SmartWay®
Transport Partnership
U.S. Environmental Protection Agency

Truck Carrier Partner 2.0.15 Tool: Technical Documentation 2015 Data Year - United States Version

EPA United States Environmental Protection Agency

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

EPA United States Environmental Protection Agency

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SmartWay 2.0.15
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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 Truck Tool, version 2.0.15. The SmartWay Truck Tool utilizes the most 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 CO_2, NOx, and PM (PM_{10} and $PM_{2.5}$), including:[1]

- Grams per mile
- Grams per average payload ton-mile
- Grams per thousand cubic foot-miles
- Grams per thousand utilized cubic foot-miles

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 grams per mile basis, rather than a mix of fleets that includes fleets that routinely weigh-out. Similarly, fleets that operate in primarily short-haul, urban environments at relatively low average speeds will have fundamentally different emission rates and constraints than

[1] At this time the Truck Tool 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.

long-haul fleets operating at highway speeds. By collecting detailed information on fleet operations (short vs. long, TL vs. LTL, urban vs. highway, etc.), as well as truck class (2b through 8b) and body type (dry van, reefer, flatbeds, etc.), individual fleets can compare their performance to other, similar fleets, which can help them to better manage their emissions performance.

2.0 Data Inputs and Sources

The SmartWay Truck Tool 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] NOx and PM 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. NOx and PM 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 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.[4]

2.1 CO_2 Factors

EPA populated the SmartWay Truck Tool 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), nitrous oxide (N_2O) and black carbon are not included in the current Truck Tool.
[3] The Truck Tool also estimates emissions associated with battery-electric trucks. In this case pollutant emissions (CO_2, NOx and PM) are determined based on the kWhrs used for charging.
[4] Future versions of the Tool may account for differences in retrofit effectiveness for running versus idle emissions.

Table 1. CO_2 Factors by Fuel Type*

	g/gal	Source[5]
Gasoline	**8,887**	**(i)**
Diesel	**10,180**	**(ii)**
Biodiesel (B100)	**9,460**	**(iii)**
Ethanol (E100)	**5,764**	**(iv)**
CNG	**7,030**	**(v)**
LNG	**4,394**	**(vi)**
LPG	**5,790**	**(vii)**

*** 100% combustion (oxidation) assumed**

Note that the Tool calculates tailpipe emissions from biofuel blends (gasoline/ethanol, diesel/biodiesel) 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-equivalent gallons (on a Btu basis), or in standard cubic feet (scf). If CNG consumption is expressed in scf, the Tool applies a fuel factor expressed in grams per scf (57.8), based on 983 Btu/scf and 58,819 g CO_2/mmBtu.[7]

2.2 NOx and PM Factors

The SmartWay Truck Tool contains NOx, PM_{10} and $PM_{2.5}$ emission factor outputs for on-road operation from EPA's MOVES2014a model for gasoline, diesel, and E10 for all

[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 http://edocket.access.gpo.gov/cfr_2004/julqtr/pdf/40cfr600.113-93.pdf.
iii) Tables IV.A.3-2 and 3-3 in A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, available at http://www.epa.gov/oms/models/analysis/biodsl/p02001.pdf
iv) Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, October 30, 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 www.epa.gov/climatechange/emissions/downloads09/documents/SubpartMMProductDefinitions.pdf.
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 (http://www.afdc.energy.gov/afdc/fuels/properties.html), 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 http://epa.gov/climatechange/emissions/downloads/US_GHG_Inv_Annexes_1990-2007.pdf

[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 – see http://205.254.135.24/tools/faqs/faq.cfm?id=24&t=10 and http://205.254.135.24/tools/faqs/faq.cfm?id=327&t=9.

[7] See footnote 4, v.

heavy truck classes (2b – 8b) under national default temperature and fuel conditions, for model years 1987 through 2016, for the 2016 calendar year (see Appendix A for a full list of factors). 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 NOx and PM were developed separately by model year, truck class, and fuel type (diesel and gasoline). MOVES2014a does not currently provide short duration idle factors in terms of grams per hour, so MOVES2014a was run using the Project Level scale with a single link and with an average speed of zero. Runs were performed for typical winter and summer conditions, taking the average of outputs from those runs to obtain g/hr factors.

MOVES2014a does provide emission factors for long-duration idle for long-haul diesel trucks. These factors are applied separately to the long-duration idle hour estimates provided for Class 8b trucks within the Truck Tool.[8] Short-duration factors are applied across the board for the remaining truck class types.

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[9]) emissions are assumed unchanged relative to their conventional vehicle counterparts. Finally, battery-electric trucks are assumed to have no idle emissions.

The resulting idle factors are presented in Appendix B.

Version 2.0.15 of the Truck Tool also calculates the NOx and PM emissions associated with use of transportation refrigeration (reefer) units. EPA's NONROAD2008a emissions model was used to develop emission rates for these units for the 2014 calendar year, following these steps:

- Three A/C refrigeration (reefer) unit standard classification codes (SCCs) were identified within the NONROAD model – 2265003060 (gasoline); 2268003060 (CNG); and 2270003060 (diesel);
- A national average model run was performed for these three fuel types for 2014;
- Tons per year outputs were converted to grams per year for each horsepower (hp) bin grouping, for each fuel type, for NOx, PM_{10} and $PM_{2.5}$;
- Grams/gallon factors were calculated for each hp bin by dividing grams/year by gallons/year, for each fuel type, for NOx, PM_{10} and $PM_{2.5}$;
- Weighting factors were applied to the gram per gallon factors for each hp bin. These weighting factors reflected relative emission impacts across the different

[8] NOx 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 SCR and EGR.

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

hp bins, accounting for differences in equipment population, hours of use, and engine load factors. For a given hp bin, the weighting factor is expressed as:

weighting factor = pop x avg hp x hrs/year x engine load factor

- Weighted g/gal factors were summed across hp bins for each fuel type and pollutant to obtain the final, national fleet-average fuel factors for reefers.

Table 2 provides the NOx and PM fuel factors used in the latest Truck Tool.

