2024 SmartWay Online Truck Tool: All Carriers

Technical Documentation

U.S. Version 1.0
(Data Year 2023)

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Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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1.0 Overview

This document provides detailed background information on the data sources, calculation methods, and assumptions used within the SmartWay Online Truck Tool for all carriers (OTT) for Data Year 2023, version 1.0. The Tool utilizes up-to-date emission factors, in combination with detailed vehicle activity data, to estimate emissions and associated performance metrics. The primary purpose of the Tool is to help fleets calculate actual pollutant emissions for specific truck types and applications and track their emissions performance over time. Shippers can, in turn, use the data that truck carriers report using these Tools to develop more advanced emissions inventories associated with their freight activity and to track their emissions performance over time.

The Tool allows the user to evaluate fleet performance in terms of different mass-based performance metrics for carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2.5}$), and black carbon (BC) including:[1]

- Grams per mile
- Grams per average payload ton-mile

The Tool can also generate estimates of emissions associated with the total miles, loaded miles, and revenue miles traveled by a fleet. Fleet performance can then be assessed at the truck-class and/or fuel-type level, or on an aggregated basis across all classes and fuels.

The Tool also collects extensive information on fleet operations and truck body types, allowing detailed segmentation of Partner fleets for more appropriate, equitable comparisons. For example, fleets that cube-out with low payloads (e.g., those hauling potato chips) will be able to compare themselves to similar fleets on a simple gram per mile basis, rather than a mix of fleets that includes fleets that routinely weigh-out. Similarly, fleets that operate in primarily urban environments at relatively low average speeds will have fundamentally different emission rates and constraints than fleets operating at highway speeds. By collecting detailed information on fleet operations (TL vs. LTL, urban vs. highway, etc.), as well as truck class (2b through 8b) and SmartWay Category (e.g., Dry Van, Reefer, Flatbed, etc.), individual fleets can compare their performance to other, similar fleets, which can help them to better manage their emissions performance.

[1] At this time, the OTT does not calculate performance metrics for specialty fleets that track their activity in terms of hours of use rather than miles traveled or freight hauled (e.g., refuse haulers and utility fleets). Future modifications may be made to the current Tool to accommodate such fleets.

2.0 Data Inputs and Sources

The OTT user provides most vehicle characteristic, operational, and activity data needed for emissions performance estimation (see Section 3 for more information). The Tool calculates emissions by multiplying fleet activity data with EPA-approved emission rate factors that are stored in look-up tables within the Tool.

The Tool contains different types of emission rate factors for different pollutants. CO_2 factors are expressed in grams of CO_2 *per gallon of fuel*.[2,3] NO_x, PM, and BC factors are expressed in grams of pollutant per mile traveled for operating emissions, and in grams per hour for idle emissions. In general, CO_2 factors are independent of the truck types, classes, and operational practices in a fleet. NO_x, PM and BC factors, however, vary depending upon a number of parameters, including:

- Truck class
- Engine model year/emission certification standard
- Vehicle speed
- Vehicle driving pattern (referred to as "drive cycle")

In addition, PM and BC emissions will also vary with the application of PM control retrofits, including diesel oxidation catalysts (DOC), closed crankcase ventilation (CCV), and diesel particulate filters ("PM traps" or flow-through filters). In the Tool, PM control retrofits are assumed to have the same impact on operating and idle emission factors, and control effectiveness for PM is assumed to equal the effectiveness for BC.[4]

2.1 CO_2 FACTORS

EPA populated the OTT with CO_2 factors that are based on fuel consumption. These factors and their sources and are summarized below in Table 1.

[2] At this time other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) are not included in the current Tool.

[3] The Tool also estimates Scope 2 emissions associated with battery-electric trucks. In this case pollutant emissions (CO_2, NOx, PM can BC) are determined based on the kWhrs used for charging. Scope 2 emissions are only reported in the Public Disclosure Report.

[4] Future versions of the Tool may account for differences in retrofit effectiveness for running versus idle emissions, and differences between PM and BC control effectiveness.

Table 1. CO_2 Factors by Fuel Type*

Fuel	g/physical gallon	Source[5]
Gasoline	8,887	(i)
Diesel	10,180	(ii)
Biofuel^ (100%)	9,460	(iii)
Ethanol (100%)	5,764	(iv)
CNG	7,030	(v)
LNG	4,394	(vi)
LPG	5,790	(vii)

* 100% combustion (oxidation) assumed

^ Biofuel includes biodiesel and renewable diesel

Note that the Tool calculates tailpipe emissions from biofuel blends (gasoline/ethanol, diesel/biofuel) by applying separate emission factors to the user-specified volume of each blend component. The Tool then adds the emissions from each blend component together to determine total CO_2 emissions. Therefore, emission factors for specific blend ratios are not needed for CO_2.[6]

Within the Tool, users may provide their CNG fuel use estimates in terms of gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in standard cubic feet (scf). If CNG consumption is expressed in DGE or scf, the Tool uses the following factors to convert the CNG fuel estimates to GGE.

For CNG:

- Diesel-Gallon Equivalent (DGE) to Gasoline-Gallon Equivalent (GGE)
  - 1 DGE = 1.112 GGE

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[5] i) Final Rule on Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards (75 FR 25324, May 7, 2010). The gasoline factor used in this rule was sourced from the California Air Resources Board and is based on measurement of carbon from a gasoline test fuel (indolene).

ii) Fuel economy calculations in 40 C.F.R 600.113 available at https://www.govinfo.gov/content/pkg/CFR-2004-title40-vol28/pdf/CFR-2004-title40-vol28-sec600-113-93.pdf, Accessed 12-8-23.

iii) Tables IV.A.3-2 and 3-3 in A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P1001ZA0.PDF?Dockey=P1001ZA0.PDF, Accessed 12-8-23.

iv) Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, September 15, 2009). Full source documentation is available on pp. 31-32 in the Technical Support Document, *Petroleum Products and Natural Gas Liquids: Definitions, Emission Factors, Methods and Assumptions*, available at

https://www.epa.gov/sites/production/files/2015-07/documents/subpartmmproductdefinitions.pdf, Accessed 12-8-23.

v) Calculations of Lifecycle Greenhouse Gas Emissions for the 2005 Gasoline and Diesel Baselines in the Notice of Availability of Expert Peer Review Record supporting the proposed revisions to the Renewable Fuel Standard Program (74 FR 41359) available in Docket EPA-HQ-OAR-2005-0161-0925.1 (Spreadsheet "Emission Factors").

vi) Assuming 74,720 Btu/gal lower heating value (https://afdc.energy.gov/fuels/properties, Accessed 12-8-23), and 0.059 g/Btu (from CNG calculation, source v).

vii) Table C-1 in the Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, October 30, 2009). Full source documentation is available in Table A-39 and pg. A-60 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2007* available at https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2007, Accessed 12-8-23.

[6] The Tool also estimates the barrels of petroleum required to make the reported gallons of diesel and gasoline based on national averages: 19 gallons of gasoline and 10 gallons of diesel assumed per barrel of petroleum.

- Note: 1 GGE = 125,000 BTU and 1 DGE = 139,000 BTU, so 1 DGE = 1.112 GGE (139,000/125,000).

- Cubic Feet (cuft) to Gasoline-Gallon Equivalent (GGE)
  - 123.57 cuft = 1 GGE[7]

For LNG, users may provide their fuel use estimates in terms of physical gallons, gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in pounds (lbs). If LNG consumption is expressed in GGE, DGE, or pounds, the Tool uses the following factors to convert the LNG fuel estimates to physical gallons.

For LNG:

- Diesel-Gallon Equivalent (DGE) to Physical Gallon
  - 1 DGE = 1.67 Gallons LNG[8]
- Gasoline-Gallon Equivalent (GGE) to Physical Gallon
  - 1 GGE = 1.50 Gallons LNG[9]
- Pounds (lbs) to Physical Gallon
  - 3.49 lbs LNG = 1 LNG Gallons[10]

When reporting fuel consumption and fuel efficiency across multiple fuel types, the OTT generally uses DGE for comparison. The following summarizes the DGE equivalent to one physical gallon of the fuel types included in the OTT.

- 1 gallon gasoline = 0.899 DGE
- 1 gallon LNG = 0.558 DGE
- 1 gallon CNG = 0.729 DGE
- 1 gallon E85 = 0.660 DGE
- 1 gallon B100 = 0.959 DGE
- 1 gallon LPG = 0.661 DGE
- 1 kWh electricity = 0.027 DGE*

*NOTE: the DGE conversion factor for electricity does not account for the very large efficiency improvement electric trucks obtain by eliminating the transmission, use of regenerative braking and other factors. The

[7] Alternative Fuels Data Center. Gasoline and Diesel Gallon Equivalency Methodology. https://afdc.energy.gov/fuels/equivalency_methodology.html, Accessed 12-8-23.

[8] Midwest Energy Solutions. Energy Volume & Weight.

[9] Ibid.

[10] Ibid.

California Air Resources Board (CARB) estimates the overall efficiency improvement of moving from conventional diesel trucks to electric power is a factor of 2.7, for an effective conversion factor of 0.0753 gallons of diesel per kWhr.[11] This factor is applied to electric truck energy consumption estimates in the tool to provide reasonable diesel-equivalent truck efficiency estimates.

CO_2e:

CO2 equivalent (CO_2e) emissions are provided in the tool's Public Disclosure report, and are calculated by multiplying CO_2 values by a scaling factor which varies by Scope:

Scope 1 emissions: CO_2e = CO2 x 1.02271

Scope 2 emissions: CO_2e = CO2 x 1.02038

The Scope 1 scaling factor was based on data from Table 2-13 in the most recent EPA Emissions and Sinks Report. The factor was derived by dividing the medium and heavy-duty truck emissions for each greenhouse gas excluding CO_2 (CH_4, N_2O, and HFCs) by the total emissions including CO_2, and then summing the ratios to obtain the total adjustment factor. The Scope 2 scaling factor was developed following the same method using emissions data for electricity-related transportation from Table 2-11 of the Emissions and Sinks Report.

2.2 NO_X, PM AND BC FACTORS

The OTT contains NO_x, PM_{10}, $PM_{2.5}$ and BC[12] emission factor outputs for on-road operation from EPA's MOVES3. 1 model for diesel and E10[13] for all heavy truck classes (2b – 8b) under national default temperature and fuel conditions, for model years 1993 and later, for the 2023 calendar year (see Appendix A for a full list of factors).[14] The emission factors are broken out by general drive cycle type (urban or highway), and average speed range, as discussed below.

Short-duration (less than 60 minutes) idle emission factors for NO_x, PM and BC were developed separately by model year, truck class, and fuel type (diesel and gasoline). MOVES3. 1 provides short duration idle in terms of grams and hours of off-network idle.

MOVES3.1 also provides emission factors for long-duration idle for long-haul combination diesel trucks. These factors are applied separately to the long-duration idle hour estimates provided for Class 8b trucks within the Tool.[15] Short-duration factors are applied to each of the truck class types.[16]

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[11] See https://ww2.arb.ca.gov/resources/documents/battery-electric-truck-and-bus-energy-efficiency-compared-conventional-diesel. Accessed 12-8-23.

[12] Black carbon factors are assumed to equal the elemental carbon gram per mile factors output by the MOVES model.

[13] All gasoline consumption in the United States and Canada is now assumed to consist of E10. Pure gasoline (E0) emission factors are no longer used in the Tool. References to "gasoline" in the Tool and the associated documentation refer to E10.

[14] Emission factors for model years prior to 1993 are assumed to equal the 1993 values, since 30 year old engines are assumed to be fully deteriorated by the MOVES model.

[15] NO_x factors for long-term extended idling are higher than short-duration factors (at least for late model engines) since engine operation temperatures and loads at idle are generally not high enough to activate late-model emission controls such as selective catalytic reduction and exhaust gas recirculation.

[16] MOVES3 is the first version of MOVES to include a class of trucks known as "gliders" that are trucks built by pairing a new chassis with an old diesel engine and powertrain. The OTT assumes no gliders are used by SmartWay partners, and emission factors do not reflect any gliders in the fleet.

Note that hybrid electric trucks are assumed to have no short-duration idle emissions (due to assumed engine auto-shut off), although long-duration idle (and regular exhaust[17]) emissions are assumed unchanged relative to their conventional vehicle counterparts. Finally, battery-electric trucks are assumed to have no idle emissions of either kind.

The resulting idle factors are presented in Appendix B.

Tool also calculates the NO_x, PM and BC emissions associated with transportation refrigeration (reefer) units. The MOVES emissions model was used to develop emission rates for these units for the 2023 calendar year, following these steps:

- A national average model run was performed for the Industrial sector, including gasoline and diesel fueled equipment;
- The A/C refrigeration (reefer) unit standard classification codes (SCCs) were extracted from the output files – 2265003060 (gasoline) and 2270003060 (diesel);
- Grams per day outputs for weekdays and weekends for each of the 12 months were converted to grams per year by aggregating emissions over day types to arrive at an average day value, multiplying by the number of days in each month, and summing over month. This resulted in annual grams of emissions (of NO_x and $PM_{2.5}$) and grams of fuel consumed (in terms of brake specific fuel consumption or BSFC), for each fuel type;
- BSFC was converted from grams to gallons fuel using the MOVES energy density values of 2,819 g/gal and 3,167 g/gal for gasoline and diesel, respectively.
- Grams/gallon emission factors were then calculated for each pollutant by dividing the annual grams of emissions of NO and $PM_{2.5}$ by the annual gallons of fuel consumed for gasoline and diesel.

Black carbon emissions associated with reefer activity were scaled from $PM_{2.5}$ reefer emissions, applying conversion factors for nonroad equipment from the Commission for Environmental Cooperation (0.349 for diesel engines and 0.122 for gasoline engines).[18] Table 2 provides the fuel factors used in the latest Tool.

Table 2. Weighted Average Reefer Fuel Factors (g/gallon)

Fuel	NO_x	$PM_{2.5}$	BC
Diesel	45.992	0.596	0.208
Gasoline	17.541	0.919	0.112

[17] While there is evidence that NO_x emissions may be decreased through the use of hybrid electric technology, EPA has not performed emission testing to assess this effect. Therefore, hybrid NO_x and PM/BC exhaust emission rates are assumed to equal conventional vehicle equivalents in the current Tool.

[18] Commission for Environmental Cooperation (CEC), 2015. North American Black Carbon Emissions Estimation Guidelines: Methods for Estimating Black Carbon Emissions. Prepared for the CEC by Eastern Research Group, Inc. Final Report, May 2015. http://www.cec.org/files/documents/publications/11629-north-american-black-carbon-emissions-recommended-methods-estimating-black-en.pdf. Accessed 12-8-23.

The next section describes the process followed to select the on-road emission factors from MOVES3.1 for use in the Tool. Emission factors in grams per mile were developed for E10 and diesel fuel types for all MOVES source types that correspond to the regulatory heavy-duty vehicle classes, 2b-8b inclusive. The MOVES source types modeled are shown in the table below. Of these, school buses, refuse trucks and motor homes represent only a small fraction of total activity.

Table 3. MOVES Source Types Associated with Class 2b – 8b Vehicles

Source Type ID	Source Type Name
31	Passenger Truck
32	Light Commercial Truck
43	School Bus
51	Refuse Truck
52	Single Unit Short-haul Truck
53	Single Unit Long-haul Truck
54	Motor Home
61	Combination Short-haul Truck
62	Combination Long-haul Truck

Separate factors were developed for "Urban" and "Highway/Rural" roadway types. These factors were apportioned according to MOVES operating mode groups, which correspond to speed ranges of 0-25 mph, 25-50 mph, and 50+ mph.

Emission factors calculated by the model, output by MOVES source type, were then converted to a vehicle class basis. In this way, the Tool can select appropriate emission factors for use by:

- weight class
- model year
- road type (urban vs. highway/rural)
- speed distribution

The following describes the methodology for the emission factor calculation.

Calculation of MOVES emission factors by operating mode

In calculating emission factors, the primary goal is to disaggregate factors by the percentage of time a given type of vehicle spends operating at certain speeds. The ranges of speeds analyzed include 0-25 mph, 25-50 mph, and greater than 50 mph. These speed ranges correspond to MOVES operating modes #11-16, 21-29, and 30-40 inclusive, where each operating mode is defined by both the speed of the vehicle and its vehicle specific power (VSP). First, for a given source type and model year, the fraction of emissions attributable to each range of speed was determined. Emissions for a vehicle can be expressed in Equation 1:

Equation 1

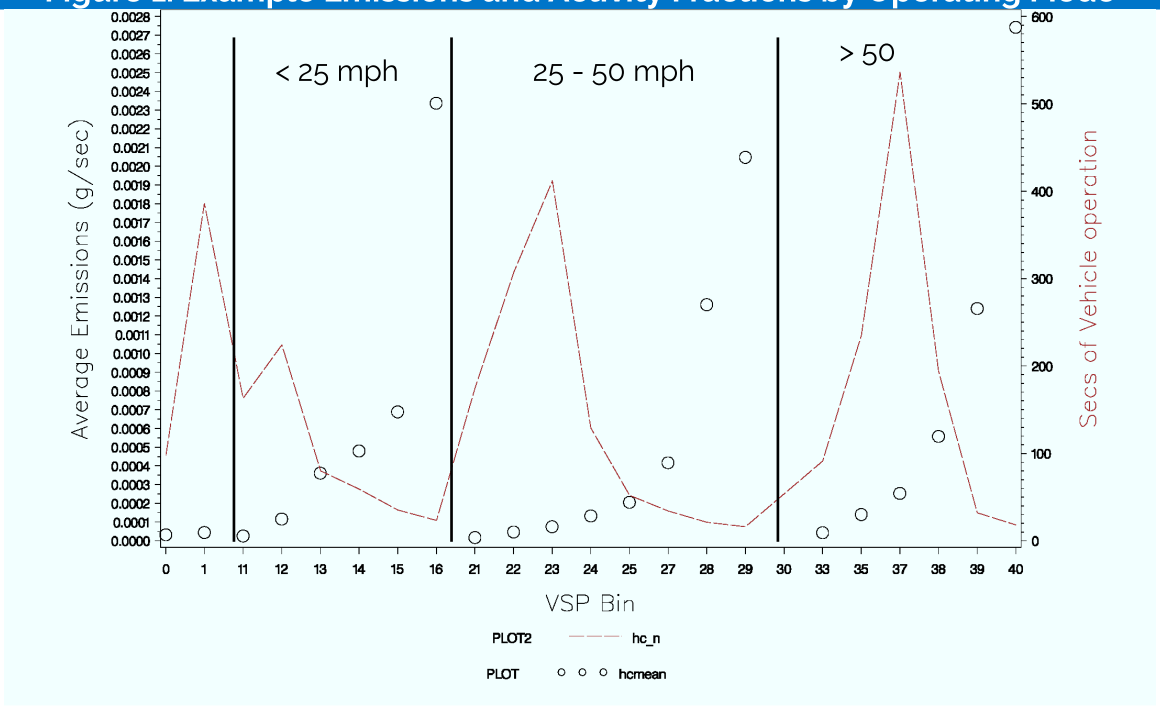
$$E` = A_1E_1` + A_2E_2` + A_3E_3` + A_IE_I + A_BE_B$$

Where:

$E`$	=	uncorrected[19] mass emissions calculated based on operating mode and emissions contribution by speed bin
$A_{1\text{-}3}$	=	the sum of activity fractions (in seconds) over speed range n. (A_I and A_B represent the activity associated with the individual operating modes for idling and braking, respectively.)
$E_{1\text{-}3}`$	=	the weighted average emissions over a given speed range n. (E_I and E_B represent the emissions associated with the individual operating modes for idling and braking, respectively.)

The following figure shows a range of emissions and activity fractions for an example source type and model year. The operating mode (or VSP bin) are shown on the x-axis. The dashed red line presents the fraction of vehicle activity associated with a given operating mode, while the black circles present average HC emissions for each operating mode.

Figure 1. Example Emissions and Activity Fractions by Operating Mode



[19] Subsequent adjustment factors are presented in Equation 3 below.

For our purposes, A_n from Equation 1 is obtained by retaining the “opmodefraction2” table from the “MOVESExecution” database, which is created by the Operating Mode Distribution Generator (OMDG) during a MOVES run. This table contains operating mode fractions by source type, roadway type, average speed bin, and pollutant/process. The fractions from this table are normalized using average speed distributions from the “avgspeeddist” table, and the sum of the normalized operating mode fractions in each speed bin constitutes A_n.

E_n` is derived from data obtained from the default MOVES “emissionratebyage” table. This table contains emission rates by pollutant process, operating mode, and age group for a wide variety of *sourcebinIDs*. For this analysis, a MySQL query was used to select *sourcebinIDs* corresponding to the source type, fuel type, and calendar year of interest, and limited our rate selection to the 4-5 year age group. The emissions obtained here were then converted to a source type basis (from their current *sourcebinID* basis); this was done by retaining the “sourcebindistribution” table from the MOVESExecution database, which is created by the Source Bin Distribution Generator (SBDG) during each MOVES run and weighting the activity fractions for each source type and model year combination in this table with the data from the “emissionratebyage” table described above. Having finished this mapping, an emission rate is generated, by source type and model year, for each operating mode (corresponding to the circles in the figure above). Since E_n` for each speed range represents the average emissions of the range weighted by the activity in that range, the weighted average emissions can be calculated from the 0-25 mph speed bin, $E_1$`, as follows in Equation 2:

Equation 2

$$E_1` = \frac{R_{11}T_{11} + R_{12}T_{12} + R_{13}T_{13} + R_{14}T_{14} + R_{15}T_{15} + R_{16}T_{16}}{\sum_{11}^{16} R_n}$$

Where:

R_n = The activity fraction for operating mode n, obtained from the “opmodedist2” table

T_n = The emissions for operating mode n.

Other speed bins will use different operating modes in their calculations; the equation above is merely an example illustrating the calculation method for the first speed bin. Having calculated an appropriate E_n` for each speed range for a given source type and model year, Equation 1 can be used, along with the appropriate activity fraction, to arrive at a total uncorrected emissions value. In and of itself, this emission factor has little value in estimating emissions. However, it can be used along with the modeled emission factor for a particular source type and model year to arrive at an overall adjustment factor, as shown in Equation 3:

Equation 3

$$Z = \frac{E}{E`}$$

Where:

E = The <u>modeled</u> emission, obtained from MOVES outputs, for an individual source type and model year

E` = The uncorrected emissions for an individual source type and model year, calculated using operating mode distributions and emission factors from the "emissionratebyage" table

This overall adjustment factor, in turn, can be applied to each individual emissions component, E_n`, as shown in Equation 4:

Equation 4

$$E_n = ZE_n`$$

The adjusted emissions, E_n, are subsequently used to calculate a total, corrected emission factor for a given source type and model year combination, as described by Equation 5:

Equation 5

$$E = A_1E_1 + A_2E_2 + A_3E_3 + A_IE_I + A_BE_B$$

In this way, a representative emission factor is calculated by operating mode/speed group. This will allow the Tool to adjust the default operating mode percentages (A_n) to more accurately represent a user-provided speed profile for the vehicles they are evaluating. Default operating mode percentages may also be used, as calculated above.

Conversion of Emission Factors from Source Type to Weight Class Basis

Ultimately, emission factor lookup tables are required for use in the Tool by weight class, fuel type, and model year. However, modeled output from MOVES is aggregated by source type. Therefore, a post-processing Tool was developed to convert vehicle emission factors from source types to weight class based on internal MOVES tables. The conversion methodology used in this Tool is described below.

First, the adjusted emissions and activity output from MOVES are combined, *by pollutantID*, by joining the "movesoutput" and "movesactivityoutput" tables by calendar year, source type, fuel type and model year. The sourcetype and model year for each record are combined in a new field, *sourcetypemodelyearID*.

Next, the emissions and activity output from the first step are combined with the MOVES "sizeweightfraction" table by joining on the *sourcetypemodelyearID*. The "sizeweightfraction" table contains, for a given combination of source type and model year, the fraction of vehicles apportioned across *weightclassID*. Given the *weightclassID*, the portion of emissions and activity attributable to a given range of vehicle weights is determined, and subsequently, those weights (along with fuel type) are mapped back to MOBILE6 vehicle classes, which are based on GVWR. (This is achieved with a separate lookup table, "M6VehType", which is derived from Appendix B, Table 3 of the EPA's MOBILE6.2 User's Guide.) For each calendar year, *sourcetypemodelyearID* and *pollutantID*, the sizeweightfraction is multiplied by the emissions (in grams) and activity (in miles) to obtain *EmissionFrac* and *ActivityFrac*, respectively.

Finally, the *EmissionFrac* and *ActivityFrac* calculated above are summed by *yearID*, *pollutantID*, *fueltypeID*, and vehicle class (e.g., HDDV8b). This provides total emissions and activity independent of the MOVES source type or vehicle model year. Finally, the aggregated emissions are divided by the activity to arrive at g/mi emission factors presented in Appendix A.

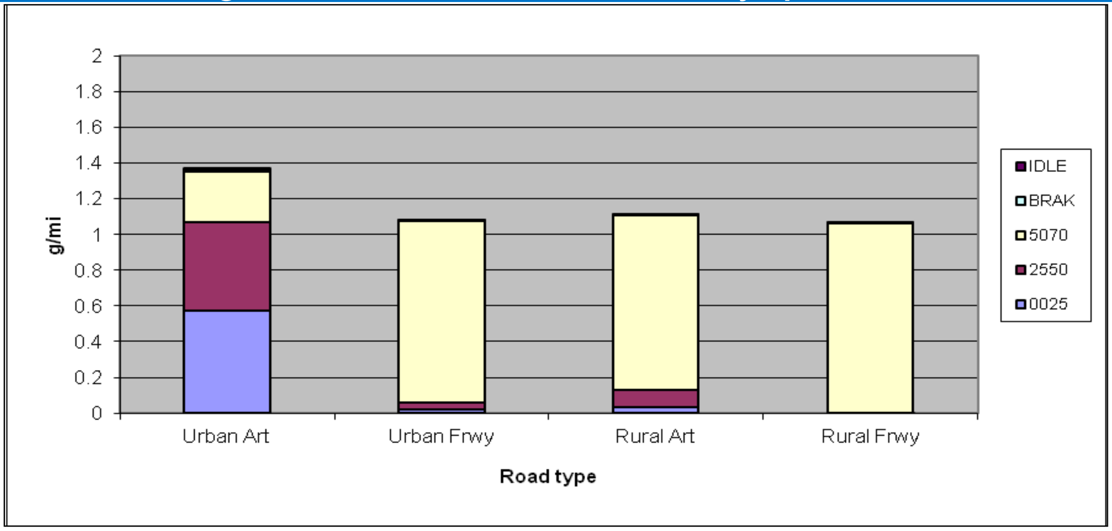
Modeling Gasoline Emission Rates

In a MOVES run that uses nationwide defaults for fuel supply, the model includes dozens of fuel formulations on a by-fuel region basis in its calculations. In addition to diesel fuels, many counties in the model defaults are characterized by varying market shares of and E10 and E15.[20]

Sensitivity Analysis Results

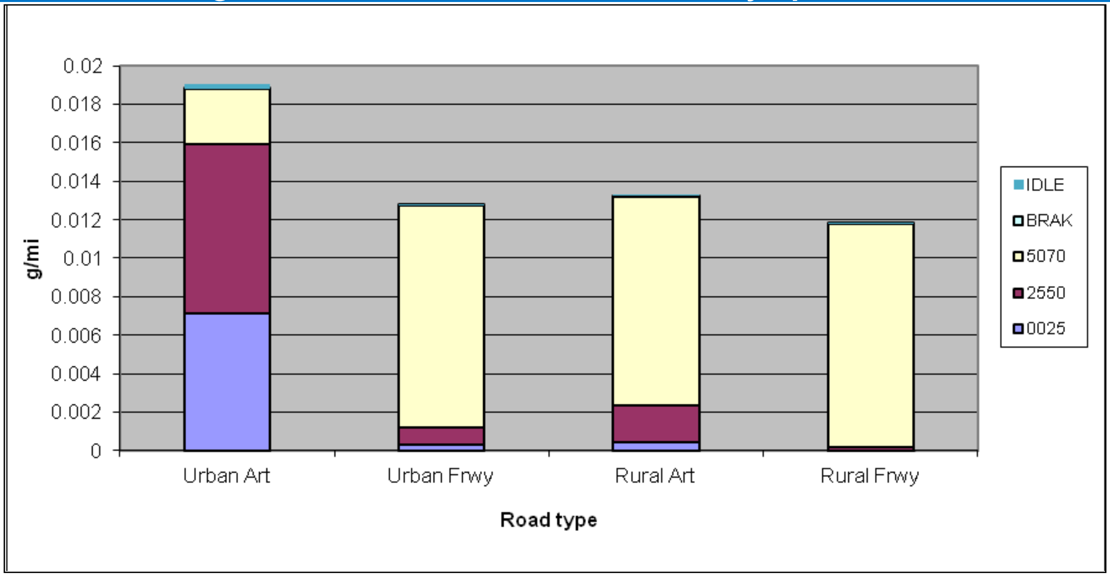
The relative emissions impact of different speed regimes was evaluated for four road types – urban arterial, urban freeway, rural arterial, and rural freeway. To simplify the sensitivity analysis, MOVES outputs were generated for diesel long-haul combination trucks, model year 2012, run for the 2014 calendar year, using national average defaults (e.g., fuel specifications, temperatures, etc.). The results of the analysis are shown for NOx and $PM_{2.5}$ below.

Figure 2. Default NO_x Contribution by Speed Bin



[20] Only 2001+ model year light-duty vehicles may use E15 fuel. See https://afdc.energy.gov/fuels/ethanol_e15.html. Accessed 12-8-23.

Figure 3. Default $PM_{2.5}$ Contribution by Speed Bin



As shown in the above charts, the emissions for urban freeways, rural arterials, and rural freeways are all heavily dominated by high speed (50 – 70 mph) operation.[21] In addition, actual emission levels are relatively insensitive to road type across these three types. However, speed distribution appears to have a significant bearing on emissions for urban arterial operation. Accordingly, the recommendation for Tool application was to develop fully disaggregated emission factor look up tables (retaining all four road types), and then weight urban freeway, rural arterial, and rural freeway road type operations to aggregate emission lookup tables within the Tool to reflect "urban" (i.e., urban arterial) and "other" road types. In addition, under this approach users can choose default speed distributions for these selections or specify the percent of operation by major speed range (0 – 25, 25 – 50, 50 – 70). Given the relative insensitivity to speed for the "other" category, specifying speed distributions would only be permitted for urban arterial operation.

Under this approach, the user is given the follow input options:

- Specify % Urban operation fraction
- Specify % distribution by speed bin for Urban operation, or select "default speed distribution"

Data entry is handled through the addition of a popup screen for non-default selections (see the OTT User Guide for details).

[21] This finding is consistent with the 2008 SmartWay Partner data submissions, wherein 87% of Partners selected the 50+ mph category as the most representative of their non-urban operations.

2.3 ALTERNATIVE FUELS

Heavy truck emission factors are not available from MOVES3.1 for certain alternative fuels, including E85 and LPG. Accordingly, EPA used adjustment factors from a number of sources described below to estimate NO_x and PM/BC factors for these other fuels.

NO_x and PM emission factors for biofuel are based on the findings from an EPA study, A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions (EPA420-P-02-001, October 2002). This study developed regression equations to predict the percentage change in NO_x and PM emission rates relative to conventional diesel fuel, as a function of biofuel blend percentage, expressed in the following form:

Equation 6

$$\% \text{ change in emissions} = \{\exp[a \times (\text{vol\% biofuel})] - 1\} \times 100\%$$

Where:

a = 0.0009794 for NO_x, and

a = -0.006384 for PM and BC[22]

Using Equation 6, adjustment factors were developed for biofuel blends based on the percentage of the biofuel component,[23] and then these adjustment factors were applied to the appropriate conventional diesel emission factors in Appendix A. (See Section 2.2 for the sources of conventional diesel emission factors). Note that the fleet-average blend value is assumed to be the same for all truck classes, since the biofuel consumption data is not collected at the truck class level. (This assumption holds for ethanol consumption data inputs as well.)

