 4.2-3a EMFAC2014 Template: Worksheets and Data Field Descriptions

EMFAC2014 Template Format (*.xlsx Excel Workbook)		
Worksheet	Data Field Name	Description
Settings	Date	Date Template Generated.
	Season/Month	Season or Month: Summer, Winter, Annual, or a Month Name. Can be changed by user.
	SB375 Run	"On" or "Off": Cannot be changed by user.
Daily_Total_VMT	Area	Area Name: Header indicates area type: "Sub-Area", "Air Basin", "Air District", "County", or "MPO"
	GAI	GAI Number, for reference only. Numerical ID of the Sub-Area.
	Sub-Area	Sub-Area Name
	Cal_Year	Calendar Year
	New Total VMT	New Total VMT for given Sub-Area within given Area.
Daily_VMT_by_Veh_Tech	Area	Area Name: Header indicates area type: "Sub-Area", "Air Basin", "Air District", "County", or "MPO"
	GAI	GAI Number, for reference only. Numerical ID of the Sub-Area.
	Sub-Area	Sub-Area Name
	Cal_Year	Calendar Year
	Veh_Tech	Vehicle Class and Fuel Type.
	New Total VMT	New Total VMT for given Vehicle Class, Fuel, Sub-Area and Area.
Hourly_Fraction_Veh_Tech_Speed	Area	Area Name: Header indicates area type: "Sub-Area", "Air Basin", "Air District", "County", or "MPO"
	GAI	GAI Number, for reference only. Numerical ID of the Sub-Area.
	Sub-Area	Sub-Area Name
	Cal_Year	Calendar Year
	Veh_Tech	Vehicle Class and Fuel Type.
	Hour	Hour of the Day
	5mph, 10mph, etc.	Percent of VMT travelling at given speed

To utilize an EMFAC2014 template format for custom activity scaling in EMFAC2014, a user must first create a default template, then edit the default data and re-load the edited EMFAC2014 template (terminology-wise, the edited default template is considered a 'custom activity' template since it now contains custom, user-specific data that replaces the default data). In the 'create' step, EMFAC2014 generates custom activity templates that contain default VMTand/or hourly speed profiles. Under this step, the user can choose whether to use Daily Total VMT by Sub-Area or Daily VMT by Sub-Area, Vehicle Class and Fuel. The user can also optionally include hourly speed fractions by sub-area, vehicle class, fuel, and hour. To generate a custom activity template, the user must select the "Emissions" run mode and the "Custom Activity" run type on the "Start a New Run" window, and then select the area, time, and activity type in the screens that follow. This entire process is a step by step process shepherded by the EMFAC2014 GUI. After all of the necessary information is provided, the user interface provides a "Generate Template" button for the user to proceed with generating a default data template (this is illustrated in detail in the User Guide).

Unlike with EMFAC2011-SG templates, EMFAC2014 formatted templates do not have the worksheet, Scenario_Base_Inputs Worksheet VMT. Scaling options using EMFAC2014 templates are limited to the specific tabs that are created in the EMFAC2014 template format. That is, the available tabs will vary depending on the options selected prior to directing EMFAC to "Generate Template" (see footnote at the bottom of Table 4.2-1). Table 4.2-3b below summarizes the effect of user-selected GUI options in EMFAC2014 on which worksheets are generated (see ** in Table 4.2-1) and how custom activity scaling is performed. Once the template is created, the manner by which scaling is conducted is fixed (i.e. the template cannot be changed later to employ an alternative scaling approach).

Table 4.2-3b EMFAC2014 Templates: Effect of Selected GUI Options on Worksheets and Scaling

User-Select GUI Options		***Scaling Approach (Cannot be Modified)***	
VMT Data Type	Custom Hourly Speed Fractions	VMT Scaling Result	Speed Scaling?
Total Daily VMT	Unchecked	Scaling by VMT Total	No
VMT by Vehicle and Fuel Type	Unchecked	Scaling by VMT-Veh Tech	No
Total Daily VMT	Checked	Scaling by VMT Total	Yes
VMT by Vehicle and Fuel Type	Checked	Scaling by VMT-Veh Tech	Yes

<u>Part 3 - Calculation of Scalar Ratios in EMFAC</u>. This section describes the process to read in the custom activity data, discussed in Steps 1 and 2 above, and how EMFAC uses these data to calculate custom-to-default scalar ratios that are used in Step 4.

More than one custom activity template can be read in at time. However, EMFAC2014 can only process data for multiple custom activity templates that have the same geographic region 'extent' and season/month. For example, templates for the SCAG MPO and the Lake Tahoe Air Basin cannot be processed simultaneously, since they represent two different types or 'extents' of geographic regions, i.e. the first is an MPO and the second is an Air Basin. Likewise, it is not possible to run templates with different seasons, such as summer and winter.

Custom activity template data are read into EMFAC in the following manner:

- *EMFAC2014 imports and checks (see detail below) the data provided by the user.*
- *If daily total VMTs by Sub-Area and Speed Fractions are provided, then EMFAC2014 internally splits this data by vehicle class and fuel by calculating the default proportions from the default activity data set. If speed fractions are not provided, daily total VMTs are divided by the default daily total VMT by Sub-Area to produce scalars. Daily total VMTs by vehicle class and fuel are then converted to (i.e. calculated internally) hourly VMTs by multiplying daily VMTs, by vehicle class and fuel, by hourly proportions calculated from the default hourly VMT data.*
- *If hourly speed profiles are provided by the user, then these hourly speed profiles are combined with the hourly VMT to get VMT by speed.*

The following checks are performed when data is imported:

- *For any sub-area and calendar year in the data, there must be either daily total VMT or daily VMT by vehicle class and fuel.*
- *The values in the "Sub-Area" columns match values contained in the sub-area column of Table 4.2-4; the values in the leftmost area column must match a value in the county, air basin name, air district name, or MPO column in Table 4.2-4.*
- *The calendar years are greater than or equal to 2000 and less than or equal to 2050.*
- *The vehicle class and fuel are spelled correctly; all 51 vehicle classes and fuels are shown in Table 4.2.5. In previous versions of EMFAC, this type of vehicle group was known as "Veh-Tech". The vehicle class and fuel are converted to a 5 digit Vehicle Class Code(VCC) for use in processing the data.*

- *A complete set of vehicle classes and fuel are present. For most sub-areas, there should be at least 50 types of vehicles; however, a few sub-areas have only 48 or 49 types of vehicle classes and fuels.*

NOTE: in Custom Activity Mode, any vehicle population and hence VMT activity data, that would otherwise be zero, are set to a very small non-zero number (1.0E-10) to facilitate avoiding a divide by zero calculation error during scalar calculations. Similarly in speed profiles, any zero fraction of VMT in any speed bin is replaced with a very small non-zero number (1.0E-10).

Table 4.2-4 Area Names Used in EMFAC2014

Sub-Area	County Name	Air Basin Name	Air District Name	MPO
Alameda (SF)	ALAMEDA	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Alpine (GBV)	ALPINE	GREAT BASIN VALLEYS	GREAT BASIN UNIFIED APCD	
Amador (MC)	AMADOR	MOUNTAIN COUNTIES	AMADOR COUNTY APCD	
Butte (SV)	BUTTE	SACRAMENTO VALLEY	BUTTE COUNTY AQMD	BCAG
Calaveras (MC)	CALAVERAS	MOUNTAIN COUNTIES	CALAVERAS COUNTY APCD	
Colusa (SV)	COLUSA	SACRAMENTO VALLEY	COLUSA COUNTY APCD	
Contra Costa (SF)	CONTRA COSTA	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Del Norte (NC)	DEL NORTE	NORTH COAST	NORTH COAST UNIFIED AQMD	
El Dorado (LT)	EL DORADO	LAKE TAHOE	EL DORADO COUNTY APCD	TMPO
El Dorado (MC)	EL DORADO	MOUNTAIN COUNTIES	EL DORADO COUNTY APCD	SACOG
Fresno (SJV)	FRESNO	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	COFCG
Glenn (SV)	GLENN	SACRAMENTO VALLEY	GLENN COUNTY APCD	
Humboldt (NC)	HUMBOLDT	NORTH COAST	NORTH COAST UNIFIED AQMD	
Imperial (SS)	IMPERIAL	SALTON SEA	IMPERIAL COUNTY APCD	SCAG
Inyo (GBV)	INYO	GREAT BASIN VALLEYS	GREAT BASIN UNIFIED APCD	
Kern (MD)	KERN	MOJAVE DESERT	KERN COUNTY APCD	KCOG
Kern (SJV)	KERN	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	KCOG
Kings (SJV)	KINGS	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	KCAG
Lake (LC)	LAKE	LAKE COUNTY	LAKE COUNTY AQMD	
Lassen (NEP)	LASSEN	NORTHEAST PLATEAU	LASSEN COUNTY APCD	
Los Angeles (MD)	LOS ANGELES	MOJAVE DESERT	ANTELOPE VALLEY AQMD	SCAG
Los Angeles (SC)	LOS ANGELES	SOUTH COAST	SOUTH COAST AQMD	SCAG
Madera (SJV)	MADERA	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	MCTC
Marin (SF)	MARIN	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Mariposa (MC)	MARIPOSA	MOUNTAIN COUNTIES	MARIPOSA COUNTY APCD	
Mendocino (NC)	MENDOCINO	NORTH COAST	MENDOCINO COUNTY AQMD	
Merced (SJV)	MERCED	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	MCAG
Modoc (NEP)	MODOC	NORTHEAST PLATEAU	MODOC COUNTY APCD	
Mono (GBV)	MONO	GREAT BASIN VALLEYS	GREAT BASIN UNIFIED APCD	
Monterey (NCC)	MONTEREY	NORTH CENTRAL COAST	MONTEREY BAY UNIFIED APCD	AMBAG
Napa (SF)	NAPA	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Nevada (MC)	NEVADA	MOUNTAIN COUNTIES	NORTHERN SIERRA AQMD	
Orange (SC)	ORANGE	SOUTH COAST	SOUTH COAST AQMD	SCAG
Placer (LT)	PLACER	LAKE TAHOE	PLACER COUNTY APCD	TMPO
Placer (MC)	PLACER	MOUNTAIN COUNTIES	PLACER COUNTY APCD	SACOG
Placer (SV)	PLACER	SACRAMENTO VALLEY	PLACER COUNTY APCD	SACOG
Plumas (MC)	PLUMAS	MOUNTAIN COUNTIES	NORTHERN SIERRA AQMD	
Riverside (MD/MDAQMD)	RIVERSIDE	MOJAVE DESERT	MOJAVE DESERT AQMD	SCAG
Riverside (MD/SCAQMD)	RIVERSIDE	MOJAVE DESERT	SOUTH COAST AQMD	SCAG
Riverside (SC)	RIVERSIDE	SOUTH COAST	SOUTH COAST AQMD	SCAG
Riverside (SS)	RIVERSIDE	SALTON SEA	SOUTH COAST AQMD	SCAG

Table 4.2-4 Area Names Used in EMFAC2014 (continued)

Sub-Area	County Name	Air Basin Name	Air District Name	MPO
Sacramento (SV)	SACRAMENTO	SACRAMENTO VALLEY	SACRAMENTO METROPOLITAN AQMD	SACOG
San Benito (NCC)	SAN BENITO	NORTH CENTRAL COAST	MONTEREY BAY UNIFIED APCD	AMBAG
San Bernardino (MD)	SAN BERNARDINO	MOJAVE DESERT	MOJAVE DESERT AQMD	SCAG
San Bernardino (SC)	SAN BERNARDINO	SOUTH COAST	SOUTH COAST AQMD	SCAG
San Diego (SD)	SAN DIEGO	SAN DIEGO	SAN DIEGO COUNTY APCD	SANDAG
San Francisco (SF)	SAN FRANCISCO	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
San Joaquin (SJV)	SAN JOAQUIN	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	SJCOG
San Luis Obispo (SCC)	SAN LUIS OBISPO	SOUTH CENTRAL COAST	SAN LUIS OBISPO COUNTY APCD	SLOCOG
San Mateo (SF)	SAN MATEO	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Santa Barbara (SCC)	SANTA BARBARA	SOUTH CENTRAL COAST	SANTA BARBARA COUNTY APCD	SBCAG
Santa Clara (SF)	SANTA CLARA	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Santa Cruz (NCC)	SANTA CRUZ	NORTH CENTRAL COAST	MONTEREY BAY UNIFIED APCD	AMBAG
Shasta (SV)	SHASTA	SACRAMENTO VALLEY	SHASTA COUNTY AQMD	SCRTPA
Sierra (MC)	SIERRA	MOUNTAIN COUNTIES	NORTHERN SIERRA AQMD	
Siskiyou (NEP)	SISKIYOU	NORTHEAST PLATEAU	SISKIYOU COUNTY APCD	
Solano (SF)	SOLANO	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Solano (SV)	SOLANO	SACRAMENTO VALLEY	YOLO/SOLANO AQMD	MTC
Sonoma (NC)	SONOMA	NORTH COAST	NORTHERN SONOMA COUNTY APCD	MTC
Sonoma (SF)	SONOMA	SAN FRANCISCO BAY AREA	BAY AREA AQMD	MTC
Stanislaus (SJV)	STANISLAUS	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	StanCOG
Sutter (SV)	SUTTER	SACRAMENTO VALLEY	FEATHER RIVER AQMD	SACOG
Tehama (SV)	TEHAMA	SACRAMENTO VALLEY	TEHAMA COUNTY APCD	
Trinity (NC)	TRINITY	NORTH COAST	NORTH COAST UNIFIED AQMD	
Tulare (SJV)	TULARE	SAN JOAQUIN VALLEY	SAN JOAQUIN VALLEY UNIFIED APCD	TCAG
Tuolumne (MC)	TUOLUMNE	MOUNTAIN COUNTIES	TUOLUMNE COUNTY APCD	
Ventura (SCC)	VENTURA	SOUTH CENTRAL COAST	VENTURA COUNTY APCD	SCAG
Yolo (SV)	YOLO	SACRAMENTO VALLEY	YOLO/SOLANO AQMD	SACOG
Yuba (SV)	YUBA	SACRAMENTO VALLEY	FEATHER RIVER AQMD	SACOG