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

Fuel	NOx	PM_{10}	$PM_{2.5}$
Diesel	62.026	4.044	3.922
Gasoline	16.369	1.010	0.929
CNG	17.732	0.790	0.790

The next section describes the process followed to select the on-road emission factors from MOVES2014a for use in the Truck Tool. Emission factors in grams per mile were developed for gasoline, E10, and diesel fuel types for all MOVES source types that correspond to MOBILE6 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 MOBILE6 vehicle class basis. In this way, the Truck 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

$$\mathbf{E` = A_1E_1` + A_2E_2` + A_3E_3` + A_IE_I + A_BE_B}$$

Where:

$E`$ = uncorrected[10] mass emissions calculated based on operating mode and emissions contribution by speed bin

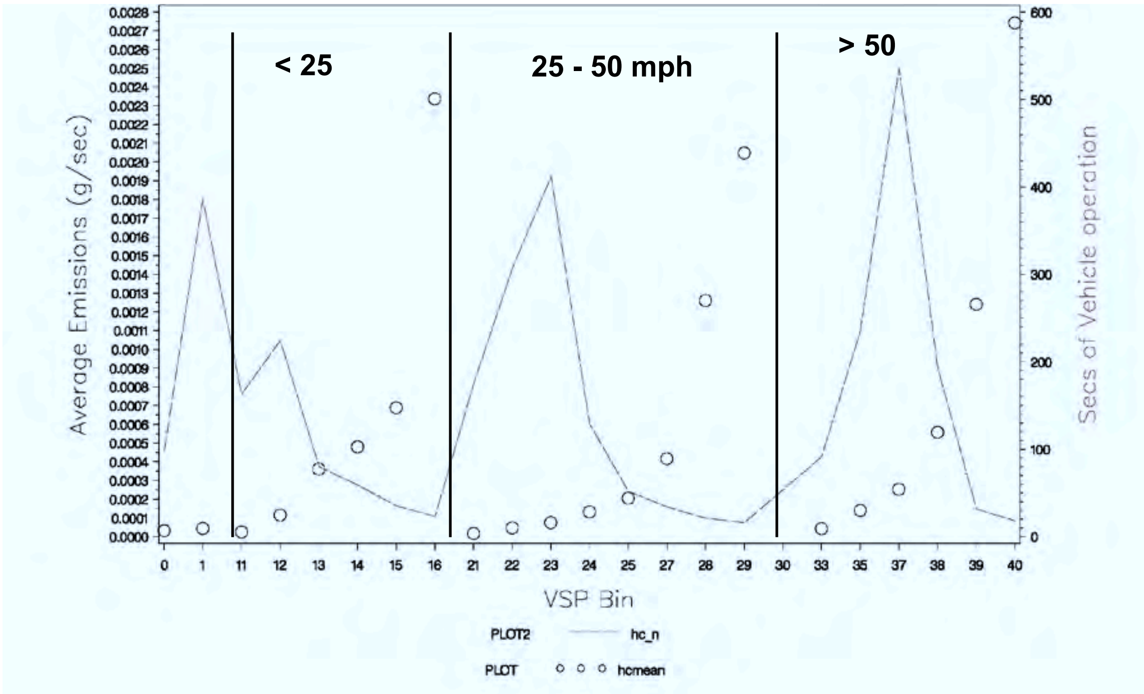
$A_{1\text{-}3}$ = the sum of activity fractions (in seconds) over speed range n. (A_I and A_B represent the activity associated with the individual operating modes for idling and braking, respectively.)

$E_{1\text{-}3}`$ = 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.

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

Figure 1. Example Emissions and Activity Fractions by Operating Mode



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 <u>modeled</u> 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

$$\mathbf{E_n = ZE_n`}$$

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

$$\mathbf{E = A_1E_1 + A_2E_2 + A_3E_3 + A_IE_I + A_BE_B}$$

In this way, a representative emission factor is calculated by operating mode/speed group. This will allow the Truck 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 Truck 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 MOBILE6 vehicle type (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 E10 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 (usually about 97.5% and 2.5%, respectively

In order to isolate Gasoline emission factors, the new Fuels Wizard included in MOVES2014a was used to alter the ethanol percentage of fuels nationwide to zero.

Thus, separate E10 and gasoline MOVES runs were then performed using the newly updated information.

Sensitivity Analysis Results

The relative emissions impact of different speed regimes were 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 1

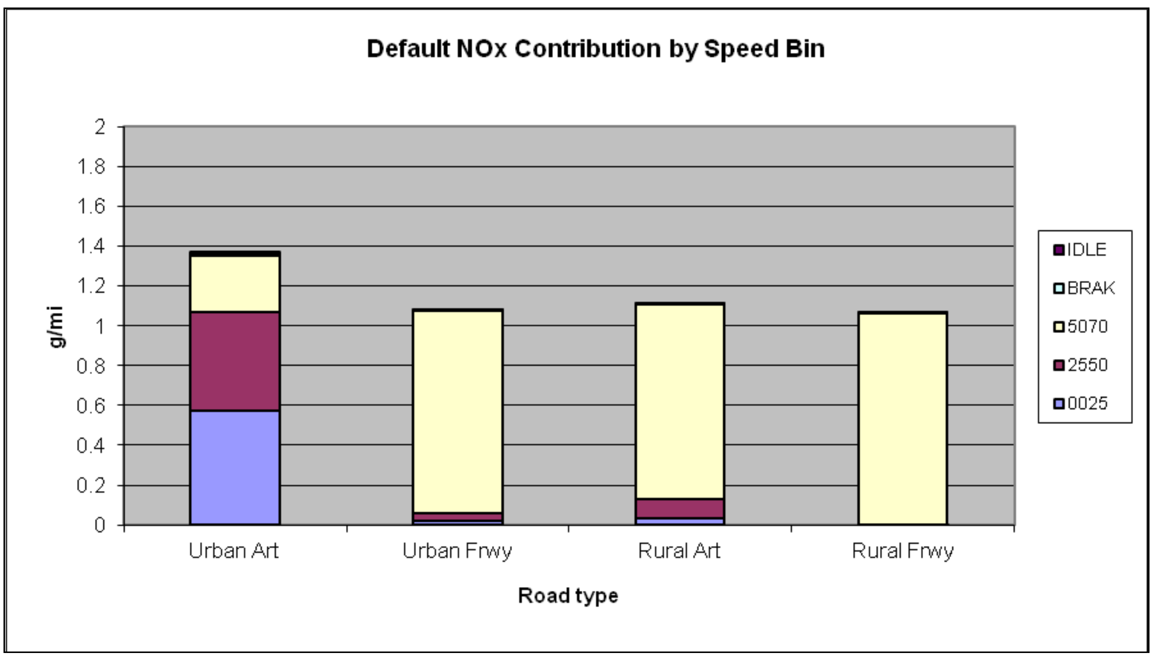
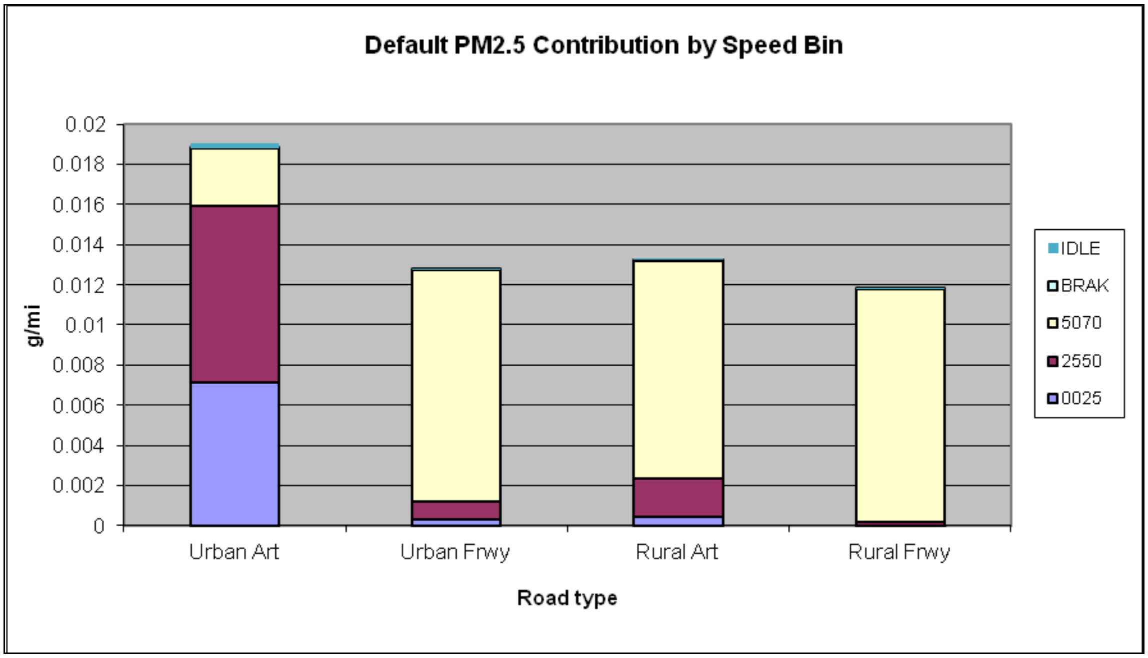