MOVES3.1 now incorporates specific modeling assumptions for biofuel, including options for modeling 5 and 20 percent biofuel (5% and 20%). While the pre-2007 vehicle estimates are consistent with EPA's 2002 study findings, MOVES does not estimate an emissions effect on 2007+ model year diesel trucks because the literature does not show consistent or significant biofuel effects on theses engines.[24, 25] Accordingly, the Tool only applies adjustment factors for diesel engine model years prior to 2007.

For gasoline-ethanol blends, the Tool only accepts fuel consumption estimates for E10 and E85 since ethanol is generally blended with gasoline at two discrete levels: 10% (E10) and 85% (E85). As discussed in Section 2.2 above, NO_x and PM factors for E10 were output directly from MOVES3.1. Given the lack of heavy-duty E85 test data, adjustment factors for E85 were based on emissions estimates for light-duty vehicles

[22] BC emission rates as a function of biofuel blend have not been identified at this time and are currently assumed identical to the PM relationship.

[23] Biofuel blend percentage is calculated by dividing 100%-equivalent gallons by total fuel gallons at the fleet level – see the OTT User Guide for details regarding biofuel use inputs.

[24] McCormick, R. and A. Williams, 2011. *Impact of Biodiesel on Modern Diesel Engine Emissions*. Project ID: FT011. National Renewable Energy Laboratory, Golden, CO. May 9, 2011. https://www.energy.gov/sites/prod/files/2014/03/f10/ft011_williams_2011_p.pdf, Accessed 12-8-23.

[25] CARB 2011. Final Report for the CE-CERT Engine Testing Portion for the CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California "Biodiesel Characterization and NOx Mitigation Study". Final Report Prepared for CARB. October 2011. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=9befb61c527cdb2a4f6eefdb1483cbbc6154c703, Accessed 12-8-23.

cited by the US DOE Alternative Fuels and Advanced Vehicles Data Center.[26] These estimates come from a technical paper published in the Journal of Air & Waste Management.[27] Relative to conventional gas vehicles, the authors of this paper estimate that vehicles running on E85 provide an average NO_x reduction of 54% (based on 73 vehicle tests), and an average PM reduction of 34% (based on 3 vehicle tests). These adjustment factors are applied to the appropriate gasoline engine emission factors in Appendix A to develop emission factors for E85.

Emission adjustment factors were used for gaseous fuels (LPG, CNG and LNG), developed by the National Renewable Energy Lab and University of West Virginia based on field studies on natural gas vehicles. For this assessment, it was assumed that CNG and LNG emissions were identical. In addition, it was also assumed LPG vehicle emissions would be equal to natural gas vehicle emissions.[28] To be conservative, the smallest emission reduction estimates were selected from the natural gas vehicle field test data (86% for PM and 17% for NOx) relative to comparable diesel vehicles. These adjustment factors are applied to the diesel emission factors in Appendix A and B to develop emission factors for these fuels.

Note, however, that the emissions associated with alternative fuels may be different for older trucks (with minimal emission controls) and newer trucks (with extensive control systems in place) due to recent vehicle emission standards. Newer studies suggest there are differences by model year in the emission rates of gaseous fuel vehicles. A 2014 study performed by West Virginia University[29] using Class 8 trucks found that a model year 2011 dual-fuel (5% diesel, 95% LNG) high-pressure direct injection (HDPI) truck emitted 63% and 48% less NO_x and PM, respectively compared to a MY 2011 diesel truck equipped with an SCR and DPF. Both vehicles operated on the urban dynamometer driving schedule (UDDS). The same WVU study found that a MY 2011 natural gas engine equipped with a three-way catalyst (TWC) emitted 79% and 56% less NO_x and PM compared to the MY 2011 diesel truck, also on the UDDS.

Based on this new information, the Tool uses a simple average across the two engines tested in the WVU study, resulting in a 71% reduction for NOx and a 52% reduction for PM, and applies these new reduction values to comparable diesel emission factors for 2010 and later model year gaseous fuel trucks. For model years prior to 2010, the adjustment factors of 17% for NO_x and 86% for PM are retained.

Emission estimates for battery-electric trucks are based on national average electric generation mix profiles from USDOE's GREET model, as described in Appendix C.

Black carbon (BC) emissions associated with gaseous fuels are determined by multiplying the ratio of elemental carbon (EC) and $PM_{2.5}$ emission factors from MOVES2014a for CNG transit buses, for calendar year 2018. The ratio EC to $PM_{2.5}$ varies by model year group (0.0925 for pre-2002 model years, and 0.1112 for 2002+

[26] See https://afdc.energy.gov/vehicles/flexible_fuel_emissions.html, Accessed 12-8-23.

[27] See https://afdc.energy.gov/files/pdfs/technical_paper_feb09.pdf, Accessed 12-8-23.

[28] The PM and NO_x estimates cited by this source for LPG vehicles were slightly lower than for natural gas vehicles - https://afdc.energy.gov/vehicles/propane_emissions.html Accessed 12-8-23. However, based on engineering judgment it was assumed that LPG PM and NO_x emissions would be similar to comparable CNG vehicles.

[29] Carder, D.K., M. Gautam, A. Thiruvengadam, M. Besch. *In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy-Duty Engines.* Prepared for the South Coast Air Quality Management District. September 2013. https://lazerinitiative.org/resources/in-use-emissions-testing-and-demonstration-of-retrofit-technology-for-control-of-on-road-heavy-duty-engines-2/, Accessed 12-8-23.

model years), so these different factors are applied for the different engine age groups as appropriate in order to determine BC levels for these fuel types.

2.4 PM CONTROL EFFECTIVENESS

The OTT applies adjustment factors to the PM emission factors in Appendix A and B for any pre-2007 diesel truck for which Partners have installed a specific retrofit control device. The following adjustment factors were obtained from EPA OTAQ (presented as a % reduction in emissions; see Section 3.2 below for details):

- Diesel oxidation catalyst (DOC) – 25%
- Closed crankcase ventilation (CCV) – 5%
- Diesel particulate filter (DPF) – 90%

References from EPA's Clean Diesel Program are generally consistent with the DOC and DPF effectiveness estimates above (20 – 40% for DOCs, and 85% or more for DPFs).[30,31] Note that an independent estimate of CCV effectiveness was not identified, as EPA and CARB only verify CCVs when packaged with DOCs.

The Tool applies the above adjustment factors to pre-2007 PM operating and idle emission estimates. The Tool also allows for situations where CCVs are applied in combination with either DOCs or DPFs. In such a case, the reduction effectiveness is calculated additively. For example, if pre-control operating emissions were 1.0 g/mile for a diesel truck, and a CCV and DOC were applied, the resulting emission rate would be:

Equation 7

$$1.0 \times [1 - (0.25 + 0.05)] = 0.07 \text{ g/mile, post-control}$$

However, the Tool assumes that DOC and DPF application are mutually exclusive.

At this time the relative effectiveness of the controls addressed above are assumed to be equal for PM and BC.

[30] EPA 2010a, National Clean Diesel Campaign Technical Bulletin: Diesel Oxidation Catalyst General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10031.pdf. Accessed 12-8-23.
[31] EPA 2010b, National Clean Diesel Campaign Technical Bulletin: Diesel Particulate Filter General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10029.pdf. Accessed 12-8-23.

3.0 Emission and Activity Estimation

The emission rates and adjustment factors discussed above are combined with appropriate activity data (provided by the Partners) to calculate mass emissions at the fleet and/or partner level for CO_2, NO_x, PM, and BC as described below.

3.1 CO_2 EMISSIONS

CO_2 is calculated within the Tool utilizing emission factors expressed in *grams per gallon of fuel*, (with the exception of battery-electric trucks), as discussed in Section 2.1 above. The general equation for calculating CO_2 emissions using reported fuel consumption values is

Equation 8

$$E_{CO2} = ((F - B) \times EF_F) + (B \times EF_B))$$

Where:

E_{CO2}	=	grams CO_2 per year
F	=	Total Fuel (Gallons per year)
B	=	Biofuel (Gallons per year)
EF_F	=	Fossil Fuel Emissions Factor (g/gal based on fuel type)
EF_B	=	Biofuel Emissions Factor (g/gal based on biofuel type)

Emissions for *all* pollutants for battery electric trucks are calculated by multiplying the reported kWhrs used for charging by the associated g/kWhr factor (see Appendix C).

In most instances, reefer fuel is aggregated with vehicle fuel inputs in the Tool, with the reefer fuel type assumed to be the same as the vehicle fuel type. However, reefer units associated with gaseous fuels (LPG, CNG, and LNG) and electric trucks are assumed to use diesel fuel (by far the most common type of reefer engine). Accordingly, any reefer fuel use reported for gaseous fuels and electric trucks is included in the total CO_2 calculation using the diesel fuel factors in Equation 8.

Fuel Allocation

The Tool asks users to enter Gallons of Fuel Used for Engine Power (including biofuel) by truck class to estimate CO_2 emissions. This information may be entered directly if available. However, if the user does not have this information but does know total fuel use and MPG by truck class, the Tool can be used to apportion fuel use across truck classes.

In the **Fuel Used for Engine Power** screen, the user can enter total fuel consumption and truck class MPG estimates. The tool then calculates the fuel used for each class based on the total fuel and class MPG. If the total fuel calculated matches the total fuel entered to within 2%, the allocator indicates a "Match".

3.2 NO_X, PM AND BC EMISSIONS

Unlike CO_2 emissions which only vary with fuel type, NO_x, PM and BC emission rates also vary substantially depending upon engine model year and/or emission certification level, vehicle class, drive cycle, speed, and operation mode (running or idle). For this reason, EPA developed lookup tables in the Tool with emission factors that correspond to user-supplied inputs regarding their fleet activity. The NO_x, PM and BC emission rates expressed in *grams per mile* were combined with the appropriate mileage metric (i.e., total miles) to estimate mass emissions. The general equation for calculating NO_x emissions is as follows:

Equation 9

$$E_{NOx} = \sum [(M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4)) \times T_{CY} / T_{CT}) + (GPH_{SDI} \times H_{SDI} \times T_{CY}) + (GPH_{LDI} \times H_{LDI} \times T_{CY})]$$

Where:

E_{NOx}	=	grams NO_x per year for a given truck class
$\sum$	=	summation across model years
M_C	=	Miles driven for Truck Class C per year
GPM_H	=	Grams/mi (by truck class & engine yr) for Highway/Rural Driving
HDC	=	Highway drive cycle % (% of miles under highway/rural driving)
$GPM_{U1/2/3/4}$	=	Grams/mi (by truck class & engine yr) for Urban Driving by mode (1 = 0 – 25 mph; 2 = 25 – 50 mph; 3 = 50+ mph; 4 = deceleration)
$UDC_{1/2/3/4}$	=	Urban drive cycle % (% of miles under urban driving conditions, by mode (1, 2, 3, 4))
T_{CY}	=	Number of trucks for a given Class/Year combination
T_{CT}	=	Number of trucks total for a given Class
GPH_{SDI}	=	Grams per hour (by truck class & engine year) for short-duration Idling[32]
H_{SDI}	=	Hours of short duration Idling per year (average per truck per year by class)
GPH_{LDI}	=	Grams per hour (by truck class & engine year) for long-duration Idling
H_{LDI}	=	Hours of long duration Idling per year (average per truck per year by class)

PM emissions for non-diesel vehicles are calculated using an equation identical to that for NO_x, utilizing PM emission factors. PM emission for diesel vehicles may be adjusted for PM control effectiveness, as shown below. (BC emissions are calculated in identical fashion.)

Equation 10

$$E_{PM} = \sum [((M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4)) \times T_{CY} / T_{CT}) + (GPH_{SDI} \times H_{SDI} \times T_{CY}) + (GPH_{LDI} \times H_{LDI} \times T_{CY})) \times (1 - ((0.25 \times T_{DOC} / T_{CY}) + (0.05 \times T_{CCV} / T_{CY}) + (0.9 \times T_{DPF} / T_{CY})))]$$

[32] The idle calculation for Class 8a and lighter trucks does not distinguish between short and long duration idling, and all idle hours are multiplied by the short duration idle factor for these trucks. Hybrid electric trucks are assumed to have no short-duration idling emissions, while battery-electric trucks have no idling emissions of any kind.

Where:

E_{PM}	=	grams PM per year for a given truck class
T_{DOC}	=	Number of trucks using Diesel Oxidation Catalysts by class
T_{CCV}	=	Number of trucks using Closed Crankcase Ventilation by class
T_{DPF}	=	Number of trucks using Diesel Particulate Filters by class
0.25	=	Effectiveness of DOCs (25%) at reducing particulate matter
0.05	=	Effectiveness of CCVs (5%) at reducing particulate matter
0.9	=	Effectiveness of DPFs (90%) at reducing particulate matter

Note the above calculation methodology assumes that the same highway/urban drive cycle fractions apply across all model years of a given truck class. Similarly, the method assumes that estimated idle hours apply equally to all model years of a given truck class.

The above methodology also utilizes estimates for the fraction of miles traveled associated with different road types and speed categories, as shown in the equations above. The Tool user must provide an estimate of the percent of total miles associated with urban driving for each truck class. The user may also provide percentages for the miles spent driving in urban conditions (e.g., unrestricted access, surface roads in well-traveled urban areas), for different speed categories (0 – 25 / 25 – 50 / 50+ mph). This information may be obtained from analysis of truck ECM or possibly GPS data. If urban speed distribution data is not available, the user may select to use default distributions, obtained from the MOVES model. The default speed distributions for urban operation (as defined in Section 2.2 above) varies with vehicle class and model year. However, the variation over model years is very slight (typically with a range of 1 to 2 percent for the largest speed category), the percentages were averaged over all model years for a given speed category/vehicle type combination for use within the Tool.

Table 4 presents the resulting default urban speed distributions by speed category for each truck class, for both diesel and gasoline vehicles. Note that the Tool utilizes the diesel default speed distributions for LPG, LNG, and CNG.

Table 4. Default Speed Category Distributions by Vehicle Class for Urban Operation (MOVES2010a basis)[33]

Vehicle Class	Speed Group	Percent by Class*
Diesels		
HDDV2b	0 - 25	35%
	25 - 50	38%
	50+	13%
	Deceleration	15%
HDDV3	0 - 25	41%
	25 - 50	36%
	50+	12%

Vehicle Class	Speed Group	Percent by Class*
Gasoline		
HDGV2b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%
HDGV3	0 - 25	45%
	25 - 50	34%
	50+	11%

[33] These values represent the urban component of driving only. If the user specifies a non-zero percentage for Highway/Rural driving, the values in the above table are automatically renormalized to make the sum across urban and highway operation modes equal to 100%.

Vehicle Class	Speed Group	Percent by Class*
	Deceleration	11%
HDDV4	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV5	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV6	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV7	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV8a	0 - 25	44%
	25 - 50	35%
	50+	12%
	Deceleration	9%
HDDV8b	0 - 25	45%
	25 - 50	34%
	50+	12%
	Deceleration	8%

Vehicle Class	Speed Group	Percent by Class*
	Deceleration	11%
HDGV4	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV5	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV6	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV7	0 - 25	45%
	25 - 50	32%
	50+	10%
	Deceleration	14%
HDGV8a	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV8b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%

* Class totals may not sum to 100% due to rounding error.

As seen in the above table, the MOVES model assumes that some fraction of vehicle operation is associated with "deceleration" events, evaluated independently from other operation due to their unique emission rate patterns.[34] However, it is assumed that most Tool users will not know their fleet's deceleration fraction. As such, the Tool will adjust any values input by the user to include a deceleration fraction based on MOVES model percentages. If the user selects the default urban speed distributions, the Tool will adjust the urban values from Table 4 to account for the percentage of miles for Highway/Rural operation as well. The following provides an illustrative example for calculating PM emissions for diesels given a specific set of road type/speed category distributions. NO_x and BC emission calculations follow the same procedure.

[34] MOVES also assigns some fraction of emissions to idle operation. However, operating fractions and emission factors associated with idle in MOVES outputs are expressed in grams per mile rather than grams per hour. Thus, to utilize the grams per hour emission factors developed for use in the Tool, MOVES outputs associated with idle operation were removed and the operating mode fractions for the four remaining categories were renormalized to equal 100%.

User specifies 1 Class 8b diesel, model year 2011, traveling 100,000 mi/yr.
User specifies the following Road type/speed category distributions:

60% urban, of which
50.0% is 0-25 mph
33.3% is 25-50 mph
16.7% is 50+ mph

For highway/rural operation, the lookup value from MOVES is 0.0187 g/mi for $PM_{2.5}$
For urban operation, the lookup values are as follows (2016 calendar year basis):

0-25:	0.0272 g/mi
25-50:	0.0463 g/mi
50+:	0.0233 g/mi
deceleration:	0.0015 g/mi

Now the urban speed distribution percentage inputs must account for deceleration, as follows:

0-25: 60% x 50% x sum of default percentages for the three speed bins (but excluding default deceleration fraction) = 30% x (45% + 34% + 12%) = 27.3%

25-50: 60% x 33.3% x sum of default percentages (45% + 34% + 12%) = 18.2%

50+: 60% x 16.7% x sum of default percentages (45% + 34% + 12%) = 9.1%

deceleration: remaining percentage, which equals 100% - 40% (highway) - 27.3% - 18.2% - 9.1% = 5.4%

Now apply these percentage weights to the total mileage, and then multiply by the corresponding emission factors to obtain mass, as follows:

Highway/rural component: 0.40 x 100,000 x 0.0187 = 748 grams
0-25 urban component: 0.273 x 100,000 x 0.0272 = 743 grams
25 - 50 urban component: 0.182 x 100,000 x 0.0463 = 843 grams
50+ urban component: 0.091 x 100,000 x 0.0233 = 212 grams
Deceleration urban component: 0.54 x 100,000 x 0.0015 = 81 grams

Therefore total = 2,627 grams of $PM_{2.5}$ (This value will then be summed with any other model year/vehicle class combinations and converted to short tons.)

As discussed in Section 2.3, the Tool assumes that 100%-equivalent biofuel volumes are distributed proportionately across all diesel vehicle classes. For example, if a fleet uses 100 B-100 equivalent gallons of biofuel, and 1,000 gallons of fuel total, the Tool assumes that B10 (100 / 1,000 = 10%) is the blend used by each truck class. Accordingly, emission rate adjustment factors are calculated for B10 using Equation 6 and applied to the diesel emission factors for each vehicle class.

Finally, note that the PM factors output by the MOVES model for use in the Tool are expressed in terms of $PM_{2.5}$. The MOVES model assumes a fixed ratio of PM_{10} / $PM_{2.5}$ for a given fuel type, as summarized below:

- Gasoline – 1.1304
- Diesel – 1.087

- CNG – 1.1304

These factors are applied directly to the $PM_{2.5}$ emission factors to obtain mass emission and performance metrics for PM_{10} within the Tool. In addition, it was assumed that LNG and LPG have PM ratios equivalent to the CNG value. The ratio for biofuel was assumed to equal that for diesel.

3.3 ACTIVITY CALCULATIONS

The Tool requires users to provide specific activity information on fuel consumption, miles traveled, payload, road type/speed, and idle hours at the vehicle class level for the emissions performance assessment (see Section 4.0 below). While the user may provide direct data inputs for any or all of these activity parameters, the Tool also allows the user to select default values for payload determination, in the absence of fleet-specific information. (Direct inputs for payload are highly preferred over the use of defaults.) The data sources and assumptions used to develop these default values are discussed below.

Default Payload Distributions

Average payloads can vary widely among fleets, even within a given vehicle class, depending upon commodity type and body/trailer type. With the exception of LTL and Package carriers (whose data are based on 2015 submissions), exact data entries were used from the 2011 Truck Tool submissions to obtain payload distributions for the current Tool.[35] This data was categorized by fuel type, truck class, and SmartWay Category. SmartWay Category is based on the Fleet Description inputs (e.g., Truckload Dry Van, Dray, Mixed, etc.). 1,850 unique records were identified using this categorization of the 2011 Partner data. This data was then reviewed, and four outliers were identified and removed from the data set.[36] Next, the payload data were aggregated across all SmartWay Category/truck class combinations.

Based on this data, Table 5 presents the payload averages and minimum/maximum values by truck class and SmartWay Category.[37] Note that the values presented below are not weighted by fleet size.

Table 5. Average, Min and Max Payloads (short tons) by Truck Class/SmartWay Category

SmartWay Category by Class	Avg Payload (tons)	Min	Max
Auto Carrier			
2b	0.64	0.001	5.70
3	1.26	0.001	9.00
4	2.04	0.001	12.00
5	3.05	0.001	15.90
6	4.49	0.001	20.70

[35] An evaluation of carrier payload data in 2016 found the vast majority of fleets selected from the tool's default ranges rather than providing exact values. Accordingly, the available 2016 data was not robust enough to use as the basis for an update to the existing ranges provided in the tool.

[36] Three Class 2bs were removed due to high payloads (16, 13, and 5 tons). A Class 8b truck was removed due to incongruous text explanation ("none used").

[37] Given the lack of data on non-diesel heavy-duty vehicles, payload ranges are assumed to apply to all fuel types.

SmartWay Category by Class	Avg Payload (tons)	Min	Max
7	5.90	0.001	60.00
8a	18.20	0.001	111.00
8b	18.20	0.001	111.00
Dray			
2b	0.77	0.001	5.70
3	1.50	0.001	9.00
4	2.27	0.001	12.00
5	3.39	0.001	15.90
6	4.14	0.001	20.70
7	5.53	0.001	60.00
8a	10.69	0.001	60.00
8b	18.46	0.001	150.00
Expedited			
2b	0.64	0.001	5.70
3	1.26	0.001	9.00
4	2.04	0.001	12.00
5	3.05	0.001	15.90
6	4.49	0.001	20.70
7	6.04	0.001	60.00
8a	10.92	0.001	111.00
8b	23.66	0.001	150.00
Flatbed			
2b	1.19	0.001	5.70
3	1.26	0.001	9.00
4	2.68	0.001	12.00
5	3.05	0.001	15.90
6	4.67	0.001	20.70
7	7.05	0.001	24.00
8a	13.51	0.001	72.00
8b	22.50	0.001	99.90
Heavy/Bulk			
2b	1.19	0.001	5.70
3	1.50	0.001	9.00
4	2.79	0.001	12.00
5	3.39	0.001	15.90
6	4.84	0.001	20.70
7	7.45	0.001	60.00

SmartWay Category by Class	Avg Payload (tons)	Min	Max
8a	18.20	0.001	111.00
8b	29.20	0.001	150.00
LTL/Package			
2b	0.73	0.001	5.70
3	1.23	0.001	9.00
4	1.90	0.001	12.00
5	2.63	0.001	15.90
6	3.31	0.001	20.70
7	4.89	0.001	60.00
8a	8.15	0.001	60.00
8b	15.29	0.001	150.00
Mixed			
2b	0.64	0.001	5.70
3	1.26	0.001	9.00
4	2.04	0.001	12.00
5	3.05	0.001	15.90
6	4.49	0.001	20.70
7	6.04	0.001	60.00
8a	10.92	0.001	111.00
8b	23.66	0.001	150.00
Moving			
2b	0.58	0.001	5.70
3	1.08	0.001	9.00
4	1.41	0.001	12.00
5	2.91	0.001	15.90
6	4.17	0.001	20.70
7	5.38	0.001	60.00
8a	12.71	0.001	111.00
8b	14.13	0.001	111.00
Refrigerated			
2b	0.77	0.001	5.70
3	1.50	0.001	9.00
4	2.27	0.001	12.00
5	3.39	0.001	15.90
6	4.84	0.001	20.70
7	6.03	0.001	60.00
8a	9.76	0.001	82.50

SmartWay Category by Class	Avg Payload (tons)	Min	Max
8b	20.10	0.001	82.50
Specialized			
2b	0.58	0.001	5.70
3	1.08	0.001	9.00
4	1.41	0.001	12.00
5	2.91	0.001	15.90
6	4.17	0.001	20.70
7	5.38	0.001	60.00
8a	12.71	0.001	111.00
8b	14.13	0.001	111.00
Tanker			
2b	0.64	0.001	5.70
3	1.26	0.001	9.00
4	2.04	0.001	12.00
5	3.05	0.001	15.90
6	4.49	0.001	20.70
7	7.45	0.001	60.00
8a	12.12	0.001	72.00
8b	24.90	0.001	103.80
TL/Dry Van			
2b	0.77	0.001	5.70
3	1.50	0.001	9.00
4	2.27	0.001	12.00
5	3.39	0.001	15.90
6	4.14	0.001	20.70
7	5.53	0.001	60.00
8a	10.69	0.001	60.00
8b	18.46	0.001	150.00

The values above serve as the basis for the default payload ranges provided in the Tool payload drop-down menu. For most vehicle class/SmartWay Category combinations,[38] five default ranges are offered for Partner selection:

- Range 1: from 0.01 tons to (Average payload – 2 x standard deviation);

[38] In a few instances, the calculated lower bound value for Range 2 was less than zero. In these cases, the lower bound value for Range 2 was set to 0.001 and the Payload screen displays Range 1 as "N/A".

- Range 2: from (Average payload – 2 x standard deviation) to (Average payload – 1 x standard deviation);
- Range 3: from (Average payload – 1 x standard deviation) to (Average payload + 1 x standard deviation);
- Range 4: from (Average payload + 1 x standard deviation) to (Average payload + 2 x standard deviation); and,
- Range 5: from (Average payload + 2 x standard deviation) to (Average payload + 3 x standard deviation).

Once a particular range is selected, the midpoint of the range is used to estimate class/SmartWay Category-level average payload, which in turn is used directly in determining grams per ton-mile performance metrics for the fleet.

Payload data based on bills of lading and entered directly into the payload screen are validated using the same data described above (see Section 3.4).

Brokered Freight

If a fleet brokers out more than 20% of its annual freight, this activity must be reported using the OTT or the online Logistics Tool. If you select the Logistics Tool to report your brokered activity you will need to provide miles or ton-miles for each company you broker your loads to. Otherwise, you can complete the OTT including your brokerage information, and the tool will apply default gram per ton-mile factors to estimate the emissions associated with this activity. You can specify your annual brokerage activity data in terms of:

- Ton-miles
- Miles
- Number of loads
- Amount spent

Ton-miles is the preferred metric for reporting brokered activity. Activity reported using other options is converted to ton-mile-equivalents using the following defaults.

1. If the user provides total miles, the OTT multiplies this value by the average payload value for the carrier as a whole to obtain ton-miles.
2. If the user provides the number of loads brokered out, the OTT multiplies this value by 527 miles/load to convert to total miles, then converts to ton-miles.

3. If the user provides total amount spent on brokered freight, the OTT divides this value by $3.00/mile[39] to obtain total miles, then converts to ton-miles.

After conversion, total ton-miles are multiplied by default gram per ton-mile emission factors for Non-SmartWay General Truck fleets for the current Data Year[40] to obtain total mass emissions for brokered activity, summarized in the OTT Emission Report. This report also presents emission factors for the non-brokered fleet as well as composite factors for brokered plus non-brokered activity. The equations used to calculate composite gram per mile and gram per ton-mile emission factors (EFs) are as follows.

G/Mile metrics

$$Composite\ EF = \frac{(partner\ fleet\ EF\ x\ Miles) + (nonSmartWay\ EF\ x\ Miles)}{Total\ Miles}$$

G/Ton-mile metrics

$$Composite\ EF = \frac{(partner\ fleet\ EF\ x\ TonMiles) + (nonSmartWay\ EF\ x\ TonMiles)}{Total\ TonMiles}$$

Composite emission factors will be used to rank your fleet against others in the same SmartWay Category.

3.4 DATA VALIDATION

The OTT has a number of standard logical, range and value checks that must be passed before Partners can submit their data to EPA. Many of these checks simply confirm the presence of required data (e.g., total miles for each truck class selected), or the accuracy of logical relationships (e.g., revenue miles less than or equal to total miles). The list of these basic checks is provided below. Partners will not be able to finalize their fleet files until all associated errors have been resolved. Also note that there is an implicit validation check on all numeric fields because the system will not accept non-numeric characters (including minus signs).

Table 6. Basic Range and Logical Checks

Contact Information	User must enter at least two distinct contacts.
Fleet Description	User must include a Partner Name.
Fleet Description	If entered, SCACs must be between 2 and 4 characters in length, and at least one character must be a letter. Multiple SCACs must be separated by commas.
Fleet Description	If entered, MCNs must be between 6 and 7 digits.
Fleet Description	If entered, DOT numbers must be 7 digits or less.
Fleet Description	User must select a Fleet Type.
Fleet Description	The Operation Category totals must add up to 100%.
Fleet Description	The Body Type totals must add up to 100%.

[39] Approximate U.S. national weighted average for dry van, flatbed, and reefer fleets. See https://www.dat.com/industry-trends/trendlines. Accessed 12-8-23.

[40] See the SmartWay Shipper Tool Technical Documentation for details regarding non-SmartWay fleet performance metrics.

Fleet Description	If a value for the Special Hauler body type is entered, a description must be provided.
Fuel Type	User must select at least one fuel type.
Fuel Type	If Reefer Body Type has been specified for a fleet, user must select at least one truck fuel type utilizing reefers.
Model Year & Class	At least one truck class must be selected.
Model Year & Class	Total truck counts for each selected truck class cannot be zero.
Activity Information	For all numeric fields except Empty Miles, Biofuel gallons, and Idle Hours, the value must be greater than zero. (An explanation must be provided for zero Empty Miles and idle hours).
Activity Information	For mileage and gallons fields, enter exact rather than rounded values. (warning)
Activity Information	For Revenue Miles, the amount cannot exceed the number of Total Miles Driven.
Activity Information	Revenue Miles that are significantly outside the expected range for percent of total miles for the given truck class (based on a lookup table) must be explained.
Activity Information	For Empty Miles, the amount must be less than the number of Total Miles.
Activity Information	Empty Miles that are significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Distance per truck that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	On the Biofuel Blend Calculator, the total gallons of biofuel cannot exceed the amount entered for Total Fuel.
Activity Information	For Idle Hours, the value cannot exceed 8,760 per year per truck.
Activity Information	Short duration idle hours + long duration idle hours cannot exceed 24 hours per truck.
Activity Information	For Idle Hours, values significantly outside the expected range for daily short duration idle hours, daily long duration idle hours, and average number of days on the road must be explained.
Activity Information	MPG must be greater than zero.
Activity Information	MPG that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Reefer fuel inputs for each fuel type must be less than 50% of the total fuel volume used for reefer truck engine power.
Activity Information	Reefer fuel as a percent of fuel used for reefer truck engine power that is significantly outside the expected range (based on lookup table) must be explained.
Payload Information	Zero is not a valid value for any payload (absolute minimum payload = 0.001 tons).
Payload Information	Values that are significantly outside the expected range for the truck class must be explained.
Data Sources	Data sources for Total Miles Driven, Gallons of Fuel Used, Average Payload, and Other Data must be specified.

Additional, rigorous validation checks of key data inputs are also needed to ensure the overall quality of the performance metrics calculated by the Tool. Validation checks serve three purposes to this end. First, unusually high or low values can be identified and flagged for the user's attention before finalizing inputs. For example, a user may misplace a decimal, inadvertently add an extra zero, or utilize the wrong units (e.g., reporting pounds instead of tons for payload) upon data entry. By comparing these data entries to reliable industry averages and distributions, these values can be flagged allowing users to quickly correct such errors.

Second, under certain circumstances Partners may operate their fleets under atypical conditions, resulting in extreme (outlier) data values. For example, permitted heavy-haul operations may routinely exceed industry-average payload values by 10 or more tons. By flagging such data entries Partners have the opportunity to provide additional information regarding their unique operating conditions through use of the Tool comment fields.