Table 4.2-5. Vehicle Class and Fuel Used in EMFAC2014

Vehicle CLass	Fuel	Vehicle Class and Fuel
LDA	Gas	LDA - Gas
LDA	Dsl	LDA - Dsl
LDA	Oth	LDA - Oth
LDT1	Gas	LDT1 - Gas
LDT1	Dsl	LDT1 - Dsl
LDT1	Oth	LDT1 - Oth
LDT2	Gas	LDT2 - Gas
LDT2	Dsl	LDT2 - Dsl
MDV	Gas	MDV - Gas
MDV	Dsl	MDV - Dsl
LHD1	Gas	LHD1 - Gas
LHD1	Dsl	LHD1 - Dsl
LHD2	Gas	LHD2 - Gas
LHD2	Dsl	LHD2 - Dsl
UBUS	Gas	UBUS - Gas
UBUS	Dsl	UBUS - Dsl
SBUS	Gas	SBUS - Gas
SBUS	Dsl	SBUS - Dsl
Motor Coach	Dsl	Motor Coach - Dsl
OBUS	Gas	OBUS - Gas
All Other Buses	Dsl	All Other Buses - Dsl
MCY	Gas	MCY - Gas
MH	Gas	MH - Gas
MH	Dsl	MH - Dsl
OBUS	Dsl	OBUS - Dsl
T6 Ag	Dsl	T6 Ag - Dsl
T6 Public	Dsl	T6 Public - Dsl
T6 CAIRP Small	Dsl	T6 CAIRP small - Dsl
T6 CAIRP Heavy	Dsl	T6 CAIRP heavy - Dsl
T6 Instate Construction Small	Dsl	T6 instate construction small - Dsl
T6 Instate Construction Heavy	Dsl	T6 instate construction heavy - Dsl
T6 Instate Small	Dsl	T6 instate small - Dsl
T6 Instate Heavy	Dsl	T6 instate heavy - Dsl
T6 OOS Small	Dsl	T6 OOS small - Dsl
T6 OOS Heavy	Dsl	T6 OOS heavy - Dsl
T6 Utility	Dsl	T6 utility - Dsl
T7 Ag	Dsl	T7 Ag - Dsl
T7 Public	Dsl	T7 Public - Dsl
PTO	Dsl	PTO - Dsl
T7 CAIRP	Dsl	T7 CAIRP - Dsl
T7 CAIRP Construction	Dsl	T7 CAIRP construction - Dsl
T7 Utility	Dsl	T7 utility - Dsl

Table 4.2-5 Vehicle Class and Fuel Used in EMFAC2014 (Continued)

Vehicle CLass	Fuel	Vehicle Class and Fuel
T7 NNOOS	Dsl	T7 NNOOS - Dsl
T7NOOS	Dsl	T7 NOOS - Dsl
T7 Other Port	Dsl	T7 other port - Dsl
T7 POAK	Dsl	T7 POAK - Dsl
T7 POLA	Dsl	T7 POLA - Dsl
T7 Single	Dsl	T7 Single - Dsl
T7 Single Construction	Dsl	T7 single construction - Dsl
T7 Tractor Construction	Dsl	T7 tractor construction - Dsl
T7 SWCV	Dsl	T7 SWCV - Dsl
T7 Tractor	Dsl	T7 tractor - Dsl
T6TS	Gas	T6TS - Gas
T7IS	Gas	T7IS - Gas

For Speed Profiles:

- *The total speed fractions for any given row add up to one. That is, the total speed fractions for a given vehicle class, in a given sub-area, in a given calendar year (and for an hour for the EMFAC2014 format) must add up to one.*
- *Any non-fraction entry such as a blank or a word will be ignored.*

Once data have been read in and passed the QA checks described above, they are stored in EMFAC MySQL tables in the EMFAC2014_user schema. Table 4.2-6 summarizes the destination MySQL tables for custom activity data.

Table 4.2-6 Destination Tables for Custom Activity Data Importation

Workbook Format Type	Worksheet Name	Destination MySQL Table	Primary Key
EMFAC2011-SG	scenario_base_inputs	sg_user_daily_vmt_total	Cal_Year-GAI-VCC
	scenario_vmt_by_vehcat	sg_user_daily_vmt_ef2011	Cal_Year-GAI-VCC
	scenario_speed_profiles	sg_user_daily_fraction_ef2011_speed	Cal_Year-GAI-VCC-Speed_Bin
	internal to EMFAC2014	sg_user_daily_vmt_ef2011_speed	Cal_Year-GAI-VCC-Speed_Bin
EMFAC2014	daily_total_vmt	sg_user_daily_vmt_total	Cal_Year-GAI-VCC
	daily_vmt_by_veh_tech	sg_user_daily_vmt_ef2014	Cal_Year-GAI-VCC
	internal to EMFAC2014	sg_user_hourly_vmt_ef2014	Cal_Year-GAI-VCC-Hour
	hourly_fraction_veh_tech_speed	sg_user_hourly_fraction_ef2014_speed	Cal_Year-GAI-VCC-Hour-Speed_Bin
	internal to EMFAC2014	sg_user_hourly_vmt_ef2014_speed	Cal_Year-GAI-VCC-Hour-Speed_Bin

Primary keys are a combination of fields in a MySQL table which define a unique data record in that table. In the far right column of Table 4.2-6, the primary keys for each of the MySQL destination tables is listed (where each of the destination tables has specific primary keys according to their type of user data). One benefit of using primary keys is that it helps to ensure that duplicate sets of custom activity data are not created in the MySQL database. For example, since EMFAC2014 allows users to import multiple sets of custom activity data of the same type designation (EMFAC2011-SG or EMFAC2014), the use of primary keys forces MySQL to import only the FIRST set of data with a given set of primary keys encountered.

Scalars are created by dividing the user-provided custom total VMT and/or speed-specific VMT by the appropriate default VMT. There are five combinations of scalars, each of which has a specific scalar table (listed below) that is created for each GAI and calendar year; these scalar tables and their primary keys are described below. Please note that the “ef2011” naming convention used in the MySQL scalar tables that are summarized in Table 4.2-7 and 4.2-8, below, relate to EMFAC2011 Vehicle Categories and Fuel, not to the EMFAC2011 input template format. These scalar tables are used in processing scalars when using either EMFAC2011-SG templates or the EMFAC2014 templates.

Table 4.2-7 Scalar Tables for Custom Activity

Scalar Tables	Primary Key
sg_scalar_daily_vmt_total	Cal_Year-GAI
sg_scalar_daily_vmt_ef2011	Cal_Year-GAI-VCC
sg_scalar_daily_vmt_ef2011_speed	Cal_Year-GAI-VCC-Speed
sg_scalar_hourly_vmt_ef2011	Cal_Year-GAI-VCC-Hour
sg_scalar_hourly_vmt_ef2011_speed	Cal_Year-GAI-VCC-Hour-Speed

*Note that the "ef2011" portion of the naming convention refers to EMFAC2011 Vehicle Categories and Fuel, not to the EMFAC2011 input template format

The fields contained in these tables are described below; not all fields are in all tables: eg. sg_scalar_daily_vmt_total does not contain the vcc, ef2011_veh_tech, hour and speed fields.

Table 4.2-8 Fields in Custom Activity Scalar Tables

Field Name	Description
Area Type	Type of Area
Area Name	Name of Area
GAI	Geographic Area of Interest Numerical ID
SubArea	Sub-Area (name of GAI)
Cal_Year	Calendar Year
VCC	Vehicle Classification Code
EF2011_Veh_Tech	Vehicle Class-Fuel Text Description of VCC
Hour	Hour of Day
Speed	Speed
Scalar	VMT Fraction

The scalars contained in all five scalar tables are generated internally within EMFAC2014 (see second bullet, page 145, regarding the calculation of hourly speed VMTs). Scalar variables in each of the five tables are calculated by dividing the custom activity VMT by the appropriate default activity VMT as follows:

$$\textbf{sg\_scalar\_daily\_vmt\_total} = \textbf{Daily Total VMT Scalar} = \frac{\textbf{Custom Daily Total VMT}}{\textbf{Default Daily Total VMT}} \tag{4.2-H}$$

$$\textbf{sg\_scalar\_daily\_vmt\_ef2011} = \textbf{Daily VMT by VC}^{122}\textbf{, Fuel Scalar} = \frac{\textbf{Custom Daily VMT}_{\textbf{VC,Fuel}}}{\textbf{Default Daily VMT}_{\textbf{VC,Fuel}}} \tag{4.2-I}$$

$$\textbf{sg\_scalar\_daily\_vmt\_ef2011\_speed} = \textbf{Daily VMT by VC, Fuel, Speed Scalar} = \frac{\textbf{Custom Daily VMT}_{\textbf{VC,Fuel,Speed}}}{\textbf{Default Daily VMT}_{\textbf{VC,Fuel,Speed}}} \tag{4.2-J}$$

$$\textbf{sg\_scalar\_hourly\_vmt\_ef2011} = \textbf{Daily VMT by VC, Fuel, Hour Scalar} = \frac{\textbf{Custom Daily VMT}_{\textbf{VC,Fuel,hour}}}{\textbf{Default Daily VMT}_{\textbf{VC,Fuel,hour}}} \tag{4.2-K}$$

$$\textbf{sg\_scalar\_hourly\_vmt\_ef2011\_speed} =$$

$$\textbf{Daily VMT by VC, Fuel, Speed, Hour Scalar} = \frac{\textbf{Custom Daily VMT}_{\textbf{VC,Fuel,Speed,hour}}}{\textbf{Default Daily VMT}_{\textbf{VC,Fuel,Speed,hour}}} \tag{4.2-L}$$

[122] VC stands for vehicle class

Part 4 - How EMFAC Scales Defaults (Emissions, Population, VMT, and Trips).

The VMT scalars developed in Step 3 are used to scale all processes as follows:

Custom Emissions by Process = Default Emissions by Process X Scalars (4.2-M)

If daily or hourly speed scalars are present, they are used to scale running exhaust emissions. The two speed scalar tables are:

- *sg_scalar_daily_vmt_ef2011_speed*
- *sg_scalar_hourly_vmt_ef2011_speed*

Again, please note that the "ef2011" naming convention used in the MySQL scalar table names above (and below) relate to EMFAC2011 Vehicle Categories and Fuel, not to the *EMFAC2011 input template format*. These scalar tables are used in processing scalars when using either EMFAC2011-SG templates or the EMFAC2014 templates.

The only exceptions to this are the following vehicle classes and fuel types which use default speed profiles. The following vehicle classes (all are diesel vehicles) are excluded when scaling by speed:

- *PTO Dsl*
- *T7 POAK –Dsl (certain areas)*
- *T7 POLA –Dsl (certain areas)*
- *T7 Other Port –Dsl (certain areas)*
- *T7 SWCV-Dsl*
- *UBUS-Dsl*
- *UBUS-Gas*

Here "certain areas" indicates that drayage trucks will always use default speed profiles in Alameda (SF), Los Angeles (MD), Los Angeles (SC), San Bernardino (MD), and San Bernardino (SC).

For running exhaust, VMT is scaled by user-provided-VMT and (if provided by the user) speed profiles. For all other processes (i.e. for the excluded vehicle classes in the bullet list above- or if speed profiles are not provided), emissions are scaled either by total daily VMT or by total hourly VMT included in the following tables:

- *sg_scalar_daily_vmt_total*
- *sg_scalar_daily_vmt_ef2011*
- *sg_scalar_hourly_vmt_ef2011*

Although custom activity templates generated with EMFAC2014 are designed so that duplicate scalars are not created, before emissions are scaled EMFAC2014 checks for duplicate scalars amongst daily total VMT, daily VMT by vehicle class-fuel, and hourly VMT by vehicle class-fuel scalar tables and eliminates these duplicates. If duplicate scalars are present amongst these three tables, then priority goes to the most detailed data available: that is, priority goes to scalars in the hourly VMT by vehicle class-fuel, then daily VMT by vehicle class-fuel, and lastly to daily total VMT. Note that EMFAC2014 is designed such that both daily and hourly VMT scalars by vehicle class and speed are never present during the same run.