Figure 2



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.[11] 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 Truck 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 in order to aggregate emission lookup tables within the SmartWay 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 % Highway/Rural ("other") operation fraction
- Specify % urban operation distribution by speed bin, or select "default speed distribution"

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

[11] 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

NOx and PM emission factors are not available from MOVES2014a for certain alternative fuels, including biodiesel, E85, natural gas, and LPG. Accordingly, EPA used adjustment factors from a number of sources described below to estimate NOx and PM factors for these other fuels.

NOx and PM emission factors for biodiesel were 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 NOx and PM emission rates relative to conventional diesel fuel, as a function of biodiesel blend percentage, expressed in the following form:

Equation 6

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

Where:

a = 0.0009794 for NOx, and
a = -0.006384 for PM

Using Equation 6, adjustment factors were developed for biodiesel blends based on the percentage of the biofuel component,[12] 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.)

For gasoline-ethanol blends, the SmartWay Truck Tool only accepts fuel consumption estimates for E10 and E85 since, unlike biodiesel where the biofuel fraction can vary significantly, ethanol is generally blended with gasoline at two discrete levels: 10% (E10) and 85% (E85). As discussed in Section 2.2 above, NOx and PM factors for E10 were output directly from MOVES2014a. Given the lack of heavy-duty E85 test data, adjustment factors for E85 were based on emissions estimates for light-duty vehicles cited by the US DOE Alternative Fuels and Advanced Vehicles Data Center.[13] These estimates come from a technical paper published in the Journal of Air & Waste Management.[14] Relative to conventional gas vehicles, the authors of this paper estimate that vehicles running on E85 provide an **average NOx 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.

[12] Biodiesel blend percentage is calculated by dividing B100-equivalent gallons by total fuel gallons at the fleet level – see the Truck Tool User Guides for details regarding biodiesel use inputs.
[13] See http://www.afdc.energy.gov/afdc/vehicles/emissions_e85.html, last validated December 22, 2011.
[14] http://www.afdc.energy.gov/afdc/pdfs/technical_paper_feb09.pdf,

If the consumption level of E10 is unknown, the Truck Tool user may also specify national average default blend levels for ethanol. National totals for gasoline use for 2012 were obtained from the Energy Information Administration's (EIA) Annual Energy Outlook Reference Case for 2013, Table 37 (Transportation Sector Energy Use by Fuel Type within a Mode). Summing the energy use values for light-duty gasoline vehicles, commercial light trucks, and freight trucks from the table yields an estimate of 16,040 TBtu (15,315 + 336 + 389) for 2012. National fuel ethanol consumption estimates for 2012 were also obtained from the EIA, totaling 1,064 TBtu (see Table 10.3, consumption minus denaturant in http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_7.pdf). Assuming 114,100 Btu/gallon of gasoline, and 76,100 Btu/gallon of E100,[15] ethanol is estimated to constitute 9.05% of gasoline/ethanol blend consumption in the U.S., on a volumetric basis.[16]

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.[17] 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.[18] 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.

The same adjustment factors are applied for all model years in the Truck Tool because model year-specific emissions data do not appear to be available at this time. Note, however, that the emissions from the combustion of alternative fuels may be different for older trucks (with minimal emission controls) and newer trucks (with extensive control systems in place) due to vehicle emission standards.

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.

2.4 PM Control Effectiveness

The Truck Tool 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

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[15] https://www.afdc.energy.gov/afdc/prep/popups/gges.html, last verified 12-22-11.

[16] 16,040 TBtu gasoline x 10^{12} Btu/TBtu / 114,100 Btu/gal = 1.41 x 10^{11} gallons of gasoline;
1,064 TBtu E100 x 10^{12} Btu/TBtu / 76,100 Btu/gal = 0.140 x 10^{11} gallons of E100;
0.140 / (1.41 + 0.140) = 9.05%.
Note this methodology disregards the relatively small volumes of ethanol consumed as E85.

[17] http://www.conaturalgascoalition.com/clean.html, last validated 3-4-16.

[18] The PM and NOx estimates cited by this source for LPG vehicles were actually slightly lower than for natural gas vehicles - http://www.afdc.energy.gov/afdc/vehicles/emissions_propane.html. However, based on engineering judgment it was assumed that LPG PM and NOx emissions would be similar to comparable CNG vehicles.

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%

The Tool applies these 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 x [1 – (0.25 + 0.05)] = 0.07 g/mile, post-control

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

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, NOx and PM, as described below.

3.1 CO_2

CO_2 is calculated within the Truck 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

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

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 Truck Tool, with the reefer fuel type assumed to be the same as the vehicle fuel type. However, reefer units associated with LPG 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 LPG and electric trucks is included in the total CO_2 calculation using the diesel fuel factors in Equation 8.