Finally, independent criteria can be established to ensure that data inputs are never allowed to exceed certain physically-constrained absolute limits. For example, a truck cannot exceed roughly 500,000 miles per year, even with dual drivers and minimal maintenance time, simply due to the available hours per year and highway speed limits. Data values above these absolute maximum levels are not allowed by the Tool, and users are required to modify the associated inputs before proceeding.

The following presents the Tool validation ranges for all parameters but payload, which is discussed above. Validation flags are of three types:

- "Yellow" values indicating that the input or derived performance value is notably lower/higher than the expected value. Partners may enter an explanation backing up such entries, but this is not mandatory.
- "Red" values indicating that the input or derived performance value differs greatly from the expected value. In this case the partner must enter text explaining why this value is accurate. Once entered, the value will change from "Red" to "Yellow" on the data entry screen.
- "Absolute errors" exceed values deemed physically possible and must be changed in order to be accepted by the tool.

Reefer Fuel Validation

1,008 diesel fleets designated as "Reefer" for the 2019 calendar year were evaluated to determine the distribution of the fraction of reefer fuel consumption to total fuel consumption. Four of these observations were dropped from the analysis data set, having greater than 50% of their total fuel consumption attributed to reefer fuel.[41] As shown in Figure 4 below, the distribution for the remaining reefer fleets was highly skewed toward low fractions (reefer consumption / total consumption). For this reason, the Tool does not generate Range 1 or Range 2 warnings at the low end of the distribution. Range 4 and Range 5 warnings were set to flag upper end reefer fuel consumption percentages as shown in Table 7.

[41] EPA suspects these reefer trucks are primarily used for storage rather than transportation. An additional validation rule has been adopted to flag such entries as errors.

Figure 4. Number of Observations vs Fraction of Fuel Used by Reefers

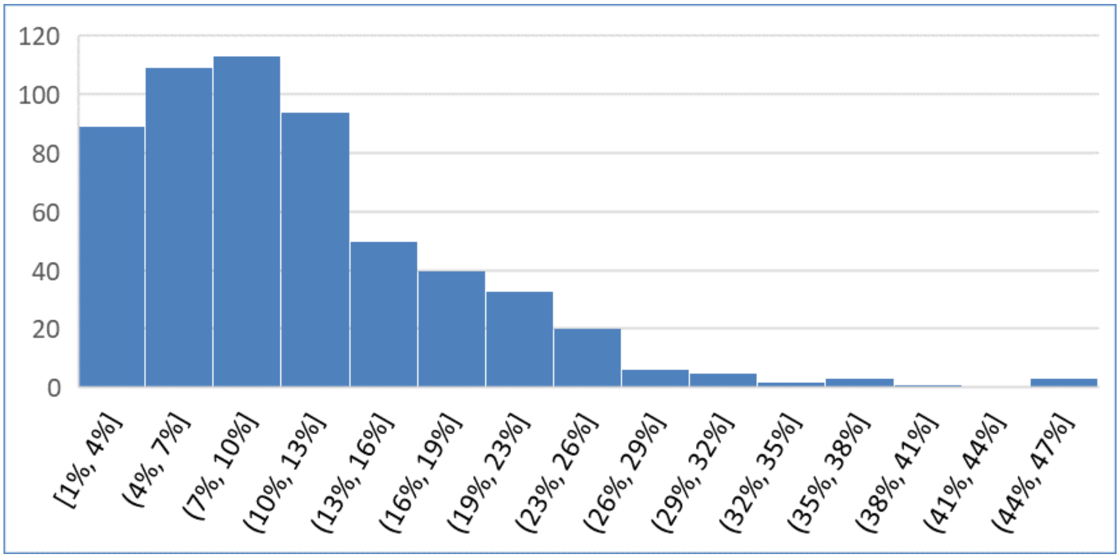


Table 7. Reefer Fuel Consumption Validation Ranges

Range	Min	Max	% of Obs
Range 1	**N/A**	**N/A**	**N/A**
Range 2	**N/A**	**N/A**	**N/A**
Range 3	>0	19%	92.7%
Range 4	19%	26%	5.6%
Range 5	26%	50%	1.7%

The mean of the distribution shown in Figure 4 (11%) can be used as the default percentage reefer fuel consumption if the partner lacks data for this parameter.

The percentages discussed above are multiplied by the total fuel value entered on the Activity screen (engine fuel plus reefer fuel) to determine the Reefer fuel validation ranges and default values for a given fleet. If the percentage designated as "Reefer" in the Body Types section of the Tool is less than 100%, then the validation ranges and default value are scaled downward by the reported percentage.

Data Processing

Except as noted, the validation range recommendations are based upon a distributional analysis performed on the 2015 Truck Partner input and performance data.[42] Fleet level data was grouped by truck class and bin category. If a particular combination had less than 20 fleets, it was aggregated to the next "higher" level until

[42] Miles per gallon distributions were updated based on 2019 partner data to reflect recent changes in fleet fuel efficiency.

at least 20 fleets were included. This process resulted in 29 groupings, as shown in Table 8. Note these groupings are mutually exclusive – e.g., "Class 6_Mixed" (Group 6) includes all Class 6 vehicles with the exception of TL/Dry Van, LTL/Dry Van, and Package (Groups 8, 10, and 11).

Table 8. Truck Fleet Groupings Used for Distributional Analysis

Group #	Name	# Fleets
1	2B_Expedited	35
2	2B_Mixed	96
3	2B_Package	34
4	2B_TL/Dry Van	42
5	3_Mixed	85
6	4_Mixed	71
7	5_Mixed	59
8	6_LTL/Dry Van	55
9	6_Mixed	124
10	6_Package	25
11	6_TL/Dry Van	51
12	7_LTL/Dry Van	61
13	7_Mixed	144
14	7_TL/Dry Van	44
15	8A_LTL/Dry Van	54
16	8A_Mixed	106
17	8A_Refrigerated	21
18	8A_TL/Dry Van	61
19	8B_AutoCarrier	36
20	8B_Dray	109
21	8B_Expedited	26
22	8B_Flatbed	159
23	8B_Heavy/Bulk	22
24	8B_LTL/Dry Van	106
25	8B_Mixed	470
26	8B_Refrigerated	574
27	8B_Specialized	60
28	8B_TL/Dry Van	912
29	8B_Tanker	84

A distributional assessment was then performed for each of the above groupings for the following parameters.

- Miles per vehicle
- Miles per gallon
- Revenue Miles (as a percent of total miles)
- Empty Miles (as a percent of total miles)

The following parameters were not updated based on 2015 data due to one of two reasons: (1) the data set for 2015 was too thin, or (2) the majority of the data relied on default values.

- Percent Biofuel
- Percent Miles Traveled, Urban
- Percent Miles Traveled, Highway
- Average Idle Hours per Year

ERG then identified suspected outliers and erroneous data entry values for each parameter/group combination, based on the criteria presented in Table 9.

Table 9. Outlier Definition

Metric	Unreasonably Low	Unreasonably High
Miles per Vehicle	Mean – 3*Std dev	Mean + 3*std dev
MPG	0	Mean + 3*std dev
Percent Revenue Miles	<40	100
Percent Empty Miles	0	>60
Percent Biofuel	0	>20
Percent Urban Operation	0	100
Percent Highway Operation	0	100
Average Idle Hours	0	Mean + 3*std dev

Using these criteria ERG identified 132 values, which were subsequently dropped from the data set in order to develop "yellow" and "red" validation ranges for generalized distributions. The dropped values are shown below in Table 10.

Table 10. Values Flagged as Outliers

Parameter	Class/Category	Value	Mean
gallons per year	2B_Expedited	412,514	53,503
gallons per year	2B_Mixed	1,118,423	97,172
gallons per year	2B_Mixed	2,575,025	97,172

Parameter	Class/Category	Value	Mean
gallons per year	2B_Mixed	1,155,575	97,172
gallons per year	2B_Package	16,598,790	1,573,156
gallons per year	2B_Package	18,812,438	1,573,156
gallons per year	2B_TL/Dry Van	9,561,432	297,320
gallons per year	3_Mixed	7,488,083	566,721
gallons per year	3_Mixed	6,000,532	566,721
gallons per year	3_Mixed	10,025,500	566,721
gallons per year	3_Mixed	6,895,410	566,721
gallons per year	4_Mixed	32,131,244	1,287,415
gallons per year	4_Mixed	23,340,749	1,287,415
gallons per year	5_Mixed	5,886,948	526,173
gallons per year	5_Mixed	8,195,008	526,173
gallons per year	5_Mixed	5,391,967	526,173
gallons per year	6_LTL/Dry Van	3,981,088	229,194
gallons per year	6_LTL/Dry Van	2,229,735	229,194
gallons per year	6_Mixed	971,878	64,977
gallons per year	6_Mixed	434,514	64,977
gallons per year	6_Mixed	655,144	64,977
gallons per year	6_Package	42,086,822	5,063,945
gallons per year	6_TL/Dry Van	4,063,283	202,354
gallons per year	7_LTL/Dry Van	2,027,074	251,393
gallons per year	7_LTL/Dry Van	2,991,399	251,393
gallons per year	7_LTL/Dry Van	2,241,644	251,393
gallons per year	7_Mixed	6,172,258	273,971
gallons per year	7_Mixed	3,374,633	273,971
gallons per year	7_Mixed	5,989,442	273,971
gallons per year	7_Mixed	3,559,828	273,971
gallons per year	7_TL/Dry Van	4,950,320	262,592
gallons per year	8A_LTL/Dry Van	36,116,464	3,648,512
gallons per year	8A_LTL/Dry Van	53,625,048	3,648,512
gallons per year	8A_Mixed	57,351,694	986,765
gallons per year	8A_Refrigerated	5,643,067	443,374
gallons per year	8A_TL/Dry Van	70,846,629	2,760,796
gallons per year	8B_AutoCarrier	25,533,283	3,748,093
gallons per year	8B_Dray	14,150,069	1,604,817

Parameter	Class/Category	Value	Mean
gallons per year	8B_Dray	34,766,125	1,604,817
gallons per year	8B_Dray	13,354,331	1,604,817
gallons per year	8B_Expedited	1,424,076	218,990
gallons per year	8B_Flatbed	36,752,966	2,361,101
gallons per year	8B_Flatbed	34,640,701	2,361,101
gallons per year	8B_Flatbed	17,704,415	2,361,101
gallons per year	8B_Flatbed	17,023,256	2,361,101
gallons per year	8B_Heavy/Bulk	9,404,277	1,037,619
gallons per year	8B_LTL/Dry Van	92,200,872	7,616,076
gallons per year	8B_LTL/Dry Van	124,000,000	7,616,076
gallons per year	8B_LTL/Dry Van	89,849,912	7,616,076
gallons per year	8B_Mixed	66,558,332	2,535,432
gallons per year	8B_Mixed	37,456,768	2,535,432
gallons per year	8B_Mixed	59,418,064	2,535,432
gallons per year	8B_Mixed	48,225,936	2,535,432
gallons per year	8B_Mixed	180,000,000	2,535,432
gallons per year	8B_Mixed	119,000,000	2,535,432
gallons per year	8B_Refrigerated	33,225,674	1,941,435
gallons per year	8B_Refrigerated	42,919,799	1,941,435
gallons per year	8B_Refrigerated	28,773,217	1,941,435
gallons per year	8B_Refrigerated	37,152,519	1,941,435
gallons per year	8B_Refrigerated	20,502,480	1,941,435
gallons per year	8B_Refrigerated	53,869,408	1,941,435
gallons per year	8B_Refrigerated	18,295,369	1,941,435
gallons per year	8B_Refrigerated	18,899,380	1,941,435
gallons per year	8B_Refrigerated	31,452,760	1,941,435
gallons per year	8B_Refrigerated	67,708,438	1,941,435
gallons per year	8B_Specialized	109,000,000	3,815,822
gallons per year	8B_TL/Dry Van	39,566,042	3,015,269
gallons per year	8B_TL/Dry Van	86,776,622	3,015,269
gallons per year	8B_TL/Dry Van	41,147,713	3,015,269
gallons per year	8B_TL/Dry Van	40,502,655	3,015,269
gallons per year	8B_TL/Dry Van	102,000,000	3,015,269
gallons per year	8B_TL/Dry Van	47,825,507	3,015,269
gallons per year	8B_TL/Dry Van	131,000,000	3,015,269

Parameter	Class/Category	Value	Mean
gallons per year	8B_TL/Dry Van	55,482,608	3,015,269
gallons per year	8B_TL/Dry Van	72,226,731	3,015,269
gallons per year	8B_TL/Dry Van	182,000,000	3,015,269
gallons per year	8B_TL/Dry Van	61,329,730	3,015,269
gallons per year	8B_TL/Dry Van	99,023,569	3,015,269
gallons per year	8B_Tanker	63,833,642	2,691,859
annual miles/vehicle	2B_Mixed	116,299	28,854
annual miles/vehicle	3_Mixed	85,788	22,873
annual miles/vehicle	3_Mixed	81,697	22,873
annual miles/vehicle	4_Mixed	87,149	23,285
annual miles/vehicle	5_Mixed	93,600	18,865
annual miles/vehicle	5_Mixed	77,510	18,865
annual miles/vehicle	6_Mixed	343,740	34,199
annual miles/vehicle	6_Package	103,854	24,362
annual miles/vehicle	6_TL/Dry Van	116,000	36,656
annual miles/vehicle	7_Mixed	135,356	35,442
annual miles/vehicle	7_Mixed	117,865	35,442
annual miles/vehicle	7_TL/Dry Van	166,021	37,351
annual miles/vehicle	8B_Flatbed	5,000	78,258
annual miles/vehicle	8B_Flatbed	7,500	78,258
annual miles/vehicle	8B_LTL/Dry Van	271,366	69,987
annual miles/vehicle	8B_Mixed	203,275	74,314
annual miles/vehicle	8B_Mixed	175,555	74,314
annual miles/vehicle	8B_Refrigerated	215,350	101,711
annual miles/vehicle	8B_Refrigerated	211,217	101,711
annual miles/vehicle	8B_Refrigerated	248,360	101,711
annual miles/vehicle	8B_Refrigerated	221,995	101,711
annual miles/vehicle	8B_Refrigerated	225,974	101,711
annual miles/vehicle	8B_Refrigerated	262,511	101,711
annual miles/vehicle	8B_Refrigerated	208,809	101,711
annual miles/vehicle	8B_Specialized	189,507	73,838
annual miles/vehicle	8B_TL/Dry Van	195,768	90,012
annual miles/vehicle	8B_TL/Dry Van	193,195	90,012
annual miles/vehicle	8B_TL/Dry Van	189,257	90,012
annual miles/vehicle	8B_TL/Dry Van	250,391	90,012

Parameter	Class/Category	Value	Mean
annual miles/vehicle	8B_TL/Dry Van	194,704	90,012
annual miles/vehicle	8B_TL/Dry Van	191,012	90,012
annual miles/vehicle	8B_TL/Dry Van	215,143	90,012
annual miles/vehicle	8B_Tanker	148,721	79,629
% Empty Miles	3_Mixed	90.19	13.39
% Empty Miles	8B_Specialized	99.38	30.34
% Empty Miles	2B_Mixed	0.02	82.54
% Empty Miles	8B_TL/Dry Van	35.17	87.37

Once values were defined as outliers and excluded from the data set, the mean and standard deviation of the distribution for each truck fleet grouping were then re-calculated for each metric. Each fleet was treated equally in the distributional assessment, independent of the number of vehicles in the fleet. Histograms presenting the distributions for each truck fleet grouping/metric combination are available electronically from SmartWay.

For groupings with large numbers of fleets (e.g., Class 8b diesel TL/Dry Van, Refrigerated, and Mixed), the data for miles per vehicle and miles per gallon appear normally distributed. Examples for Class 8b TL/Dry Van Diesel fleets are shown in Figures 5 and 6.

Figure 5. Annual Miles per Vehicle Distribution, Class 8b TL/Dry Van Diesel Fleets

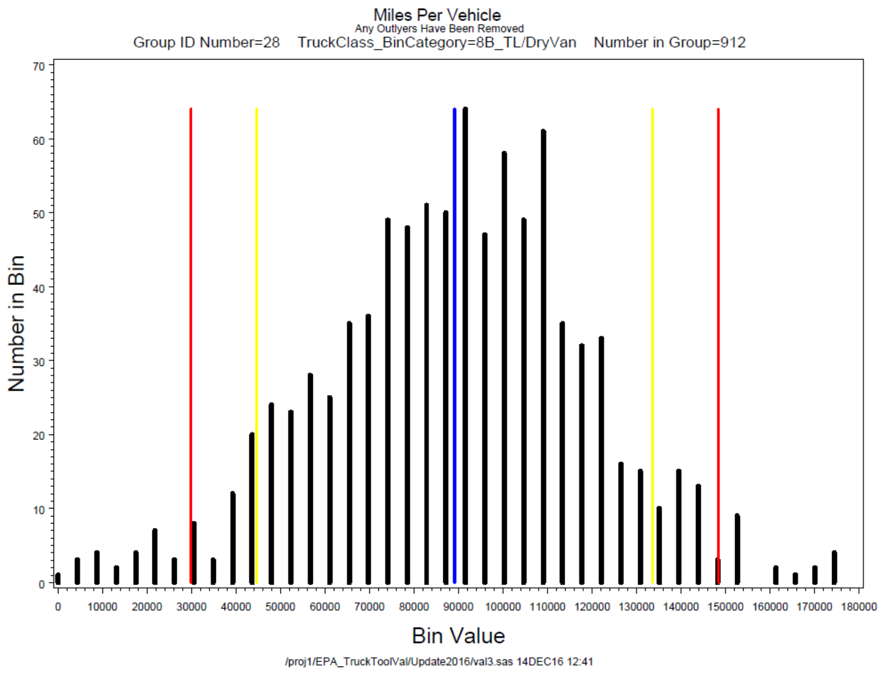
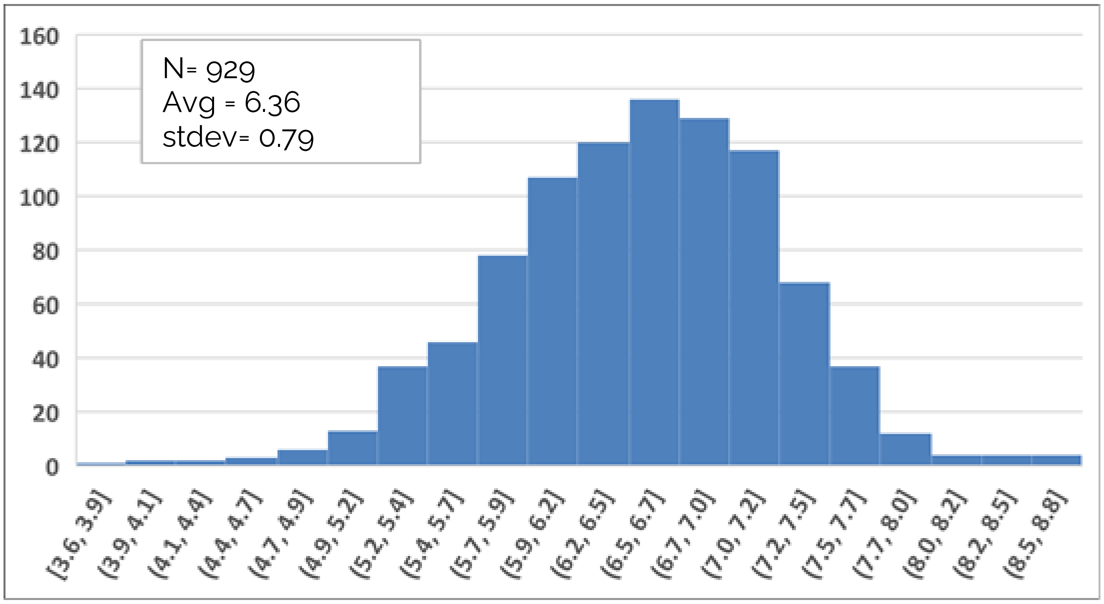


Figure 6. Miles per Gallon Distribution, Class 8b TL/Dry Van Diesel Fleets



Other fleet group/metric combinations displayed sharp drop offs at certain discrete levels. For example, % Revenue Miles were seldom less than 50% of total miles, and conversely, % Empty Miles were seldom greater than 50% of total miles. % Biofuel also displayed a discrete maximum value with no fleets using blends higher than 20% biofuel.[43]

Based on this assessment, red and yellow flag areas were defined for each fleet group/metric combination as shown in Table 11.

Table 11. "Red" and "Yellow" Flag Criteria

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
2B_Expedited	35	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_TL/Dry Van	42	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
4_Mixed	71	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_LTL/Dry Van	55	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Package	25	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_TL/Dry Van	51	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_LTL/Dry Van	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
7_TL/Dry Van	44	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_LTL/Dry Van	54	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_TL/Dry Van	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Dray	109	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	26	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	22	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_LTL/Dry Van	106	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%

[43] As such, a yellow warning is issued for any biofuel blend > 20%, with no red warning.

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8B_TL/Dry Van	912	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B	72	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
3	45	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
4	38	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
5	38	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
6	214	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
7	234	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8A	234	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	40	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_Dray	107	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	18	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_Flatbed	166	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	37	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_LTL/Dry Van	76	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed/Moving	452	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	492	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	41	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_TL/Dry Van	929	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Tanker	80	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
2B_Expedited	35	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Mixed	96	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Package	34	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_TL/Dry Van	42	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
3_Mixed	85	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
4_Mixed	71	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
5_Mixed	59	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_LTL/Dry Van	55	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Mixed	124	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Package	25	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_TL/Dry Van	51	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_LTL/Dry Van	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_Mixed	144	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_TL/Dry Van	44	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_LTL/Dry Van	54	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_Mixed	106	Percent Revenue Miles	5.0%	15.0%	NONE	NONE

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8A_Refrigerated	21	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_TL/Dry Van	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_AutoCarrier	36	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Dray	109	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Expedited	26	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Flatbed	159	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Heavy/Bulk	22	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_LTL/Dry Van	106	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Mixed	470	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Refrigerated	574	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Specialized	60	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_TL/Dry Van	912	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Tanker	84	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B_Expedited	35	Percent Empty Miles	NONE	NONE	85.0%	95.0%
2B_Mixed	96	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_Package	34	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_TL/Dry Van	42	Percent Empty Miles	5.0%	15.0%	Mean+1.5StD	Mean+2StD
3_Mixed	85	Percent Empty Miles	NONE	NONE	85.0%	95.0%
4_Mixed	71	Percent Empty Miles	NONE	NONE	85.0%	95.0%
5_Mixed	59	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_LTL/Dry Van	55	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Mixed	124	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Package	25	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_TL/Dry Van	51	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_LTL/Dry Van	61	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_Mixed	144	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_TL/Dry Van	44	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_LTL/Dry Van	54	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_Mixed	106	Percent Empty Miles	NONE	NONE	85.0%	95.0%
8A_Refrigerated	21	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_TL/Dry Van	61	Percent Empty Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	36	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8B_LTL/Dry Van	106	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_TL/Dry Van	912	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Percent Empty Miles	5.0%	15.0%	NONE	50.0%
2B_Expedited	35	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_TL/Dry Van	42	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
4_Mixed	71	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_LTL/Dry Van	55	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_Package	25	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_TL/Dry Van	51	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_LTL/Dry Van	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_TL/Dry Van	44	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_LTL/Dry Van	54	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_TL/Dry Van	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_LTL/Dry Van	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Mixed	470	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Refrigerated	574	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Specialized	60	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_TL/Dry Van	912	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Tanker	84	Percent Biofuel	5.0%	15.0%	85.0%	95.0%

For distributions that appeared to have a relatively normal distribution on the low and/or high end, yellow flag criteria were set at ± 1.5 times the standard deviation (StD), and the red flag criteria at ± 2.0 times the standard deviation of the distribution for each truck fleet grouping. In most cases these criteria result in roughly 10-20% of the values for these metrics being flagged as either red or yellow for partner attention. For several variables with a clearly skewed distribution yellow cutoffs were set to include approximately 15% of observations, and red cutoffs were selected to include approximately 5% of observations. Selecting cutoffs at these levels of stringency is intended to identify likely input errors without unduly burdening the large majority of Tool users with unnecessary data checks and text explanations.

Finally, certain distributions showed common values up to and including the absolute min/max values. For example, a substantial number of truck carriers reported revenue miles equal to 100% of total miles. In these instances no yellow/red flags are assigned for that variable.

Tables 12-16 present the actual yellow and red flag values for each fleet group/metric combination, given the decision criteria presented in Table 11. Tables 17-20 present the number of observations that would be flagged with yellow and red warnings for these combinations. The complete set of histograms associated with the distributional analysis of the 2016 data is available upon request from SmartWay.

Table 12. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Miles per Vehicle

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	>0	9,698	16,183	63,029	90,800	500,000
2B-Mixed	>0	2,046	7,741	53,432	71,391	500,000
2B-PD	>0	5,247	11,565	47,936	65,500	500,000
2B-TL/Dry van	>0	6,799	18,007	52,984	58,368	500,000
3-Mixed	>0	0	5,000	45,712	53,814	500,000
4-Mixed	>0	1,402	6,556	40,071	51,362	500,000
5-Mixed	>0	306	3,470	40,000	49,485	500,000
6-LTL/Dry van	>0	9,631	11,696	49,080	60,950	500,000
6-Mixed	>0	2,036	10,931	51,916	67,014	500,000
6-Moving	>0	3,000	8,000	68,107	79,506	500,000
6-PD	>0	5,921	9,073	65,000	72,065	500,000
6-TL/Dry van	>0	8,632	14,133	56,713	68,836	500,000
7-LTL/Dry van	>0	12,488	15,654	54,122	72,666	500,000
7-Mixed	>0	0	5,000	67,560	78,694	500,000
7-TL/Dry van	>0	2,326	10,312	57,249	79,650	500,000
8A-LTL/.Dry van	>0	10,558	15,625	68,215	88,352	500,000
8A-Mixed	>0	6,271	13,039	85,890	102,000	500,000
8A-Reefer	>0	15,505	26,162	70,000	79,308	500,000
8A-TL/Dry van	>0	10,069	13,877	97,567	128,406	500,000
8B-Auto	>0	43,112	51,769	103,710	112,367	500,000
8B-Dray	>0	6,985	18,413	86,984	98,413	500,000
8B-Expedited	>0	23,226	27,112	92,857	140,232	500,000
8B-Flatbed	>0	36,935	47,495	110,856	121,416	500,000
8B-Heavy	>0	44,171	48,663	101,118	108,168	500,000
8B-LTL/Dry van	>0	13,983	27,504	108,634	122,156	500,000
8B-Mixed	>0	12,029	27,477	120,168	135,616	500,000
8B-Reefer	>0	36,939	52,743	147,566	163,370	500,000
8B-Special	>0	20,765	39,854	105,338	117,433	500,000
8B-TL/Dry van	>0	29,853	44,672	133,586	148,405	500,000
8B-Tanker	>0	36,503	47,076	110,517	121,090	500,000

Table 13. Yellow/Red Criteria by Fleet Group/Metric Combination Miles per Gallon[44]

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B	>0	5.38	7.58	20.75	22.95	37.5
3	>0	3.52	6.41	13.52	14.37	28.5
4	>0	6.45	7.10	12.22	13.20	24.4
5	>0	4.42	5.69	12.40	15.10	21.4
6	>0	5.41	6.21	10.98	11.77	16.8
7	>0	4.74	5.57	10.58	11.41	15.8
8A	>0	3.94	4.66	8.97	9.69	12.2
8B-Auto	>0	4.27	4.61	5.51	6.20	9.3
8B-Dray	>0	4.88	5.14	6.70	6.96	10.5
8B-Expedited	>0	5.76	5.82	7.14	7.20	10.2
8B-Flatbed	>0	4.38	4.75	6.97	7.34	10.8
8B-Heavy	>0	2.95	3.77	5.91	5.95	9.9
8B-LTL/Dry van	>0	5.52	5.79	7.41	7.68	11.8
8B-Mixed/Moving	>0	4.78	5.18	7.55	7.94	11.8
8B-Reefer	>0	5.09	5.57	8.42	8.89	11.9
8B-Specialized	>0	3.04	3.75	6.21	6.66	10.1
8B-TL/Dry van	>0	5.02	5.39	7.61	7.98	12.4
8B-Tanker	>0	3.74	4.34	6.75	7.10	10.8

[44] Equivalent MPG cutoffs can be found by dividing these values by 1.26 for gasoline and CNG vehicles; dividing by 1.35 for LPG vehicles; and dividing by 1.52 for LNG vehicles – see "Non-Diesel MPG" section below for details.