4.3 REPORTS

4.3.1 CONFORMITY ASSESSMENT

4.3.1.1 CSV DUMP

This report is a simple comma-separated value (CSV) dump of the emissions table. Also produced are CSV dumps of the VMT, Trip, and Population activity tables scaled to match the custom activity data provided by the user.

4.3.1.2 PLANNING INVENTORY REPORT

The Planning Inventory Report is an Excel 2007 format workbook that contains emissions and activity summed by area, calendar year, and vehicle class type. It provides a column for every pollutant and process, with sub-total columns at the appropriate places. It will provide a summary worksheet for a given area and another worksheet titled “By Sub-Area” that is broken out by the sub-areas within the area specified by the user. If a run is only for a single sub-area or if an area only has one sub-area (such as the Lake County Air Basin), the “By Sub-Area” worksheet will not be produced.

4.3.1.3 CTF REPORT

The CEIDARS Transfer Format (CTF) is an internal format used by the ARB to import emission inventory data into its internal emission inventory database and forecasting system. The area and sub-area fields produced by EMFAC are replaced with the County-Air Basin-District coding system, and the Emission Inventory Code (EIC) system replaces the vehicle class type and the processes.

4.3.2 SB375 ASSESSMENT

Only one report is possible for the SB375 assessment; it is not shown on the graphical user interface.

IMPORTANT! – Note again that, for SB375 analyses, the Advanced Clean Cars (ACC)/Pavley and LCFS rules are deactivated. Also, because the ACC regulation has certain assumptions about vehicle usage built into it, default data in custom activity templates produced for conformity assessments will not match the default data in templates for SB375 assessments (differences will result and affect any comparisons between the two). Additionally, please note that EMFAC2014 does not produce official GHG emissions.

4.3.2.1 SB375 REPORT

The SB375 report is an Excel workbook that is a sub-set of the above described Planning Inventory Report. It is limited to carbon dioxide emissions and the related activity. The only vehicle class types included are:

- *LDA - DSL*
- *LDA - GAS*
- *LDT1 - DSL*
- *LDT1 - GAS*
- *LDT2 - DSL*
- *LDT2 - GAS*
- *MDV - DSL*
- *MDV – GAS*

5 EMFAC2014-PL (PROJECT LEVEL ASSESSMENT)

5.1 INTRODUCTION

In addition to producing emission inventories, EMFAC2014) can be used to generate emission rates for project-level (PL) analyses, such as a Particulate Matter Hot Spot Analyses required in transportation conformity determinations. This chapter discusses the basic methodology used by the model to compute emission rates for PL analyses. A separate PL-Handbook is available as guidance on PL analyses.[123]

Typically, a PL analysis quantifies emission impacts at a smaller geographic scale than the usual EMFAC emission inventory analysis. For example, emissions may be needed for a freeway section or drayage truck terminal rather than for an entire county or GAI. Users are interested in emissions under specific conditions that may be different from the default assumptions, including fleet composition, ambient temperature, humidity and travel speed.

The PL module in EMFAC2014 produces emission rates at user-specified ambient temperatures, ambient humidities, and vehicle speeds for user-selected vehicle classes or groups of vehicle classes. The PL module outputs emission rates by calendar year (CY) for:

- *Any vehicle class or group of classes under one of four different vehicle classification schemes: EMFAC2007 vehicle classes; EMFAC2011 vehicle classes; truck/non-truck; or truck1/truck2/non-truck (Refer to Appendix 6.1 for details).*
- *Any of the EMFAC2014 area type designations (statewide, air basin, air district, MPO, county, sub-area). Although most PL analyses are for a small project-specific geographic area, the model provides the flexibility to allow a user to model projects that cover multiple geographic regions. Please note that the choice of area does impact the emission rates derived in a PL analysis. For more information on how area selection influences emission rates, please see the Project-Level Assessment Handbook.*[124]
- *User specified temperatures and humidities (up to twenty four temperature-humidity pairs)*
- *Project specific of speed bins, which are stratified at five mph intervals*
- *Specific MY vehicles or for groups of vehicles aggregated across all MYs*

Consistent with the default emission runs, EMFAC2014-PL assessment runs assume the following regulations are in place:

- *Inspection and Maintenance (I/M) Program ("Smog Check")*[125]
- *Assembly Bill No. 1493 (Pavley) Regulations*[126]
- *On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulations*[127]
- *Heavy-Duty Phase I GHG Regulations*[128]

[123] http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol2-pl-handbook-052015.pdf
[124] http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol2-pl-handbook-052015.pdf
[125] http://www.arb.ca.gov/msprog/smogcheck/smogcheck.htm
[126] http://www.arb.ca.gov/cc/ccms/ccms.htm
[127] http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm
[128] http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013.htm

- *ARB Heavy-Duty Tractor-Trailer GHG Regulation*[129]
- *Advanced Clean Cars Regulations*[130]

To model natural gas vehicles separately in a regional project, EMFAC2014-PL produces emission rates for natural gas vehicles (which are available for the Urban Transit Bus (UBUS) and T7 SWCV vehicle classes) separately when the user chooses to output by fuel type. This is different from the emissions run mode, where natural gas vehicle emission estimates are merged with emission estimates for diesel vehicles. The output emission rates are specified by processes to enable further refined analyses. Note that, given the lack of data on natural gas consumption by unit of activity, the current model release does not estimate fuel consumption rates in a PL analysis for any fuel type.

5.2 EMFAC-PL EMISSION RATE AGGREGATION

Emission rates in EMFAC2014-PL are initially calculated at the finest level of detail (CY, region, EMFAC2011 vehicle class and fuel, model year (MY), emission process, temperature, relative humidity, soak time, speed, and pollutant). These emission rates (ER) are then aggregated, using weighted averages, to the level requested by user using the detail specific activities (population, vehicle miles traveled (VMT), number of starts, and number of idle hours) using equation (5.2.A) as,

$$\boldsymbol{Activity\ Weighted\ Avg\ ER} = \frac{\sum[\boldsymbol{ER}]\bullet[\boldsymbol{Activity}]}{\sum[\boldsymbol{Activity}]} \qquad \textbf{(5.2-A)}$$

Where the *[ER]* contains the emission rates at the finest level of detail and *[Activity]* contains the detail activities corresponding to those emission rates. Note that the multiplication in the numerator is a dot product. The aggregation is executed based on the choices the user makes when setting up the run. For example, if a user needs emission rates by EMFAC2011 vehicle classes aggregated over MY and fuel, the summations are executed across MY and fuel type specific emission rates and activities for each EMFAC2011 vehicle class.

Table 5.2-1 provides, for each process, emission rate units, the activities that are used in each process-specific weighted average calculation, and the equation used to derive the emission rates (Note that, in general, PL emission rates are developed consistently with the .rts or .rtl emission rates in previous versions of EMFAC model). Please note that tabulated activities, used in weighted averaging, are not the same as the activities that should be used to couple with the calculated emission rates in a project-level analysis.

Please note that for start process, EMFAC2014-PL only include emissions from gasoline vehicles, which is consistent with previous versions of EMFAC. Diesel Heavy-duty truck (HDT) start emission rates are not estimated in PL runs.

The decision to leave HDT start emission rates out of the model was based upon the reasons below.

- *Data on HDT start emissions are limited*
- *The current method used to define HDT start activity is different from that which is used for LDV start activity*

Therefore, to avoid confusion and possible misuse, HDT start emission rates were removed from the PL mode.

For idle exhaust, the emission rate calculation excludes the emissions from auxiliary power systems (APS). The APS is operated independently from truck main engine and behaves very differently. In emission inventory estimation, the APS emissions are included as part of the HHDT idle emissions.

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[129] http://www.arb.ca.gov/cc/hdghg/hdghg.htm
[130] http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm

However, the PL idle emission rates, refers to the emissions from the main engine only. For APS emission rates, users can refer to the EMFAC2014-PL Handbook[131].

Table 5.2-1 EMFAC2014-PL Emission Rate Aggregation (Units and Activity)

Process type	Unit	Vehicle Specific Activity	Equation used to aggregated
Running Exhaust	grams/vehicle-mile	Daily VMT (over all speeds)	$\frac{\sum[ER] \bullet [VMT]}{\sum[VMT]}$
Start Exhaust	grams/vehicle-start	Number of starts per day	$\frac{\sum[ER] \bullet [\#Starts]}{\sum[\#Starts]}$
Idle Exhaust	grams/vehicle-idle hours	Number of Idle Hours per day	$\frac{\sum[ER] \bullet [Idle\ Hours]}{\sum[Idle\ Hours]}$
Hot Soak Evaporative	grams/vehicle-start	Number of starts per day	$\frac{\sum[ER] \bullet [\#Starts]}{\sum[\#Starts]}$
Running Loss Evaporative	grams/vehicle-hour	Number of starts per day*	$\frac{\sum[ER] \bullet [\#Starts]}{\sum[\#Starts] \bullet [Operation\ Hours]}$
Resting/Diurnal Loss Evaporative	grams/vehicle-hour	Vehicle Population	$\frac{\sum[ER] \bullet [Population]}{\sum[Population]}$
Brake Wear	grams/vehicle-mile	Daily VMT (over all speeds)	$\frac{\sum[ER] \bullet [VMT]}{\sum[VMT]}$
Tire Wear	grams/vehicle-mile	Daily VMT (over all speeds)	$\frac{\sum[ER] \bullet [VMT]}{\sum[VMT]}$

*For running loss evaporative emission rates, the *Operation Hours* are used to convert the gram/starts emission rates to gram/hour emission rates. *Operation Hours* are the average number of hours that vehicles are operated per start/trip.

*For start, hotsoak, running loss,diurnal and resting loss processes, the aggregated emission rates across fuel type for MHDT, HHDT, SBUS and OBUS represent the emission rates of gasoline trucks or buses only.

131 http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol2-pl-handbook-052015.pdf

6 APPENDICES

6.1 VEHICLE CLASS CATEGORIZATION

Table 6.1-A. Summary List of Vehicle Classes

EMFAC2011 Veh & Tech	Description (GVWR = Gross Vehicle Weight Rating, ETW = Equivalent Test Weight)	EMFAC2007 Vehicle
LDA - DSL	Passenger Cars	LDA
LDA - GAS		
LDT1 - DSL	Light-Duty Trucks (GVWR <6000 lbs. and ETW <= 0-3750 lbs)	LDT1
LDT1 - GAS		
LDT2 - DSL	Light-Duty Trucks (GVWR <6000 lbs. and ETW 3751-5750 lbs)	LDT2
LDT2 - GAS		
LHD1 - DSL	Light-Heavy-Duty Trucks (GVWR 8501-10000 lbs)	LHDT1
LHD1 - GAS		
LHD2 - DSL	Light-Heavy-Duty Trucks (GVWR 10001-14000 lbs)	LHDT2
LHD2 - GAS		
MCY - GAS	Motorcycles	MCY
MDV - DSL	Medium-Duty Trucks (GVWR 6000 - 8500 lbs)	MDV
MDV - GAS		
MH - DSL	Motor Homes	MH
MH - GAS		
T6 Ag - DSL	Medium-Heavy Duty Diesel Agriculture Truck	MHDT
T6 CAIRP heavy - DSL	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR>26000 lbs	
T6 CAIRP small - DSL	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR<=26000 lbs	
T6 instate construction heavy - DSL	Medium-Heavy Duty Diesel instate construction Truck with GVWR>26000 lbs	
T6 instate construction small - DSL	Medium-Heavy Duty Diesel instate construction Truck with GVWR<=26000 lbs	
T6 instate heavy - DSL	Medium-Heavy Duty Diesel instate Truck with GVWR>26000 lbs	
T6 instate small - DSL	Medium-Heavy Duty Diesel instate Truck with GVWR<=26000 lbs	
T6 OOS heavy - DSL	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR>26000 lbs	
T6 OOS small - DSL	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR<=26000 lbs	
T6 Public - DSL	Medium-Heavy Duty Diesel Public Fleet Truck	
T6 utility - DSL	Medium-Heavy Duty Diesel Utility Fleet Truck	
T6TS - GAS	Medium-Heavy Duty Gasoline Truck	
T7 Ag - DSL	Heavy-Heavy Duty Diesel Agriculture Truck	HHDT
T7 CAIRP - DSL	Heavy-Heavy Duty Diesel CA International Registration Plan Truck	
T7 CAIRP construction - DSL	Heavy-Heavy Duty Diesel CA International Registration Plan Construction Truck	
T7 NNOOS - DSL	Heavy-Heavy Duty Diesel Non-Neighboring Out-of-state Truck	
T7 NOOS - DSL	Heavy-Heavy Duty Diesel Neighboring Out-of-state Truck	
T7 other port - DSL	Heavy-Heavy Duty Diesel Drayage Truck at Other Facilities	
T7 POAK - DSL	Heavy-Heavy Duty Diesel Drayage Truck in Bay Area	
T7 POLA - DSL	Heavy-Heavy Duty Diesel Drayage Truck near South Coast	
T7 Public - DSL	Heavy-Heavy Duty Diesel Public Fleet Truck	
T7 Single - DSL	Heavy-Heavy Duty Diesel Single Unit Truck	
T7 single construction - DSL	Heavy-Heavy Duty Diesel Single Unit Construction Truck	
T7 SWCV - DSL	Heavy-Heavy Duty Diesel Solid Waste Collection Truck	
T7 SWCV – NG*		
T7 tractor - DSL	Heavy-Heavy Duty Diesel Tractor Truck	
T7 tractor construction - DSL	Heavy-Heavy Duty Diesel Tractor Construction Truck	
T7 utility - DSL	Heavy-Heavy Duty Diesel Utility Fleet Truck	
T7IS - GAS	Heavy-Heavy Duty Gasoline Truck	
PTO - DSL	Power Take Off	
SBUS - DSL	School Buses	SBUS
SBUS - GAS		
UBUS - DSL	Urban Buses	UBUS
UBUS - GAS		
UBUS-NG*		
Motor Coach - DSL	Motor Coach	OBUS
OBUS - GAS	Other Buses	
All Other Buses - DSL	All Other Buses	
*Note that T7 SWCV - NG and UBUS -NG emissions will not be shown in emission inventory run output files		