Fuel Allocator

The Truck Carrier Tool asks users to enter Gallons of Diesel Used by truck class in order 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 Truck Tool's **Fuel Allocator** can be used to apportion fuel use across truck classes.

In the **Fuel Allocator**, the user enters total fuel consumption and truck class MPG estimates. The allocator 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". However, instead of writing the exact calculated value seen in the Fuel Allocator to the Activity screen, the Tool adjusts the class fuel amounts (and therefore MPG) so the sum matches the Total Fuel entered exactly, and then writes these values on the Activity screen. That means, the MPG entered into the Fuel Allocator, and the calculated fuel used seen on the Fuel Allocator, are not necessarily equal to the MPG and the fuel used that is written to the Activity Screen.

If the user re-opens the Fuel Allocator at this point, the Allocator brings in the MPGs listed on the Activity Screen, NOT the MPGs the user input into the calculator the first time (although it doesn't overwrite the saved MPGs entered on the worksheet, if the user presses Cancel). For remaining calculations in the Tool, the values shown on the Activity Screen are used. The Allocator values the user entered are saved for the XML file, but aren't used for further calculations. Separately in the XML, the MPG and fuel totals that were put onto the Activity Screen are also written.

3.2 NOx and PM

Unlike CO_2 emissions which only vary with fuel type, NOx and PM 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 Truck Tool with emission factors that correspond to user-supplied inputs regarding their fleet activity. The NOx and PM emission rates expressed in *grams per mile* were combined with the appropriate mileage metric (i.e., total miles) in order to estimate mass emissions. The general equation for calculating NOx emissions is as follows:

Equation 9

$$\mathbf{E_{NOx} = \sum [(M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2}\ x\ UDC_2) + (GPM_{U3}\ x\ UDC_3) + (GPM_{U4}\ x\ UDC_4))) \times T_{CY} / T_{CT}) + (GPH_I \times H_I \times T_{CY}) + (GPH_I \times H_I \times T_{CY})]}$$

Where:

E_{NOx} = grams NOx 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[19]

[19] 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.

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 NOx, utilizing PM emission factors. PM emission for diesel vehicles may be adjusted for PM control effectiveness, as shown below.

Equation 10

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

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 Truck Tool user must provide an estimate of the percent of total miles associated with highway/rural 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 Truck 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 Truck Tool utilizes the diesel default speed distributions for LPG, LNG, and CNG.

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%
	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*
Gasoline		
HDGV2b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%
HDGV3	0 - 25	45%
	25 - 50	34%
	50+	11%
	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%

* May not sum to 100 due to rounding errors

Table 4. Default Speed Category Distributions by Vehicle Class for Urban Operation (MOVES2010a basis)[20]

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

[20] 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, so as to make the sum across urban and highway operation modes equal to 100%.

operation due to their unique emission rate patterns.[21] However, it is assumed that most Truck Tool users will not know their fleet's deceleration fraction. As such, the Truck 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 Truck Tool will adjust the urban values from Table 4 to account for the percentage of miles specified 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. NOx emission calculations follow the same procedure.

[21] 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, in order to utilize the grams per hour emission factors developed especially for use in the Truck 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:

40% highway/rural
30% 0-25 mph
20% 25-50 mph
10% 50+ mph

For highway/rural operation, the lookup value from MOVES is 0.0187 g/mi for PM2.5
For urban operation, the lookup values are as follows:

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 to account for deceleration, as follows:

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

25-50: 20% x sum of default percentages (45% + 34% + 12%) = 18.2%

50+: 10% x sum of default percentages (45% + 34% + 12%) = 9.1%

deceleration: the 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 PM2.5 (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 Truck Tool assumes that B100-equivalent biodiesel volumes are distributed proportionately across all diesel vehicle classes. For example, if a fleet uses 100 B-100 equivalent gallons of biodiesel, 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.

Emission calculations for ethanol blends follow a different methodology, however, applying discrete emission factors for gasoline and E10 from MOVES (and adjusted gasoline emission factors for E85) with the specific fuel volume estimates provided by the user. The following provides an example illustrating how the miles of travel are apportioned across different blend volumes, in order to estimate mass emissions.

User specifies 1,000 gallons of fuel total, and 10,000 miles of travel total

User inputs:
100 gallons of E10
100 gallons of E85

Therefore there are 800 gallons of pure gasoline (1,000 – 100 - 100)

Apportion the 10,000 miles of travel across the different blend levels using gasoline-gallon equivalent (gge) factors (from https://www.afdc.energy.gov/afdc/prep/popups/gges.html) as follows:

100 gallons of E10 is equivalent to 100/1.05 = 95 gallons of gasoline*
100 gallons of E85 is equivalent to 100/1.39 = 72 gallons of gasoline

Therefore there are 800 + 95 + 72 = 967 gasoline equivalent gallons of fuel, total.

Applying the energy-equivalent fuel volume ratios to the 10,000 miles of total travel:

gasoline (E0) miles = 10,000 x 800/967 = 8,273 miles
E10 miles = 10,000 x 95/967 = 982 miles
E85 miles = 10,000 x 72/967 = 745 miles

Finally, multiplying these mileage values by the appropriate E0 and E10 gram/mile emission factors from MOVES results in the desired mass emission estimates. Similarly, multiplying the E85 miles by the E85 emission factors (adjusted from E0 factors as discussed in Section 2.3, provides mass emissions associated with E85).

* E10 gge factor developed from linear interpolation of E100 and gasoline Btu/gallon values

In addition, if national default ethanol blend levels are specified for gasoline fuel use, the Truck Tool assumes that *all* ethanol consumed is in an E10 blend. For example, assuming 1,000 gallons of gasoline are specified by the user, there would be 90.5 gallons of E10 (1,000 x 0.0905 – see Section 2.3), and 909.5 (1,000 – 90.5) gallons of gasoline. Mass emissions would then be calculated for the gasoline and E10 components of the fuel as in the above example, apportioning total miles across gasoline and E10 in order to apply the appropriate g/mi factors.

Finally, note that the PM factors output by the MOVES model for use in the Truck 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 – 1.086
- Diesel – 1.031
- CNG – 1.000

These factors were applied directly to the $PM_{2.5}$ emission factors to obtain mass emission and performance metrics for PM_{10} within the Truck Tool. In addition, it was assumed that LNG and LPG had PM ratios equivalent to the CNG value (1.00). Ethanol was assumed to have a ratio equal to that for gasoline, while the ratio for biodiesel was assumed to equal that for diesel.