Table 14. Yellow/Red Criteria by Fleet Group/Metric Combination
% Revenue Miles

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	52	59	N/A	N/A	N/A
2B-Mixed	N/A	53	61	N/A	N/A	N/A
2B-PD	N/A	66	72	N/A	N/A	N/A
2B-TL/Dry van	N/A	69	74	N/A	N/A	N/A
3-Mixed	N/A	65	71	N/A	N/A	N/A
4-Mixed	N/A	65	71	N/A	N/A	N/A
5-Mixed	N/A	59	67	N/A	N/A	N/A
6-LTL/Dry van	N/A	61	68	N/A	N/A	N/A
6-Mixed	N/A	55	63	N/A	N/A	N/A
6-Moving	N/A	55	65	N/A	N/A	N/A
6-PD	N/A	75	80	N/A	N/A	N/A
6-TL/Dry van	N/A	56	64	N/A	N/A	N/A
7-LTL/Dry van	N/A	64	71	N/A	N/A	N/A
7-Mixed	N/A	57	64	N/A	N/A	N/A
7-TL/Dry van	N/A	64	70	N/A	N/A	N/A
8A-LTL/.Dry van	N/A	67	73	N/A	N/A	N/A
8A-Mixed	N/A	52	59	N/A	N/A	N/A
8A-Reefer	N/A	59	65	N/A	N/A	N/A
8A-TL/Dry van	N/A	69	74	N/A	N/A	N/A
8B-Auto	N/A	43	50	N/A	N/A	N/A
8B-Dray	N/A	46	54	N/A	N/A	N/A
8B-Expedited	N/A	57	63	N/A	N/A	N/A
8B-Flatbed	N/A	62	67	N/A	N/A	N/A
8B-Heavy	N/A	34	43	N/A	N/A	N/A
8B-LTL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Mixed	N/A	62	68	N/A	N/A	N/A
8B-Reefer	N/A	72	76	N/A	N/A	N/A
8B-Special	N/A	40	49	N/A	N/A	N/A
8B-TL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Tanker	N/A	48	50	N/A	N/A	N/A

Table 15. Yellow/Red Criteria by Fleet Group/Metric Combination
% Empty Miles

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	1	5	38	44	N/A
2B-Mixed	N/A	1	5	41	48	N/A
2B-PD	N/A	1	5	31	37	N/A
2B-TL/Dry van	N/A	1	5	28	33	N/A
3-Mixed	N/A	1	5	28	34	N/A
4-Mixed	N/A	1	5	30	35	N/A
5-Mixed	N/A	1	5	33	40	N/A
6-LTL/Dry van	N/A	1	5	36	44	N/A
6-Mixed	N/A	1	5	38	45	N/A
6-Moving	N/A	1	5	40	50	N/A
6-PD	N/A	1	5	15	31	N/A
6-TL/Dry van	N/A	1	5	35	47	N/A
7-LTL/Dry van	N/A	1	5	32	35	N/A
7-Mixed	N/A	1	5	33	44	N/A
7-TL/Dry van	N/A	1	5	33	39	N/A
8A-LTL/.Dry van	N/A	1	5	30	36	N/A
8A-Mixed	N/A	1	5	36	47	N/A
8A-Reefer	N/A	1	5	35	41	N/A
8A-TL/Dry van	N/A	1	5	31	36	N/A
8B-Auto	N/A	5	15	40	49	N/A
8B-Dray	N/A	5	7	40	50	N/A
8B-Expedited	N/A	5	6	33	37	N/A
8B-Flatbed	N/A	5	7	27	37	N/A
8B-Heavy	N/A	1	5	56	64	N/A
8B-LTL/Dry van	N/A	1	5	29	34	N/A
8B-Mixed	N/A	1	5	34	40	N/A
8B-Reefer	N/A	1	5	25	29	N/A
8B-Special	N/A	1	5	49	50	N/A
8B-TL/Dry van	N/A	1	5	28	32	N/A
8B-Tanker	N/A	20	36	50	50	N/A

Table 16. Yellow/Red Criteria by Fleet Group/Metric Combination Idle Hours and Days of Use per Year

Class Category	Low Red	Low Yellow	High Yellow	High Red
Average Service Days/Year				
Non-Class 8b (less Package/Specialty)	96	171	320	--
Non-Class 8b (Package/Specialty)	142	200	315	--
Class 8b (less LTL/Package)	157	213	325	--
Class 8b (LTL/Package)	135	193	309	--
Average Hours Long Duration Idle/Day				
Non-Class 8b (less Package/Specialty)	--	1.00	1.73	2.81
Non-Class 8b (Package/Specialty)	--	1.00	24.00	--
Class 8b (less LTL/Package)	--	1.00	4.11	6.10
Class 8b (LTL/Package)	--	1.00	2.53	4.18
Average Hours Short Duration Idle/Day				
Non-Class 8b (less Package/Specialty)	--	0	1.87	2.81
Non-Class 8b (Package/Specialty)	--	0	1.42	1.99
Class 8b (less LTL/Package)	--	0	2.36	3.60
Class 8b (LTL/Package)	--	0	2.63	4.15

Table 17. Number of Values Flagged by Fleet Group/Metric Combination Annual Miles per Vehicle

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	6,001	1	3	40,870	3	1	95,938
2B_Mixed	96	720	4	9	27,933	9	4	76,590
2B_Package	34	4,144	1	3	30,012	3	1	70,685
2B_TL/Dry Van	42	505	2	3	31,821	3	2	59,203
3_Mixed	85	581	0	6	21,406	6	4	76,320
4_Mixed	71	117	3	6	22,373	6	3	53,172
5_Mixed	59	83	2	5	16,525	5	2	54,486
6_LTL/Dry Van	55	1,429	2	5	29,919	5	2	70,391
6_Mixed	124	53	6	11	31,682	11	6	79,858
6_Package	25	814	1	1	21,050	1	1	90,196
6_TL/Dry Van	51	3,179	2	4	35,069	4	2	93,498
7_LTL/Dry Van	61	5,701	3	5	34,379	5	3	87,534
7_Mixed	144	100	0	10	34,158	7	6	106,615
7_TL/Dry Van	44	1,693	2	3	34,359	3	2	109,287
8A_LTL/Dry Van	54	3,458	2	5	45,351	5	2	108,183
8A_Mixed	106	155	5	9	47,086	9	5	124,901
8A_Refrigerated	21	1,738	1	1	45,741	1	1	79,469
8A_TL/Dry Van	61	7,460	3	5	59,438	5	3	155,136
8B_AutoCarrier	36	47,525	0	2	77,740	1	1	120,671
8B_Dray	109	3,165	1	9	52,699	4	4	102,164
8B_Expedited	26	22,697	1	1	63,362	1	1	150,415
8B_Flatbed	159	15,680	3	5	79,175	8	2	130,597
8B_Heavy/Bulk	22	40,305	1	1	73,132	1	1	116,004
8B_LTL/Dry Van	106	14,096	0	5	68,069	3	3	146,016
8B_Mixed	470	3,658	7	20	73,822	22	11	151,353
8B_Refrigerated	574	9,171	20	20	100,155	22	10	203,947
8B_Specialized	60	4,568	2	5	71,877	5	2	178,303
8B_TL/Dry Van	912	2,072	27	33	89,129	39	19	176,478
8B_Tanker	84	28,055	4	3	78,796	0	3	136,449

Table 18. Number of Values Flagged by Fleet Group/Metric Combination Miles per Gallon

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	10.00	1	3	14.47	3	1	25.00
2B_Mixed	96	2.00	4	9	12.93	9	4	22.91
2B_Package	34	3.51	1	3	11.68	3	1	20.74
2B_TL/Dry Van	42	2.50	2	3	10.68	3	2	19.50
3_Mixed	85	1.07	2	3	9.82	6	1	18.99
4_Mixed	71	1.34	3	6	8.98	6	3	16.27
5_Mixed	59	0.96	3	1	7.77	2	1	14.25
6_LTL/Dry Van	55	0.68	2	5	8.01	5	2	11.17
6_Mixed	124	4.02	1	6	7.93	2	2	12.06
6_Package	25	0.91	1	1	7.39	1	1	11.37
6_TL/Dry Van	51	0.76	1	0	7.86	0	0	10.00
7_LTL/Dry Van	61	5.48	0	2	7.82	2	2	10.50
7_Mixed	144	3.69	4	4	7.55	3	4	11.25
7_TL/Dry Van	44	4.60	2	3	7.76	3	2	9.76
8A_LTL/Dry Van	54	4.25	1	0	6.31	1	1	8.13
8A_Mixed	106	3.38	3	3	6.57	5	3	8.97
8A_Refrigerated	21	5.19	1	2	6.38	2	1	8.34
8A_TL/Dry Van	61	1.84	1	1	6.43	0	1	8.69
8B_AutoCarrier	36	4.29	1	3	4.96	3	1	6.22
8B_Dray	109	3.35	5	2	5.83	3	0	7.00
8B_Expedited	26	4.79	1	1	6.04	1	1	6.80
8B_Flatbed	159	3.10	5	4	5.80	6	2	7.20
8B_Heavy/Bulk	22	4.11	1	1	5.32	1	1	6.63
8B_LTL/Dry Van	106	4.08	5	3	6.27	1	1	7.87
8B_Mixed	470	3.18	17	11	5.94	17	6	7.88
8B_Refrigerated	574	1.11	12	15	5.96	19	15	7.96
8B_Specialized	60	0.50	3	6	5.07	6	3	6.72
8B_TL/Dry Van	912	2.30	26	21	6.18	36	16	8.26
8B_Tanker	84	2.66	2	4	5.95	4	0	7.21

Table 19. Number of Values Flagged by Fleet Group/Metric Combination % Revenue Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	54.2	0	3	80.9	0	0	100
2B_Mixed	96	50.0	3	9	83.4	0	0	100
2B_Package	34	60.1	3	1	88.6	0	0	100
2B_TL/Dry Van	42	63.3	1	2	89.7	0	0	100
3_Mixed	85	57.0	3	7	89.7	0	0	100
4_Mixed	71	65.0	3	9	90.4	0	0	100
5_Mixed	59	50.0	2	5	88.5	0	0	100
6_LTL/Dry Van	55	50.0	3	4	88.4	0	0	100
6_Mixed	124	47.0	8	2	84.4	0	0	100
6_Package	25	64.0	2	0	94.2	0	0	100
6_TL/Dry Van	51	45.2	3	1	87.3	0	0	100
7_LTL/Dry Van	61	65.0	0	10	89.2	0	0	100
7_Mixed	144	50.0	6	2	84.4	0	0	100
7_TL/Dry Van	44	41.1	2	2	89.5	0	0	100
8A_LTL/Dry Van	54	55.0	5	2	90.5	0	0	100
8A_Mixed	106	46.1	5	4	82.3	0	0	100
8A_Refrigerated	21	60.0	0	2	85.0	0	0	100
8A_TL/Dry Van	61	49.1	3	3	91.3	0	0	100
8B_AutoCarrier	36	50.0	0	0	71.8	0	0	100
8B_Dray	109	49.5	0	7	79.2	0	0	100
8B_Expedited	26	56.2	1	2	82.8	0	0	100
8B_Flatbed	159	50.0	6	5	82.8	0	0	100
8B_Heavy/Bulk	22	46.0	0	0	70.9	0	0	100
8B_LTL/Dry Van	106	55.0	4	5	89.0	0	0	100
8B_Mixed	470	50.0	18	30	85.4	0	0	100
8B_Refrigerated	574	50.0	25	25	88.4	0	0	100
8B_Specialized	60	49.4	0	0	74.6	0	0	100
8B_TL/Dry Van	912	50.0	49	34	87.4	0	0	100
8B_Tanker	84	44.9	4	2	61.9	1	1	100

Table 20. Number of Values Flagged by Fleet Group/Metric Combination % Empty Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	2.96	0	0	20.65	3	1	45.75
2B_Mixed	96	0.00	0	0	18.10	8	3	50.00
2B_Package	34	0.00	0	0	12.26	1	4	39.91
2B_TL/Dry Van	42	0.00	0	3	14.00	0	2	39.60
3_Mixed	85	0.00	0	0	12.47	7	4	42.23
4_Mixed	71	0.00	0	0	12.55	6	3	40.00
5_Mixed	59	0.00	0	0	16.01	5	2	50.00
6_LTL/Dry Van	55	0.00	0	0	14.99	3	2	50.00
6_Mixed	124	0.00	0	0	16.57	2	9	52.99
6_Package	25	0.00	0	0	6.27	1	1	35.98
6_TL/Dry Van	51	0.00	0	0	17.42	4	2	54.76
7_LTL/Dry Van	61	0.00	0	0	13.09	5	3	40.00
7_Mixed	144	0.00	0	0	17.54	13	7	50.00
7_TL/Dry Van	44	0.00	0	0	15.42	4	1	45.00
8A_LTL/Dry Van	54	0.00	0	0	11.35	5	2	45.00
8A_Mixed	106	0.00	0	0	19.51	9	5	53.91
8A_Refrigerated	21	0.00	0	0	14.93	2	0	40.00
8A_TL/Dry Van	61	0.00	0	0	13.44	3	2	50.94
8B_AutoCarrier	36	0.00	0	3	29.68	3	1	50.00
8B_Dray	109	0.00	3	10	25.36	10	5	50.45
8B_Expedited	26	5.00	1	1	18.12	1	1	43.83
8B_Flatbed	159	0.00	3	15	18.12	15	7	50.00
8B_Heavy/Bulk	22	0.00	0	0	31.51	0	0	50.81
8B_LTL/Dry Van	106	0.00	0	0	12.65	4	6	50.00
8B_Mixed	470	0.00	0	0	16.49	28	22	50.00
8B_Refrigerated	574	0.00	0	0	12.91	20	25	50.00
8B_Specialized	60	0.00	0	4	29.17	4	2	50.61
8B_TL/Dry Van	912	0.00	0	0	13.71	39	51	50.00
8B_Tanker	84	3.00	4	7	43.51	0	9	55.12

Absolute errors were also developed for each fleet category/metric combination. Cutoffs for absolute errors are intended to prevent users from inadvertently entering data with incorrect units and typos. For this reason, SmartWay defined absolute errors to ensure an adequate "safety" interval between the highest values observed in the cleaned (no outlier) dataset. The recommended values for absolute errors and their associated justifications are discussed below for each metric.

Annual Miles per Vehicle

The maximum number of miles a vehicle can accumulate in a year are constrained by truck highway speed limits (typically 65 mph or less) and the number of hours in a year.[45] Excluding engine down-time associated with maintenance and repairs, the absolute maximum annual mileage possible for a truck is estimated to be ~500,000 miles per year. This estimate is more than twice the highest observed value of 228,151 miles per year (for Class 8b TL/Dry Van diesels). Therefore 500,000 miles per year value is set as the absolute maximum for all vehicle classes. Values greater than 0 and less than 500,000 are permissible.

Miles per Gallon

The maximum and minimum miles per gallon from the diesel dataset are presented in Table 21.

Table 21. Maximum and Minimum Observed Miles per Gallon

Class/Category	N	Minimum Value	Maximum Value
2B	72	2.37	24.48
3	45	0.68	16.90
4	38	5.75	15.60
5	38	1.83	16.93
6	214	2.35	14.59
7	234	2.45	12.23
8A	234	0.84	10.98
8B_AutoCarrier	48	4.27	6.38
8B_Dray	107	3.95	7.33
8B_Expedited	18	5.76	7.30
8B_Flatbed	166	3.15	7.99
8B_Heavy/Bulk	37	2.95	6.15
8B_LTL/Dry Van	75	5.10	7.69
8B_Mixed/Moving	452	1.42	8.40
8B_Refrigerated	492	4.85	10.46
8B_Specialized	41	3.00	7.17
8B_TL/Dry Van	929	2.10	8.76
8B_Tanker	80	1.49	7.36

[45] While DOT regulations limit drivers' daily hours, some companies utilize driver teams to maximize on-road time.

[Note: Unlike the other parameters discussed above, miles per gallon values are derived from other inputs (total miles and gallons). Therefore, any changes to address absolute limits on MPG (as well as red and yellow warnings) must be handled through updates to one or both of these primary inputs.]

As seen from the above table, fuel efficiency estimates can be very low (<1.0 mpg) and for this reason the absolute lower bound is set to 0.001 for miles per gallon. To establish absolute upper bounds for miles per gallon estimates the results from the PERE modeling analysis previously developed for the 2010 Truck Tool were used. Background on the PERE modeling exercise is provided in Appendix D.

Absolute maximum miles per gallon estimates were developed for conventional diesel trucks using the PERE model and are shown in Table 22 by truck class.

Table 22. Maximum Diesel Miles per Gallon Estimates (PERE Model Basis)

Class	Maximum MPG
2b	25.0
3	23.3
4	20.2
5	18.7
6	18.0
7	14.5
8a	11.2
8b	11.2

Note that the maximum MPG estimates obtained from the PERE model are substantially higher than almost all of the maximum value observed for diesel trucks in the 2018 Truck Tool data.

Non-Diesel MPG

The 2018 data submissions from SmartWay Truck partners did not include enough information on non-diesel trucks in order to develop a robust distribution of mpg values specific to non-diesels for validation purposes. Accordingly, engineering judgment was used to adjust the diesel mpg values for other fuel types, accounting for general, relative vehicle and/or fuel efficiency differences. First, a ratio was developed for adjusting diesel mpg values to comparable gasoline mpg values, based upon simulated modeling performed by Argonne National Laboratory.[46] The Argonne data for gas and diesel trucks was based on PSAT simulations of a typical pickup in the Class 2b or Class 3 range. The fuel consumption was reported for the same truck equipped with both gasoline and diesel engines over the various EPA emissions and fuel economy driving cycles. Using this data, a combined fuel economy was calculated using the method from EPA's pre-2008 combined 2-cycle fuel economy using the FTP and Highway cycles as given in 40 CFR

[46] Delorme, A. et. al., *Impact of Advanced Technologies on Medium-Duty Trucks Fuel Efficiency*, Argonne National Laboratory, 2010-01-1929. https://www.researchgate.net/publication/268352400_Impact_of_Advanced_Technologies_on_Medium-Duty_Trucks_Fuel_Efficiency, Accessed 12-8-23.

Part 600. This method uses a weighted harmonic average of the two values, with the FTP weighted at 55% and the Highway weighted at 45%.

The difference in the calculated combined fuel economies for the gas- and diesel-powered model results showed that the diesel had a 25.9% greater fuel economy than gasoline. These results are a direct volumetric comparison rather than in terms of gasoline-equivalent gallons. As such, the diesel mpg values shown in Table 27 above can be divided by 1.259 to obtain comparable mpg ranges for gasoline vehicles. Since CNG vehicle fuel consumption is reported in terms of gasoline-equivalent gallons, the mpg validation ranges for CNG vehicles can be set equal to those for comparable gasoline vehicles.

Validation ranges for LPG and LNG vehicles can be developed from the gasoline ranges, dividing the gasoline values by the appropriate gasoline gallon-equivalent factor for these fuels (1.35 for LPG and 1.52 for LNG),[47] thereby adjusting mpg values for volumetric energy density. Table 23 presents the corresponding upper bound MPG values for non-diesel vehicles by truck class.

Table 23. Maximum Miles per Gallon Estimates – Non-Diesel Vehicles

Class	Gasoline/CNG	LPG	LNG
2b	19.9	18.5	16.4
3	18.5	17.3	15.3
4	16.0	15.0	13.3
5	14.9	13.9	12.3
6	14.3	13.3	11.8
7	11.5	10.7	9.5
8a	8.9	8.3	7.4
8b	8.9	8.3	7.4

Hybrid MPG

EPA's Physical Emission Rate Estimator (PERE) model was used to establish estimates of the fuel economy benefit of hybridization of medium- and heavy-duty trucks. The details of the modeling are presented in Appendix D.

However, the in-use fuel economy of hybrid vehicles is highly dependent upon drive cycle. Specifically, the expected hybrid truck fuel economy will vary depending upon the relative fraction of highway versus urban driving. Therefore, the MPG ranges used for validation of hybrid fuel economy are calculated using the following steps.

[47] See https://afdc.energy.gov/fuels/equivalency_methodology.html, Accessed 12-8-23.

Step 1 – Weight the following GALLON PER MILE (Not MPG) values based on the Highway/Urban split

Gallons/Mile - Urban

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	0.2641	0.1813	0.0942	0.0636	0.0576
2	3_Mixed	0.2340	0.1857	0.1147	0.0830	0.0760
3	4_Mixed	0.2090	0.1763	0.1213	0.0925	0.0861
4	5_Mixed	0.2599	0.2127	0.1392	0.1026	0.0943
5	6_LTL/Dry Van_Diesel	0.1951	0.1765	0.1390	0.1147	0.1080
6	6_Mixed	0.2200	0.1972	0.1467	0.1179	0.1111
7	6_Moving	0.1906	0.1783	0.1514	0.1301	0.1242
8	6_Package_Diesel	0.1788	0.1628	0.1254	0.1029	0.0965
9	6_TL/Dry Van_Diesel	0.2350	0.2056	0.1495	0.1175	0.1097
10	7_LTL/Dry Van_Diesel	0.1968	0.1806	0.1450	0.1211	0.1148
11	7_Mixed	0.2506	0.2169	0.1545	0.1200	0.1117
12	7_TL/Dry Van_Diesel	0.2131	0.1915	0.1467	0.1202	0.1130
13	8A_LTL/Dry Van_Diesel	0.2184	0.2104	0.1837	0.1653	0.1607
14	8A_Mixed	0.2747	0.2519	0.1950	0.1591	0.1492
15	8A_Refrigerated_Diesel	0.2502	0.2402	0.2036	0.1793	0.1716
16	8A_TL/Dry Van_Diesel	0.2477	0.2337	0.1966	0.1697	0.1630
17	8B_AutoCarrier_Diesel	0.2980	0.2781	0.2407	0.2158	0.2052
18	8B_Dray_Diesel	0.2434	0.2338	0.2056	0.1835	0.1780
19	8B_Flatbed_Diesel	0.2912	0.2727	0.2248	0.1942	0.1857
20	8B_Heavy/Bulk_Diesel	0.3768	0.3371	0.2562	0.2033	0.1912
21	8B_LTL/Dry Van_Diesel	0.2383	0.2250	0.2025	0.1814	0.1761
22	8B_Mixed	0.2597	0.2493	0.2149	0.1889	0.1807
23	8B_Refrigerated_Diesel	0.2656	0.2500	0.2236	0.1992	0.1931
24	8B_Specialized_Diesel	0.3389	0.2995	0.2342	0.1894	0.1789
25	8B_TL/Dry Van_Diesel	0.2534	0.2436	0.2147	0.1891	0.1836
26	8B_Tanker_Diesel	0.2596	0.2492	0.2149	0.1888	0.1806

Gallons/Mile – Highway

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	0.1759	0.1208	0.0627	0.0424	0.0383
2	3_Mixed	0.1594	0.1265	0.0781	0.0565	0.0518
3	4_Mixed	0.1482	0.1250	0.0860	0.0656	0.0611
4	5_Mixed	0.1805	0.1477	0.0967	0.0713	0.0655
5	6_LTL/Dry Van_Diesel	0.1470	0.1330	0.1047	0.0864	0.0813
6	6_Mixed	0.1657	0.1486	0.1105	0.0889	0.0837
7	6_Moving	0.1436	0.1343	0.1141	0.0980	0.0936
8	6_Package_Diesel	0.1347	0.1226	0.0944	0.0775	0.0727
9	6_TL/Dry Van_Diesel	0.1770	0.1549	0.1127	0.0885	0.0826
10	7_LTL/Dry Van_Diesel	0.1513	0.1389	0.1115	0.0931	0.0883
11	7_Mixed	0.1928	0.1668	0.1188	0.0923	0.0859
12	7_TL/Dry Van_Diesel	0.1640	0.1473	0.1128	0.0924	0.0869
13	8A_LTL/Dry Van_Diesel	0.1558	0.1501	0.1310	0.1179	0.1147
14	8A_Mixed	0.1960	0.1796	0.1391	0.1135	0.1065
15	8A_Refrigerated_Diesel	0.1785	0.1714	0.1452	0.1279	0.1224
16	8A_TL/Dry Van_Diesel	0.1767	0.1667	0.1402	0.1210	0.1163
17	8B_AutoCarrier_Diesel	0.2126	0.1984	0.1717	0.1539	0.1464
18	8B_Dray_Diesel	0.1736	0.1668	0.1467	0.1309	0.1270
19	8B_Flatbed_Diesel	0.2078	0.1945	0.1604	0.1385	0.1325
20	8B_Heavy/Bulk_Diesel	0.2688	0.2405	0.1828	0.1450	0.1364
21	8B_LTL/Dry Van_Diesel	0.1700	0.1605	0.1445	0.1294	0.1256
22	8B_Mixed	0.1853	0.1779	0.1533	0.1347	0.1289
23	8B_Refrigerated_Diesel	0.1894	0.1783	0.1595	0.1421	0.1378
24	8B_Specialized_Diesel	0.2418	0.2137	0.1670	0.1351	0.1276
25	8B_TL/Dry Van_Diesel	0.1807	0.1738	0.1532	0.1349	0.1310
26	8B_Tanker_Diesel	0.1852	0.1778	0.1533	0.1347	0.1288

Example:

Truck Class 2b has 40% urban, 60% highway.
The Low Red Gallon/Mile value is therefore 0.2641 x 0.40 + 0.1759 x 0.60 = 0.2112

Step 2: Convert the weighted gallon per mile values back to MPG

Example:

0.2112 gal/mi = 4.74 MPG

Step 3: Use these final, weighted, converted MPG values for validation

Electric Truck Efficiency

Mi/kWhr estimates for battery electric trucks were developed based on available data sources and engineering judgment. Estimates for Class 8b trucks were developed using 10 submissions from SmartWay partners for the 2021 Data Year. These submissions included 52 electric trucks. The average and standard deviation of the mi/kWhr values were weighted by miles travelled. The "yellow" warning cutoffs were set to equal the average value +/- 1.5 times the standard deviation, and the "red" cutoffs to the average +/- 2 times the standard deviation. At this level 10 percent of the 2021 Data Year submittals are flagged with yellow warnings, and another 10 percent receive red flags.

Few battery electric trucks were reported for the other truck classes in the 2021 Data Year submittals, requiring an alternative approach The average mi/kWhr value for Class 2b and Class 6 trucks was assumed to equal the estimates for the light commercial and single unit long-haul truck categories respectively in the 2020 AFLEET model.[48] Red and yellow validation ranges were established for these trucks based on simple multiplicative factors applied to the averages – Low red from 0 to 0.5 x average; low yellow from 0.5 x average to 0.75 x average; high yellow from 1.25 x average to 1.5 x average; and high red from 1.5 x average to 10 x average (absolute max). Estimates for Class 3-5, 7 and 8a trucks were estimated from these values, scaling by the relative values used in the prior version of the Truck Tool. The prior averages and updated mi/kWhr estimates are presented by truck class in Table 24.

Table 24. Electric Truck Average mi/kWhr and Validation Ranges

Truck Class	Prior Avg	Updated Avg	Low Red	Low Yellow	High Yellow	High Red	Max
2a	1.14	1.19	0.60	0.89	1.49	1.79	11.90
3	0.94	0.95	0.48	0.71	1.19	1.43	9.50
4	0.73	0.75	0.38	0.56	0.94	1.13	7.50
5	0.68	0.71	0.36	0.53	0.89	1.07	7.10
6	0.62	0.62	0.31	0.47	0.78	0.93	6.20
7	0.48	0.52	0.26	0.39	0.66	0.79	5.24
8a	0.34	0.43	0.21	0.32	0.54	0.64	4.29
8b	0.29	0.39	0.22	0.26	0.53	0.57	3.95

[48] Argonne National Laboratory, Welcome to AFLEET. https://afleet-web.es.anl.gov/home/. Accessed 12-8-23.

Percent Revenue Miles

Revenue miles were frequently equal to total miles in the dataset. Accordingly, no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Percent Empty Miles

Empty miles were occasionally equal to 0 in the dataset. Accordingly, no absolute lower (or upper) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Percent Biofuel

While the maximum observed blend level for biofuel was 20 percent, 100% use is possible. Therefore, no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Average Payload

The maximum and minimum payloads from the 2011 dataset are presented in Table 5 above.

Based on a review of previous out of range values, unit conversion problems are the most common source of data entry errors for payload. One type of error results from data being entered in pounds instead of short tons, resulting in overestimates by a factor of 2,000. Such errors should be easy to prevent using a reasonable upper bound ton level. Another possible source of error could be reporting metric or long tons instead of short tons, although detecting these errors will be extremely difficult, due to the small difference in units (roughly 10 percent difference). Finally, standard payload limitations can be waived by obtaining permits for heavy loads, or by avoiding over-the-road operation. Accordingly, the absolute upper bound payload levels were set equal to 3 times the maximum observed values shown in Table 5.

The absolute lower-bound payload value was set at 0.001 tons, to allow for light package and specialty deliveries.

Percent Urban/Highway Miles

There is no clear distributional pattern associated with these data fields, with values frequently ranging from 0 to 100. Therefore, no lower or upper bound values are set.

Idle Hours per Day and Days of Use per Year

Absolute limits are placed on the number of hours per day (short plus long duration idle hours less than or equal to 24) and days of use per year (less than or equal to 365). In addition, since extended idling is defined as sustained idling events an hour or more in duration, warnings are issued for extended idle hour per day entries less than an hour.

Brokerage Activity Inputs

All brokerage activity inputs must be greater than 0. Maximum values cannot exceed the following.

- Ton-miles must be <= 209,207,446,000
- Miles must be <= 209,207,446,000 / 17.5 (avg payload) = 11,954,711,200
- Number of loads must be <= 11,954,711,200 / 527 (avg miles/load) = 22,684,461
- Amount spent must be <= 11,954,711,200 x 3.00 (avg $/mile) = $35,864,133,600

Finally, users will receive an error if the total reported (or back-calculated) value for brokered ton-miles is less than 20% of the fleet's total.

4.0 Performance Metrics

The OTT allows the user to calculate their emissions performance using different metrics and different levels of aggregation. Available performance metrics include:

- Grams per mile
- Grams per Payload Ton-Mile

The Emissions Report within the Tool presents the results of the following two calculations for each of the five pollutants (CO_2, NOx, PM_{10}, $PM_{2.5}$ and BC) and for each of three different mileage types (total, loaded, and revenue). Note that all capitalized fields represent fields in the user interface:

$$\text{g/mile: } \sum E \,/\, M$$

where

E = Emissions,

M = Miles Driven

$$\text{g/avg payload ton-mile: } \sum E \,/\, (M \times AP)$$

where

E = Emissions,

M = Miles Driven,

AP = Average Payload

For each of the two calculations:

Emissions = grams of pollutant (as specified above)

Miles Driven = Total Miles, Revenue Miles, or Loaded Miles (Total Miles minus Empty Miles)

As shown in the equations above, summations are performed for the different metrics. Each of the metrics is automatically aggregated across model years for each pollutant for all reporting purposes. Additional aggregation may be reported across truck classes, fuel types, fleets, and at the company level, as specified by the user.