6.2 TEST DATA

Table 6.2-A Summary of ARB Diesel Truck Dynamometer Testing Data

Test Vehicle ID	Test Cycle**	HC (g/mi)*	CO (g/mi)	NOx (g/mi)	PM (g/mi)***	CO_2 (g/mi)
2007 Cummins	UDDS	0.43	0.16	11.3	0.012	1,910
2007 Cummins	Creep	2.74	4.75	19.5	0.007	4,772
2007 Cummins	Transient	0.02	0.33	13.0	0.002	2,035
2007 Cummins	Cruise	n.a.	0.02	7.90	0.000	1,128
2007 Cummins	High Speed Cruise	n.a.	0.04	8.80	0.001	1,459
2007 Cummins	Idle	2.58	7.30	20.9	n.r.	6,873
2007 DDC	UDDS	n.a.	0.04	7.05	0.009	2,175
2007 DDC	Creep	0.064	0.08	23.2	0.016	3,873
2007 DDC	Transient	0.003	0.05	6.72	0.002	2,362
2007 DDC	Cruise	n.a.	0.02	3.19	0.001	1,387
2007 DDC	High Speed Cruise	n.a.	0.02	4.57	0.055	1,775
2007 DDC	Idle	1.19	0.12	45.2	0.000	3,762
2010 Cummins	UDDS	0.03	1.64	4.22	0.001	1,831
2010 Cummins	Creep	0.56	9.09	12.3	0.010	3,739
2010 Cummins	Transient	1.44	4.15	4.64	0.028	2,432
2010 Cummins	Cruise	n.a.	0.25	2.21	0.001	1,014
2010 Cummins	High Speed Cruise	0.49	0.35	1.65	0.012	1,310
2010 Cummins	Idle	0.61	0.96	4.82	0.000	3,457
2010 Navistar	UDDS	n.a.	0.03	3.73	0.005	2,033
2010 Navistar	Creep	n.a.	0.29	16.8	0.008	5,006
2010 Navistar	Transient	n.a.	0.03	6.33	0.004	2,206
2010 Navistar	Cruise	n.a.	0.03	0.63	0.004	1,549
2010 Navistar	High Speed Cruise	n.a.	0.03	0.74	0.004	1,898
2010 Navistar	Idle	n.a.	0.27	16.1	0.000	6,130
2010 Volvo	UDDS	0.007	0.04	1.95	0.003	1,877
2010 Volvo	Creep	n.a.	2.16	16.1	n.r.	3,805
2010 Volvo	Transient	0.007	0.03	3.39	0.003	2,034
2010 Volvo	Cruise	n.a.	0.03	0.19	0.004	1,358
2010 Volvo	High Speed Cruise	n.a.	0.02	0.27	0.006	1,559
2010 Volvo	Idle	0.21	1.01	15.4	n.r.	4,136

* n.a. = "Not Applicable" because the amount of background sample collected is higher than that of exhaust sample or possible CH_4 contamination from the testing facility.

** Idle = ERs for idle are in g/hour (not g/mi).

*** n.r. = "Not Reported" due to PM collection failure.

Table 6.2-B SCAQMD Diesel Truck Dynamometer Testing Data

Test Vehicle ID	Test Cycle	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)
2009 Navistar	UDDS	0.14	0.51	8.20	0.038	2,964
2011 Navistar	UDDS	0.12	4.54	5.51	0.004	2,115
2011 Mack	UDDS	0.001	0.22	1.98	0.008	2,422

Table 6.2-C SCAQMD Refuse Truck and CNG Bus Dynamometer Testing Data

Vehicle Type	Engine	Fuel	Cycle	HC (g/mi)	CO (g/mi)	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)
Refuse Truck	2005 Cummins	ULSD	RTC	0.01	0.075	17.2	0.059	4,801
Refuse Truck	2005 Cummins	ULSD	C3	0.00	0.009	5.82	0.062	2,488
Refuse Truck	2011 Cummins	ULSD	RTC	1.09	2.71	1.28	0.003	2,657
Refuse Truck	2011 Cummins	ULSD	C3	0.33	2.07	0.72	0.007	1,344
Refuse Truck	2011 Cummins	ULSD	RTC	0.03	0.092	0.71	0.008	4,871
Refuse Truck	2011 Cummins	ULSD	C3	0.01	0.076	0.47	0.004	1,701
Refuse Truck	2002 Caterpillar	LNG	RTC	85.0	0.41	22.7	0.011	3,459
Refuse Truck	2002 Caterpillar	LNG	C3	32.8	0.024	8.88	0.032	1,665
Refuse Truck	2004 Mack	LNG	RTC	24.9	8.08	36.9	0.15	3,293
Refuse Truck	2004 Mack	LNG	C3	5.06	2.74	54.3	0.022	1,540
Refuse Truck	2006 Cummins	LNG	RTC	28.9	0.32	25.4	0.010	3,821
Refuse Truck	2006 Cummins	LNG	C3	6.55	0.027	11.3	0.043	1,910
Refuse Truck	2008 Cummins	LNG	RTC	7.84	22.7	0.78	0.004	3,766
Refuse Truck	2008 Cummins	LNG	C3	2.29	13.8	0.10	0.000	1,311
Urban Bus	2008 Cummins	CNG	CBD	3.1	14.4	0.65	0.001	2,305

Refuse Truck is also referred to as solid waste collection vehicle (SWCV).

Table 6.2-D Compilation of Pre-2006 Model Year CNG Bus Test Data

Bus Engines	MY	HC (g/mi)**	NOx (g/mi)	PM (g/mi)	CO_2 (g/mi)**	Source*
Detroit Diesel S50G	1994	n.r.	49.7	0.24	2,551	1
Detroit Diesel S50G	1994	n.r.	39.8	0.13	2,588	1
Cummins L10G	1995	n.r.	15.3	0.09	2,737	1
Cummins L10G	1995	n.r.	17.6	0.09	2,761	1
Cummins L10G	1996	n.r.	21.0	0.033	2,517	2
Cummins L10G	1996	n.r.	15.4	0.029	2,370	2
Cummins L10G	1996	n.r.	21.6	0.061	2,436	2
Cummins L10G	1996	n.r.	19.5	0.024	2,486	2
Cummins L10G	1996	n.r.	12.0	0.019	2,536	2
Cummins L10G	1996	n.r.	9.87	0.048	2,506	2
Cummins L10G	1996	n.r.	22.4	0.029	2,537	2
Cummins L10G	1996	n.r.	35.8	0.016	2,510	2
Cummins L10G	1996	n.r.	35.0	0.021	2,364	2
Detroit Diesel S50G	1999	17.5	46.7	0.017	2,126	3
Detroit Diesel S50G	1999	17.9	16.6	0.013	2,230	3
Detroit Diesel S50G	1999	17.9	19.1	0.019	2,506	3
Cummins L10-280G	1999	15.2	25.0	0.02	2,392	4
Detroit Diesel S50G	1999	26.1	9.7	0.02	2,785	4
Detroit Diesel S50G	1999	20.6	14.9	0.02	2,343	4
Detroit Diesel S50G	2000	11.2	16.5	0.013	2,037	5
Detroit Diesel S50G	2001	12.8	13.9	0.005	2,055	5
Detroit Diesel S50G	2000	12.0	19.0	0.037	2,159	6
Detroit Diesel S50G	2000	n.r.	13.3	0.020	2,161	7
Detroit Diesel S50G	2000	n.r.	15.6	0.028	2,160	7
Cummins Westport C8.3G+	2001	14.1	13.9	0.021	1,987	7
John Deere 6081H	2005	n.r.	9.72	0.023	n.r.	8
Cummins Westport C8.3G+	2005	n.r.	21.0	n.r.	n.r.	8

* 1 = SAE Technical Paper 1999-01-1507;
2 = SAE Technical Paper 981393;
3 = SAE Technical Paper 2003-01-0300;
4 = Northeast Advanced Vehicle Consortium 2000 Report;
5 = SAE Technical Paper No. 2002-01-0433;
6 = SAE Technical Paper 2002-01-1722;
7 = SAE Technical Paper 2003-01-1900;
8 = SAE Technical Paper 2007-01-0054.

** n.r. = No data were reported.

Table 6.2-E HDT Model Year vs Engine Year Mismatch Fraction

Eng / Veh	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pre1987																						
1987-90																						
1991-93	1.2%																					
1994	98.8%	23.4%																				
1995		76.6%	22.2%																			
1996			77.8%	24.3%																		
1997				75.7%	25.6%																	
1998					74.4%	27.4%																
1999						72.6%	31.1%															
2000							68.9%	33.2%														
2001								66.8%	35.0%													
2002									65.0%	30.7%												
2003										69.3%	32.1%											
2004											67.9%	47.1%	4.3%	3.1%								
2005												52.4%	47.8%	1.1%								
2006												0.5%	47.5%	71.7%	2.8%							
2007													0.4%	24.1%	61.8%	5.4%	2.0%	1.3%				
2008															35.4%	62.0%	0.7%	0.3%				
2009																32.6%	82.7%	17.0%				
2010																	14.6%	66.8%	14.9%	7.9%		
2011																		14.7%	67.9%	15.9%		
2012																			17.0%	65.9%	17.7%	
2013																			0.1%	10.3%	79.0%	
2014																					3.2%	
2015																						100.0%

Table 6.2-F Comparison of Diesel HHDT ZMRs and DRs of EMFAC2014 and EMFAC2011

Vehicle MY	HC				CO				NOx				PM				CO_2			
	EMFAC2014		EMFAC2011		EMFAC2014		EMFAC2011		EMFAC2014		EMFAC2011		EMFAC2014		EMFAC2011		EMFAC2014		EMFAC2011	
	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre 1987	1.51	0.034	1.20	0.027	8.04	0.183	7.71	0.176	23.0	0.019	23.0	0.019	1.75	0.0278	1.73	0.0275	2,335	0.0	2,335	0.0
1987-90	1.18	0.041	0.94	0.032	6.32	0.218	6.06	0.209	22.7	0.026	22.7	0.026	1.90	0.0248	1.88	0.0245	2,262	0.0	2,262	0.0
1991-93	0.86	0.029	0.62	0.021	2.90	0.099	2.64	0.090	19.6	0.039	19.6	0.039	0.80	0.0145	0.78	0.0142	2,176	0.0	2,176	0.0
1994-97	0.64	0.034	0.46	0.024	2.15	0.114	1.95	0.103	19.3	0.046	19.3	0.046	0.52	0.0112	0.51	0.0108	2,086	0.0	2,086	0.0
1998-02	0.65	0.034	0.47	0.024	2.19	0.113	1.99	0.103	19.0	0.053	18.9	0.053	0.57	0.0101	0.56	0.0098	2,135	0.0	2,137	0.0
2003-05	0.55	0.021	0.30	0.011	1.20	0.046	0.87	0.031	13.0	0.052	12.5	0.052	0.39	0.0060	0.35	0.0054	2,114	0.0	2,112	0.0
2006	0.55	0.021	0.30	0.011	1.20	0.046	0.87	0.031	13.0	0.052	12.5	0.052	0.39	0.0060	0.35	0.0054	2,114	0.0	2,112	0.0
2007	0.51	0.017	0.26	0.007	1.10	0.036	0.74	0.022	11.3	0.059	7.66	0.047	0.29	0.0045	0.035	0.0010	2,169	0.0	2,171	0.0
2008	0.43	0.008	0.26	0.007	1.06	0.021	0.74	0.022	7.46	0.081	7.25	0.047	0.037	0.0009	0.035	0.0010	2,343	0.0	2,171	0.0
2009	0.42	0.008	0.26	0.007	1.06	0.020	0.74	0.022	7.31	0.082	6.44	0.046	0.028	0.0008	0.035	0.0010	2,350	0.0	2,171	0.0
2010	0.38	0.007	0.21	0.004	1.02	0.020	0.61	0.012	6.59	0.081	1.72	0.041	0.024	0.0007	0.035	0.0010	2,307	0.0	2,099	0.0
2011	0.19	0.004	0.21	0.004	0.82	0.016	0.61	0.012	3.26	0.074	1.47	0.041	0.009	0.0003	0.035	0.0010	2,110	0.0	2,099	0.0
2012	0.14	0.003	0.21	0.004	0.76	0.015	0.61	0.012	2.33	0.073	1.14	0.041	0.004	0.0001	0.035	0.0010	2,056	0.0	2,099	0.0
2013	0.14	0.003	0.21	0.003	0.76	0.014	0.61	0.008	2.28	0.069	1.14	0.032	0.004	0.0001	0.035	0.0007	2,056	0.0	2,094	0.0
2014	0.14	0.002	0.21	0.003	0.76	0.010	0.61	0.008	1.97	0.047	1.14	0.032	0.004	0.0001	0.035	0.0007	2,056	0.0	2,094	0.0
2015+	0.14	0.002	0.21	0.003	0.76	0.009	0.61	0.008	1.89	0.042	1.14	0.032	0.004	0.0001	0.035	0.0007	2,056	0.0	2,094	0.0