3.3 Activity Calculations

The Truck Tool requires users to provide specific activity information on fuel consumption, miles traveled, payload, cargo volume, average used cargo volume %, 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 Truck Tool also allows the user to select default values for payload and volume determination, in the absence of fleet-specific information. (Direct inputs for payload are highly preferred over the use of calculator 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, and Class 8b auto, moving and heavy-bulk carriers (see below), exact data entries were used from the 2011 Truck Tool submissions to obtain payload distributions for the 2015 Tool. This data was categorized by fuel type, truck class, body-type, and SmartWay ranking category. Body-type refers to the categories presented in the Truck Tool payload calculator (e.g., Step Van, Beverage, Combination Flatbed, etc.). Ranking 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.[22] Next, the data was grouped by truck class and body type and examined for notable differences in payload values across ranking categories. However, with the exception of certain Class 8 trucks, no truck class/body-type/ranking category combination had greater than 20 observations. Therefore it was concluded that there was not an adequately large data set available for establishing ranking-category specific

[22] Three Class 2b entries were removed due to suspiciously high payloads (16, 13, and 5 tons). One Class 8b truck was also removed (1 ton) due to an incongruous text explanation ("none used").

payload distributions for Truck Classes 2b-7. In these cases payload data were aggregated across all ranking categories for each truck class/body-type combination.

The larger population of Class 8 trucks in the 2011 data set allowed for a differentiation of payload distributions across ranking categories. Considering both available sample size and average payloads, the following unique truck class/body-type/SmartWay ranking category groupings were established.

- Class 8a Dry Van Single body-types: differentiate LTL (9.9 tons average) and non-LTL (12.4 tons average) categories. No differentiation across categories for other body-types.
- Class 8b Dry Van Single body-types: differentiate Heavy-bulk (24.1 tons), LTL/Moving/Package (15.0 tons), Tanker (24 tons), and all other categories (18.5 tons).
- Class 8b Specialty body-types: differentiate Auto Carriers (16.2 tons), Heavy/Mixed (30.3 tons), Flatbed (21.6 tons), and all other categories (25.6 tons).
- Class 8b Dry Van Double body-types: differentiate TL/Reefer/Mixed (27.7 tons) and all other categories (19.4 tons)
- Class 8b Other body-types: differentiate Heavy/Flatbed/Mixed (27.4 tons) and all other categories (21.5 tons).

Based on this data, Table 5 presents the payload averages, standard deviations, minimum and maximum values by truck class/body-type/and-or ranking category.[23] Note that the average values and standard deviations presented below are not weighted by fleet size.

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

Table 5. Average Payload and Standard Deviation (short tons) by Vehicle Class/Body-Type/Ranking Category (2011 SmartWay Partner Data – Exact Payload Entries)

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
Class 2b		
Flatbed	1.19	0.69
Step Van	1.14	0.48
Walk-In Van	1.05	0.48
Conventional Van	0.77	0.41
Other	0.58	0.49
Class 3		
Step Van	1.65	0.53
Walk-In Van	1.64	0.57
Conventional Van	1.50	0.83
Other	1.08	0.90
Class 4		
Flatbed	2.68	1.53
Step Van	2.24	1.19
Walk-In Van	1.70	0.80
Conventional Van	2.27	0.90
Other	1.16	0.76
Class 5		
Walk-In Van	1.99	1.08
Conventional Van	3.39	0.99
Other	2.91	1.19
Class 6		
Flatbed	4.67	1.71
Reefer	4.84	1.80
Walk-In Van	4.01	1.68
Single-Axle Van	3.78	1.19
Other	4.17	1.48
Class 7		
Beverage	6.10	2.22
Flatbed	7.05	0.85
Reefer	6.03	1.27
Tanker	7.45	0.92
Single-Axle Van	5.53	1.83
Other - straight truck	8.30	4.63
Combination Flatbed	5.22	0.41

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
Combination Reefer	3.58	1.01
Dry Van - Single	5.44	2.57
Other - combo	5.90	1.15
Class 8a		
Flatbed	10.04	5.88
Tanker	12.12	5.43
Single-Axle Van	8.09	3.80
Other - straight truck	9.76	4.08
Beverage	12.30	4.40
Combination Flatbed	12.51	1.41
Dry Van - Single (other than LTL)	12.42	4.66
Other - combo	12.68	4.56
Class 8b		
Dry Van - Single (Heavy-Bulk)	24.1	2.98
Dry Van - Single (other bins)	18.46	3.97
Dry Van - Double (Tanker)	24.06	2.96
Dry Van - Double (Mixed-TL-Reefer)	27.74	13.33
Dry Van - Double (Other bins)	19.39	3.82
Dry Van – Triple	27.10	3.20
Combination Reefer	20.10	2.82
Combination Flatbed	22.50	4.23
Combination Tanker	24.90	2.89
Chassis	21.80	5.28
Specialty (Other bins)	25.62	2.72
Other (Other bins)	21.50	8.41
Specialty (Auto bin)*	18.22	5.29
Specialty (Heavy-bulk bin)*	29.23	7.15
Specialty (Moving bin)*	14.57	2.70
Specialty (Flatbed bin)	21.56	2.58
Other (Heavy-Flatbed-Mixed bins)	27.41	6.36

* calculated using 2014 calendar year data, for new body type additions to the payload calculator.

The values above serve as the basis for the default payload ranges provided in the Truck Tool payload calculator. For most vehicle class/body-type/ranking category combinations,[24] seven default ranges are offered for Partner selection:

- Range 1: from 0 tons to (Average payload – 2 x standard deviation);
- Range 2: from (Average payload – 2 x standard deviation) to (Average payload – 1 x standard deviation);
- Ranges 3-5: evenly split in three sections, from (Average payload – 1 x standard deviation) to (Average payload + 1 x standard deviation);
- Range 6: from (Average payload + 1 x standard deviation) to (Average payload + 2 x standard deviation); and,
- Range 7: from (Average payload + 2 x standard deviation) to (Average payload + 3 x standard deviation).

Once a particular range is selected, the payload calculator estimates the midpoint of the range in order to estimate class level average payloads. The estimated midpoint payload values for each body type are weighted by one of the four allocation methods specified by the user in the payload calculator: # miles, # trips, % operation, and # vehicles by body type. The weighted sum is then used as the class 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 calculator are validated using the same data described above (see Section 3.4).

LTL and Package Fleet Payloads

For most payload validations in the Tool, ranges are calculated by class and by body type as described above. LTL and package delivery payload validation ranges were recently updated, and are calculated simply on a truck class basis, as there is not enough LTL and Package Delivery Partner information to break payload out by body type. Therefore each body type in a class is validated using the same range, as shown in Table 6 below.

[24] 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 zero and the Payload Calculator indicates Range 1 as "N/A".