Appendix A: MOVES3.1 NO_x, PM & BC Emission Factors (g/mi) 2023 Calendar Year

Table A-1. Diesel Truck Emission Factors

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1993	2a	6.15500	0.30727	0.39213	1.4860	0.07100	0.09167	9.69069	0.94049	1.21181	11.8206	0.71764	0.92575	8.52739	0.42941	0.5538
1993	3	7.50758	0.36634	0.46498	1.6127	0.07495	0.09668	12.1890	1.07136	1.37690	13.8929	0.79218	1.01999	8.91861	0.47345	0.6094
1993	4	11.4651	0.49912	0.62901	1.8367	0.07121	0.09070	19.5194	1.34605	1.71458	21.9649	0.94763	1.20708	9.97528	0.55927	0.7124
1993	5	12.7280	0.52453	0.66089	1.8067	0.06820	0.08683	21.3056	1.43783	1.83027	25.2996	1.01673	1.29424	12.2255	0.60244	0.7668
1993	6	12.5852	0.51737	0.65191	1.8103	0.06888	0.08771	20.7454	1.39599	1.77736	24.3752	1.00007	1.27319	11.7841	0.58819	0.7488
1993	7	14.3249	0.52337	0.65939	1.7871	0.06791	0.08647	20.6801	1.33089	1.69446	24.7593	1.02210	1.30081	12.8756	0.58288	0.7419
1993	8a	23.0796	0.57895	0.72893	1.5520	0.05425	0.06900	23.6945	1.08152	1.37463	33.8646	1.30564	1.65732	24.5712	0.63235	0.8030
1993	8b	27.0828	0.60537	0.76196	1.3126	0.04007	0.05084	26.5245	0.88977	1.12832	42.1321	1.56064	1.97771	34.8940	0.68134	0.8635
1993	2a	6.15500	0.30727	0.39213	1.4860	0.07100	0.09167	9.69069	0.94049	1.21181	11.8206	0.71764	0.92575	8.52739	0.42941	0.5538
1993	3	7.50758	0.36634	0.46498	1.6127	0.07495	0.09668	12.1890	1.07136	1.37690	13.8929	0.79218	1.01999	8.91861	0.47345	0.6094
1993	4	11.4651	0.49912	0.62901	1.8367	0.07121	0.09070	19.5194	1.34605	1.71458	21.9649	0.94763	1.20708	9.97528	0.55927	0.7124
1993	5	12.7280	0.52453	0.66089	1.8067	0.06820	0.08683	21.3056	1.43783	1.83027	25.2996	1.01673	1.29424	12.2255	0.60244	0.7668
1993	6	12.5852	0.51737	0.65191	1.8103	0.06888	0.08771	20.7454	1.39599	1.77736	24.3752	1.00007	1.27319	11.7841	0.58819	0.7488
1993	7	14.3249	0.52337	0.65939	1.7871	0.06791	0.08647	20.6801	1.33089	1.69446	24.7593	1.02210	1.30081	12.8756	0.58288	0.7419
1993	8a	23.0796	0.57895	0.72893	1.5520	0.05425	0.06900	23.6945	1.08152	1.37463	33.8646	1.30564	1.65732	24.5712	0.63235	0.8030
1993	8b	27.0828	0.60537	0.76196	1.3126	0.04007	0.05084	26.5245	0.88977	1.12832	42.1321	1.56064	1.97771	34.8940	0.68134	0.8635
1994	2a	6.15500	0.30727	0.39213	1.4860	0.07100	0.09167	9.69069	0.94049	1.21181	11.8206	0.71764	0.92575	8.52739	0.42941	0.5538
1994	3	7.50758	0.36634	0.46498	1.6127	0.07495	0.09668	12.1890	1.07136	1.37690	13.8929	0.79218	1.01999	8.91861	0.47345	0.6094
1994	4	11.4651	0.49912	0.62901	1.8367	0.07121	0.09070	19.5194	1.34605	1.71458	21.9649	0.94763	1.20708	9.97528	0.55927	0.7124
1994	5	12.7280	0.52453	0.66089	1.8067	0.06820	0.08683	21.3056	1.43783	1.83027	25.2996	1.01673	1.29424	12.2255	0.60244	0.7668

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1994	6	12.5852	0.51737	0.65191	1.8103	0.06888	0.08771	20.7454	1.39599	1.77736	24.3752	1.00007	1.27319	11.7841	0.58819	0.7488
1994	7	14.3249	0.52337	0.65939	1.7871	0.06791	0.08647	20.6801	1.33089	1.69446	24.7593	1.02210	1.30081	12.8756	0.58288	0.7419
1994	8a	23.0796	0.57895	0.72893	1.5520	0.05425	0.06900	23.6945	1.08152	1.37463	33.8646	1.30564	1.65732	24.5712	0.63235	0.8030
1994	8b	27.0828	0.60537	0.76196	1.3126	0.04007	0.05084	26.5245	0.88977	1.12832	42.1321	1.56064	1.97771	34.8940	0.68134	0.8635
1995	2a	5.85319	0.28561	0.36438	1.4318	0.06832	0.08825	9.06513	0.88786	1.14497	11.4371	0.68715	0.88689	8.51690	0.40965	0.5286
1995	3	10.5983	0.44887	0.56677	1.6687	0.06949	0.08896	18.0129	1.26088	1.60918	20.5190	0.91052	1.16328	10.7012	0.53159	0.6790
1995	4	12.6659	0.49845	0.62828	1.7691	0.07012	0.08947	20.5023	1.33876	1.70567	24.2679	1.01231	1.29003	12.3429	0.57689	0.7351
1995	5	14.7624	0.54573	0.68746	1.7685	0.06462	0.08222	23.5342	1.48085	1.88379	29.6613	1.11587	1.41933	15.4891	0.64351	0.8185
1995	6	15.6608	0.53747	0.67706	1.7389	0.06466	0.08229	22.7281	1.35117	1.71912	28.9843	1.12505	1.43081	16.2028	0.61877	0.7870
1995	7	17.9569	0.55286	0.69633	1.6863	0.06149	0.07823	23.3674	1.29813	1.65106	30.9909	1.18613	1.50763	18.8266	0.63075	0.8019
1995	8a	26.1588	0.60093	0.75646	1.3597	0.04297	0.05455	26.1931	0.94670	1.20121	41.0066	1.51713	1.92368	32.9392	0.67800	0.8598
1995	8b	27.6141	0.60991	0.76768	1.2458	0.03621	0.04589	27.2282	0.85554	1.08418	44.1210	1.61247	2.04287	37.2124	0.69319	0.8782
1996	2a	5.95684	0.27771	0.35347	1.2975	0.06107	0.07903	9.33374	0.84337	1.08786	11.0950	0.63995	0.82670	7.92150	0.38074	0.4917
1996	3	12.1444	0.49479	0.62362	1.8171	0.07147	0.09114	20.9417	1.34771	1.71678	24.2856	1.01303	1.29082	11.6409	0.57863	0.7372
1996	4	13.9037	0.51703	0.65140	1.8259	0.06980	0.08884	22.0838	1.34252	1.70878	26.6036	1.07380	1.36636	13.5354	0.59798	0.7609
1996	5	14.5951	0.54889	0.69147	1.7642	0.06565	0.08357	23.2193	1.48776	1.89286	28.8353	1.10818	1.40994	15.2582	0.64487	0.8204
1996	6	17.1697	0.54913	0.69164	1.7595	0.06531	0.08311	23.1608	1.34890	1.71602	29.4855	1.15090	1.46344	16.7462	0.62848	0.7993
1996	7	17.9905	0.55635	0.70072	1.7091	0.06234	0.07931	23.6470	1.31107	1.66742	31.1393	1.19562	1.51976	18.9106	0.63825	0.8114
1996	8a	26.1219	0.60127	0.75687	1.3904	0.04414	0.05605	26.2506	0.95659	1.21390	40.6677	1.51049	1.91555	32.5937	0.67778	0.8596
1996	8b	27.7100	0.61241	0.77081	1.2519	0.03622	0.04591	27.3711	0.85817	1.08745	44.0593	1.61635	2.04773	37.4309	0.69561	0.8813
1997	2a	4.86990	0.23057	0.29689	1.1833	0.05655	0.07337	7.01324	0.72199	0.93548	9.17373	0.56119	0.72771	7.30064	0.33562	0.4351
1997	3	9.44808	0.39365	0.49870	1.4579	0.06291	0.08091	14.8138	1.09087	1.39614	16.4167	0.78600	1.00762	9.69053	0.46376	0.5943
1997	4	11.8402	0.50936	0.64179	1.8679	0.07308	0.09307	20.4710	1.40154	1.78494	23.2670	0.99822	1.27126	10.7294	0.58395	0.7436
1997	5	13.4823	0.55620	0.70064	1.8080	0.06977	0.08879	22.0017	1.52481	1.94028	26.4141	1.07300	1.36531	13.3344	0.64108	0.8157
1997	6	13.7094	0.52972	0.66735	1.8161	0.07005	0.08919	21.3426	1.39250	1.77265	25.5163	1.05918	1.34796	13.2227	0.60559	0.7707
1997	7	15.4944	0.54048	0.68081	1.7811	0.06792	0.08646	21.8038	1.35620	1.72611	26.9843	1.10358	1.40394	15.0448	0.61397	0.7812
1997	8a	25.3206	0.59286	0.74631	1.4500	0.04791	0.06088	25.4958	0.98913	1.25601	38.5429	1.46111	1.85345	30.2185	0.66478	0.8435
1997	8b	27.4562	0.60628	0.76310	1.2824	0.03799	0.04817	27.1361	0.85720	1.08660	43.3047	1.60542	2.03416	36.4972	0.68855	0.8725

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1998	2a	5.12376	0.19699	0.25021	1.4671	0.09204	0.12224	8.45797	0.30952	0.40942	10.2991	0.33828	0.44808	7.72896	0.37185	0.4931
1998	3	11.2153	0.27363	0.34557	1.8701	0.07447	0.09662	18.3756	0.50006	0.64554	21.6622	0.55179	0.71283	12.8074	0.41580	0.5376
1998	4	11.9438	0.28278	0.35695	1.9570	0.07064	0.09103	19.5673	0.52294	0.67388	23.5740	0.58772	0.75735	13.5861	0.42250	0.5444
1998	5	12.7680	0.27252	0.34407	1.9354	0.06956	0.08992	19.7418	0.47593	0.61518	24.1178	0.50737	0.65575	14.7340	0.43422	0.5613
1998	6	12.3423	0.27848	0.35155	1.9467	0.07009	0.09045	19.6484	0.50200	0.64773	23.8607	0.55317	0.71369	14.1620	0.42808	0.5524
1998	7	13.2776	0.28190	0.35584	1.9249	0.06866	0.08868	19.8648	0.48978	0.63220	24.5299	0.54123	0.69833	15.3597	0.43428	0.5607
1998	8a	23.1779	0.39241	0.49440	1.6554	0.04819	0.06178	22.4837	0.57558	0.73500	33.3878	0.86756	1.10688	29.8084	0.47948	0.6123
1998	8b	25.8216	0.41907	0.52780	1.4763	0.03522	0.04485	23.9484	0.60450	0.76871	37.9415	1.00111	1.27280	37.4944	0.50512	0.6423
1999	2a	4.74242	0.19781	0.25112	1.4546	0.09385	0.12458	7.94618	0.30926	0.40929	9.67161	0.33613	0.44545	7.34911	0.37414	0.4961
1999	3	7.74300	0.25957	0.32797	1.4377	0.08230	0.10727	13.2102	0.46450	0.60196	13.3273	0.47360	0.61457	8.30514	0.38554	0.5009
1999	4	8.37581	0.27258	0.34416	1.4308	0.07784	0.10058	14.3272	0.49744	0.64281	14.4145	0.51450	0.66485	8.56371	0.38860	0.5021
1999	5	8.40902	0.27305	0.34475	1.4294	0.07771	0.10042	14.3371	0.49771	0.64315	14.4707	0.51695	0.66799	8.63495	0.38923	0.5029
1999	6	8.47041	0.27289	0.34455	1.3377	0.07353	0.09508	13.9578	0.48112	0.62201	14.4553	0.50377	0.65121	9.40271	0.41119	0.5316
1999	7	8.99018	0.28037	0.35393	1.3445	0.07313	0.09453	14.2530	0.48941	0.63221	14.9916	0.52830	0.68214	9.94223	0.41031	0.5300
1999	8a	17.2763	0.39483	0.49745	1.1066	0.04936	0.06338	18.1478	0.57252	0.73137	23.5898	0.87094	1.11148	21.6323	0.47491	0.6067
1999	8b	19.3374	0.42291	0.53262	0.9508	0.03524	0.04488	20.0124	0.60851	0.77370	27.3844	1.01323	1.28799	27.1645	0.50713	0.6448
2000	2a	4.88563	0.20112	0.25524	1.4512	0.09336	0.12387	8.20067	0.31676	0.41858	9.81909	0.34140	0.45192	7.41819	0.37601	0.4981
2000	3	7.76635	0.26129	0.33009	1.3888	0.07900	0.10279	13.2600	0.46505	0.60234	13.4928	0.47656	0.61785	8.54546	0.39370	0.5108
2000	4	8.24478	0.27091	0.34207	1.3700	0.07500	0.09694	14.0291	0.48756	0.63023	14.3364	0.50813	0.65679	8.86545	0.39793	0.5143
2000	5	8.31114	0.27182	0.34321	1.3673	0.07475	0.09662	14.0472	0.48807	0.63086	14.4469	0.51287	0.66288	9.00536	0.39910	0.5158
2000	6	8.38579	0.27297	0.34464	1.2926	0.07048	0.09108	13.9773	0.48250	0.62347	14.6966	0.51741	0.66852	9.80781	0.42109	0.5441
2000	7	9.80337	0.29231	0.36889	1.2997	0.06999	0.09042	14.4179	0.49321	0.63650	15.4911	0.55039	0.70980	10.7203	0.41865	0.5402
2000	8a	16.0490	0.37767	0.47594	1.1296	0.05330	0.06857	17.1977	0.55117	0.70551	21.7613	0.79609	1.01771	19.2869	0.46148	0.5908
2000	8b	19.2457	0.42202	0.53150	0.9607	0.03640	0.04641	19.8310	0.60467	0.76909	27.0113	0.99869	1.26981	26.6693	0.50467	0.6419
2001	2a	4.60483	0.19533	0.24802	1.4562	0.09432	0.12524	7.70578	0.30236	0.40073	9.53713	0.33093	0.43900	7.30048	0.37419	0.4965
2001	3	7.63596	0.25811	0.32611	1.4127	0.08140	0.10602	12.9319	0.45563	0.59086	12.9818	0.45368	0.58897	8.01069	0.38195	0.4962
2001	4	8.05419	0.26692	0.33706	1.4018	0.07801	0.10095	13.6901	0.47788	0.61844	13.6558	0.47741	0.61784	8.09488	0.38297	0.4956
2001	5	8.08734	0.26738	0.33764	1.4003	0.07787	0.10078	13.7001	0.47816	0.61879	13.7126	0.47986	0.62098	8.16630	0.38360	0.4964

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2001	6	8.84217	0.27837	0.35140	1.3395	0.07362	0.09521	13.9551	0.48207	0.62314	14.4482	0.50694	0.65504	9.38295	0.40522	0.5237
2001	7	8.65194	0.27547	0.34779	1.3472	0.07408	0.09582	13.9437	0.48211	0.62323	14.4590	0.50769	0.65604	9.34665	0.40111	0.5184
2001	8a	16.9278	0.38966	0.49096	1.1152	0.05153	0.06627	17.6297	0.55958	0.71556	22.6456	0.83025	1.06027	20.5457	0.46632	0.5964
2001	8b	19.1174	0.42006	0.52904	0.9653	0.03712	0.04736	19.6696	0.60089	0.76449	26.7425	0.98733	1.25564	26.3253	0.50131	0.6378
2002	2a	4.68119	0.19695	0.25003	1.4570	0.09422	0.12508	7.83761	0.30629	0.40563	9.60020	0.33315	0.44173	7.30759	0.37428	0.4965
2002	3	7.46995	0.25447	0.32158	1.4288	0.08328	0.10868	12.6526	0.44759	0.58098	12.6731	0.44223	0.57487	7.83674	0.37857	0.4926
2002	4	8.06315	0.26678	0.33688	1.4178	0.07896	0.10220	13.7000	0.47833	0.61911	13.5958	0.47484	0.61460	7.95924	0.37952	0.4912
2002	5	8.06315	0.26678	0.33688	1.4178	0.07896	0.10220	13.7000	0.47833	0.61911	13.5958	0.47484	0.61460	7.95924	0.37952	0.4912
2002	6	8.28833	0.27068	0.34176	1.3433	0.07403	0.09575	13.8413	0.47952	0.62011	14.2300	0.49787	0.64377	9.09862	0.40565	0.5245
2002	7	8.99633	0.28018	0.35368	1.3573	0.07463	0.09654	14.0023	0.48340	0.62485	14.4363	0.50638	0.65423	9.29904	0.40011	0.5171
2002	8a	14.7254	0.35904	0.45257	1.2224	0.06133	0.07912	16.2103	0.53093	0.68172	19.7341	0.71797	0.92030	16.4223	0.43964	0.5645
2002	8b	18.8835	0.41678	0.52494	0.9905	0.03947	0.05044	19.3939	0.59524	0.75779	26.1397	0.96381	1.22627	25.4808	0.49560	0.6309
2003	2a	3.34367	0.16653	0.21147	0.4408	0.07953	0.10560	4.26028	0.25916	0.34326	7.33457	0.28152	0.37333	5.69472	0.31592	0.4191
2003	3	4.93002	0.22083	0.27907	0.8523	0.07227	0.09430	7.53943	0.39006	0.50623	8.65534	0.38462	0.49991	6.69709	0.32562	0.4237
2003	4	5.27585	0.23267	0.29380	1.0180	0.06940	0.08981	8.26495	0.41905	0.54232	9.06000	0.41608	0.53847	6.97437	0.32822	0.4247
2003	5	5.27585	0.23267	0.29380	1.0180	0.06940	0.08981	8.26495	0.41905	0.54232	9.06000	0.41608	0.53847	6.97437	0.32822	0.4247
2003	6	5.58409	0.23938	0.30224	1.1840	0.06555	0.08476	9.11480	0.42629	0.55110	9.79300	0.44512	0.57534	7.53825	0.35629	0.4605
2003	7	5.82282	0.25095	0.31673	1.1281	0.06559	0.08482	8.96416	0.42952	0.55491	9.74043	0.45583	0.58853	7.55263	0.35142	0.4539
2003	8a	7.84188	0.33238	0.41888	1.1165	0.05191	0.06690	10.1177	0.48240	0.61846	11.8585	0.67539	0.86446	9.72662	0.39767	0.5098
2003	8b	9.00376	0.37950	0.47795	1.1607	0.03394	0.04332	11.6949	0.54223	0.68990	13.9239	0.88983	1.13165	11.8887	0.45134	0.5742
2004	2a	3.32462	0.16540	0.21002	0.4398	0.07885	0.10469	4.24933	0.25727	0.34073	7.28885	0.27958	0.37072	5.66030	0.31403	0.4166
2004	3	4.95805	0.22072	0.27893	0.8852	0.07104	0.09270	7.70542	0.38854	0.50423	8.75281	0.38540	0.50089	6.77738	0.33097	0.4305
2004	4	5.31624	0.23286	0.29405	1.0652	0.06796	0.08794	8.47351	0.41775	0.54061	9.20756	0.41805	0.54099	7.09129	0.33578	0.4345
2004	5	5.31624	0.23286	0.29405	1.0652	0.06796	0.08794	8.47351	0.41775	0.54061	9.20756	0.41805	0.54099	7.09129	0.33578	0.4345
2004	6	5.61704	0.24095	0.30420	1.2243	0.06470	0.08364	9.29177	0.43002	0.55570	9.92363	0.45443	0.58713	7.61455	0.36255	0.4684
2004	7	5.84452	0.25156	0.31750	1.1693	0.06463	0.08356	9.13731	0.43123	0.55700	9.86322	0.46160	0.59586	7.63056	0.35767	0.4619
2004	8a	7.81870	0.33133	0.41756	1.1370	0.05185	0.06682	10.1651	0.48029	0.61584	11.8124	0.66664	0.85332	9.67362	0.39885	0.5114
2004	8b	9.00626	0.37988	0.47843	1.1660	0.03393	0.04331	11.7092	0.54272	0.69052	13.9288	0.89093	1.13302	11.8900	0.45234	0.5755

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2005	2a	3.23925	0.16155	0.20518	0.4264	0.07765	0.10314	4.10708	0.25037	0.33186	7.14744	0.27319	0.36248	5.55029	0.30846	0.4094
2005	3	4.85590	0.21714	0.27445	0.8377	0.07141	0.09333	7.45619	0.38005	0.49363	8.57990	0.37497	0.48787	6.65527	0.32676	0.4256
2005	4	5.30253	0.23248	0.29357	1.0489	0.06822	0.08830	8.39414	0.41636	0.53890	9.14294	0.41481	0.53689	7.04840	0.33324	0.4313
2005	5	5.30253	0.23248	0.29357	1.0489	0.06822	0.08830	8.39414	0.41636	0.53890	9.14294	0.41481	0.53689	7.04840	0.33324	0.4313
2005	6	5.55450	0.24007	0.30310	1.1780	0.06568	0.08493	9.06249	0.42887	0.55433	9.73529	0.44905	0.58028	7.47078	0.35505	0.4588
2005	7	5.91867	0.25554	0.32249	1.1329	0.06490	0.08392	9.00797	0.43187	0.55775	9.78983	0.46425	0.59907	7.59829	0.35354	0.4565
2005	8a	8.04520	0.34031	0.42882	1.1286	0.04965	0.06395	10.3484	0.48827	0.62529	12.0591	0.69475	0.88822	9.95354	0.40437	0.5179
2005	8b	9.04799	0.38125	0.48015	1.1659	0.03291	0.04197	11.7793	0.54498	0.69317	14.0341	0.90062	1.14509	12.0055	0.45461	0.5782
2006	2a	3.28423	0.16411	0.20840	0.4315	0.07907	0.10503	4.15564	0.25434	0.33715	7.25314	0.27738	0.36806	5.63091	0.31335	0.4159
2006	3	4.83093	0.21657	0.27374	0.8062	0.07283	0.09522	7.29342	0.37874	0.49216	8.49396	0.36920	0.48062	6.60521	0.32303	0.4210
2006	4	5.25548	0.23092	0.29161	0.9979	0.06957	0.09009	8.16910	0.41340	0.53531	8.97523	0.40481	0.52419	6.94750	0.32618	0.4223
2006	5	5.25548	0.23092	0.29161	0.9979	0.06957	0.09009	8.16910	0.41340	0.53531	8.97523	0.40481	0.52419	6.94750	0.32618	0.4223
2006	6	5.45240	0.23730	0.29962	1.0999	0.06754	0.08739	8.69443	0.42429	0.54876	9.44229	0.43406	0.56124	7.27300	0.34328	0.4439
2006	7	5.82606	0.25273	0.31897	1.0658	0.06662	0.08619	8.69254	0.42763	0.55260	9.53549	0.45011	0.58114	7.42612	0.34346	0.4437
2006	8a	7.96574	0.33761	0.42543	1.0990	0.05118	0.06596	10.1628	0.48463	0.62095	11.8786	0.68164	0.87177	9.79910	0.39873	0.5109
2006	8b	9.03696	0.38107	0.47992	1.1607	0.03334	0.04254	11.7427	0.54455	0.69270	13.9934	0.89831	1.14220	11.9671	0.45366	0.5770
2007	2a	1.72349	0.00109	0.00933	0.9942	0.00075	0.00639	2.98993	0.00167	0.01430	3.96651	0.00183	0.01559	2.72873	0.00202	0.0172
2007	3	2.85172	0.00146	0.01252	0.8458	0.00060	0.00513	5.25149	0.00262	0.02246	5.28397	0.00270	0.02313	3.53201	0.00220	0.0188
2007	4	3.06711	0.00153	0.01312	0.7929	0.00055	0.00468	5.69286	0.00281	0.02405	5.63765	0.00294	0.02515	3.72592	0.00224	0.0191
2007	5	3.06711	0.00153	0.01312	0.7929	0.00055	0.00468	5.69286	0.00281	0.02405	5.63765	0.00294	0.02515	3.72592	0.00224	0.0191
2007	6	3.19926	0.00157	0.01346	0.7717	0.00052	0.00444	5.88246	0.00286	0.02452	5.88637	0.00310	0.02650	4.01696	0.00233	0.0199
2007	7	3.67218	0.00174	0.01491	0.7437	0.00051	0.00435	6.06168	0.00292	0.02504	6.16062	0.00330	0.02829	4.24747	0.00237	0.0202
2007	8a	5.53078	0.00239	0.02049	0.4746	0.00035	0.00303	7.61007	0.00342	0.02931	8.68068	0.00512	0.04385	6.54706	0.00284	0.0242
2007	8b	6.21805	0.00264	0.02258	0.2548	0.00023	0.00194	8.73891	0.00379	0.03246	10.3141	0.00633	0.05417	8.06977	0.00316	0.0270
2008	2a	1.66459	0.00107	0.00915	0.9938	0.00075	0.00640	2.87339	0.00163	0.01390	3.87563	0.00177	0.01514	2.64077	0.00200	0.0170
2008	3	2.57261	0.00137	0.01174	0.9343	0.00068	0.00580	4.66540	0.00240	0.02057	4.66163	0.00224	0.01916	2.81848	0.00201	0.0171
2008	4	2.78797	0.00144	0.01235	0.9069	0.00065	0.00553	5.09882	0.00259	0.02218	4.92467	0.00239	0.02050	2.86926	0.00201	0.0171
2008	5	2.78797	0.00144	0.01235	0.9069	0.00065	0.00553	5.09882	0.00259	0.02218	4.92467	0.00239	0.02050	2.86926	0.00201	0.0171

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2008	6	2.89951	0.00148	0.01263	0.8806	0.00061	0.00525	5.28707	0.00265	0.02266	5.16336	0.00255	0.02184	3.16357	0.00210	0.0179
2008	7	3.06032	0.00153	0.01313	0.8764	0.00062	0.00528	5.31525	0.00266	0.02276	5.21343	0.00260	0.02222	3.18609	0.00209	0.0179
2008	8a	4.57722	0.00206	0.01764	0.7063	0.00051	0.00440	6.35759	0.00300	0.02570	6.85374	0.00379	0.03241	4.72750	0.00242	0.0206
2008	8b	6.00771	0.00256	0.02193	0.3471	0.00029	0.00246	8.31146	0.00365	0.03123	9.67118	0.00586	0.05014	7.44062	0.00302	0.0258
2009	2a	1.65450	0.00107	0.00897	0.9104	0.00070	0.00587	2.87989	0.00163	0.01377	3.72070	0.00179	0.01510	2.56496	0.00194	0.0163
2009	3	2.94712	0.00150	0.01279	0.8036	0.00058	0.00492	5.45399	0.00272	0.02323	5.44579	0.00286	0.02442	3.65994	0.00222	0.0189
2009	4	3.14667	0.00156	0.01338	0.7718	0.00054	0.00464	5.86107	0.00289	0.02473	5.81775	0.00309	0.02644	3.87306	0.00227	0.0194
2009	5	3.14667	0.00156	0.01338	0.7718	0.00054	0.00464	5.86107	0.00289	0.02473	5.81775	0.00309	0.02644	3.87306	0.00227	0.0194
2009	6	3.21834	0.00159	0.01357	0.7621	0.00053	0.00455	5.93850	0.00291	0.02493	5.93017	0.00316	0.02707	3.99459	0.00230	0.0197
2009	7	3.74751	0.00177	0.01516	0.7269	0.00051	0.00438	6.17527	0.00299	0.02556	6.28434	0.00342	0.02928	4.31949	0.00237	0.0202
2009	8a	5.54875	0.00240	0.02051	0.4594	0.00035	0.00298	7.69261	0.00346	0.02959	8.77479	0.00520	0.04449	6.63234	0.00285	0.0243
2009	8b	6.19005	0.00262	0.02246	0.2522	0.00022	0.00192	8.73109	0.00379	0.03242	10.3051	0.00632	0.05410	8.06586	0.00316	0.0270
2010	2a	0.64716	0.00072	0.00592	0.1066	0.00012	0.00102	1.53119	0.00114	0.00952	1.86532	0.00142	0.01166	1.08151	0.00132	0.0108
2010	3	1.41592	0.00143	0.01219	0.2040	0.00023	0.00192	4.02180	0.00380	0.03244	3.13276	0.00174	0.01477	1.71793	0.00185	0.0157
2010	4	1.55103	0.00156	0.01331	0.2353	0.00026	0.00221	4.46776	0.00428	0.03658	3.44536	0.00182	0.01554	1.86082	0.00196	0.0168
2010	5	1.55103	0.00156	0.01331	0.2353	0.00026	0.00221	4.46776	0.00428	0.03658	3.44536	0.00182	0.01554	1.86082	0.00196	0.0168
2010	6	1.61971	0.00162	0.01383	0.2417	0.00027	0.00229	4.63272	0.00457	0.03913	3.56873	0.00186	0.01592	1.93806	0.00205	0.0175
2010	7	1.98937	0.00143	0.01222	0.2433	0.00026	0.00220	4.97498	0.00421	0.03599	3.84105	0.00177	0.01511	2.04623	0.00191	0.0163
2010	8a	3.31474	0.00089	0.00765	0.2754	0.00021	0.00183	7.38446	0.00280	0.02394	5.87465	0.00134	0.01148	2.92362	0.00134	0.0114
2010	8b	3.79655	0.00067	0.00574	0.2986	0.00017	0.00149	9.03976	0.00168	0.01440	7.21105	0.00097	0.00826	3.50315	0.00084	0.0072
2011	2a	0.72266	0.00072	0.00592	0.1137	0.00013	0.00104	1.59527	0.00108	0.00895	2.09451	0.00145	0.01195	1.26449	0.00134	0.0110
2011	3	1.23594	0.00129	0.01100	0.1655	0.00020	0.00171	3.33695	0.00302	0.02578	2.70229	0.00166	0.01408	1.46139	0.00166	0.0141
2011	4	1.32622	0.00139	0.01191	0.1821	0.00022	0.00192	3.64958	0.00337	0.02882	2.85029	0.00171	0.01461	1.50423	0.00173	0.0148
2011	5	1.32622	0.00139	0.01191	0.1821	0.00022	0.00192	3.64958	0.00337	0.02882	2.85029	0.00171	0.01461	1.50423	0.00173	0.0148
2011	6	1.37835	0.00142	0.01218	0.1875	0.00023	0.00197	3.82910	0.00355	0.03036	2.96664	0.00173	0.01478	1.55244	0.00178	0.0151
2011	7	1.56442	0.00133	0.01136	0.1863	0.00023	0.00193	4.01254	0.00337	0.02887	3.09776	0.00168	0.01436	1.58574	0.00171	0.0146
2011	8a	2.58703	0.00093	0.00797	0.1963	0.00020	0.00175	6.02445	0.00264	0.02261	4.59197	0.00139	0.01188	2.03387	0.00136	0.0116
2011	8b	3.15549	0.00068	0.00579	0.2072	0.00017	0.00149	8.17074	0.00168	0.01441	6.13910	0.00098	0.00841	2.48868	0.00086	0.0073

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2012	2a	0.68145	0.00075	0.00604	0.1082	0.00013	0.00103	1.57368	0.00117	0.00961	1.94137	0.00145	0.01173	1.14130	0.00135	0.0109
2012	3	1.22856	0.00134	0.01144	0.1699	0.00021	0.00179	3.42769	0.00325	0.02775	2.70852	0.00169	0.01433	1.43125	0.00171	0.0145
2012	4	1.30411	0.00143	0.01220	0.1852	0.00023	0.00198	3.68909	0.00355	0.03034	2.85458	0.00173	0.01482	1.48129	0.00178	0.0152
2012	5	1.30411	0.00143	0.01220	0.1852	0.00023	0.00198	3.68909	0.00355	0.03034	2.85458	0.00173	0.01482	1.48129	0.00178	0.0152
2012	6	1.34031	0.00143	0.01223	0.1871	0.00023	0.00199	3.78300	0.00359	0.03073	2.91884	0.00173	0.01483	1.50443	0.00179	0.0152
2012	7	1.59744	0.00131	0.01123	0.1872	0.00023	0.00195	4.09577	0.00343	0.02930	3.13785	0.00167	0.01433	1.56343	0.00171	0.0146
2012	8a	2.63408	0.00088	0.00755	0.1960	0.00020	0.00172	6.36149	0.00253	0.02166	4.80940	0.00131	0.01122	2.03483	0.00127	0.0108
2012	8b	3.06163	0.00067	0.00575	0.2015	0.00017	0.00148	8.10647	0.00166	0.01423	6.07701	0.00097	0.00826	2.38310	0.00084	0.0071
2013	2a	0.82543	0.00076	0.00594	0.1172	0.00013	0.00101	1.74110	0.00120	0.00972	2.30478	0.00146	0.01153	1.45405	0.00136	0.0107
2013	3	1.30501	0.00134	0.01142	0.1674	0.00021	0.00180	3.53271	0.00351	0.03000	2.91371	0.00163	0.01382	1.55853	0.00173	0.0146
2013	4	1.37384	0.00143	0.01221	0.1803	0.00023	0.00201	3.79553	0.00386	0.03301	3.03295	0.00167	0.01428	1.57553	0.00179	0.0153
2013	5	1.37384	0.00143	0.01221	0.1803	0.00023	0.00201	3.79553	0.00386	0.03301	3.03295	0.00167	0.01428	1.57553	0.00179	0.0153
2013	6	1.40315	0.00143	0.01227	0.1818	0.00024	0.00203	3.89557	0.00394	0.03369	3.09752	0.00167	0.01430	1.58762	0.00181	0.0154
2013	7	1.59818	0.00127	0.01087	0.1796	0.00023	0.00196	4.15903	0.00366	0.03135	3.27092	0.00159	0.01360	1.60552	0.00170	0.0145
2013	8a	2.23169	0.00079	0.00673	0.1701	0.00019	0.00159	5.78843	0.00240	0.02057	4.40842	0.00116	0.00996	1.74191	0.00115	0.0098
2013	8b	2.44762	0.00060	0.00513	0.1626	0.00015	0.00131	6.79535	0.00151	0.01295	5.08885	0.00086	0.00733	1.81732	0.00075	0.0064
2014	2a	0.38424	0.00042	0.00203	0.0449	0.00003	0.00017	1.04273	0.00044	0.00245	1.02613	0.00079	0.00369	0.54286	0.00068	0.0032
2014	3	0.82977	0.00040	0.00329	0.1016	0.00005	0.00044	3.04371	0.00085	0.00713	2.00781	0.00067	0.00535	0.74775	0.00066	0.0053
2014	4	0.88095	0.00040	0.00343	0.1131	0.00006	0.00050	3.27539	0.00090	0.00767	2.16293	0.00066	0.00562	0.77700	0.00066	0.0056
2014	5	0.88095	0.00040	0.00343	0.1131	0.00006	0.00050	3.27539	0.00090	0.00767	2.16293	0.00066	0.00562	0.77700	0.00066	0.0056
2014	6	0.90535	0.00041	0.00349	0.1143	0.00006	0.00050	3.35298	0.00091	0.00782	2.21047	0.00067	0.00570	0.78593	0.00066	0.0056
2014	7	1.08262	0.00041	0.00347	0.1138	0.00006	0.00049	3.56931	0.00090	0.00770	2.35225	0.00066	0.00567	0.82323	0.00065	0.0055
2014	8a	1.79935	0.00041	0.00354	0.1146	0.00005	0.00043	5.16456	0.00086	0.00738	3.43803	0.00068	0.00578	1.09904	0.00056	0.0047
2014	8b	2.10513	0.00040	0.00343	0.1152	0.00004	0.00036	6.45688	0.00081	0.00689	4.31543	0.00066	0.00561	1.32281	0.00047	0.0040
2015	2a	0.29718	0.00042	0.00188	0.0353	0.00003	0.00016	0.86818	0.00041	0.00217	0.82793	0.00079	0.00345	0.40351	0.00068	0.0030
2015	3	0.73508	0.00040	0.00324	0.0864	0.00005	0.00043	2.89156	0.00084	0.00698	1.82933	0.00068	0.00526	0.59457	0.00066	0.0052
2015	4	0.79713	0.00040	0.00343	0.0994	0.00006	0.00049	3.18020	0.00090	0.00767	2.02653	0.00066	0.00562	0.62853	0.00066	0.0056
2015	5	0.79713	0.00040	0.00343	0.0994	0.00006	0.00049	3.18020	0.00090	0.00767	2.02653	0.00066	0.00562	0.62853	0.00066	0.0056