Figure 6.2-1 Current and Revised SCFs for Diesel HHD Trucks

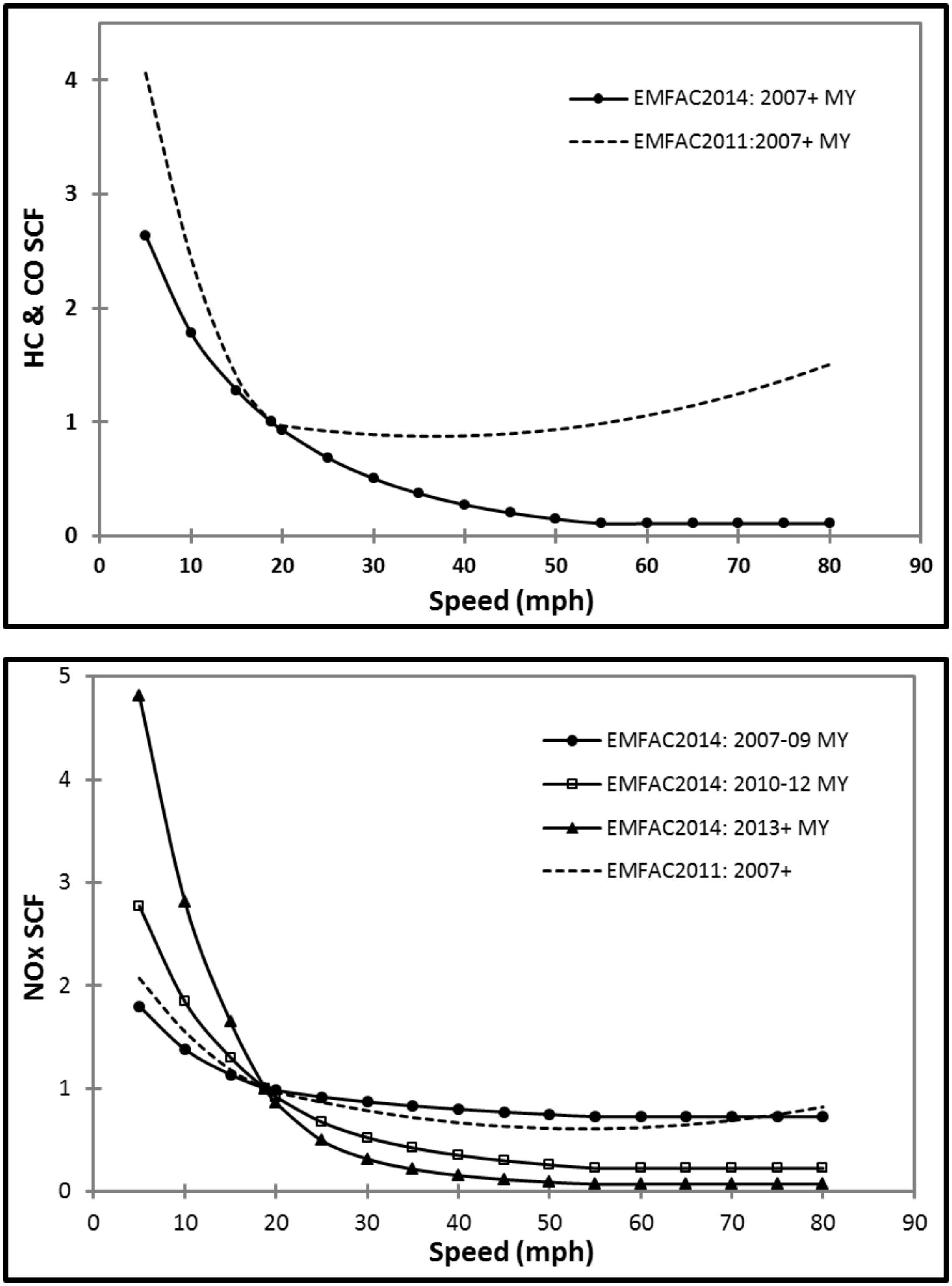
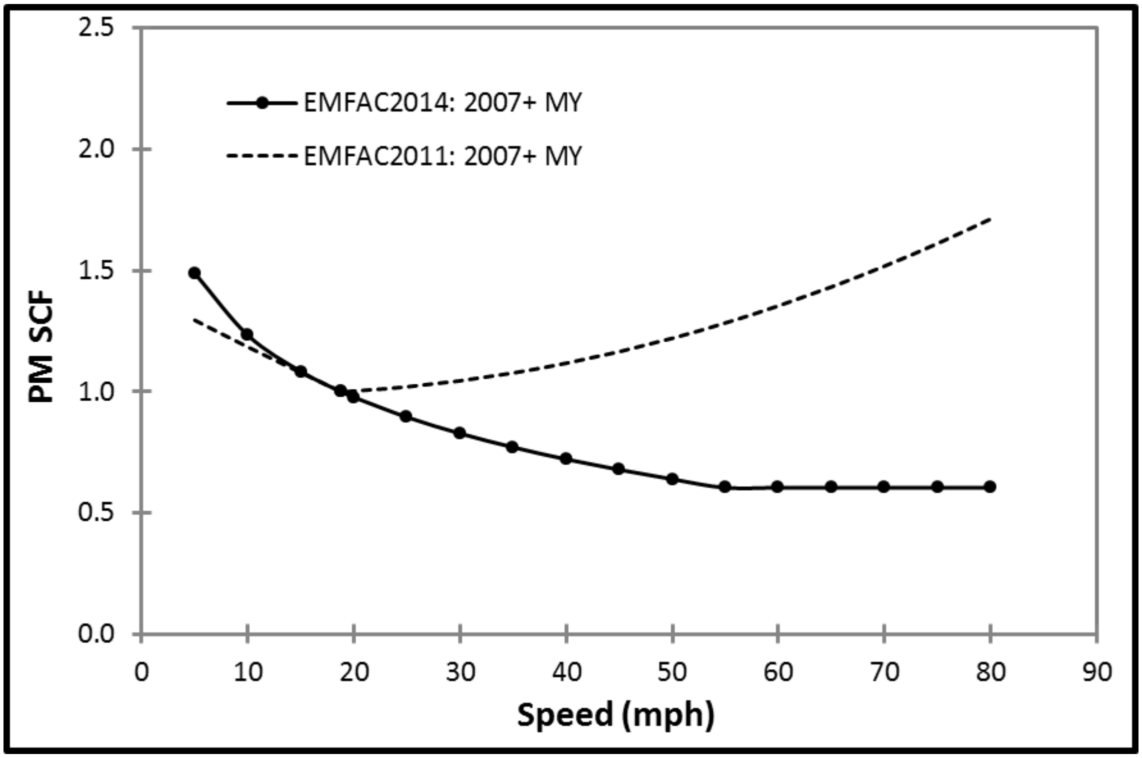
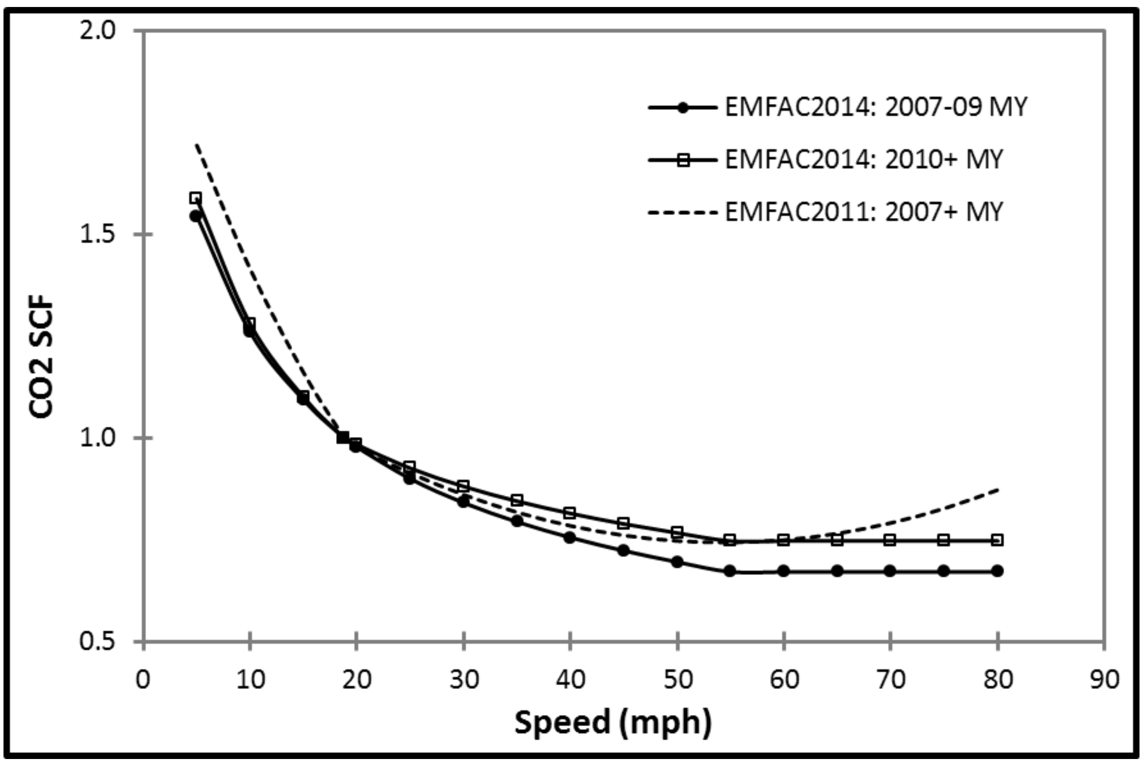


Figure 6.2-1 (continued)





6.3 FORECASTING DATA SOURCES

The primary data sources used for statistical model development and forecasting included UCLA Anderson Forecast (UCLA), California Department of Finance (DOF), California Department of Motor Vehicles (DMV), California Board of Equalization (BOE), California Energy Commission (CEC), U.S. DOE Energy Information Administration (EIA), and U.S. Bureau of Economic Analysis (BEA). Additional information is provided below.

6.3-A. Gasoline and diesel consumption

The statewide annual gasoline and diesel consumption data are all historical, not projected. The 1995-2001 data are from DOF and the 2002-2013 data are from BOE. Below are the specific data sources.

DOF

California Statistical Abstract, Released January 2009

Table J-6 — Fuel Distributions: Taxable Gallons Distributed, California

http://www.dof.ca.gov/html/fs_data/STAT-ABS/Toc_xls.htm

http://www.dof.ca.gov/html/fs_data/STAT-ABS/documents/J6.xls

BOE, Monthly Motor Vehicle Fuel Distributions Reports

Taxable Gasoline Gallons 10 Year Report

Taxable Aviation Gasoline Gallons 10 Year Report: to be subtracted from "Taxable Gasoline Gallons 10 Year Report".

Taxable Diesel Gallons 10 Year Report

http://www.boe.ca.gov/sptaxprog/spftrpts.htm

6.3-B. New sales of LD vehicles

The new vehicle sales data (1995-2011) are from DMV registrations. Also, this is essentially the same data as DOF presents. Some new automobile registrations are processed by the Business Partner Automation Program (BPA) (i.e. car dealers, car rental companies such as Avis Rent-a-Car and Budget Car Rental, etc.). The BPA program first started in 1996 and the new sales data does take into account the BPA components. The new vehicle sales data (2012 and 2013) are from DOF. Below is the specific data source.