Table 6. Payload Validation Ranges (Tons) for LTL and Package Delivery Fleets

Truck Class	Avg Payload	# Obs	Standard Dev	R1 Min	R2 Min	R3 Min	R4 Min	R5 Min	R6 Min	R7 Min
2B	0.96	12	0.195	>0	0.565	0.761	0.891	1.021	1.151	1.249
3	1.57	19	0.303	>0	0.967	1.270	1.472	1.674	1.876	2.027
4	1.92	11	0.679	>0	0.562	1.241	1.693	2.146	2.598	2.937
5	2.79	10	0.790	>0	1.212	2.002	2.529	3.055	3.582	3.977
6	3.72	70	0.678	>0	2.362	3.040	3.492	3.945	4.397	4.736
7	5.44	64	0.981	>0	3.481	4.462	5.116	5.770	6.424	6.914
8A	9.78	63	2.170	>0	5.437	7.607	9.054	10.501	11.948	13.033
8B	15.79	110	3.532	>0	8.729	12.261	14.615	16.970	19.324	21.090
All	8.50	359	5.862							

The lower payload ranges (for “R1” and “R2”) were set so as to identify less than 20% of the observed LTL/package fleets during validation. The middle R3-R5 ranges extend from one standard deviation less than the average payload to one standard deviation greater than the average. The upper payload values for “R6” range from the payload average plus one standard deviation to the average plus 1.5 standard deviations. The range for “R7” extends above the “R6” maximum value. The maximum R7 range values are taken directly from the original R7 maximum values described above by class and by body type.[25]

Note: Starting with the 2015 Truck Tool fleets with a SmartWay Category designation of LTL must also provide estimates for the average weight per shipment and the average number of shipments per truck. These values will be used to help refine the payload validation ranges for Shippers using LTL carriers.

Default Cargo Volumes[26]

The Truck Tool also provides a volume calculator to estimate the cubic feet associated with the common straight truck body types (classes 2b through 7) identified using the 2011 Partner dataset, as well as typical trailer, container, carrier, and tanker sizes, for combination trucks (classes 8a and b).[27] Cargo volumes in cubic feet are relatively easy to estimate for many combination trucks. Per unit interior volume defaults are assumed for standard dry vans - no high cubes, reefers, etc.), and containers. Trailer calculations assume an 8’ x 9’ cross-section, and the exterior length less 1/2 foot. 20 and 40 foot container dimensions are referenced in many places, such as http://www.mussonfreight.com/containers/containers.html.[28] Table 7 summarizes the default volumes assumed for a number of standard trailers, containers, tankers, and bulk carriers.

Table 7. Default Average Cubic Feet (Class 8a – 8b trucks)

Type	Size	Cubic Feet
Trailers	28ft	1,980
	40ft	2,844
	42ft	2,988
	45ft	3,204
	48ft	3,420
	53ft	3,780

[25] For two body types under Class 7 trucks (Combination Flatbed and Combination Reefer), the original Range 7 max value is less than the new Range 6 max value. (R7 max is 6.45 and 6.61 respectively, while the new R6 max value for all class 7 body types is 6.914). Therefore, for just these two body types within Class 7, instead of using the original Range 5 max, we use the Range 5 max that would be calculated from the new table values. This is calculated as Avg + 2.5 x standard deviation, based on the table above (7.896 in this case). [Note it is Avg + 2.5 x standard deviation instead of Avg + 3 x standard deviation because of the 1.5 sigma rule for Range 6. Therefore the Range 5 max value is simply 1 standard deviation larger than the Range 6 max.]

[26] The Truck Tool allows users to enter cargo volume in either cubic feet or TEUs, with one TEU assumed equal to 1,360 cubic feet – see http://www.dimensionsinfo.com/20ft-container-size/.

[27] Default cargo volumes for Class 7 combination vehicles were not available, and were set equal to the average volume for Class 8 combination trucks in the 2010 SmartWay database.

[28] 53 foot containers are assumed to have interior dimensions of 52’ 5” x 7’ 8” x 7’ 10”

Type	Size	Cubic Feet
	57ft	4,068
	28x28	3,960
	48x28	4,824
	40x40	5,688
	48x48	6,840
	28x28x28	5,940
Containers	20ft	1,159
	40ft	2,347
	45 ft[29]	3,031
	48 ft	3,454
	53ft	3,148
Tankers	Small (3,000 gal)	401
	Medium (5,250 gal)	702
	Large (7,500 gal)	1,003
Bulk Carriers	Small (22'x8'10.25')	1,804
	Medium (32'x8'x11')	2,816
	Large (42'x8.5'x11.5')	4,106

Cargo volume capacity data is often not readily available for straight trucks, however. Such trucks are highly variable in their configuration and when volume estimates are found, the data often do not permit cross-referencing with vehicle class. Most highway infrastructure and operating agencies, including enforcement, are concerned about weight (e.g., pavement and structure damage), but not cubic capacity. The operating agencies are also concerned about maximum dimensions, of length, height and width (for, respectively, turning radii, vertical clearance, and lane width) but the shape of the box and its relation to the truck superstructure, not these maximums, dictates cubic capacity. Little public research on the cubic capacity of the box has been done, and thus little information is published.

A relatively small number of volume estimates were compiled from the 2011 Partner data (218 unique observations for truck class/body-type combinations). Of these observations 13 were identified as outliers and removed from the data set (11 observations of less than 100 cu ft; one Class 3 truck at 1,360 cu ft; and one Class 2b truck at 3,600 cu ft). Given the overall "thinness" of the dataset, those truck class/body-type combinations with three or more observations were used to estimate average cargo volumes. The following truck class/body-type combinations had fewer than three observations in the Partner dataset.

- Class 2b Flatbed
- Class 3 Other
- Class 4 Flatbed, Step Van, Other
- Class 6 Flatbed, Walk-In Van
- Class 7 Flatbed, Tanker

[29] 45 and 48 foot container references from http://www.shippingcontainers24.com/dimensions/45-foot/, and http://www.containertech.com/container-sales/48ft-high-cube-container-domestic/

- Class 8a Beverage

For these remaining truck class/body-type combinations available information was compiled as it relates to cargo *volume* capacity for the common straight truck body types.

Without a comprehensive data source, such as the Partner data, other strategies needed to be employed to develop examples, or ranges, of volume capacity for the remaining body type/truck class combinations of interest. A literature review and vendor interviews were performed to determine appropriate values for cargo volume capacity. The first step in the literature review involved preparing a list of vendors responsible for designing, manufacturing, or operating all the different truck types identified.

Cubic capacity is also dependent upon a variety of factors and is not uniform for even the same make and model, as many truck manufactures will design to specifications based on a client's unique needs for their cargo. For example, a client may request a manufacturer to design a truck interior to best accommodate the delivery of a certain size of parcel, and install shelving or otherwise compartmentalize to that end. Consideration was given to these factors during the review.