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2015	6	0.82331	0.00041	0.00348	0.1006	0.00006	0.00050	3.25760	0.00091	0.00780	2.07516	0.00067	0.00570	0.63921	0.00066	0.0056
2015	7	1.01894	0.00041	0.00347	0.1009	0.00006	0.00049	3.49007	0.00090	0.00769	2.23188	0.00066	0.00567	0.68834	0.00065	0.0055
2015	8a	1.79433	0.00041	0.00355	0.1072	0.00005	0.00042	5.16417	0.00086	0.00739	3.40218	0.00068	0.00579	1.04177	0.00056	0.0047
2015	8b	2.11929	0.00040	0.00344	0.1133	0.00004	0.00036	6.49013	0.00081	0.00691	4.32962	0.00066	0.00563	1.32392	0.00047	0.0040
2016	2a	0.28454	0.00044	0.00187	0.0345	0.00004	0.00016	0.81545	0.00042	0.00207	0.80786	0.00084	0.00345	0.39653	0.00072	0.0030
2016	3	0.69897	0.00041	0.00321	0.0831	0.00005	0.00042	2.76929	0.00083	0.00688	1.75698	0.00069	0.00521	0.55347	0.00067	0.0051
2016	4	0.76639	0.00040	0.00343	0.0974	0.00006	0.00049	3.08911	0.00090	0.00767	1.97264	0.00066	0.00561	0.58554	0.00066	0.0056
2016	5	0.76639	0.00040	0.00343	0.0974	0.00006	0.00049	3.08911	0.00090	0.00767	1.97264	0.00066	0.00561	0.58554	0.00066	0.0056
2016	6	0.78816	0.00041	0.00348	0.0984	0.00006	0.00050	3.15507	0.00091	0.00779	2.01393	0.00066	0.00569	0.59389	0.00066	0.0056
2016	7	0.94299	0.00041	0.00347	0.0987	0.00006	0.00049	3.33785	0.00090	0.00770	2.13678	0.00066	0.00566	0.63241	0.00065	0.0055
2016	8a	1.67162	0.00042	0.00356	0.1051	0.00005	0.00043	4.84186	0.00087	0.00745	3.18169	0.00068	0.00579	0.94497	0.00057	0.0048
2016	8b	2.04067	0.00040	0.00346	0.1127	0.00004	0.00036	6.27917	0.00081	0.00696	4.18424	0.00066	0.00566	1.24737	0.00048	0.0041
2017	2a	0.26852	0.00043	0.00176	0.0337	0.00004	0.00015	0.77999	0.00041	0.00195	0.78286	0.00082	0.00324	0.38162	0.00070	0.0028
2017	3	0.66479	0.00040	0.00319	0.0819	0.00005	0.00041	2.64604	0.00082	0.00683	1.69286	0.00069	0.00515	0.51991	0.00067	0.0051
2017	4	0.73257	0.00040	0.00343	0.0968	0.00006	0.00049	2.96704	0.00090	0.00767	1.91053	0.00066	0.00561	0.54959	0.00066	0.0056
2017	5	0.73257	0.00040	0.00343	0.0968	0.00006	0.00049	2.96704	0.00090	0.00767	1.91053	0.00066	0.00561	0.54959	0.00066	0.0056
2017	6	0.74964	0.00041	0.00347	0.0977	0.00006	0.00050	3.02000	0.00091	0.00777	1.94389	0.00066	0.00568	0.55525	0.00066	0.0056
2017	7	0.86998	0.00041	0.00347	0.0981	0.00006	0.00049	3.16856	0.00090	0.00769	2.04279	0.00066	0.00566	0.58159	0.00065	0.0055
2017	8a	1.47293	0.00042	0.00357	0.1048	0.00005	0.00044	4.44469	0.00087	0.00748	2.92249	0.00068	0.00580	0.80517	0.00058	0.0049
2017	8b	1.79985	0.00041	0.00347	0.1132	0.00004	0.00036	5.75378	0.00082	0.00700	3.82860	0.00066	0.00568	1.03648	0.00048	0.0041
2018	2a	0.20399	0.00045	0.00175	0.0247	0.00004	0.00015	0.62863	0.00042	0.00194	0.58004	0.00087	0.00323	0.27299	0.00074	0.0028
2018	3	0.62317	0.00041	0.00319	0.0753	0.00005	0.00041	2.54465	0.00083	0.00683	1.59118	0.00069	0.00515	0.46403	0.00067	0.0051
2018	4	0.69388	0.00040	0.00343	0.0907	0.00006	0.00049	2.87006	0.00090	0.00767	1.82997	0.00066	0.00561	0.50476	0.00066	0.0056
2018	5	0.69388	0.00040	0.00343	0.0907	0.00006	0.00049	2.87006	0.00090	0.00767	1.82997	0.00066	0.00561	0.50476	0.00066	0.0056
2018	6	0.73210	0.00041	0.00353	0.0940	0.00006	0.00051	3.01717	0.00093	0.00799	1.92118	0.00068	0.00579	0.52004	0.00067	0.0056
2018	7	0.83982	0.00041	0.00349	0.0935	0.00006	0.00050	3.12850	0.00091	0.00781	1.99786	0.00067	0.00572	0.54427	0.00065	0.0055
2018	8a	1.43065	0.00042	0.00357	0.1015	0.00005	0.00043	4.40931	0.00088	0.00751	2.90396	0.00068	0.00585	0.78720	0.00057	0.0049
2018	8b	1.74241	0.00040	0.00345	0.1109	0.00004	0.00036	5.66092	0.00082	0.00701	3.76447	0.00067	0.00570	1.01721	0.00048	0.0041

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2019	2a	0.16355	0.00042	0.00164	0.0194	0.00004	0.00014	0.51681	0.00039	0.00179	0.45849	0.00080	0.00303	0.21281	0.00069	0.0026
2019	3	0.58033	0.00039	0.00306	0.0696	0.00005	0.00039	2.40037	0.00079	0.00649	1.48391	0.00066	0.00490	0.42576	0.00064	0.0048
2019	4	0.65656	0.00039	0.00332	0.0862	0.00006	0.00047	2.74712	0.00086	0.00736	1.74733	0.00063	0.00539	0.47526	0.00063	0.0054
2019	5	0.65656	0.00039	0.00332	0.0862	0.00006	0.00047	2.74712	0.00086	0.00736	1.74733	0.00063	0.00539	0.47526	0.00063	0.0054
2019	6	0.69397	0.00040	0.00340	0.0893	0.00006	0.00049	2.88696	0.00089	0.00764	1.83451	0.00065	0.00554	0.49068	0.00064	0.0054
2019	7	0.80733	0.00040	0.00338	0.0892	0.00006	0.00048	3.01000	0.00088	0.00749	1.91852	0.00064	0.00549	0.51676	0.00063	0.0053
2019	8a	1.41824	0.00041	0.00351	0.0989	0.00005	0.00042	4.34785	0.00085	0.00730	2.86111	0.00067	0.00569	0.77216	0.00056	0.0047
2019	8b	1.73855	0.00040	0.00341	0.1103	0.00004	0.00036	5.64094	0.00081	0.00692	3.75079	0.00066	0.00562	1.01287	0.00048	0.0040
2020	2a	0.13892	0.00038	0.00154	0.0162	0.00003	0.00013	0.44428	0.00036	0.00168	0.38495	0.00072	0.00285	0.17717	0.00062	0.0024
2020	3	0.55726	0.00039	0.00302	0.0660	0.00005	0.00038	2.32434	0.00077	0.00640	1.42193	0.00065	0.00482	0.40222	0.00063	0.0048
2020	4	0.64186	0.00039	0.00332	0.0843	0.00006	0.00047	2.70685	0.00086	0.00736	1.71739	0.00063	0.00538	0.46027	0.00063	0.0054
2020	5	0.64186	0.00039	0.00332	0.0843	0.00006	0.00047	2.70685	0.00086	0.00736	1.71739	0.00063	0.00538	0.46027	0.00063	0.0054
2020	6	0.67788	0.00040	0.00339	0.0873	0.00006	0.00049	2.84008	0.00089	0.00762	1.80075	0.00065	0.00553	0.47552	0.00064	0.0054
2020	7	0.78700	0.00039	0.00338	0.0872	0.00006	0.00048	2.95863	0.00087	0.00748	1.88160	0.00064	0.00549	0.50074	0.00063	0.0053
2020	8a	1.39882	0.00041	0.00350	0.0975	0.00005	0.00042	4.28266	0.00085	0.00730	2.81485	0.00066	0.00569	0.75624	0.00056	0.0047
2020	8b	1.73498	0.00040	0.00342	0.1099	0.00004	0.00036	5.62139	0.00081	0.00692	3.73664	0.00066	0.00562	1.00844	0.00048	0.0040
2021	2a	0.09450	0.00021	0.00090	0.0110	0.00002	0.00007	0.30640	0.00021	0.00103	0.26271	0.00040	0.00165	0.12026	0.00034	0.0014
2021	3	0.38874	0.00024	0.00193	0.0461	0.00003	0.00025	1.63840	0.00051	0.00420	0.99859	0.00041	0.00312	0.27849	0.00040	0.0031
2021	4	0.44861	0.00025	0.00214	0.0591	0.00004	0.00031	1.91106	0.00057	0.00485	1.20958	0.00041	0.00355	0.31955	0.00042	0.0035
2021	5	0.44861	0.00025	0.00214	0.0591	0.00004	0.00031	1.91106	0.00057	0.00485	1.20958	0.00041	0.00355	0.31955	0.00042	0.0035
2021	6	0.47268	0.00026	0.00219	0.0612	0.00004	0.00032	2.00144	0.00059	0.00502	1.26633	0.00043	0.00365	0.33021	0.00042	0.0035
2021	7	0.54387	0.00026	0.00219	0.0611	0.00004	0.00032	2.08255	0.00058	0.00494	1.32162	0.00042	0.00362	0.34756	0.00041	0.0035
2021	8a	0.95909	0.00027	0.00230	0.0686	0.00003	0.00028	3.01105	0.00057	0.00488	1.97721	0.00044	0.00380	0.52875	0.00037	0.0032
2021	8b	1.19523	0.00027	0.00227	0.0779	0.00003	0.00024	3.98613	0.00055	0.00468	2.64894	0.00044	0.00380	0.71445	0.00032	0.0027
2022	2a	0.08426	0.00021	0.00090	0.0095	0.00002	0.00007	0.28086	0.00021	0.00102	0.22945	0.00040	0.00164	0.10285	0.00034	0.0014
2022	3	0.38079	0.00024	0.00193	0.0449	0.00003	0.00025	1.61808	0.00051	0.00420	0.97920	0.00041	0.00312	0.26757	0.00040	0.0031
2022	4	0.44106	0.00025	0.00214	0.0580	0.00004	0.00031	1.89151	0.00057	0.00485	1.19399	0.00041	0.00355	0.31031	0.00042	0.0035
2022	5	0.44106	0.00025	0.00214	0.0580	0.00004	0.00031	1.89151	0.00057	0.00485	1.19399	0.00041	0.00355	0.31031	0.00042	0.0035

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2022	6	0.46549	0.00026	0.00219	0.0601	0.00004	0.00032	1.98204	0.00059	0.00501	1.25102	0.00043	0.00364	0.32136	0.00042	0.0035
2022	7	0.53966	0.00026	0.00219	0.0601	0.00004	0.00032	2.06773	0.00058	0.00494	1.30941	0.00042	0.00362	0.33969	0.00041	0.0035
2022	8a	0.96186	0.00027	0.00230	0.0681	0.00003	0.00028	3.01764	0.00057	0.00487	1.98015	0.00044	0.00380	0.52706	0.00037	0.0031
2022	8b	1.19601	0.00027	0.00227	0.0779	0.00003	0.00024	3.99069	0.00055	0.00468	2.65195	0.00044	0.00380	0.71481	0.00032	0.0027
2023	2a	0.08228	0.00021	0.00089	0.0094	0.00002	0.00007	0.27543	0.00020	0.00101	0.22588	0.00040	0.00163	0.10082	0.00034	0.0014
2023	3	0.37884	0.00024	0.00192	0.0446	0.00003	0.00025	1.60984	0.00050	0.00418	0.97288	0.00041	0.00311	0.26603	0.00040	0.0031
2023	4	0.44106	0.00025	0.00214	0.0580	0.00004	0.00031	1.89151	0.00057	0.00485	1.19400	0.00041	0.00355	0.31031	0.00042	0.0035
2023	5	0.44106	0.00025	0.00214	0.0580	0.00004	0.00031	1.89151	0.00057	0.00485	1.19400	0.00041	0.00355	0.31031	0.00042	0.0035
2023	6	0.46494	0.00026	0.00219	0.0601	0.00004	0.00032	1.98035	0.00059	0.00501	1.24995	0.00043	0.00364	0.32113	0.00042	0.0035
2023	7	0.53685	0.00026	0.00219	0.0601	0.00004	0.00032	2.06282	0.00058	0.00493	1.30615	0.00042	0.00362	0.33882	0.00041	0.0035
2023	8a	0.95594	0.00027	0.00230	0.0680	0.00003	0.00028	2.99856	0.00057	0.00487	1.96711	0.00044	0.00379	0.52343	0.00037	0.0032
2023	8b	1.19492	0.00027	0.00227	0.0778	0.00003	0.00024	3.98449	0.00055	0.00468	2.64752	0.00044	0.00380	0.71358	0.00032	0.0027
2024	2a	0.08061	0.00021	0.00089	0.0093	0.00002	0.00007	0.27140	0.00020	0.00100	0.22290	0.00040	0.00163	0.09894	0.00034	0.0014
2024	3	0.37723	0.00024	0.00192	0.0443	0.00003	0.00024	1.60335	0.00050	0.00416	0.96790	0.00041	0.00310	0.26474	0.00040	0.0031
2024	4	0.44092	0.00025	0.00214	0.0580	0.00004	0.00031	1.89106	0.00057	0.00484	1.19372	0.00041	0.00355	0.31024	0.00042	0.0035
2024	5	0.44092	0.00025	0.00214	0.0580	0.00004	0.00031	1.89106	0.00057	0.00484	1.19372	0.00041	0.00355	0.31024	0.00042	0.0035
2024	6	0.46385	0.00026	0.00219	0.0600	0.00004	0.00032	1.97731	0.00058	0.00500	1.24804	0.00043	0.00364	0.32071	0.00042	0.0035
2024	7	0.52831	0.00025	0.00218	0.0600	0.00004	0.00031	2.05338	0.00058	0.00493	1.29998	0.00042	0.00361	0.33718	0.00041	0.0035
2024	8a	0.91909	0.00026	0.00226	0.0674	0.00003	0.00028	2.95044	0.00057	0.00484	1.93512	0.00044	0.00376	0.51466	0.00037	0.0031
2024	8b	1.14663	0.00026	0.00220	0.0768	0.00003	0.00024	3.92597	0.00054	0.00462	2.60826	0.00044	0.00375	0.70294	0.00032	0.0027
2025	2a	0.08061	0.00021	0.00089	0.0093	0.00002	0.00007	0.27140	0.00020	0.00100	0.22290	0.00040	0.00163	0.09894	0.00034	0.0014
2025	3	0.37723	0.00024	0.00192	0.0443	0.00003	0.00024	1.60335	0.00050	0.00416	0.96790	0.00041	0.00310	0.26474	0.00040	0.0031
2025	4	0.44092	0.00025	0.00214	0.0580	0.00004	0.00031	1.89106	0.00057	0.00484	1.19372	0.00041	0.00355	0.31024	0.00042	0.0035
2025	5	0.44092	0.00025	0.00214	0.0580	0.00004	0.00031	1.89106	0.00057	0.00484	1.19372	0.00041	0.00355	0.31024	0.00042	0.0035
2025	6	0.46385	0.00026	0.00219	0.0600	0.00004	0.00032	1.97731	0.00058	0.00500	1.24804	0.00043	0.00364	0.32071	0.00042	0.0035
2025	7	0.52831	0.00025	0.00218	0.0600	0.00004	0.00031	2.05338	0.00058	0.00493	1.29998	0.00042	0.00361	0.33718	0.00041	0.0035
2025	8a	0.91909	0.00026	0.00226	0.0674	0.00003	0.00028	2.95044	0.00057	0.00484	1.93512	0.00044	0.00376	0.51466	0.00037	0.0031
2025	8b	1.14663	0.00026	0.00220	0.0768	0.00003	0.00024	3.92597	0.00054	0.00462	2.60826	0.00044	0.00375	0.70294	0.00032	0.0027

Table A-2. Gasoline Truck Emission Factors

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
Pre 1993	2a	3.69448	0.00472	0.03222	0.1793	0.00026	0.00178	3.44885	0.00131	0.00893	6.71733	0.00398	0.02718	6.21730	0.01314	0.0896
Pre 1993	3	4.97230	0.00772	0.05266	0.5741	0.00043	0.00296	5.37019	0.00191	0.01306	7.42477	0.00669	0.04564	7.84321	0.03302	0.2252
Pre 1993	4	5.10752	0.00772	0.05265	0.6111	0.00045	0.00306	5.49482	0.00195	0.01332	7.62497	0.00688	0.04692	8.15957	0.03415	0.2330
Pre 1993	5	5.11522	0.00771	0.05263	0.6143	0.00045	0.00307	5.50121	0.00195	0.01332	7.63235	0.00688	0.04695	8.18077	0.03422	0.2335
Pre 1993	6	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
Pre 1993	7	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
Pre 1993	8a	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
Pre 1993	8b	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
1993	2a	3.69448	0.00472	0.03222	0.1793	0.00026	0.00178	3.44885	0.00131	0.00893	6.71733	0.00398	0.02718	6.21730	0.01314	0.0896
1993	3	4.97230	0.00772	0.05266	0.5741	0.00043	0.00296	5.37019	0.00191	0.01306	7.42477	0.00669	0.04564	7.84321	0.03302	0.2252
1993	4	5.10752	0.00772	0.05265	0.6111	0.00045	0.00306	5.49482	0.00195	0.01332	7.62497	0.00688	0.04692	8.15957	0.03415	0.2330
1993	5	5.11522	0.00771	0.05263	0.6143	0.00045	0.00307	5.50121	0.00195	0.01332	7.63235	0.00688	0.04695	8.18077	0.03422	0.2335
1993	6	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
1993	7	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
1993	8a	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
1993	8b	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
1994	2a	3.69448	0.00472	0.03222	0.1793	0.00026	0.00178	3.44885	0.00131	0.00893	6.71733	0.00398	0.02718	6.21730	0.01314	0.0896
1994	3	4.97230	0.00772	0.05266	0.5741	0.00043	0.00296	5.37019	0.00191	0.01306	7.42477	0.00669	0.04564	7.84321	0.03302	0.2252
1994	4	5.10752	0.00772	0.05265	0.6111	0.00045	0.00306	5.49482	0.00195	0.01332	7.62497	0.00688	0.04692	8.15957	0.03415	0.2330
1994	5	5.11522	0.00771	0.05263	0.6143	0.00045	0.00307	5.50121	0.00195	0.01332	7.63235	0.00688	0.04695	8.18077	0.03422	0.2335
1994	6	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
1994	7	4.54163	0.00773	0.05275	0.4543	0.00039	0.00263	4.97467	0.00179	0.01224	6.79454	0.00610	0.04163	6.83010	0.02940	0.2005
1994	8a	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
1994	8b	6.63065	0.00977	0.06666	0.3450	0.00044	0.00299	7.74775	0.00375	0.02559	12.2139	0.01224	0.08352	9.76954	0.04029	0.2748
1995	2a	3.79716	0.00642	0.04384	0.2038	0.00070	0.00475	3.68643	0.00628	0.04286	6.69335	0.00751	0.05125	6.21295	0.01187	0.0809

		Highway			Urban												
					Deceleration			0 25 mph			25 50 mph			>50 mph			
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	
1995	3	5.07820	0.01899	0.12955	0.5956	0.00351	0.02395	5.47141	0.02617	0.17857	7.58071	0.01782	0.12158	8.06603	0.04547	0.3102	
1995	4	5.15493	0.01961	0.13377	0.6219	0.00371	0.02532	5.53930	0.02752	0.18775	7.69458	0.01875	0.12794	8.26204	0.04812	0.3282	
1995	5	5.13736	0.01947	0.13284	0.6166	0.00367	0.02505	5.52344	0.02724	0.18586	7.66549	0.01851	0.12627	8.22028	0.04756	0.3245	
1995	6	4.55406	0.01473	0.10047	0.4117	0.00211	0.01436	5.01170	0.01681	0.11470	6.82623	0.01169	0.07973	6.71206	0.02715	0.1852	
1995	7	4.55406	0.01473	0.10047	0.4117	0.00211	0.01436	5.01170	0.01681	0.11470	6.82623	0.01169	0.07973	6.71206	0.02715	0.1852	
1995	8a	6.54848	0.02620	0.17877	0.4848	0.00313	0.02135	7.34017	0.02802	0.19114	11.9132	0.05787	0.39485	9.49583	0.05608	0.3826	
1995	8b	6.54848	0.02620	0.17877	0.4848	0.00313	0.02135	7.34017	0.02802	0.19114	11.9132	0.05787	0.39485	9.49583	0.05608	0.3826	
1996	2a	3.08363	0.00367	0.02507	0.1673	0.00088	0.00599	2.89184	0.00537	0.03661	4.96249	0.01049	0.07160	4.98207	0.00618	0.0421	
1996	3	5.12787	0.01159	0.07907	0.6126	0.00509	0.03473	5.52314	0.02550	0.17396	7.66479	0.02869	0.19572	8.19666	0.02750	0.1876	
1996	4	5.16803	0.01183	0.08071	0.6262	0.00524	0.03573	5.55393	0.02619	0.17866	7.71841	0.02946	0.20101	8.29656	0.02830	0.1930	
1996	5	5.16637	0.01182	0.08068	0.6268	0.00524	0.03576	5.55194	0.02621	0.17880	7.71172	0.02939	0.20052	8.29655	0.02831	0.1931	
1996	6	4.59747	0.00838	0.05715	0.4222	0.00305	0.02081	5.12095	0.01594	0.10877	6.99219	0.01876	0.12801	6.83563	0.01647	0.1123	
1996	7	4.59747	0.00838	0.05715	0.4222	0.00305	0.02081	5.12095	0.01594	0.10877	6.99219	0.01876	0.12801	6.83563	0.01647	0.1123	
1996	8a	6.54850	0.01711	0.11674	0.4848	0.00395	0.02697	7.34013	0.02242	0.15296	11.9131	0.07701	0.52541	9.49576	0.03005	0.2050	
1996	8b	6.54850	0.01711	0.11674	0.4848	0.00395	0.02697	7.34013	0.02242	0.15296	11.9131	0.07701	0.52541	9.49576	0.03005	0.2050	
1997	2a	2.98079	0.00335	0.02286	0.1116	0.00020	0.00136	2.01986	0.00170	0.01162	4.51060	0.00488	0.03331	5.02397	0.00776	0.0529	
1997	3	5.06800	0.00981	0.06697	0.5962	0.00120	0.00821	5.47027	0.00815	0.05558	7.57961	0.01032	0.07045	8.05889	0.04284	0.2922	
1997	4	5.17214	0.01015	0.06928	0.6290	0.00128	0.00872	5.55544	0.00860	0.05865	7.71871	0.01079	0.07363	8.31163	0.04551	0.3105	
1997	5	5.14978	0.01009	0.06881	0.6225	0.00126	0.00862	5.53696	0.00851	0.05804	7.68789	0.01069	0.07296	8.25928	0.04499	0.3069	
1997	6	4.57916	0.00822	0.05610	0.4425	0.00085	0.00581	5.06979	0.00603	0.04117	6.92532	0.00813	0.05549	6.87123	0.03026	0.2064	
1997	7	4.57916	0.00822	0.05610	0.4425	0.00085	0.00581	5.06979	0.00603	0.04117	6.92532	0.00813	0.05549	6.87123	0.03026	0.2064	
1997	8a	7.76798	0.01021	0.06966	0.1009	0.00007	0.00049	8.71544	0.00195	0.01333	13.1180	0.01683	0.11481	10.5529	0.01070	0.0730	
1997	8b	7.76798	0.01021	0.06966	0.1009	0.00007	0.00049	8.71544	0.00195	0.01333	13.1180	0.01683	0.11481	10.5529	0.01070	0.0730	
1998	2a	2.68513	0.00294	0.02005	0.1206	0.00029	0.00197	1.59733	0.00206	0.01408	4.10279	0.00532	0.03628	4.67617	0.00529	0.0361	
1998	3	3.31917	0.01133	0.07728	0.4048	0.00215	0.01466	2.63652	0.01170	0.07983	5.62894	0.01882	0.12844	5.88118	0.03036	0.2071	
1998	4	3.35209	0.01214	0.08282	0.4143	0.00244	0.01664	2.61632	0.01305	0.08901	5.71572	0.02111	0.14402	5.94905	0.03384	0.2308	
1998	5	3.31184	0.01121	0.07649	0.4055	0.00216	0.01473	2.62975	0.01166	0.07952	5.61261	0.01801	0.12285	5.86312	0.03025	0.2064	
1998	6	3.22146	0.00894	0.06100	0.3777	0.00132	0.00898	2.69237	0.00781	0.05327	5.37133	0.01190	0.08122	5.67793	0.02023	0.1380	

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1998	7	3.22146	0.00894	0.06100	0.3777	0.00132	0.00898	2.69237	0.00781	0.05327	5.37133	0.01190	0.08122	5.67793	0.02023	0.1380
1998	8a	3.67583	0.01747	0.11917	0.3928	0.00220	0.01500	2.93945	0.01672	0.11407	6.42913	0.05558	0.37923	6.73321	0.04029	0.2748
1998	8b	3.67583	0.01747	0.11917	0.3928	0.00220	0.01500	2.93945	0.01672	0.11407	6.42913	0.05558	0.37923	6.73321	0.04029	0.2748
1999	2a	2.05297	0.00326	0.02224	0.1238	0.00024	0.00165	1.29859	0.00338	0.02304	3.15925	0.00829	0.05654	3.54423	0.00570	0.0389
1999	3	3.30427	0.01053	0.07188	0.3822	0.00160	0.01093	2.78159	0.01681	0.11470	5.53210	0.02067	0.14105	5.86652	0.02557	0.1744
1999	4	3.43200	0.01052	0.07178	0.3684	0.00149	0.01013	3.04928	0.01736	0.11847	5.71052	0.02040	0.13918	6.13559	0.02933	0.2001
1999	5	3.45687	0.01039	0.07088	0.3653	0.00146	0.00996	3.10732	0.01747	0.11919	5.74126	0.01926	0.13143	6.18702	0.03000	0.2047
1999	6	3.45851	0.01039	0.07087	0.3651	0.00146	0.00995	3.11077	0.01748	0.11924	5.74352	0.01926	0.13137	6.19047	0.03005	0.2050
1999	7	3.18313	0.01052	0.07177	0.3951	0.00171	0.01169	2.52910	0.01629	0.11114	5.36160	0.02069	0.14116	5.61059	0.02197	0.1499
1999	8a	3.20286	0.01103	0.07528	0.3950	0.00170	0.01163	2.54257	0.01637	0.11169	5.40529	0.02497	0.17034	5.65590	0.02280	0.1555
1999	8b	3.20286	0.01103	0.07528	0.3950	0.00170	0.01163	2.54257	0.01637	0.11169	5.40529	0.02497	0.17034	5.65590	0.02280	0.1555
2000	2a	1.82493	0.00324	0.02212	0.1116	0.00017	0.00113	1.15471	0.00161	0.01099	2.82417	0.00629	0.04294	3.16800	0.00610	0.0416
2000	3	3.34731	0.01042	0.07109	0.3684	0.00126	0.00858	2.96027	0.00776	0.05293	5.57367	0.01458	0.09949	5.97037	0.02702	0.1843
2000	4	3.50385	0.00912	0.06224	0.3487	0.00099	0.00675	3.31552	0.00706	0.04820	5.78433	0.01242	0.08476	6.31024	0.02581	0.1761
2000	5	3.54208	0.00881	0.06008	0.3439	0.00092	0.00630	3.40207	0.00690	0.04705	5.83565	0.01190	0.08117	6.39305	0.02552	0.1741
2000	6	3.54445	0.00879	0.05995	0.3436	0.00092	0.00628	3.40744	0.00689	0.04698	5.83883	0.01186	0.08095	6.39818	0.02550	0.1739
2000	7	3.22855	0.01140	0.07780	0.3833	0.00146	0.00998	2.68986	0.00828	0.05652	5.41331	0.01622	0.11070	5.71166	0.02794	0.1906
2000	8a	3.22855	0.01140	0.07780	0.3833	0.00146	0.00998	2.68986	0.00828	0.05652	5.41331	0.01622	0.11070	5.71166	0.02794	0.1906
2000	8b	3.22855	0.01140	0.07780	0.3833	0.00146	0.00998	2.68986	0.00828	0.05652	5.41331	0.01622	0.11070	5.71166	0.02794	0.1906
2001	2a	0.59753	0.00184	0.01256	0.0516	0.00006	0.00039	0.42243	0.00114	0.00775	0.99445	0.00580	0.03956	1.03379	0.00575	0.0392
2001	3	1.37944	0.00575	0.03924	0.1629	0.00034	0.00230	1.14547	0.00257	0.01753	2.30951	0.00929	0.06335	2.44101	0.04037	0.2753
2001	4	1.43625	0.00572	0.03904	0.1556	0.00030	0.00201	1.27786	0.00254	0.01736	2.38669	0.00843	0.05747	2.56497	0.04024	0.2744
2001	5	1.45613	0.00571	0.03898	0.1530	0.00028	0.00191	1.32408	0.00254	0.01730	2.41364	0.00812	0.05542	2.60825	0.04019	0.2741
2001	6	1.45748	0.00571	0.03897	0.1528	0.00028	0.00191	1.32721	0.00254	0.01730	2.41546	0.00810	0.05528	2.61118	0.04019	0.2741
2001	7	1.35187	0.00577	0.03933	0.1664	0.00036	0.00244	1.08108	0.00258	0.01761	2.27198	0.00971	0.06621	2.38073	0.04044	0.2758
2001	8a	1.35187	0.00577	0.03933	0.1664	0.00036	0.00244	1.08108	0.00258	0.01761	2.27198	0.00971	0.06621	2.38073	0.04044	0.2758
2001	8b	1.35187	0.00577	0.03933	0.1664	0.00036	0.00244	1.08108	0.00258	0.01761	2.27198	0.00971	0.06621	2.38073	0.04044	0.2758
2002	2a	0.57326	0.00202	0.01379	0.0471	0.00020	0.00136	0.40295	0.00197	0.01345	0.95276	0.00394	0.02690	0.99034	0.00315	0.0215