DOF

New Car Sales, California and U.S.

http://www.dof.ca.gov/html/fs_data/latestecondata/FS_Misc.htm

http://www.dof.ca.gov/html/fs_data/latestecondata/documents/BBCARS_017.xls

6.3-C. Gasoline price

Note that gasoline retail prices are eventually converted to constant 2010 dollars by using CPI. The 1995-2012 gasoline price data are from CEC. See below.

CEC
Historical Yearly Average California Gasoline
Prices per Gallon 1970 to 2012
Based on 2010 Dollars, Adjusted for Inflation
(Gross Domestic Product Implicit Price Deflator)
http://energyalmanac.ca.gov/gasoline/gasoline_cpi_adjusted.html

The 2013 gasoline price data is from EIA. See below.

EIA, California All Grades Reformulated Retail Gasoline Prices
http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_a.htm
http://www.eia.gov/dnav/pet/hist_xls/EMM_EPM0R_PTE_SCA_DPGa.xls
http://www.eia.gov/dnav/pet/hist_xls/EMM_EPM0_PTE_SCA_DPGa.xls

The 2014-2050 gasoline price forecasts are from CEC. See below. We take the reference case forecasts of CEC to represent the default situation.

CEC
Presentations for the June 26, 2013, Joint Lead Commissioner Workshop on Inputs and Methods for Transportation Energy Demand Forecasts
http://www.energy.ca.gov/2013_energypolicy/documents/2013-06-26_workshop/presentations/
http://www.energy.ca.gov/2013_energypolicy/documents/2013-06-26_workshop/presentations/04_Price_Forecasts-Ryan_RAS_21Jun2013.pdf

6.3-D. Disposable personal income

Note that statewide disposable personal income data are eventually converted to be in trillions of 2010 dollars by using CPI. The 1995-2013 disposable personal income data are from BEA. See below.

Bureau of Economic Analysis (BEA)
Personal income, per capita personal income, disposable personal income, and population (SA1-3, SA51-53)
SA51-53 - Disposable personal income summary
California
All years
http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=4

The 2014-2023 forecasts are from UCLA Anderson Forecast. See below.

UCLA Anderson Forecast
CaJune13.xls
Generate annual numbers by averaging quarterly data.
YDF@CA

For years 2024+, ARB assumes a linear extrapolation of the 1995-2023 data to reflect the trend.

6.3-E. Human population

The 1995-2013 human population data are from DOF. See below.

DOF
E-7. California Population Estimates, with Components of Change and Crude Rates, July 1, 1900-2013
Released December 2013
http://www.dof.ca.gov/research/demographic/reports/estimates/e-7/view.php

2014-2050 population forecasts are from DOF's long-term projections, with a linear interpolation of five year increments.

DOF, January 2013
Report P-1: Summary Population Projections by Race/Ethnicity and by Major Age Groups
Report P-1 (County): State and County Total Population Projections, 2010-2060 (5-year increments)
http://www.dof.ca.gov/research/demographic/reports/projections/P-1/

6.3-F. Unemployment rate

The 1995-2013 unemployment rates are from DOF. See below.

DOF
UNEMPLOYMENT RATE
CALIFORNIA AND UNITED STATES
http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/Data_home.htm
http://www.dof.ca.gov/html/fs_data/latestecondata/FS_Employment.htm
http://www.dof.ca.gov/html/fs_data/latestecondata/documents/BBUNR.XLS

The 2014-2020 unemployment rates are from UCLA. See below.

UCLA Anderson Forecast

CaJune13.xls

Generate annual numbers by averaging quarterly data.

RU@CA

For years 2021+, ARB simply assumes the unemployment rates to be constant at 6%.

6.3-G. Nonfarm jobs

The historical 1995-2013 nonfarm jobs data are from DOF. See below.

DOF

Nonagricultural Wage and Salary Employment (payroll survey), California & U.S.

Annual: from 1985

Monthly: from 1990

http://www.dof.ca.gov/html/fs_data/latestecondata/FS_Employment.htm

http://www.dof.ca.gov/html/fs_data/latestecondata/documents/BBNONAG.XLS

The 2014-2023 nonfarm jobs are from UCLA. See below.

UCLA Anderson Forecast

CaJune13.xls

EMPLOYMENT IN NONAGRICULTURAL ESTABLISHMENTS

Generate annual numbers by averaging quarterly data.

EEA@CA, EHH@CA

For years 2024+, ARB assumes a linear extrapolation of the 1995-2023 data.

6.3-H. Consumer price index

The 1995-2010 CPI data are from DOF. See below.

DOF

CONSUMER PRICE INDEX, SELECTED AREAS, 1950 TO 2010

(1982-84=100)

http://www.dof.ca.gov/HTML/FS_DATA/STAT-ABS/documents/D16.xls

The 2011-2013 CPI data are from DOF. See below.

DOF

CONSUMER PRICE INDICES, UNITED STATES AND CALIFORNIA

CALENDAR YEAR AVERAGES, (1982-84=100)

ANNUAL AVERAGES FOR CALIFORNIA CONSUMER PRICE INDICES (CPI)

http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/Data_home.htm

http://www.dof.ca.gov/html/fs_data/latestecondata/FS_Price.htm

http://www.dof.ca.gov/html/fs_data/latestecondata/documents/BBCYCPI.xls

The 2014-2023 CPI forecast data are from UCLA. See below.

UCLA Anderson Forecast

CaJune13.xls

Generate annual numbers by averaging quarterly data.

(1982-84=100)

CPIU@CA

6.4 REGIONAL COMPARISONS BETWEEN EMFAC2011 AND EMFAC2014

FIGURE 6.4-A. Comparison of LD Vehicle Activity and Emissions in South Coast air basin between EMFAC2011 and EMFAC2014

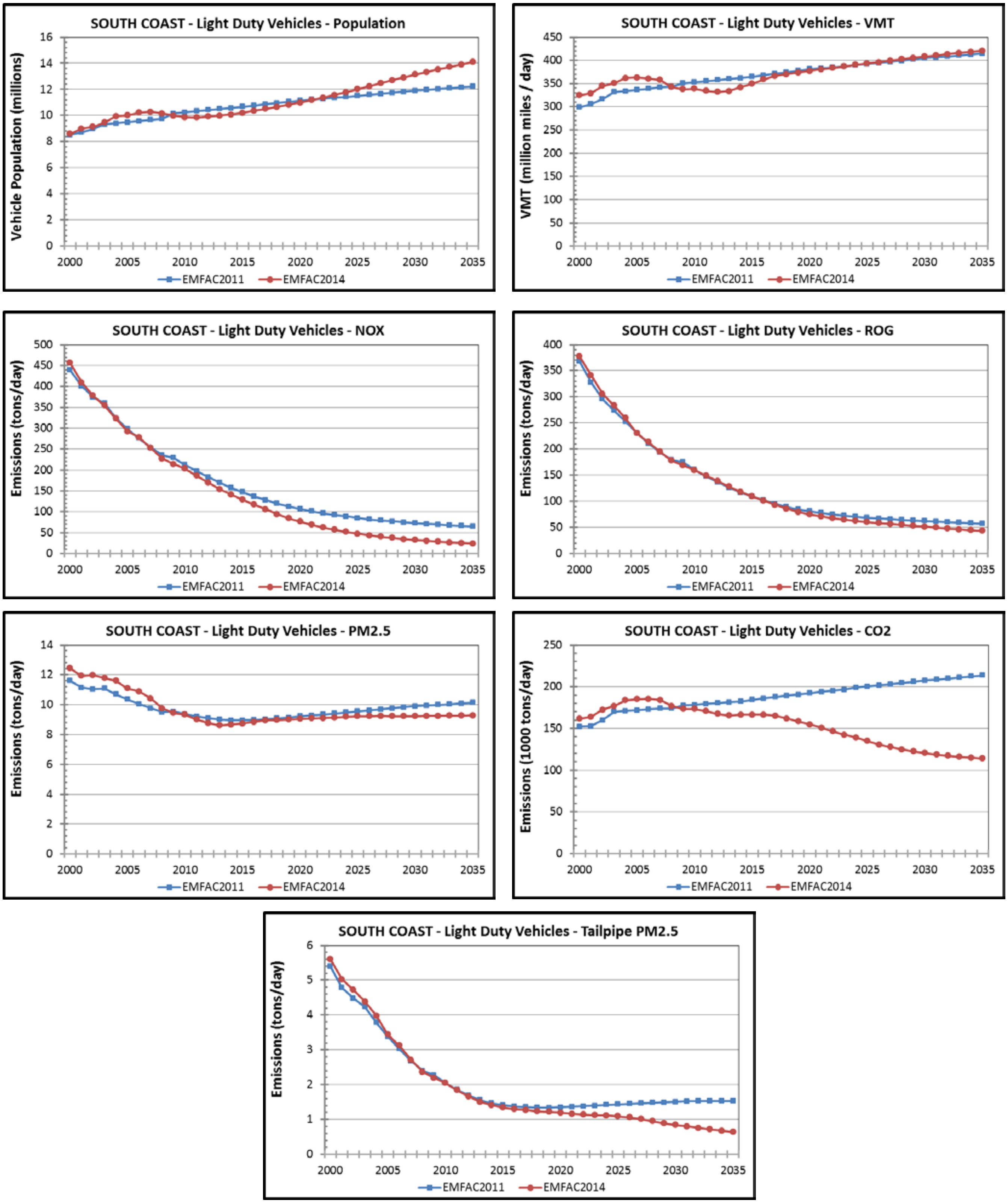


FIGURE 6.4-B Comparison of LD vehicle Activity and Emissions in San Joaquin Valley air basin between EMFAC2011 and EMFAC2014

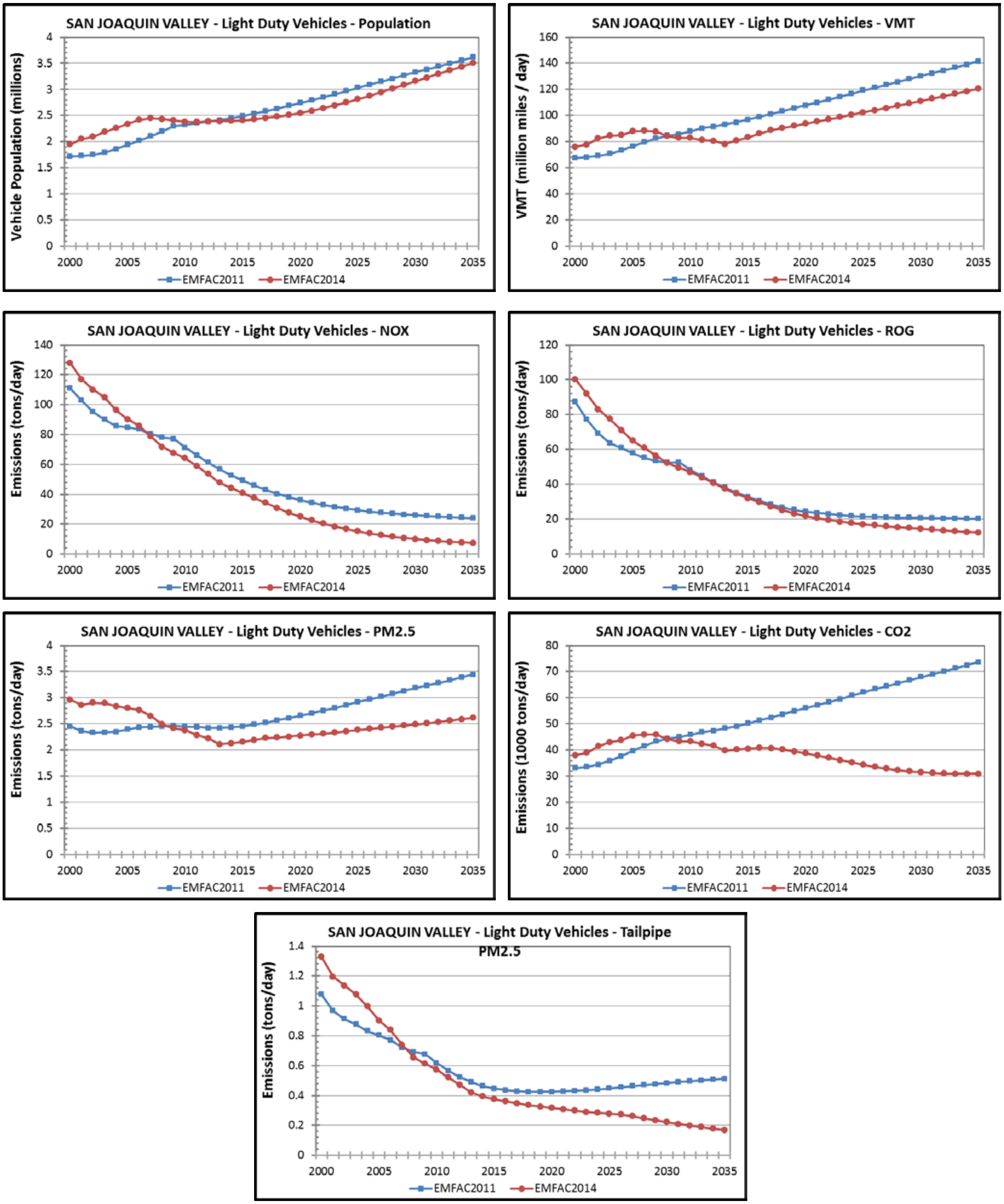


FIGURE 6.4-C Comparison of HD vehicle Activity and Emissions in South Coast air basin between EMFAC2011 and EMFAC2014