The literature review encompassed Internet searches of vendors of the truck types described above. Sources explored included truck manufacturers, dealers, and fleet lessors of vehicles such as Budget/U-haul/Enterprise/Ryder/E-Dart). Additionally, validation searches were performed on websites outlining current truck sales to help identify the appropriate size/class of the vehicles and applicable specifications. The following information was collected from these searches for over 40 different vehicles currently available on the market:

- Length, width, height of the cargo hold
- Reported cargo space (cubic feet)
- Gross Vehicle Weight
- Payload
- Manufacturer
- Make/Model
- Reference website

Outreach to key stakeholders in the commercial vehicle industry was also performed to further validate the information collected from the literature and resource review. Contact was made with representatives from Volvo Trucks North America; the American Transportation Research Institute (ATRI); the Commercial Vehicle Safety Alliance (CVSA); the Truck Manufacturers Association (TMA); Federal Highway Administration (FHWA) Truck Size and Weight; and a wide variety of trucking manufactures and other vendors.

The results of this review are combined with the averages from the Partner data and are provided in Table 8 below for straight trucks, classes 2b through 7. In those instances where multiple vehicle models were identified for a given body type/vehicle class combination, simple averages were calculated across models.

Table 8. Estimated Cargo Volumes (cubic feet) for Straight Truck Body Types, by Vehicle Class

Body- type	Average Cargo Volume (Cubic Feet)
Class 2b	
Flatbed*	336
Step Van	479
Walk-In Van	580
Conventional Van	357
Other	303
Class 3	
Step Van	468
Walk-In Van	706
Conventional Van	538
Other*	599
Class 4	
Flatbed*	448
Step Van*	700
Walk-In Van	667
Conventional Van	699
Other*	830
Class 5	
Walk-In Van	655
Conventional Van	1,010
Other	691
Class 6	
Flatbed*	672
Reefer	1,146
Walk-In Van*	1,496
Single-Axle Van	1,583
Other	1,257
Class 7	
Beverage	1,576
Flatbed*	728
Reefer	1,413
Tanker*	267
Single-Axle Van	1,476
Other	1,486

*From literature/web review

Once a default cargo volume is selected, the volume calculator weights the volume estimates for each body type by one of the four allocation methods: # miles, # trips, % operation, and # vehicles by body type. The weighted sum is then used as the class level average cargo volume, which in turn is used directly in determining grams per volume-mile performance metrics for the fleet.

A list of websites utilized in the literature review is provided below.

<u>Truck manufacturers</u>:
www.gmc.com
www.chevrolet.com
www.ford.com
www.freightlinersprinterusa.com
www.silvercrowncoach.com

<u>Fleet operators</u>:
www.uhaul.com
www.pensketruckrental.com
www.budgettruck.com
www.hendersonrentals.co.nz
www.hackneybeverage.com
www.hackneyusa.com
www.fedex.com
www.grummanolson.com

<u>Other sources</u>:
www.usedtruckdepot.com
www.usedtrucks.ryder.com
www.truckingauctions.com
www.truckpaper.com
www.motortrend.com
files.harc.edu/Projects/Transportation/FedExReportTask3.pdf

The detailed findings of the literature/web review are presented in Appendix D.

3.4 Data Validation

The SmartWay Truck Tool 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 <= 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 any non-numeric characters (including minus signs) within these fields.

Table 9. Basic Range and Logical Checks – Conditions Resulting in Error or Warning Messages

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	User must indicate operational control over at least 95% of the fleet. (If Partner does not have at least 95% operational control, Truck Tool may not be used for the fleet.)
Fleet Description	The Operation Category totals must add up to 100%.
Fleet Description	The Body Type totals must add up to 100%.
Fleet Description	Warnings are issued for any of the following Operation Type/Body Type combinations. NOTE: This validation will only be invoked if there is a single selection made for either Operation or Body Type - otherwise combinations can't be determined with certainty. LTL/Chassis; LTL/Moving; LTL/Heavy; LTL/Specialized; Dray/Flatbed; Dray/Moving; Dray/Utility; Package/Flatbed; Package/Chassis; Package/Heavy; Package/Auto; Package/Moving; Package/Utility; Package/Specialized.
General Information	User must designate the operations split between U.S. and Canadian operations.
General Information	User must designate the Short-haul vs. Long-haul split.
General Information	User must select at least one fuel type.
Activity Information	All fields are required, so no field can be left blank. (If appropriate, a zero can be placed in certain fields.)
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	For Revenue Miles, if the Data Source Detail "Equal to total miles" is selected on the Data Sources screen, the amount must equal the Total Miles Driven.
Activity Information	For Revenue Miles, if the Data Source Detail "Total miles less empty miles" is selected on the Data Sources screen, the amount must equal the Total Miles Driven minus Empty Miles Driven.
Activity Information	For Empty Miles, the amount must be less than the number of Total Miles.
Activity Information	For Empty Miles, if the Data Source Detail "Total miles less revenue miles " is selected on the Data Sources screen, the amount must equal the Total Miles Driven minus Revenue Miles Driven.
Activity Information	On the Biofuel Blend Worksheet, the total gallons of biofuel cannot exceed the amount entered for Total Fuel on the Activity Information screen.
Activity Information	For Average used cargo volume, the value cannot exceed 100%.
Activity Information	For Average Used Cargo Volume Percent, the value must be less than 100% if user

	indicated that the fleet is 100% Less-Than-Truckload (LTL). (By definition, LTL fleets cannot have 100% average used cargo volume.)
Activity Information	The implicit commodity density derived from the payload, volume, and average used cargo volume inputs must be between 0.001 and 0.65 tons/cubic foot.[30]
Activity Information	For Idle Hours, the value cannot exceed 8,760.
Activity Information	For Idle Hours, values significantly outside the expected range must be explained.
Activity Information	If company no idle policy is specified under the Data Sources screen, then a warning is displayed if idle hours/yr are > 200.
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 the total vehicle fuel volume input.
Model Year & Class	Total truck count for each fleet cannot be zero.
Model Year & Class	Total truck counts for each selected truck class (those with a check mark) cannot be zero.
PM Reduction	The number of trucks using any particular PM reduction strategy cannot be greater than the number of trucks for the given class and model year.
PM Reduction	The sum of the trucks using either DOC or Particulate Matter Traps cannot be greater than the number of trucks for the given class and model year.
PM Reduction	If user indicates that the company uses PM reduction equipment, there must be at least one truck included on the PM Reduction sub-tab.
Payload & Volume Calculators	User must provide a preferred allocation method for the information entered on the calculators.
Payload & Volume Calculators	The sum of the total miles or total trucks entered in the calculator must equal the number entered on the Activity Information screen.
Payload & Volume Calculators	The calculated average cannot be equal to zero.
Payload & Volume Calculators	For percentages, the total must equal 100%.
Payload & Volume Calculators	For each body type for which some information has been entered, all of the visible field must be completed (including the explanation field if shown).
Payload & Volume Calculators	Zero is not a valid value for any payload or volume.
Payload & Volume Calculators	Values that are significantly outside the expected range for the given body type and class must be explained.
Payload & Volume Calculators	The body types indicated in the Volume Calculator must agree with those used in the Payload Calculator.
Payload & Volume Calculators	Ensure consistency between body-type selections in the Fleet Description section with those from the Payload and Volume Calculators. For example, if 100% is specified for Dry Van under Fleet Description, only Dry Vans (single, double, triple) may be selected within the calculators. See Table 9.