		Highway			Urban												
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2002	3	1.40350	0.00638	0.04353	0.1594	0.00095	0.00651	1.20678	0.00718	0.04898	2.34238	0.00993	0.06775	2.49482	0.01067	0.0728
2002	4	1.47569	0.00568	0.03876	0.1499	0.00076	0.00519	1.37733	0.00670	0.04569	2.43976	0.00856	0.05839	2.65324	0.01042	0.0710
2002	5	1.49568	0.00549	0.03745	0.1473	0.00071	0.00483	1.42442	0.00656	0.04478	2.46665	0.00818	0.05580	2.69698	0.01034	0.0705
2002	6	1.49695	0.00548	0.03736	0.1471	0.00071	0.00481	1.42742	0.00656	0.04472	2.46836	0.00816	0.05564	2.69977	0.01034	0.0705
2002	7	1.35725	0.00683	0.04658	0.1656	0.00108	0.00735	1.09711	0.00749	0.05110	2.27977	0.01082	0.07378	2.39295	0.01084	0.0739
2002	8a	1.35725	0.00683	0.04658	0.1656	0.00108	0.00735	1.09711	0.00749	0.05110	2.27977	0.01082	0.07378	2.39295	0.01084	0.0739
2002	8b	1.35725	0.00683	0.04658	0.1656	0.00108	0.00735	1.09711	0.00749	0.05110	2.27977	0.01082	0.07378	2.39295	0.01084	0.0739
2003	2a	0.49498	0.00182	0.01244	0.0475	0.00013	0.00087	0.35520	0.00162	0.01106	0.82878	0.00485	0.03307	0.86182	0.00396	0.0270
2003	3	1.38768	0.00568	0.03871	0.1632	0.00089	0.00606	1.15676	0.00782	0.05337	2.32544	0.00848	0.05784	2.46048	0.02150	0.1466
2003	4	1.45070	0.00548	0.03740	0.1550	0.00075	0.00509	1.30246	0.00759	0.05178	2.40976	0.00779	0.05314	2.59597	0.02178	0.1485
2003	5	1.46892	0.00543	0.03702	0.1526	0.00071	0.00482	1.34453	0.00752	0.05133	2.43407	0.00759	0.05177	2.63512	0.02186	0.1491
2003	6	1.47010	0.00542	0.03700	0.1524	0.00070	0.00480	1.34724	0.00752	0.05130	2.43563	0.00758	0.05169	2.63764	0.02187	0.1491
2003	7	1.34955	0.00579	0.03951	0.1682	0.00097	0.00665	1.06833	0.00797	0.05433	2.27425	0.00890	0.06070	2.37824	0.02133	0.1455
2003	8a	1.34965	0.00579	0.03950	0.1682	0.00097	0.00665	1.06846	0.00796	0.05432	2.27445	0.00890	0.06070	2.37832	0.02133	0.1454
2003	8b	1.34965	0.00579	0.03950	0.1682	0.00097	0.00665	1.06846	0.00796	0.05432	2.27445	0.00890	0.06070	2.37832	0.02133	0.1454
2004	2a	0.39930	0.00123	0.00854	0.0411	0.00016	0.00111	0.29299	0.00123	0.00848	0.66163	0.00232	0.01618	0.69127	0.00244	0.0169
2004	3	1.39979	0.00520	0.03547	0.1598	0.00087	0.00592	1.19831	0.00610	0.04158	2.33802	0.00633	0.04315	2.48932	0.01228	0.0837
2004	4	1.48361	0.00505	0.03442	0.1484	0.00067	0.00459	1.40168	0.00557	0.03801	2.45082	0.00544	0.03712	2.67440	0.01213	0.0827
2004	5	1.50655	0.00500	0.03413	0.1453	0.00062	0.00423	1.45718	0.00543	0.03704	2.48161	0.00520	0.03548	2.72490	0.01209	0.0824
2004	6	1.50801	0.00500	0.03411	0.1451	0.00062	0.00421	1.46070	0.00542	0.03697	2.48356	0.00519	0.03537	2.72811	0.01209	0.0824
2004	7	1.34527	0.00530	0.03616	0.1673	0.00100	0.00679	1.06554	0.00644	0.04392	2.26438	0.00690	0.04708	2.36849	0.01237	0.0843
2004	8a	1.34527	0.00530	0.03616	0.1673	0.00100	0.00679	1.06554	0.00644	0.04392	2.26438	0.00690	0.04708	2.36849	0.01237	0.0843
2004	8b	1.34527	0.00530	0.03616	0.1673	0.00100	0.00679	1.06554	0.00644	0.04392	2.26438	0.00690	0.04708	2.36849	0.01237	0.0843
2005	2a	0.32851	0.00079	0.00545	0.0355	0.00010	0.00071	0.24336	0.00074	0.00512	0.55872	0.00159	0.01112	0.58088	0.00156	0.0108
2005	3	1.38409	0.00388	0.02644	0.1584	0.00062	0.00426	1.18393	0.00451	0.03076	2.30641	0.00465	0.03171	2.44973	0.00908	0.0619
2005	4	1.43346	0.00380	0.02593	0.1524	0.00055	0.00374	1.30023	0.00426	0.02906	2.37560	0.00427	0.02913	2.56090	0.00891	0.0608
2005	5	1.45451	0.00377	0.02572	0.1498	0.00052	0.00352	1.34984	0.00415	0.02833	2.40498	0.00411	0.02803	2.60836	0.00884	0.0603
2005	6	1.45603	0.00377	0.02570	0.1496	0.00051	0.00350	1.35341	0.00415	0.02828	2.40710	0.00410	0.02795	2.61177	0.00884	0.0602

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2005	7	1.36464	0.00390	0.02663	0.1608	0.00065	0.00447	1.13805	0.00461	0.03144	2.27911	0.00480	0.03273	2.40588	0.00915	0.0624
2005	8a	1.36480	0.00390	0.02663	0.1607	0.00065	0.00446	1.13823	0.00461	0.03143	2.27941	0.00480	0.03273	2.40599	0.00915	0.0624
2005	8b	1.36480	0.00390	0.02663	0.1607	0.00065	0.00446	1.13823	0.00461	0.03143	2.27941	0.00480	0.03273	2.40599	0.00915	0.0624
2006	2a	0.36052	0.00088	0.00613	0.0424	0.00012	0.00083	0.27027	0.00087	0.00605	0.61950	0.00181	0.01267	0.64347	0.00180	0.0125
2006	3	1.38780	0.00399	0.02723	0.1616	0.00070	0.00480	1.17374	0.00491	0.03349	2.32436	0.00512	0.03489	2.46400	0.00980	0.0668
2006	4	1.44977	0.00389	0.02655	0.1531	0.00059	0.00400	1.32301	0.00454	0.03096	2.40717	0.00455	0.03101	2.60067	0.00955	0.0651
2006	5	1.47235	0.00386	0.02630	0.1500	0.00054	0.00371	1.37737	0.00440	0.03004	2.43721	0.00434	0.02959	2.65049	0.00947	0.0645
2006	6	1.47390	0.00385	0.02628	0.1498	0.00054	0.00369	1.38110	0.00439	0.02998	2.43927	0.00432	0.02949	2.65390	0.00946	0.0645
2006	7	1.35912	0.00404	0.02754	0.1655	0.00076	0.00517	1.10451	0.00508	0.03467	2.28594	0.00538	0.03669	2.40061	0.00991	0.0676
2006	8a	1.35932	0.00404	0.02754	0.1655	0.00076	0.00517	1.10474	0.00508	0.03466	2.28631	0.00538	0.03670	2.40074	0.00991	0.0675
2006	8b	1.35932	0.00404	0.02754	0.1655	0.00076	0.00517	1.10474	0.00508	0.03466	2.28631	0.00538	0.03670	2.40074	0.00991	0.0675
2007	2a	0.30974	0.00078	0.00545	0.0354	0.00010	0.00072	0.23149	0.00075	0.00521	0.53299	0.00163	0.01135	0.55333	0.00158	0.0110
2007	3	1.39133	0.00397	0.02710	0.1606	0.00069	0.00468	1.18925	0.00489	0.03332	2.32954	0.00506	0.03451	2.47246	0.00980	0.0668
2007	4	1.44556	0.00387	0.02642	0.1532	0.00058	0.00399	1.31904	0.00452	0.03085	2.40237	0.00454	0.03099	2.59223	0.00947	0.0646
2007	5	1.46674	0.00383	0.02614	0.1503	0.00054	0.00371	1.37033	0.00438	0.02988	2.43020	0.00433	0.02954	2.63968	0.00935	0.0637
2007	6	1.46826	0.00383	0.02612	0.1501	0.00054	0.00369	1.37398	0.00437	0.02981	2.43223	0.00432	0.02944	2.64305	0.00934	0.0636
2007	7	1.36849	0.00401	0.02738	0.1637	0.00073	0.00497	1.13452	0.00504	0.03436	2.29874	0.00528	0.03599	2.42197	0.00994	0.0677
2007	8a	1.36957	0.00402	0.02739	0.1636	0.00073	0.00496	1.13588	0.00503	0.03434	2.30108	0.00528	0.03604	2.42309	0.00993	0.0677
2007	8b	1.36957	0.00402	0.02739	0.1636	0.00073	0.00496	1.13588	0.00503	0.03434	2.30108	0.00528	0.03604	2.42309	0.00993	0.0677
2008	2a	0.23824	0.00087	0.00591	0.0238	0.00012	0.00079	0.17277	0.00084	0.00572	0.39882	0.00178	0.01214	0.41827	0.00175	0.0119
2008	3	0.96212	0.00396	0.02700	0.1060	0.00069	0.00472	0.74106	0.00477	0.03252	1.52012	0.00500	0.03409	1.57420	0.00941	0.0642
2008	4	0.91532	0.00391	0.02666	0.0989	0.00064	0.00438	0.72233	0.00460	0.03136	1.44730	0.00475	0.03240	1.50798	0.00927	0.0632
2008	5	0.89132	0.00388	0.02648	0.0952	0.00062	0.00421	0.71273	0.00451	0.03077	1.40997	0.00462	0.03152	1.47413	0.00920	0.0627
2008	6	0.88947	0.00388	0.02646	0.0949	0.00062	0.00420	0.71200	0.00450	0.03073	1.40710	0.00461	0.03145	1.47152	0.00920	0.0627
2008	7	0.97765	0.00398	0.02712	0.1083	0.00071	0.00483	0.74728	0.00482	0.03291	1.54431	0.00508	0.03466	1.59620	0.00946	0.0645
2008	8a	0.97749	0.00398	0.02712	0.1083	0.00071	0.00483	0.74722	0.00482	0.03290	1.54409	0.00508	0.03466	1.59590	0.00946	0.0645
2008	8b	0.97749	0.00398	0.02712	0.1083	0.00071	0.00483	0.74722	0.00482	0.03290	1.54409	0.00508	0.03466	1.59590	0.00946	0.0645
2009	2a	0.16203	0.00098	0.00629	0.0057	0.00013	0.00084	0.11331	0.00093	0.00614	0.25165	0.00198	0.01285	0.27134	0.00195	0.0127

		Highway			Urban														
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2009	3	0.68531	0.00397	0.02709	0.0349	0.00071	0.00483	0.55547	0.00476	0.03245	0.93435	0.00503	0.03432	0.85858	0.00930	0.0634
2009	4	0.67718	0.00396	0.02701	0.0353	0.00068	0.00465	0.55678	0.00470	0.03207	0.92924	0.00493	0.03361	0.86643	0.00932	0.0635
2009	5	0.67280	0.00395	0.02695	0.0355	0.00067	0.00456	0.55749	0.00467	0.03189	0.92628	0.00487	0.03319	0.87087	0.00934	0.0637
2009	6	0.67245	0.00395	0.02695	0.0355	0.00067	0.00456	0.55754	0.00467	0.03187	0.92605	0.00486	0.03316	0.87122	0.00934	0.0637
2009	7	0.68784	0.00398	0.02712	0.0348	0.00072	0.00488	0.55506	0.00478	0.03257	0.93592	0.00506	0.03453	0.85615	0.00929	0.0633
2009	8a	0.68764	0.00398	0.02713	0.0347	0.00071	0.00487	0.55509	0.00477	0.03255	0.93603	0.00507	0.03456	0.85612	0.00928	0.0633
2009	8b	0.68764	0.00398	0.02713	0.0347	0.00071	0.00487	0.55509	0.00477	0.03255	0.93603	0.00507	0.03456	0.85612	0.00928	0.0633
2010	2a	0.05974	0.00050	0.00281	0.0030	0.00006	0.00036	0.04560	0.00045	0.00260	0.10071	0.00096	0.00540	0.10176	0.00082	0.0045
2010	3	0.09311	0.00153	0.01043	0.0108	0.00026	0.00177	0.11110	0.00209	0.01425	0.16374	0.00246	0.01682	0.12277	0.00180	0.0122
2010	4	0.09314	0.00153	0.01044	0.0108	0.00026	0.00177	0.11111	0.00209	0.01425	0.16376	0.00246	0.01682	0.12279	0.00180	0.0122
2010	5	0.09316	0.00153	0.01044	0.0108	0.00026	0.00177	0.11112	0.00209	0.01425	0.16378	0.00246	0.01682	0.12280	0.00180	0.0122
2010	6	0.09316	0.00153	0.01044	0.0108	0.00026	0.00177	0.11112	0.00209	0.01425	0.16378	0.00246	0.01682	0.12280	0.00180	0.0122
2010	7	0.09311	0.00153	0.01043	0.0108	0.00026	0.00177	0.11109	0.00209	0.01425	0.16373	0.00246	0.01681	0.12277	0.00180	0.0122
2010	8a	0.09311	0.00153	0.01043	0.0108	0.00026	0.00177	0.11109	0.00209	0.01425	0.16373	0.00246	0.01681	0.12277	0.00180	0.0122
2010	8b	0.09311	0.00153	0.01043	0.0108	0.00026	0.00177	0.11109	0.00209	0.01425	0.16373	0.00246	0.01681	0.12277	0.00180	0.0122
2011	2a	0.06115	0.00061	0.00321	0.0034	0.00008	0.00043	0.05058	0.00058	0.00320	0.10435	0.00117	0.00614	0.10433	0.00100	0.0052
2011	3	0.10153	0.00149	0.01017	0.0113	0.00026	0.00181	0.11898	0.00208	0.01419	0.17396	0.00242	0.01654	0.13169	0.00176	0.0119
2011	4	0.11732	0.00142	0.00970	0.0123	0.00027	0.00187	0.13230	0.00206	0.01404	0.19152	0.00234	0.01595	0.14730	0.00167	0.0114
2011	5	0.12496	0.00139	0.00948	0.0127	0.00028	0.00190	0.13872	0.00205	0.01396	0.20000	0.00230	0.01567	0.15484	0.00163	0.0111
2011	6	0.12553	0.00139	0.00946	0.0127	0.00028	0.00190	0.13921	0.00204	0.01396	0.20063	0.00229	0.01565	0.15540	0.00163	0.0111
2011	7	0.09599	0.00152	0.01033	0.0110	0.00026	0.00178	0.11431	0.00209	0.01425	0.16779	0.00245	0.01674	0.12621	0.00179	0.0122
2011	8a	0.09599	0.00152	0.01033	0.0110	0.00026	0.00178	0.11431	0.00209	0.01425	0.16779	0.00245	0.01674	0.12621	0.00179	0.0122
2011	8b	0.09599	0.00152	0.01033	0.0110	0.00026	0.00178	0.11431	0.00209	0.01425	0.16779	0.00245	0.01674	0.12621	0.00179	0.0122
2012	2a	0.06247	0.00067	0.00347	0.0037	0.00009	0.00047	0.05434	0.00066	0.00362	0.10672	0.00127	0.00656	0.10570	0.00108	0.0055
2012	3	0.10230	0.00147	0.01003	0.0114	0.00026	0.00180	0.12081	0.00207	0.01410	0.17583	0.00240	0.01639	0.13319	0.00174	0.0118
2012	4	0.10864	0.00145	0.00986	0.0118	0.00027	0.00183	0.12605	0.00206	0.01405	0.18279	0.00237	0.01617	0.13938	0.00171	0.0116
2012	5	0.11222	0.00143	0.00976	0.0120	0.00027	0.00184	0.12900	0.00205	0.01402	0.18673	0.00235	0.01604	0.14288	0.00169	0.0115
2012	6	0.11251	0.00143	0.00975	0.0120	0.00027	0.00184	0.12924	0.00205	0.01401	0.18705	0.00235	0.01603	0.14316	0.00169	0.0115

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2012	7	0.10036	0.00148	0.01009	0.0113	0.00026	0.00179	0.11921	0.00207	0.01412	0.17370	0.00241	0.01645	0.13129	0.00175	0.0119
2012	8a	0.10036	0.00148	0.01009	0.0113	0.00026	0.00179	0.11921	0.00207	0.01412	0.17370	0.00241	0.01645	0.13129	0.00175	0.0119
2012	8b	0.10036	0.00148	0.01009	0.0113	0.00026	0.00179	0.11921	0.00207	0.01412	0.17370	0.00241	0.01645	0.13129	0.00175	0.0119
2013	2a	0.06059	0.00067	0.00297	0.0032	0.00009	0.00038	0.04831	0.00060	0.00281	0.10197	0.00131	0.00568	0.10217	0.00111	0.0048
2013	3	0.10862	0.00134	0.00917	0.0118	0.00024	0.00166	0.12729	0.00191	0.01305	0.18396	0.00220	0.01501	0.14006	0.00159	0.0108
2013	4	0.11975	0.00130	0.00889	0.0125	0.00025	0.00170	0.13600	0.00189	0.01293	0.19584	0.00214	0.01464	0.15061	0.00154	0.0104
2013	5	0.12506	0.00128	0.00875	0.0128	0.00025	0.00172	0.14025	0.00188	0.01286	0.20162	0.00212	0.01446	0.15569	0.00151	0.0103
2013	6	0.12549	0.00128	0.00874	0.0128	0.00025	0.00172	0.14059	0.00188	0.01286	0.20207	0.00211	0.01445	0.15609	0.00151	0.0103
2013	7	0.10486	0.00136	0.00926	0.0116	0.00024	0.00165	0.12435	0.00192	0.01310	0.17996	0.00221	0.01513	0.13650	0.00160	0.0109
2013	8a	0.10530	0.00136	0.00926	0.0116	0.00024	0.00165	0.12458	0.00192	0.01310	0.18029	0.00221	0.01513	0.13686	0.00160	0.0109
2013	8b	0.10530	0.00136	0.00926	0.0116	0.00024	0.00165	0.12458	0.00192	0.01310	0.18029	0.00221	0.01513	0.13686	0.00160	0.0109
2014	2a	0.06275	0.00086	0.00313	0.0031	0.00010	0.00038	0.04853	0.00073	0.00296	0.10296	0.00165	0.00571	0.10260	0.00138	0.0047
2014	3	0.10827	0.00130	0.00885	0.0118	0.00024	0.00163	0.12821	0.00186	0.01270	0.18398	0.00213	0.01453	0.14042	0.00153	0.0104
2014	4	0.11256	0.00129	0.00877	0.0120	0.00024	0.00165	0.13148	0.00186	0.01268	0.18856	0.00211	0.01442	0.14445	0.00152	0.0103
2014	5	0.11503	0.00128	0.00872	0.0122	0.00024	0.00166	0.13337	0.00185	0.01267	0.19120	0.00210	0.01436	0.14676	0.00151	0.0103
2014	6	0.11523	0.00128	0.00872	0.0122	0.00024	0.00166	0.13352	0.00185	0.01266	0.19141	0.00210	0.01436	0.14695	0.00151	0.0102
2014	7	0.10698	0.00130	0.00888	0.0117	0.00024	0.00163	0.12722	0.00186	0.01271	0.18260	0.00213	0.01456	0.13921	0.00154	0.0105
2014	8a	0.10698	0.00130	0.00888	0.0117	0.00024	0.00163	0.12722	0.00186	0.01271	0.18260	0.00213	0.01456	0.13921	0.00154	0.0105
2014	8b	0.10698	0.00130	0.00888	0.0117	0.00024	0.00163	0.12722	0.00186	0.01271	0.18260	0.00213	0.01456	0.13921	0.00154	0.0105
2015	2a	0.05327	0.00084	0.00279	0.0027	0.00010	0.00034	0.04212	0.00071	0.00268	0.08729	0.00162	0.00508	0.08678	0.00136	0.0042
2015	3	0.10811	0.00130	0.00886	0.0118	0.00024	0.00163	0.12806	0.00186	0.01270	0.18378	0.00213	0.01453	0.14026	0.00153	0.0104
2015	4	0.11201	0.00129	0.00878	0.0120	0.00024	0.00165	0.13104	0.00186	0.01268	0.18795	0.00211	0.01444	0.14392	0.00152	0.0103
2015	5	0.11428	0.00128	0.00874	0.0121	0.00024	0.00166	0.13277	0.00185	0.01267	0.19037	0.00210	0.01438	0.14605	0.00151	0.0103
2015	6	0.11446	0.00128	0.00873	0.0121	0.00024	0.00166	0.13291	0.00185	0.01267	0.19056	0.00210	0.01438	0.14622	0.00151	0.0103
2015	7	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12717	0.00186	0.01271	0.18253	0.00213	0.01456	0.13917	0.00154	0.0104
2015	8a	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12717	0.00186	0.01271	0.18253	0.00213	0.01456	0.13917	0.00154	0.0104
2015	8b	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12717	0.00186	0.01271	0.18253	0.00213	0.01456	0.13917	0.00154	0.0104
2016	2a	0.05283	0.00090	0.00277	0.0027	0.00011	0.00033	0.04146	0.00074	0.00261	0.08676	0.00174	0.00509	0.08646	0.00146	0.0042

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2016	3	0.10798	0.00130	0.00886	0.0118	0.00024	0.00163	0.12795	0.00186	0.01270	0.18363	0.00213	0.01454	0.14014	0.00153	0.0104
2016	4	0.11148	0.00129	0.00879	0.0120	0.00024	0.00164	0.13063	0.00186	0.01268	0.18738	0.00211	0.01445	0.14343	0.00152	0.0103
2016	5	0.11354	0.00128	0.00875	0.0121	0.00024	0.00165	0.13220	0.00185	0.01267	0.18957	0.00211	0.01440	0.14536	0.00151	0.0103
2016	6	0.11370	0.00128	0.00875	0.0121	0.00024	0.00165	0.13232	0.00185	0.01267	0.18975	0.00211	0.01439	0.14552	0.00151	0.0103
2016	7	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12715	0.00186	0.01271	0.18252	0.00213	0.01456	0.13916	0.00154	0.0104
2016	8a	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12715	0.00186	0.01271	0.18252	0.00213	0.01456	0.13916	0.00154	0.0104
2016	8b	0.10694	0.00130	0.00888	0.0117	0.00024	0.00163	0.12715	0.00186	0.01271	0.18252	0.00213	0.01456	0.13916	0.00154	0.0104
2017	2a	0.04047	0.00087	0.00249	0.0021	0.00011	0.00030	0.03345	0.00073	0.00242	0.06564	0.00169	0.00451	0.06479	0.00142	0.0037
2017	3	0.10778	0.00130	0.00886	0.0117	0.00024	0.00163	0.12777	0.00186	0.01270	0.18338	0.00213	0.01454	0.13994	0.00153	0.0104
2017	4	0.11080	0.00129	0.00880	0.0119	0.00024	0.00164	0.13008	0.00186	0.01269	0.18661	0.00212	0.01446	0.14277	0.00152	0.0104
2017	5	0.11258	0.00129	0.00877	0.0120	0.00024	0.00165	0.13144	0.00185	0.01267	0.18852	0.00211	0.01442	0.14445	0.00152	0.0103
2017	6	0.11273	0.00128	0.00876	0.0120	0.00024	0.00165	0.13155	0.00185	0.01267	0.18867	0.00211	0.01441	0.14459	0.00151	0.0103
2017	7	0.10688	0.00130	0.00888	0.0117	0.00024	0.00163	0.12709	0.00186	0.01271	0.18243	0.00213	0.01456	0.13910	0.00154	0.0104
2017	8a	0.10688	0.00130	0.00888	0.0117	0.00024	0.00163	0.12709	0.00186	0.01271	0.18243	0.00213	0.01456	0.13910	0.00154	0.0104
2017	8b	0.10688	0.00130	0.00888	0.0117	0.00024	0.00163	0.12709	0.00186	0.01271	0.18243	0.00213	0.01456	0.13910	0.00154	0.0104
2018	2a	0.03914	0.00093	0.00258	0.0021	0.00011	0.00031	0.03274	0.00079	0.00259	0.06360	0.00181	0.00458	0.06263	0.00151	0.0038
2018	3	0.09469	0.00129	0.00882	0.0101	0.00024	0.00164	0.11109	0.00186	0.01269	0.15842	0.00212	0.01448	0.12172	0.00152	0.0104
2018	4	0.10585	0.00127	0.00863	0.0108	0.00025	0.00167	0.12043	0.00185	0.01264	0.17168	0.00209	0.01425	0.13291	0.00149	0.0101
2018	5	0.11159	0.00125	0.00854	0.0112	0.00025	0.00169	0.12523	0.00185	0.01261	0.17850	0.00207	0.01413	0.13867	0.00147	0.0100
2018	6	0.11203	0.00125	0.00853	0.0113	0.00025	0.00169	0.12560	0.00185	0.01261	0.17903	0.00207	0.01412	0.13912	0.00147	0.0100
2018	7	0.09098	0.00130	0.00888	0.0098	0.00024	0.00163	0.10799	0.00186	0.01271	0.15402	0.00213	0.01456	0.11800	0.00154	0.0104
2018	8a	0.09098	0.00130	0.00888	0.0098	0.00024	0.00163	0.10799	0.00186	0.01271	0.15402	0.00213	0.01456	0.11800	0.00154	0.0104
2018	8b	0.09098	0.00130	0.00888	0.0098	0.00024	0.00163	0.10799	0.00186	0.01271	0.15402	0.00213	0.01456	0.11800	0.00154	0.0104
2019	2a	0.02891	0.00086	0.00241	0.0015	0.00011	0.00029	0.02498	0.00074	0.00251	0.04669	0.00165	0.00418	0.04564	0.00138	0.0034
2019	3	0.07620	0.00129	0.00879	0.0083	0.00024	0.00163	0.09192	0.00185	0.01263	0.13077	0.00211	0.01442	0.10053	0.00152	0.0103
2019	4	0.08537	0.00126	0.00861	0.0089	0.00024	0.00166	0.10000	0.00184	0.01255	0.14229	0.00207	0.01417	0.11020	0.00148	0.0101
2019	5	0.09017	0.00125	0.00851	0.0093	0.00024	0.00167	0.10422	0.00183	0.01251	0.14831	0.00206	0.01405	0.11524	0.00147	0.0100
2019	6	0.09054	0.00125	0.00851	0.0093	0.00025	0.00167	0.10455	0.00183	0.01251	0.14877	0.00205	0.01404	0.11563	0.00146	0.0100

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2019	7	0.07319	0.00130	0.00885	0.0080	0.00024	0.00162	0.08926	0.00185	0.01266	0.12699	0.00212	0.01450	0.09737	0.00153	0.0104
2019	8a	0.07319	0.00130	0.00885	0.0080	0.00024	0.00162	0.08926	0.00185	0.01266	0.12699	0.00212	0.01450	0.09737	0.00153	0.0104
2019	8b	0.07319	0.00130	0.00885	0.0080	0.00024	0.00162	0.08926	0.00185	0.01266	0.12699	0.00212	0.01450	0.09737	0.00153	0.0104
2020	2a	0.02545	0.00077	0.00222	0.0013	0.00009	0.00026	0.02224	0.00068	0.00239	0.04057	0.00145	0.00376	0.03949	0.00121	0.0031
2020	3	0.07253	0.00129	0.00880	0.0078	0.00024	0.00163	0.08753	0.00185	0.01263	0.12418	0.00211	0.01442	0.09558	0.00152	0.0103
2020	4	0.08155	0.00126	0.00862	0.0085	0.00024	0.00166	0.09560	0.00184	0.01256	0.13573	0.00208	0.01419	0.10520	0.00149	0.0101
2020	5	0.08632	0.00125	0.00853	0.0089	0.00024	0.00167	0.09986	0.00183	0.01252	0.14182	0.00206	0.01407	0.11028	0.00147	0.0100
2020	6	0.08669	0.00125	0.00853	0.0089	0.00024	0.00167	0.10019	0.00183	0.01252	0.14229	0.00206	0.01406	0.11067	0.00147	0.0100
2020	7	0.06960	0.00130	0.00885	0.0076	0.00024	0.00162	0.08491	0.00185	0.01265	0.12044	0.00212	0.01450	0.09246	0.00153	0.0104
2020	8a	0.06960	0.00130	0.00885	0.0076	0.00024	0.00162	0.08491	0.00185	0.01265	0.12044	0.00212	0.01450	0.09246	0.00153	0.0104
2020	8b	0.06960	0.00130	0.00885	0.0076	0.00024	0.00162	0.08491	0.00185	0.01265	0.12044	0.00212	0.01450	0.09246	0.00153	0.0104
2021	2a	0.01816	0.00041	0.00124	0.0010	0.00005	0.00015	0.01690	0.00038	0.00139	0.02810	0.00078	0.00207	0.02691	0.00065	0.0017
2021	3	0.06798	0.00077	0.00528	0.0074	0.00014	0.00098	0.08263	0.00112	0.00763	0.11705	0.00128	0.00872	0.09024	0.00092	0.0062
2021	4	0.07604	0.00076	0.00518	0.0080	0.00015	0.00100	0.09016	0.00112	0.00760	0.12784	0.00126	0.00859	0.09919	0.00091	0.0061
2021	5	0.08034	0.00075	0.00513	0.0084	0.00015	0.00101	0.09417	0.00112	0.00758	0.13358	0.00126	0.00853	0.10397	0.00090	0.0060
2021	6	0.08067	0.00075	0.00513	0.0084	0.00015	0.00101	0.09449	0.00112	0.00758	0.13403	0.00125	0.00852	0.10434	0.00090	0.0060
2021	7	0.06539	0.00078	0.00531	0.0072	0.00014	0.00098	0.08020	0.00112	0.00764	0.11358	0.00129	0.00875	0.08735	0.00093	0.0063
2021	8a	0.06539	0.00078	0.00531	0.0072	0.00014	0.00098	0.08020	0.00112	0.00764	0.11358	0.00129	0.00875	0.08735	0.00093	0.0063
2021	8b	0.06539	0.00078	0.00531	0.0072	0.00014	0.00098	0.08020	0.00112	0.00764	0.11358	0.00129	0.00875	0.08735	0.00093	0.0063
2022	2a	0.01556	0.00042	0.00125	0.0008	0.00005	0.00015	0.01476	0.00038	0.00141	0.02342	0.00078	0.00207	0.02223	0.00065	0.0017
2022	3	0.06447	0.00077	0.00528	0.0069	0.00014	0.00098	0.07837	0.00112	0.00763	0.11059	0.00128	0.00872	0.08544	0.00092	0.0062
2022	4	0.07275	0.00076	0.00519	0.0076	0.00015	0.00100	0.08622	0.00112	0.00760	0.12185	0.00127	0.00860	0.09474	0.00091	0.0061
2022	5	0.07718	0.00075	0.00513	0.0079	0.00015	0.00101	0.09040	0.00112	0.00758	0.12787	0.00126	0.00853	0.09970	0.00090	0.0060
2022	6	0.07752	0.00075	0.00513	0.0080	0.00015	0.00101	0.09073	0.00112	0.00758	0.12834	0.00125	0.00853	0.10009	0.00090	0.0060
2022	7	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07585	0.00112	0.00764	0.10697	0.00129	0.00875	0.08245	0.00093	0.0063
2022	8a	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07585	0.00112	0.00764	0.10697	0.00129	0.00875	0.08245	0.00093	0.0063
2022	8b	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07585	0.00112	0.00764	0.10697	0.00129	0.00875	0.08245	0.00093	0.0063
2023	2a	0.01343	0.00042	0.00124	0.0007	0.00005	0.00015	0.01334	0.00038	0.00139	0.01976	0.00078	0.00205	0.01852	0.00065	0.0016

		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2023	3	0.06443	0.00077	0.00528	0.0069	0.00014	0.00098	0.07834	0.00112	0.00763	0.11054	0.00128	0.00872	0.08540	0.00092	0.0062
2023	4	0.07261	0.00076	0.00519	0.0076	0.00015	0.00100	0.08608	0.00112	0.00760	0.12166	0.00127	0.00860	0.09458	0.00091	0.0061
2023	5	0.07699	0.00075	0.00514	0.0079	0.00015	0.00101	0.09022	0.00112	0.00758	0.12761	0.00126	0.00853	0.09949	0.00090	0.0060
2023	6	0.07733	0.00075	0.00513	0.0080	0.00015	0.00101	0.09054	0.00112	0.00758	0.12807	0.00126	0.00853	0.09987	0.00090	0.0060
2023	7	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07586	0.00112	0.00764	0.10698	0.00129	0.00875	0.08246	0.00093	0.0063
2023	8a	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07586	0.00112	0.00764	0.10698	0.00129	0.00875	0.08246	0.00093	0.0063
2023	8b	0.06181	0.00078	0.00531	0.0067	0.00014	0.00098	0.07586	0.00112	0.00764	0.10698	0.00129	0.00875	0.08246	0.00093	0.0063
2024	2a	0.01125	0.00042	0.00123	0.0006	0.00005	0.00015	0.01187	0.00038	0.00138	0.01604	0.00078	0.00203	0.01474	0.00065	0.0016
2024	3	0.06434	0.00077	0.00528	0.0069	0.00014	0.00098	0.07824	0.00112	0.00763	0.11040	0.00128	0.00872	0.08529	0.00092	0.0062
2024	4	0.07235	0.00076	0.00519	0.0076	0.00015	0.00100	0.08583	0.00112	0.00760	0.12130	0.00127	0.00860	0.09428	0.00091	0.0061
2024	5	0.07666	0.00075	0.00514	0.0079	0.00015	0.00101	0.08991	0.00112	0.00758	0.12716	0.00126	0.00854	0.09912	0.00090	0.0061
2024	6	0.07700	0.00075	0.00513	0.0079	0.00015	0.00101	0.09023	0.00112	0.00758	0.12761	0.00126	0.00853	0.09949	0.00090	0.0060
2024	7	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063
2024	8a	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063
2024	8b	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063
2025	2a	0.01125	0.00042	0.00123	0.0006	0.00005	0.00015	0.01187	0.00038	0.00138	0.01604	0.00078	0.00203	0.01474	0.00065	0.0016
2025	3	0.06434	0.00077	0.00528	0.0069	0.00014	0.00098	0.07824	0.00112	0.00763	0.11040	0.00128	0.00872	0.08529	0.00092	0.0062
2025	4	0.07235	0.00076	0.00519	0.0076	0.00015	0.00100	0.08583	0.00112	0.00760	0.12130	0.00127	0.00860	0.09428	0.00091	0.0061
2025	5	0.07666	0.00075	0.00514	0.0079	0.00015	0.00101	0.08991	0.00112	0.00758	0.12716	0.00126	0.00854	0.09912	0.00090	0.0061
2025	6	0.07700	0.00075	0.00513	0.0079	0.00015	0.00101	0.09023	0.00112	0.00758	0.12761	0.00126	0.00853	0.09949	0.00090	0.0060
2025	7	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063
2025	8a	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063
2025	8b	0.06178	0.00078	0.00531	0.0067	0.00014	0.00098	0.07582	0.00112	0.00764	0.10692	0.00129	0.00875	0.08241	0.00093	0.0063

Note – MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore gasoline 8bs are set equal to 8as.