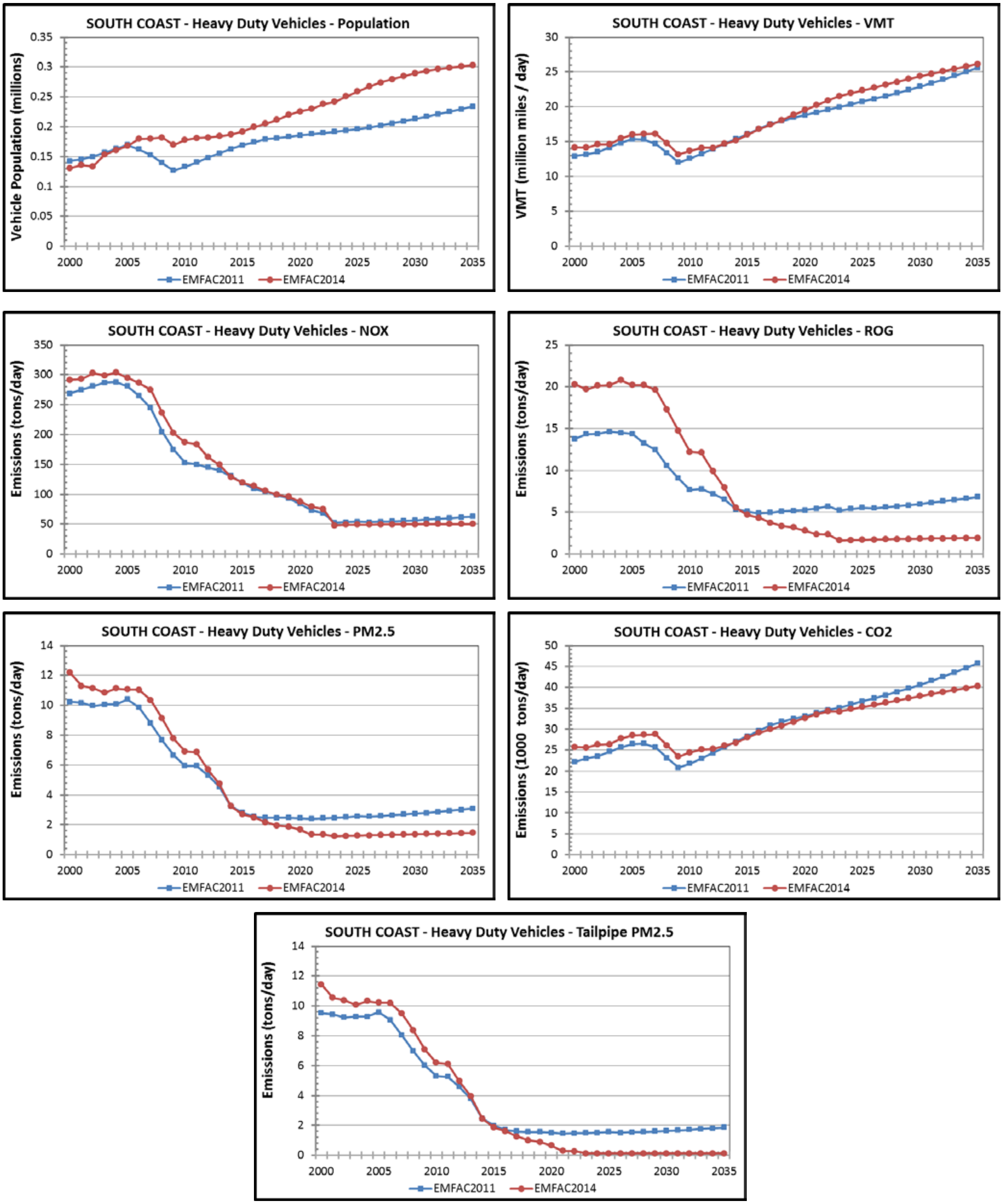
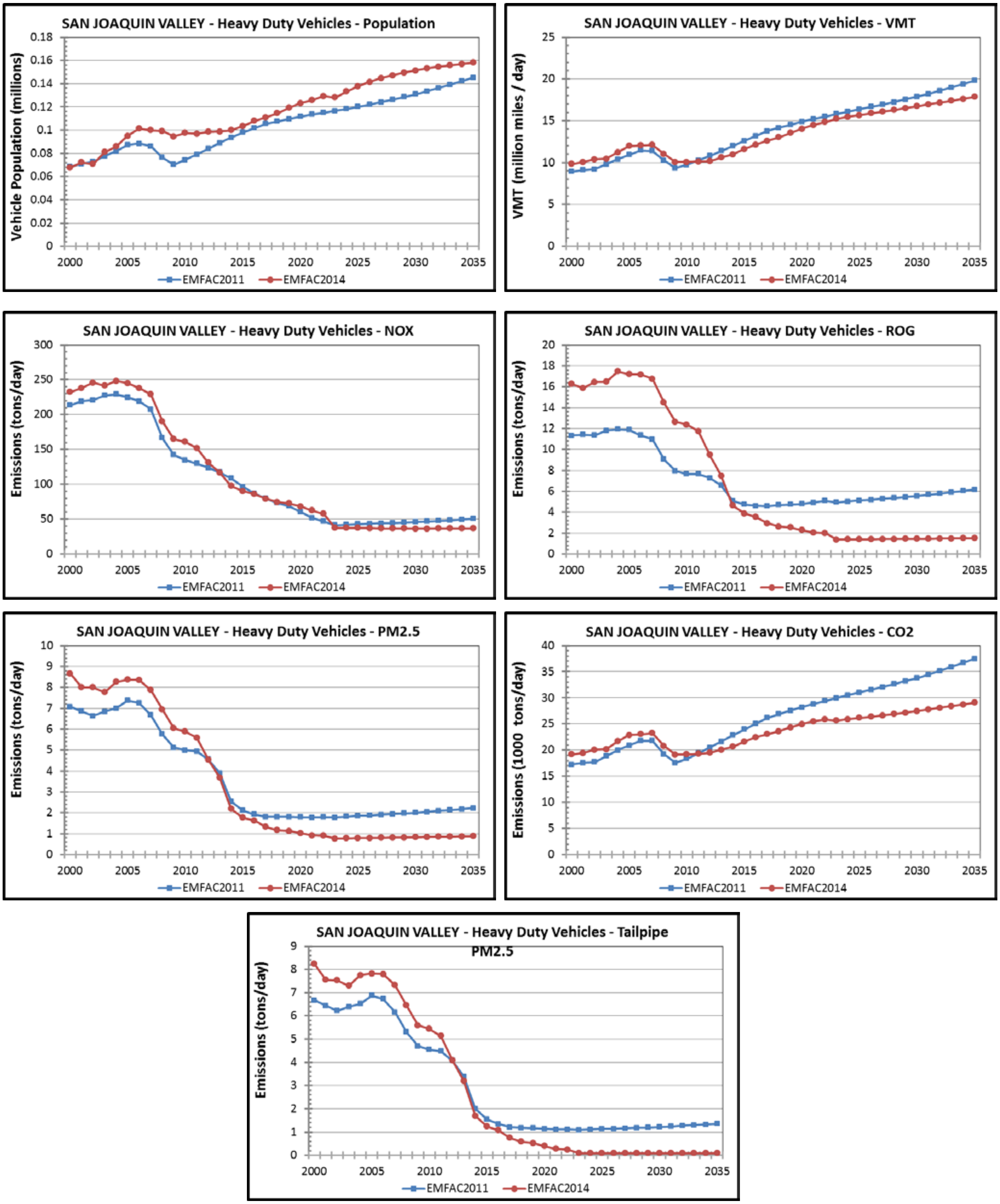


FIGURE 6.4-D Comparison of HD Vehicle Activity and Emissions in San Joaquin Valley air Basin between EMFAC2011 and EMFAC2014



6.5 GLOSSARY

Acronym	Grouping	Definition
ARB	Agency/Company/Organization/Region	California Air Resources Board
BAR	Agency/Company/Organization/Region	California Bureau of Automotive Repair
BEA	Agency/Company/Organization/Region	U.S. Bureau of Economic Analysis
BLS	Agency/Company/Organization/Region	U.S. Bureau of Labor Statistics
BOE	Agency/Company/Organization/Region	California Board of Equalization
CE-CERT	Agency/Company/Organization/Region	College of Engineering-Center for Environmental Research and Technology, University of California at Riverside
CRC	Agency/Company/Organization/Region	Coordinating Research Council
DMV	Agency/Company/Organization/Region	California Department of Motor Vehicles
DOE	Agency/Company/Organization/Region	U.S. Department of Energy
DOF	Agency/Company/Organization/Region	California Department of Finance
DOJ	Agency/Company/Organization/Region	Department of Justice
EIA	Agency/Company/Organization/Region	U.S. DOE Energy Information Administration
EPA	Agency/Company/Organization/Region	U.S. Environmental Protection Agency
ERG	Agency/Company/Organization/Region	Eastern Research Group, Inc.
FHWA	Agency/Company/Organization/Region	U.S. Federal Highway Administration
LA	Agency/Company/Organization/Region	Los Angeles
MPO	Agency/Company/Organization/Region	Metropolitan Planning Organization
NHTSA	Agency/Company/Organization/Region	U.S. Department of Transportation’s National Highway Traffic Safety Administration
RTC	Agency/Company/Organization/Region	Regional Transportation Commission
SCAG	Agency/Company/Organization/Region	South Coast Association of Governments
SCAQMD	Agency/Company/Organization/Region	South Coast Air Quality Management District
SD	Agency/Company/Organization/Region	School District
UCLA	Agency/Company/Organization/Region	University of California, Los Angeles (source of Anderson Forecast)
USEPA	Agency/Company/Organization/Region	U.S. Environmental Protection Agency
Accr	EMFAC Factor or Data Used in Development	Accrual
ACES	EMFAC Factor or Data Used in Development	CRC’s Advanced Collaborative Emissions Study Crankcase Emissions data
AEO data	EMFAC Factor or Data Used in Development	Annual Energy Outlook data (from EIA)
BER	EMFAC Factor or Data Used in Development	Base Emission Rate
BW	EMFAC Factor or Data Used in Development	Brake Wear
c_d	EMFAC Factor or Data Used in Development	Coefficient of Drag
CIR	EMFAC Factor or Data Used in Development	Current Industrial Reports data
CPI	EMFAC Factor or Data Used in Development	Consumer Price Index
CY	EMFAC Factor or Data Used in Development	Calendar Year, also referred to as Cyr
DR	EMFAC Factor or Data Used in	Deterioration Rate

Acronym	Grouping	Definition
	Development	
DTR data	EMFAC Factor or Data Used in Development	ARB's Drayage Truck Registry data
EF	EMFAC Factor or Data Used in Development	Emission Factor
ER	EMFAC Factor or Data Used in Development	Emission Rate
Ev TG	EMFAC Factor or Data Used in Development	Evaporative Technology Group
Ex TG	EMFAC Factor or Data Used in Development	Exhaust Technology Group
FAF data	EMFAC Factor or Data Used in Development	Freight Analysis Framework data (from FHWA)
GAI	EMFAC Factor or Data Used in Development	Geographical Area Indices
HPMS data	EMFAC Factor or Data Used in Development	Highway Performance Monitoring System Data
IRP data	EMFAC Factor or Data Used in Development	International Registration Plan Clearinghouse Data [*CA IRP = California Registered*]
LCFS Factors	EMFAC Factor or Data Used in Development	Low Carbon Fuel Standard Reduction Factors
LIC	EMFAC Factor or Data Used in Development	Vehicle License (from DMV)
MY	EMFAC Factor or Data Used in Development	Model Year
OGV data	EMFAC Factor or Data Used in Development	Ocean-Going Vessel Model data
Pop	EMFAC Factor or Data Used in Development	Population (such as human population or vehicle population)
RCF	EMFAC Factor or Data Used in Development	Chip Reflash Correction Factor
RH	EMFAC Factor or Data Used in Development	Relative Humidity
SCF	EMFAC Factor or Data Used in Development	Speed Correction Factor
Sub-Area	EMFAC Factor or Data Used in Development	Usually GAI but could also be another regional designation (county, sub-county, etc.)
T&M	EMFAC Factor or Data Used in Development	Tampering and malfunction rates
Temp	EMFAC Factor or Data Used in Development	Temperature
TG	EMFAC Factor or Data Used in Development	Technology Group (for specific engine technology, may vary by vehicle class/fuel/MY)
TRUCRS data	EMFAC Factor or Data Used in Development	ARB's Truck Regulation Upload, Compliance, and Reporting System data
TW	EMFAC Factor or Data Used in Development	Tire Wear
UR	EMFAC Factor or Data Used in Development	Unemployment Rate
VC	EMFAC Factor or Data Used in Development	Combined vehicle class and fuel group (required for imported data)
Veh	EMFAC Factor or Data Used in Development	Vehicle
VIN	EMFAC Factor or Data Used in	Vehicle Identification Number (from DMV)

Acronym	Grouping	Definition
	Development	
VIUS	EMFAC Factor or Data Used in Development	Vehicle Inventory and Use Survey data (from BLS)
VMT	EMFAC Factor or Data Used in Development	Vehicle Miles Travelled
ZM	EMFAC Factor or Data Used in Development	Zero-Mile (for emission rates of new vehicles with no deterioration)
EMFAC	Emissions Modeling	ARB Emission Factors Model
GUI	Emissions Modeling	Graphical User Interface
MOBILE6	Emissions Modeling	U.S. EPA Motor Vehicle Emissions Simulator (older, not current model)
MOVES	Emissions Modeling	U.S. EPA Motor Vehicle Emissions Simulator
OGV	Emissions Modeling	Ocean-Going Vessel Model
PERE	Emissions Modeling	U.S. EPA MOVES Physical Emission Rate Estimator
SG	Emissions Modeling	Scenario Generator
VISION	Emissions Modeling	ARB Vision Scenario Planning Modeling Tool
CARB	Engine Technology/Control	Carbureted
CAT	Engine Technology/Control	Catalyst Equipped
DPF	Engine Technology/Control	Diesel Particultate Filter
EGR	Engine Technology/Control	Exhaust Gas Recirculation
FI	Engine Technology/Control	Fuel Injection System
GDI	Engine Technology/Control	Gasoline Direct Injection System
MFI	Engine Technology/Control	Multiport Fuel Injection System
NCAT	Engine Technology/Control	Non-Catalyst Equipped
OBD	Engine Technology/Control	On Board Diagnostic Control System
OEM DPF	Engine Technology/Control	Original Equipment Manufacturer Installed DPF (not a retrofit)
OxCat	Engine Technology/Control	Oxidation Catalyst System
PFI	Engine Technology/Control	Port-Fuel Injection System
SCR	Engine Technology/Control	Selective Catalytic Reduction
std	Engine Technology/Control	Standard (or stds for standards)
TBI	Engine Technology/Control	Throttle Body Injection System
TWC	Engine Technology/Control	Three Way Catalyst System
CNG	Fuel Type	Compressed natural gas
DSL	Fuel Type	Diesel
LNG	Fuel Type	Liquefied natural gas
LPG	Fuel Type	Propane
NG	Fuel Type	Natural gas
ACES	Measurement Terminology	CRC's Advanced Collaborative Emissions Study
avg	Measurement Terminology	Average
BAU	Measurement Terminology	Business as usual
ETW	Measurement Terminology	Equivalent Test Weight
g/bhp-hr	Measurement Terminology	grams per brake horsepower hour (may also be shown as g/bhp-h)
g/h	Measurement Terminology	grams per hour
g/mi	Measurement Terminology	grams per mile

Acronym	Grouping	Definition
gal	Measurement Terminology	Gallons
GVW	Measurement Terminology	Gross Vehicle Weight
GVWR	Measurement Terminology	Gross Vehicle Weight Rating
kmi	Measurement Terminology	Kilo (1000) miles
lbs	Measurement Terminology	pounds
mg/mi	Measurement Terminology	milligrams per mile
mi	Measurement Terminology	miles
mi/d	Measurement Terminology	miles per day
mi/h	Measurement Terminology	miles per hour
min	Measurement Terminology	minutes
mph	Measurement Terminology	miles per hour
pct	Measurement Terminology	percent
SHED	Measurement Terminology	Sealed Housing Evaporative Determination (for evaporative emissions testing)
TEU	Measurement Terminology	Twenty-Foot Equivalent Unit (intermodal container)
TPD	Measurement Terminology	tons per day
Wtd	Measurement Terminology	Weighted
CH4	Pollutant	Methane
CO	Pollutant	Carbon Monoxide
CO2	Pollutant	Carbon Dioxide
CO2e	Pollutant	Carbon Dioxide Equivalent
GHG	Pollutant	Greenhouse Gas
HC	Pollutant	Hydro-Carbons
NMOG	Pollutant	Non-Methane Organic Gas Emissions
NOx	Pollutant	Nitrous Oxides
PM	Pollutant	Particulate Matter
PM10	Pollutant	Particulate Matter with particles 10 microns or less in diameter
PM2.5	Pollutant	Particulate Matter with particles 2.5 microns or less in diameter
PM30	Pollutant	Particulate Matter with particles 30 microns or less in diameter
ROG	Pollutant	Reactive Organic Gases
THC	Pollutant	Total Hydro-Carbons
TOG	Pollutant	Total Organic Gases
ACC	Programs/Reports/Planning documents	ARB's California Advanced Clean Cars Program
BACT	Programs/Reports/Planning documents	Best Available Control Technology BACT Standard (specified in regulations)
CTF	Programs/Reports/Planning documents	CEIDARS Transfer Format
EIC	Programs/Reports/Planning documents	Emission Inventory Code System
EO	Programs/Reports/Planning documents	ARB Executive Order (EO No = Executive Order number)
I/M	Programs/Reports/Planning documents	Inspection and Maintenance Program (“Smog Check”)
ISOR	Programs/Reports/Planning documents	Initial Statement of Reasons (Regulatory Package Documentation)

Acronym	Grouping	Definition
PAVLEY	Programs/Reports/Planning documents	Federal Pavley Regulations (GHG emission reduction standards)
PL	Programs/Reports/Planning documents	Project Level (EMFAC2014 has PL Assessment Mode)
PT Rule	Programs/Reports/Planning documents	ARB Pulic Transit Regulation
RIA	Programs/Reports/Planning documents	EPA's Final Regulatory Impact Analysis
RTP	Programs/Reports/Planning documents	Regional Transportation Plan
SB375	Programs/Reports/Planning documents	Sustainable Communities and Climate Protection Act of 2008
SCS	Programs/Reports/Planning documents	Sustainable Community Strategies (required element of RTP)
SIP	Programs/Reports/Planning documents	State Implementation Plan (for Clean Air Act)
TIP	Programs/Reports/Planning documents	federal transportation improvement program
TSD	Programs/Reports/Planning documents	Technical Support Document
TTGHG	Programs/Reports/Planning documents	Tractor-Trailer Greenhouse Gas Regulation
ASM	Testing Terminology	Inspection & Maintenance Acceleration Simulation Mode Test Equipment
C3	Testing Terminology	AQMD refuse truck compaction cycle
CBD	Testing Terminology	Central Business District
FID	Testing Terminology	Flame Ionization Detector
FTP	Testing Terminology	Federal Testing Procedure
HS	Testing Terminology	High Speed
IM240	Testing Terminology	Inspection & Maintenance 240 Second Transient Test Cycle Equipment
LA 4 cycle	Testing Terminology	Test Cycle used prior to FTP
LS	Testing Terminology	Low Speed
PEMS	Testing Terminology	Portable Emission Measurement System
RTC	Testing Terminology	AQMD refuse truck test cycle
UC	Testing Terminology	Unified Cycle (Testing Procedure)
UCC	Testing Terminology	Unified Correction Cycle (Testing Procedure)
UDDS	Testing Terminology	Urban Dynamometer Driving Schedule
Ag	Vehicle Category	Agricultural Vehicles
AT PZEV	Vehicle Category	Advanced Technology Partial Zero-Emissions Vehicle
BEV	Vehicle Category	Battery-Electric Vehicle
EV	Vehicle Category	Electric Vehicle
FCV	Vehicle Category	Fuel-Cell Vehicle
HD	Vehicle Category	Heavy Duty Vehicle
HDT	Vehicle Category	Heavy Duty Truck
HHD	Vehicle Category	Heavy-Heavy-Duty Vehicle
HHDDT	Vehicle Category	Heavy Heavy-Duty Diesel Truck
HHDT	Vehicle Category	Heavy Heavy-Duty Truck (33000 lbs and over), also referred to as T7

Acronym	Grouping	Definition
HHDV	Vehicle Category	Heavy-Heavy-Duty Vehicle
LD	Vehicle Category	Light Duty Vehicle, also referred to as LDV
LDA	Vehicle Category	Passenger Car (0-3760 lbs.), also referred to as PC
LDT	Vehicle Category	Light Duty Truck
LDT1	Vehicle Category	Light-Duty Truck (0-3750 lbs.), also referred to as T1
LDT2	Vehicle Category	Light-Duty Truck (3751-5750 lbs.), also referred to as T2
LEV	Vehicle Category	Low Emission Vehicle
LEVII	Vehicle Category	Low Emission Vehicle II (meeting LEVII program standards)
LEVIII	Vehicle Category	Low Emission Vehicle III (meeting LEVIII program standards)
LHD	Vehicle Category	Light-Heavy-Duty Vehicle
LHD1	Vehicle Category	Light-Heavy-Duty Truck (8501-10000 lbs.), also referred to in the past as LHDT1
LHD2	Vehicle Category	Light-Heavy-Duty Truck (10001-14000 lbs.), also referred to in the past as LHDT2
LHDT	Vehicle Category	Light-Heavy-Duty Truck
MCY	Vehicle Category	Motorcycle, also referred to as MC
MD	Vehicle Category	Medium-Duty Vehicle, also referred to as MDV
MDT	Vehicle Category	Medium-Duty Truck (5751-8500 lbs.), also referred to as T3
MH	Vehicle Category	Motor Home
MHDT	Vehicle Category	Medium Heavy-Duty Truck 14001-33000 lbs), also referred to as T6
NNOOS	Vehicle Category	Out-of-State Vehicles from Non-Neighboring States
NOOS	Vehicle Category	Out-of-State Vehicles from Neighboring States (including BC, WA, OR , ID, NV, AZ)
OBUS	Vehicle Category	Other Bus (not owned or operated by transit agencies or school districts)
OOS	Vehicle Category	Out-of-State Vehicles
PAU	Vehicle Category	Public Agencies and Utilities (*fleets are subject to PAU rules*)
PC	Vehicle Category	Passenger Car (0-3760 lbs.), also referred to as LDA
PHEV	Vehicle Category	Plug-in Hybrid Vehicle
POAK	Vehicle Category	Port of Oakland Drayage Trucks
POLA	Vehicle Category	Port of Los Angeles Drayage Trucks
PTO	Vehicle Category	Power Take Off
PZEV	Vehicle Category	Partial Zero Emissions Vehicle
SBUS	Vehicle Category	School Bus
SULEV	Vehicle Category	Super Ultra-Low Emission Vehicle
SWCV	Vehicle Category	Solid Waste Collectioni Vehicle
T1	Vehicle Category	Light-Duty Truck (ETW < = 3750 lbs.), also referred to as LDT1
T2	Vehicle Category	Light-Duty Truck (ETW 3751-5750 lbs.), also referred to as LDT2
T3	Vehicle Category	Medium-Duty Truck (GVWR 6000-8500 lbs.), also referred to as MDT
T4	Vehicle Category	Light-Heavy-Duty Truck (GVWR 8501-10000 lbs.)
T5	Vehicle Category	Light-Heavy-Duty Truck (GVWR 10001-14000 lbs.)
T6	Vehicle Category	Medium Heavy-Duty Truck (GVWR 14001-33000 lbs), also referred to as MHDT
T6TS - GAS	Vehicle Category	Medium-Heavy Duty Gasoline Truck (GVWR 14001-33000 lbs), also referred to as MHDT

Acronym	Grouping	Definition
T7	Vehicle Category	Heavy Heavy-Duty Truck (GVWR 33000 lbs and over), also referred to as HHDT
T7IS - GAS	Vehicle Category	Heavy-Heavy Duty Gasoline Truck (GVWR 33000 lbs and over), also referred to as HHDT
TFV	Vehicle Category	Transit Fleet Vehicle (*fleets are subject to TFV rules*)
TZEV	Vehicle Category	Transitional Zero Emission Vehicle
UBUS	Vehicle Category	Urban Transit Bus, also referred to as UB or BT
ULEV	Vehicle Category	Ultra-Low Emission Vehicle
Veh	Vehicle Category	Vehicle
VV	Vehicle Category	Vocational Vehicles
ZEV	Vehicle Category	Zero Emissions Vehicle
ZEVII	Vehicle Category	Zero Emissions Vehicle (meeting ZEVII program standards)