Appendix B: NOx, PM & BC Idle Factors – g/hr

(MOVES3.1, 2023 Calendar Year, ULSD)

Table B-1. Short Duration Idle Emission Factors (< 60 minutes per idle event) (g/hr)

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Gasoline	Pre-1993	6.848	7.086	7.086	7.086
NO_x	Gasoline	1993	6.848	7.086	7.086	7.086
NO_x	Gasoline	1994	6.848	7.086	7.086	7.086
NO_x	Gasoline	1995	6.852	7.086	7.086	7.086
NO_x	Gasoline	1996	6.708	7.086	7.086	7.086
NO_x	Gasoline	1997	6.704	7.086	7.086	7.086
NO_x	Gasoline	1998	13.901	14.683	14.683	14.683
NO_x	Gasoline	1999	13.924	14.683	14.683	14.683
NO_x	Gasoline	2000	13.825	14.683	14.683	14.683
NO_x	Gasoline	2001	6.658	5.478	5.478	5.478
NO_x	Gasoline	2002	6.675	5.478	5.478	5.478
NO_x	Gasoline	2003	6.710	5.478	5.478	5.478
NO_x	Gasoline	2004	6.644	5.478	5.478	5.478
NO_x	Gasoline	2005	6.573	5.478	5.478	5.478
NO_x	Gasoline	2006	6.583	5.478	5.478	5.478
NO_x	Gasoline	2007	6.604	5.478	5.478	5.478
NO_x	Gasoline	2008	3.287	2.785	1.643	1.643
NO_x	Gasoline	2009	0.107	0.091	1.643	1.643
NO_x	Gasoline	2010	0.258	0.227	0.227	0.227

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Gasoline	2011	0.252	0.227	0.227	0.227
NO_x	Gasoline	2012	0.251	0.227	0.227	0.227
NO_x	Gasoline	2013	0.245	0.227	0.227	0.227
NO_x	Gasoline	2014	0.251	0.227	0.227	0.227
NO_x	Gasoline	2015	0.248	0.227	0.227	0.227
NO_x	Gasoline	2016	0.250	0.227	0.227	0.227
NO_x	Gasoline	2017	0.250	0.227	0.227	0.227
NO_x	Gasoline	2018	0.229	0.227	0.227	0.227
NO_x	Gasoline	2019	0.097	0.124	0.124	0.124
NO_x	Gasoline	2020	0.070	0.124	0.124	0.124
NO_x	Gasoline	2021	0.052	0.124	0.124	0.124
NO_x	Gasoline	2022	0.033	0.124	0.124	0.124
NO_x	Gasoline	2023	0.033	0.124	0.124	0.124
NO_x	Gasoline	2024	0.033	0.124	0.124	0.124
NO_x	Gasoline	2025	0.033	0.124	0.124	0.124
NO_x	Diesel	Pre-1993	121.100	121.100	140.253	140.253
NO_x	Diesel	1993	121.100	121.100	140.253	140.253
NO_x	Diesel	1994	121.100	121.100	140.253	140.253
NO_x	Diesel	1995	121.100	121.100	140.253	140.253
NO_x	Diesel	1996	121.100	121.100	140.253	140.254
NO_x	Diesel	1997	121.100	121.100	140.253	140.253
NO_x	Diesel	1998	96.880	96.880	117.769	117.769
NO_x	Diesel	1999	96.880	96.880	96.880	155.358
NO_x	Diesel	2000	96.880	96.880	96.880	155.358
NO_x	Diesel	2001	96.783	96.880	96.880	155.358

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Diesel	2002	96.783	96.880	96.880	155.358
NO_x	Diesel	2003	22.000	22.022	45.975	57.149
NO_x	Diesel	2004	22.000	22.022	45.975	57.148
NO_x	Diesel	2005	22.000	22.022	45.975	57.149
NO_x	Diesel	2006	22.000	22.022	45.975	57.148
NO_x	Diesel	2007	20.381	20.381	22.935	53.518
NO_x	Diesel	2008	20.381	20.381	22.935	53.518
NO_x	Diesel	2009	20.381	20.381	22.935	53.518
NO_x	Diesel	2010	17.283	19.720	35.913	47.276
NO_x	Diesel	2011	22.762	25.971	34.851	41.910
NO_x	Diesel	2012	19.936	22.747	34.929	41.362
NO_x	Diesel	2013	31.209	31.209	21.065	35.652
NO_x	Diesel	2014	14.205	14.205	29.132	49.226
NO_x	Diesel	2015	10.042	10.042	27.988	49.007
NO_x	Diesel	2016	10.042	10.042	27.999	49.748
NO_x	Diesel	2017	10.042	10.042	27.881	52.602
NO_x	Diesel	2018	7.016	10.042	27.755	52.601
NO_x	Diesel	2019	5.646	10.042	26.054	52.601
NO_x	Diesel	2020	4.854	10.042	26.054	52.601
NO_x	Diesel	2021	3.062	6.797	18.412	38.119
NO_x	Diesel	2022	2.528	6.797	18.412	38.119
NO_x	Diesel	2023	2.528	6.797	18.412	38.119
NO_x	Diesel	2024	2.528	6.797	18.412	38.119
NO_x	Diesel	2025	2.528	6.797	18.412	38.119
$PM_{2.5}$	Gasoline	Pre-1993	0.04372	0.04372	0.04372	0.04372

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Gasoline	1993	0.04372	0.04372	0.04372	0.04372
$PM_{2.5}$	Gasoline	1994	0.04372	0.04372	0.04372	0.04372
$PM_{2.5}$	Gasoline	1995	0.05211	0.05211	0.05211	0.05211
$PM_{2.5}$	Gasoline	1996	0.12125	0.12125	0.12125	0.12125
$PM_{2.5}$	Gasoline	1997	0.12755	0.12755	0.12755	0.12755
$PM_{2.5}$	Gasoline	1998	0.07616	0.07616	0.07616	0.07616
$PM_{2.5}$	Gasoline	1999	0.03694	0.03694	0.03694	0.03694
$PM_{2.5}$	Gasoline	2000	0.01641	0.01641	0.01641	0.01641
$PM_{2.5}$	Gasoline	2001	0.01496	0.01496	0.01496	0.01496
$PM_{2.5}$	Gasoline	2002	0.06339	0.06339	0.06339	0.06339
$PM_{2.5}$	Gasoline	2003	0.03743	0.03743	0.03743	0.03743
$PM_{2.5}$	Gasoline	2004	0.09009	0.08739	0.08739	0.08739
$PM_{2.5}$	Gasoline	2005	0.06812	0.06618	0.06618	0.06618
$PM_{2.5}$	Gasoline	2006	0.06813	0.06618	0.06618	0.06618
$PM_{2.5}$	Gasoline	2007	0.06817	0.06618	0.06618	0.06618
$PM_{2.5}$	Gasoline	2008	0.06795	0.06618	0.06618	0.06618
$PM_{2.5}$	Gasoline	2009	0.06793	0.06618	0.06618	0.06618
$PM_{2.5}$	Gasoline	2010	0.05302	0.05948	0.01983	0.01983
$PM_{2.5}$	Gasoline	2011	0.05286	0.05948	0.01983	0.01983
$PM_{2.5}$	Gasoline	2012	0.05284	0.05948	0.01983	0.01983
$PM_{2.5}$	Gasoline	2013	0.05265	0.05194	0.01795	0.01795
$PM_{2.5}$	Gasoline	2014	0.05282	0.05194	0.01795	0.01795
$PM_{2.5}$	Gasoline	2015	0.05275	0.05194	0.01795	0.01795
$PM_{2.5}$	Gasoline	2016	0.05281	0.05194	0.01795	0.01795
$PM_{2.5}$	Gasoline	2017	0.05281	0.05194	0.01795	0.01795

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Gasoline	2018	0.05293	0.05194	0.01795	0.01795
$PM_{2.5}$	Gasoline	2019	0.05290	0.05194	0.01603	0.01603
$PM_{2.5}$	Gasoline	2020	0.05271	0.05194	0.01603	0.01603
$PM_{2.5}$	Gasoline	2021	0.03161	0.03117	0.01134	0.01134
$PM_{2.5}$	Gasoline	2022	0.03161	0.03117	0.01134	0.01134
$PM_{2.5}$	Gasoline	2023	0.03162	0.03117	0.01134	0.01134
$PM_{2.5}$	Gasoline	2024	0.03163	0.03117	0.01134	0.01134
$PM_{2.5}$	Gasoline	2025	0.03163	0.03117	0.01134	0.01134
$PM_{2.5}$	Diesel	Pre-1993	11.12997	11.12994	10.40181	9.19828
$PM_{2.5}$	Diesel	1993	11.12997	11.12994	10.40181	9.19828
$PM_{2.5}$	Diesel	1994	11.12997	11.12994	10.40181	9.19828
$PM_{2.5}$	Diesel	1995	11.12992	11.12993	10.40182	9.19829
$PM_{2.5}$	Diesel	1996	11.12992	11.12992	10.40181	9.19829
$PM_{2.5}$	Diesel	1997	11.12989	11.12994	10.40183	9.19828
$PM_{2.5}$	Diesel	1998	10.46815	10.46812	9.87561	8.79678
$PM_{2.5}$	Diesel	1999	10.46816	10.46816	9.87561	8.79677
$PM_{2.5}$	Diesel	2000	10.46815	10.46815	9.87562	8.79678
$PM_{2.5}$	Diesel	2001	6.99717	10.46819	9.87563	8.79676
$PM_{2.5}$	Diesel	2002	6.99718	10.46818	9.87561	8.79678
$PM_{2.5}$	Diesel	2003	5.95161	8.90395	8.90392	7.94996
$PM_{2.5}$	Diesel	2004	5.95162	8.90396	8.90396	7.94995
$PM_{2.5}$	Diesel	2005	5.95161	8.90392	8.90395	7.94996
$PM_{2.5}$	Diesel	2006	5.95162	8.90397	8.90394	7.94994
$PM_{2.5}$	Diesel	2007	0.38894	0.38894	0.26990	0.26722
$PM_{2.5}$	Diesel	2008	0.38894	0.38894	0.26990	0.26722

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Diesel	2009	0.38894	0.38894	0.26990	0.26722
$PM_{2.5}$	Diesel	2010	0.04629	0.05242	0.53740	0.01797
$PM_{2.5}$	Diesel	2011	0.04629	0.05242	0.53740	0.01797
$PM_{2.5}$	Diesel	2012	0.04629	0.05242	0.53740	0.01797
$PM_{2.5}$	Diesel	2013	0.04629	0.04629	0.47484	0.01588
$PM_{2.5}$	Diesel	2014	0.00573	0.00573	0.06262	0.02371
$PM_{2.5}$	Diesel	2015	0.00573	0.00573	0.06262	0.02371
$PM_{2.5}$	Diesel	2016	0.00573	0.00573	0.06262	0.02371
$PM_{2.5}$	Diesel	2017	0.00573	0.00573	0.06262	0.02371
$PM_{2.5}$	Diesel	2018	0.00573	0.00573	0.06262	0.02371
$PM_{2.5}$	Diesel	2019	0.00505	0.00573	0.05843	0.02371
$PM_{2.5}$	Diesel	2020	0.00499	0.00573	0.05843	0.02371
$PM_{2.5}$	Diesel	2021	0.00358	0.00372	0.03958	0.01658
$PM_{2.5}$	Diesel	2022	0.00358	0.00372	0.03958	0.01658
$PM_{2.5}$	Diesel	2023	0.00358	0.00372	0.03958	0.01658
$PM_{2.5}$	Diesel	2024	0.00358	0.00372	0.03958	0.01658
$PM_{2.5}$	Diesel	2025	0.00358	0.00372	0.03958	0.01658
Black Carbon	Gasoline	Pre-1993	0.006412	0.006412	0.006412	0.006412
Black Carbon	Gasoline	1993	0.006412	0.006412	0.006412	0.006412
Black Carbon	Gasoline	1994	0.006412	0.006412	0.006412	0.006412
Black Carbon	Gasoline	1995	0.007642	0.007642	0.007642	0.007642
Black Carbon	Gasoline	1996	0.017782	0.017782	0.017782	0.017782
Black Carbon	Gasoline	1997	0.018705	0.018705	0.018705	0.018705
Black Carbon	Gasoline	1998	0.011169	0.011169	0.011169	0.011169
Black Carbon	Gasoline	1999	0.005418	0.005418	0.005418	0.005418

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
Black Carbon	Gasoline	2000	0.002406	0.002406	0.002406	0.002406
Black Carbon	Gasoline	2001	0.002193	0.002193	0.002193	0.002193
Black Carbon	Gasoline	2002	0.009291	0.009291	0.009291	0.009291
Black Carbon	Gasoline	2003	0.005486	0.005486	0.005486	0.005486
Black Carbon	Gasoline	2004	0.012810	0.012810	0.012810	0.012810
Black Carbon	Gasoline	2005	0.009701	0.009701	0.009701	0.009701
Black Carbon	Gasoline	2006	0.009701	0.009701	0.009701	0.009701
Black Carbon	Gasoline	2007	0.009701	0.009701	0.009701	0.009701
Black Carbon	Gasoline	2008	0.009701	0.009701	0.009701	0.009701
Black Carbon	Gasoline	2009	0.009701	0.009701	0.009701	0.009701
Black Carbon	Gasoline	2010	0.007907	0.008895	0.002965	0.002965
Black Carbon	Gasoline	2011	0.007907	0.008896	0.002965	0.002965
Black Carbon	Gasoline	2012	0.007907	0.008895	0.002965	0.002965
Black Carbon	Gasoline	2013	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2014	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2015	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2016	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2017	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2018	0.007907	0.007907	0.002965	0.002965
Black Carbon	Gasoline	2019	0.007907	0.007907	0.001977	0.001977
Black Carbon	Gasoline	2020	0.007907	0.007907	0.001977	0.001977
Black Carbon	Gasoline	2021	0.004942	0.004942	0.001977	0.001977
Black Carbon	Gasoline	2022	0.004942	0.004942	0.001977	0.001977
Black Carbon	Gasoline	2023	0.004942	0.004942	0.001977	0.001977
Black Carbon	Gasoline	2024	0.004942	0.004942	0.001977	0.001977

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
Black Carbon	Gasoline	2025	0.004942	0.004942	0.001977	0.001977
Black Carbon	Diesel	Pre-1993	3.531599	3.531591	3.300558	2.918671
Black Carbon	Diesel	1993	3.531599	3.531591	3.300558	2.918671
Black Carbon	Diesel	1994	3.531599	3.531591	3.300558	2.918671
Black Carbon	Diesel	1995	3.531594	3.531590	3.300555	2.918677
Black Carbon	Diesel	1996	3.531591	3.531595	3.300555	2.918678
Black Carbon	Diesel	1997	3.531585	3.531597	3.300558	2.918673
Black Carbon	Diesel	1998	3.321605	3.321596	3.133592	2.791269
Black Carbon	Diesel	1999	3.321608	3.321609	3.133594	2.791265
Black Carbon	Diesel	2000	3.321610	3.321609	3.133595	2.791267
Black Carbon	Diesel	2001	3.308434	3.321617	3.133602	2.791266
Black Carbon	Diesel	2002	3.308443	3.321613	3.133589	2.791268
Black Carbon	Diesel	2003	2.814085	2.825278	2.825274	2.522573
Black Carbon	Diesel	2004	2.814080	2.825280	2.825282	2.522572
Black Carbon	Diesel	2005	2.814077	2.825271	2.825276	2.522570
Black Carbon	Diesel	2006	2.814075	2.825282	2.825279	2.522566
Black Carbon	Diesel	2007	0.045436	0.045436	0.031529	0.031217
Black Carbon	Diesel	2008	0.045436	0.045436	0.031529	0.031217
Black Carbon	Diesel	2009	0.045436	0.045436	0.031529	0.031217
Black Carbon	Diesel	2010	0.005411	0.006127	0.062815	0.002100
Black Carbon	Diesel	2011	0.005411	0.006127	0.062815	0.002100
Black Carbon	Diesel	2012	0.005411	0.006127	0.062815	0.002100
Black Carbon	Diesel	2013	0.005411	0.005411	0.055503	0.001856
Black Carbon	Diesel	2014	0.000670	0.000670	0.007320	0.002772
Black Carbon	Diesel	2015	0.000670	0.000670	0.007320	0.002772

Pollutant	Fuel	Model Year	Class 2b 3	Classes 4 5	Classes 6 7	Classes 8a/b
Black Carbon	Diesel	2016	0.000670	0.000670	0.007320	0.002772
Black Carbon	Diesel	2017	0.000670	0.000670	0.007320	0.002772
Black Carbon	Diesel	2018	0.000670	0.000670	0.007320	0.002772
Black Carbon	Diesel	2019	0.000590	0.000670	0.006829	0.002772
Black Carbon	Diesel	2020	0.000583	0.000670	0.006829	0.002772
Black Carbon	Diesel	2021	0.000419	0.000435	0.004627	0.001938
Black Carbon	Diesel	2022	0.000418	0.000435	0.004627	0.001938
Black Carbon	Diesel	2023	0.000418	0.000435	0.004627	0.001938
Black Carbon	Diesel	2024	0.000418	0.000435	0.004627	0.001938
Black Carbon	Diesel	2025	0.000418	0.000435	0.004627	0.001938

Table B-2. Extended Idle Emission Factors – Class 8b Diesels Only (g/hr)

Model Year	NO_x	$PM_{2.5}$	Black Carbon
Pre-1993	144.45471	2.77407	1.12709
1993	144.45471	2.77407	1.12709
1994	144.45471	2.77407	1.12709
1995	144.45525	2.77407	1.12709
1996	144.45492	2.77408	1.12709
1997	144.45480	2.77409	1.12709
1998	144.45474	2.77408	1.12709
1999	144.45490	2.77408	1.12710
2000	144.45511	2.77408	1.12709
2001	144.45476	2.77407	1.12710
2002	144.45520	2.77409	1.12709
2003	144.45524	2.77408	1.12709
2004	144.45478	2.77408	1.12709
2005	144.45553	2.77408	1.12709
2006	144.45503	2.77407	1.12709
2007	106.66577	0.09682	0.01488
2008	106.66606	0.09682	0.01488
2009	106.66589	0.09682	0.01488
2010	45.50105	0.05172	0.01100
2011	45.50095	0.05172	0.01100
2012	45.50094	0.05172	0.01100
2013	45.50100	0.03173	0.00733
2014	45.50431	0.04045	0.00934
2015	45.50600	0.04052	0.00935

Model Year	NO_x	$PM_{2.5}$	Black Carbon
2016	45.50657	0.04055	0.00936
2017	45.50825	0.04062	0.00938
2018	45.50441	0.04045	0.00934
2019	45.50740	0.04059	0.00937
2020	45.50749	0.04059	0.00937
2021	45.50760	0.04060	0.00937
2022	45.50773	0.04060	0.00937
2023	45.50783	0.04061	0.00937
2024	45.50815	0.04061	0.00938
2025	45.87603373	0.04061	0.00938

Appendix C: Derivation of National Average g/kW-hr Emission Factors

FROM ARGONNE GREET MODEL Version 2021. https://greet.anl.gov/

1. Electric Generation Mix (eGRID U.S. Average 2021 Data (https://www.epa.gov/egrid/summary-data)

Table C-1. Electric Generation Mix

Generation Resource	U.S. Mix
Residual oil	0.6%
Natural gas	38.4%
Coal	21.9%
Nuclear power	18.9%
Biomass	1.3%
Hydro	6.0%
Wind	9.2%
Solar	2.8%
Geothermal	0.4%
Other	0.1%

2. Electric Transmission and Distribution Loss = 4.5%

3. Power Plant Emissions: in Grams per kWh of Electricity Available at Power Plant Gate

Table C-2. Power Plant Emissions at Gate

Pollutant	TOTAL based on US Mix^
NO_x	0.238
PM_{10}*	0.048
$PM_{2.5}$*	0.023
BC*	0.0022
CO_2	387

* From 2020 eGRID estimates. 2021 values not available.

^ Assumes no emissions from nuclear power plants, hydro, wind, solar, geothermal, and "Other"

4. Power Plant Emissions: Grams per kWh of Electricity Available at User Sites (wall outlets)

Total power plant gate emissions/(1-electric transmission and distribution loss)

Table C-3. Power Plant Emissions at Wall Outlet

Pollutant	Total delivered based on US electric generation mix
NO_x	0.249
PM_{10}	0.051
$PM_{2.5}$	0.024
BC	0.0023
CO_2	405

Appendix D: PERE Efficiency Modeling Methodology

The PERE model is not specifically designed for modeling heavy duty hybrid trucks, but as it is a physical model that is primarily dependent upon input values, its use was considered appropriate for the estimation of the fuel economy effects of truck hybridization. The model calculates second-by-second fuel consumption for user-defined drive cycles based on a physical model. The model takes a number of user-specified parameters, along with some of its own defaults, to perform these calculations for a variety of vehicle and powertrain types. The assumptions and data sources for the model inputs that were used are presented below. The defaults for some parameters, such as hybrid regeneration efficiency and hybrid battery efficiency, were assumed to remain unchanged when scaling from light-duty to heavy-duty vehicles.

Many vehicle parameters, such as road load and transmission data, were used from work already done with the PERE model for the SmartWay program. Many of the parameters for that previous work were taken from findings of internet searches for specifications of various trucks in new "as-delivered" condition, prior to the addition of various vocational or cargo equipment installations that would increase drag and vehicle weight. To establish the test weights for each truck class in this modeling effort, the original estimate of minimum weight was averaged with the maximum possible weight for each truck class. This was done with the intent of modeling an average or medium payload for each truck class. An important source of information was an EPA draft document discussing the use of the PERE model by Nam and Gianelli[49]. This document contained equations that could be used for estimates of some of the input parameters, along with information describing the use of the model.

The two foremost inputs to the model include the vehicle weight and engine size. Vehicle empty weights and engine sizes were taken from manufacturer supplied truck specifications where possible. For example, Ford published a .pdf file titled *F-250/F-350/F-450/F-550 Specifications*[50] that contains base curb weights and engine sizes for some of their offerings in the light and medium duty market. Another useful source of manufacturer data was in the *Kenworth T170/T270/T370 Body Builders* Manual[51]. The T170-T370 range consists of medium duty trucks that can be delivered with a cab-only chassis. The manual describes all of the dimensions relevant to the builder of a body or cargo area on the rear of the chassis. As such, it includes curb weights, length and width dimensions, and gross vehicle weight ratings that were instrumental in creating many of the inputs for the Class 5, 6, and 7 fuel economy models. Where specifications of multiple trucks in a class were found, values were taken that would result in maximum fuel economy unless they seemed noticeably atypical of in-use vehicles. Variations in weight and engine size over the ranges found in literature did not have as large an effect on fuel economy as some of the other inputs to the PERE model. For hybrid modeling, the engine size reduction due to hybridization ranged from 1 liter for the Class 2b and 3 trucks, up to 4 liters for the Class 8 trucks. This range was chosen based on the nature of hybrid trucks

[49] Nam, Edward and Gianelli, Robert, Fuel Consumption Modeling of Conventional and Advanced Technology Vehicles in the Physical Emission Rate Estimator (PERE). US EPA Publication EPA420-P-05-001, February 2005.

[50] FordF150.net. F-250/F-350/F-450/F-550 Specifications. Retrieved from https://www.fordf150.net/specs/05sd_specs.pdf Accessed 12-8-23.

[51] Kenworth. Kenworth T170/T270/T370 and Hybrid 2011 Body Builders Manual. Retrieved from https://www.kenworth.com/media/ag2hk33t/kenworth-t170-t270-t370-and-hybrid-body-builder-manual-2011.pdf. Accessed 12-8-23.

currently available on the market. Class 2 hybrid trucks on the market typically have very little engine downsizing from hybridization, however larger trucks were found to have more engine downsizing.

The number of transmission gears in each truck class was also based on specifications found on manufacturers' web sites, but there is a wide range of the number of gears in the different available transmissions. While it is very likely that the most efficient setup for Class 2b through 4 would be a 6-speed manual transmission, there are a variety of options for Classes 5 through 8. It is also typical for a modern Class 8 truck to have 10 gears, so the model input for Class 6 was taken to be 8 as a representation of typical trucks in that class, and all trucks were modeled with manual transmissions. The PERE model also requires shift speeds as an input to the model, and examples of these were not found in literature or internet searches. ERG has previously logged on-road data from Class 8 trucks with 10-speed manual transmissions, and this data was analyzed briefly to create an estimate of typical upshift speeds for this type of truck. Using this speed/gear curve, two other curves were created by scaling for the 6 and 8 speed trucks modeled in the study. Unfortunately, the shift speed chart has a very strong effect on the model's predicted fuel economy but using carefully scaled shift point curves hopefully mitigated this source of error. The hybrid trucks were modeled with the same transmissions as the conventional trucks. The model did not readily include a provision for changing the transmission characteristics when changing from conventional to hybrid powertrains. All transmission parameters were kept the same when making this change with the intent of ensuring the resulting fuel economy effects were only due to hybridization, not due to transmission effects.

There were three other values regarding the driveline that were input for this study. The engine efficiency was taken to be 40% over the cycle. The maximum engine speeds and highway cruise speeds were adjusted together as well, to account for the larger displacement heavy duty engines turning more slowly than typical Class 2b truck engines. The effects of the engine speed parameters on fuel economy were fairly small.

The road load estimation required assumptions and calculations as road load curves are not generally a part of manufacturers' literature. The method of road load calculation used for this PERE modeling was based on the coefficient of rolling resistance (C_R), the aerodynamic drag coefficient (C_d), and the vehicle frontal area (A_F) in a physical equation of the truck's road load, given in Equation 1 from Nam and Gianelli (2005). Coefficients of drag were based on values in literature, such as manufacturers' specifications for Class 2b and in a report publication by Argonne National Laboratory[52]. Values for C_d ranged from .45 for the Class 2b and the smaller medium duty trucks, to .5 for the class 8 long-haul trucks. The heavier medium duty trucks were assumed to have a C_d of .55 as they were assumed to be vocational trucks with less streamlined aerodynamics. Frontal area was taken from manufacturer specifications where available. As given in Nam and Gianelli, the product of truck height and width was multiplied by a factor of 0.93 to get an estimate of effective A_F. Engineering judgment was applied to the dimensions found in literature to ensure a representative increase in frontal area from the smaller to larger trucks. The rolling resistance values were estimated using the trends observed by both Nam and Gianelli (2005) along with Delorme Karbowski, and Sharer (2009), ranging from 0.01 for the light and medium duty trucks, down to 0.008 for the class 8 trucks.

[52] Delorme, A., Karbowski, D., and Sharer, P. Evaluation of Fuel Consumption Potential of Medium and Heavy-Duty Vehicles through Modeling and Simulation. Argonne National Laboratory, DEPS-BEES-001, October 2009.

The final input to the PERE model was the driving cycle. To get a representative range of fuel economy benefit, two drive cycles were modeled. The first was the Heavy-Duty Urban Dynamometer Driving Schedule (HDUDDS), and the second was the EPA Highway Fuel Economy Test (HwFET). The HDUDDS can be thought of as a city-type cycle with frequent stops and starts. The HwFET simulates rural driving with varying speeds but no stops. Even though the HwFET is designed only for light duty vehicles, it was still used as it was the best representation available for in-use highway driving.

The key values used as the inputs for the PERE model fuel economy calculations are given by truck class in Table D-1.

Table D-1. PERE Model Inputs for Fuel Economy Estimation

Class	Modeled Test Weight, lbs	Conventional Engine Disp., L	Hybrid Engine Disp., L	Number of Gears	Effective Gear Ratio, RPM/mph
2b	7,875	6.0	5	6	35
3	10,000	6.0	5	6	35
4	12,250	6.4	5.4	6	33
5	14,500	6.7	5.7	6	33
6	19,500	6.7	5.7	8	33
7	24,000	8.3	6.3	10	31
8	52,500	13	9	10	30

For modeling hybrid vehicles in the PERE model, the user must adjust the hybrid threshold for each different vehicle and drive cycle combination. This variable represents the amount of power demand during acceleration that is required to cause the engine to start up to assist the electric motor. The user must adjust this value such that the amount of energy taken from the battery is approximately equal to the amount of energy charged back into the battery during regenerative braking. If this is not done, the fuel economy will be misrepresented due to the battery ending up with a different state of charge at the end of the cycle compared to the beginning of the cycle.

For the HwFET cycle in the lower truck classes, there were not enough deceleration events charge the battery back to its initial charge level, even with the hybrid threshold variable at its minimum value. This meant that the battery was ending at a lower level of charge at the end of the cycle than the beginning, which has the effect of overestimating the trucks actual fuel economy. For this reason, ERG added an extra calculation to the model to account for the net change in battery power. This calculation used the various efficiencies of the hybrid system to estimate the fuel required to make up the change in battery charge over the cycle and add that number to the modeled fuel consumption. This calculation was needed for the trucks in Classes 2b through 5.

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