[30] The upper bound density range was based on gold (~0.6 tons/cubic foot) and the lower bound range on potato chips (~0.003 tons/cubic foot) – see http://www.aqua-calc.com/page/density-table/substance/Snacks-coma-and-blank-potato-blank-chips-coma-and-blank-white-coma-and-blank-restructured-coma-and-blank-baked.

Payload & Volume Calculators	If “# of Vehicles in this class” is selected for both the Payload and Volume calculators for a given truck class, the number of trucks entered into each calculator must agree.
Payload & Volume Calculators	If “# of Vehicles in this class” is selected for either the Payload or Volume calculator, the number of body-types selected cannot exceed the number of vehicles specified.
Payload & Volume Calculators	If “# of miles in this class” is selected for both the Payload and Volume calculators for a given truck class, the number of miles entered into each calculator must agree.
Payload & Volume Calculators	If “# of Trips done by this class” is selected for both the Payload and Volume calculators for a given truck class, the number of trips entered into each calculator must agree.
Payload & Volume Calculators	Ensure consistency between the body-type selections in the Class 8a/b payload calculator and the corresponding Volume calculator – i.e., issue warnings for any type of dry van, reefer or beverage selected in the payload calculator but no Trailers specified in volume calculator.

Validations have been added to the Truck Tool to ensure the selections in the 8a/8b volume calculator are consistent with the selections in the payload calculator for those classes:

RED errors (must address):

- If the user has values for 8a body type “Beverage” or “Dry Van – Single” in the Payload calculator, they must have a value in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Dry Van – Single” or “Dry Van – Double” or “Dry Van – Triple” in the Payload calculator, they must have a value in the “Trailer” section of the volume calculator.

YELLOW warnings (comments/changes not mandatory):

- If the user has values for 8a body type “Flatbed” or “Combination Flatbed” in the Payload calculator, they must have a “Flatbed” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Single-Axle Van” or “Dry Van - Single” in the Payload calculator, they must have a “Box” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Beverage” in the Payload calculator, they must have a “Box” or “Reefer” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Tanker” in the Payload calculator, they must have a value in the “Tanker” section of the volume calculator.
- If the user has values for 8a body type “Other (straight truck)” or “Other (combo)” in the Payload calculator, they must have a value in the “Bulk”, “Auto Carrier”, or “Other” section of the volume calculator.

- If the user has values for 8b body type “Dry Van – Single” or “Dry Van – Double” or “Dry Van – Triple” in the Payload calculator, they must have a “Box” checkbox checked in the “Trailer” section of the volume calculator.

- If the user has values for 8b body type “Combination Reefer” in the Payload calculator, they must have a “Reefer” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Combination Flatbed” in the Payload calculator, they must have a “Flatbed” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Combination Tanker” in the Payload calculator, they must have a value in the “Tanker” section of the volume calculator.
- If the user has values for 8b body type “Chassis” in the Payload calculator, they must have a value in the “Chassis” section of the volume calculator.
- If the user has values for 8b body type “Specialty” or “Other” in the Payload calculator, they must have a value in the “Bulk”, “Auto Carrier”, or “Other” section of the volume calculator.

As noted in Table 9 above, a warning is issued if an inconsistency is identified between body-types specified within the Fleet Description Section and those within the Payload/Volume Calculators. Warning conditions (associated with 100% body-type entries under Fleet Description) are presented in Table 10 below.

Table 10. Consistent Body-Types Resulting in No Warning Messages

Acceptable selections -								
Body Type (100%)	**2b**	**3**	**4**	**5**	**6**	**7**	**8a**	**8b**
Dry Van	all except flatbed	all	all except flatbed	all	walk-in, single axle van	single axle van, dry van single	single axle van, dry van single	dry van (single, double, triple)
Refrigerated	other	other	other	other	reefer, other	reefer, beverage, combination reefer, other	beverage, other	combination reefer, other
Flatbed	flatbed	other	flatbed	other	flatbed	flatbed, combination flatbed	flatbed, combination flatbed	combination flatbed
Tanker	other	other	other	other	other	tanker	tanker	combination tanker
Chassis	N/A	N/A	N/A	N/A	N/A	other	other	chassis
Hvy-Bulk	N/A	N/A	N/A	N/A	N/A	other	other	other
Auto Carrier	N/A	N/A	N/A	N/A	N/A	other	other	other
Moving	all except flatbed	all	all except flatbed	all	all except reefer, flatbed	single axle van, dry van-single, other	single axle van, dry van-single, other	dry van single, specialty, other
Spec Hauler	other	other	other	other	other	other	other	specialty
Utility	all	all	all	all	all except reefer	flatbed, combination flatbed, other	flatbed, combination flatbed, other	combination flatbed, specialty, other

Additional, rigorous validation checks of key data inputs are also needed to ensure the overall quality of the performance metrics calculated by the Truck 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 Truck 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 Truck Tool, and users are required to modify the associated inputs before proceeding.

The following presents the updates to the Truck Tool validation ranges for all parameters but payload and volume, which are discussed above. Validation ranges are of three types:

1. "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.
2. "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 "Orange" on the data entry screen.
3. "Absolute errors" exceed values deemed physically possible and must be changed in order to be accepted by the tool.

Reefer Fuel Validation

507 diesel fleets designated as "Reefer" for the 2013 calendar year were evaluated to determine the distribution of the fraction of reefer fuel consumption to total fuel consumption. Ten of these observations were dropped from the analysis data set, having either 0 gallons of reefer fuel entered, or reefer fuel consumption was greater than total consumption.[31] As shown in Figure 3 below, the distribution for the remaining reefer fleets was highly skewed toward low fractions (reefer consumption / total

[31] Additional validation rules have been implemented, so such data entries are no longer possible.

consumption). For this reason EPA simply used 5% increments for the Range 1 and 2 validation values, but used the average plus 1 to 2 standard deviations for Range 4, and > 2 standard deviations for Range 5. The resulting values are shown in Table 11 below.

Figure 3

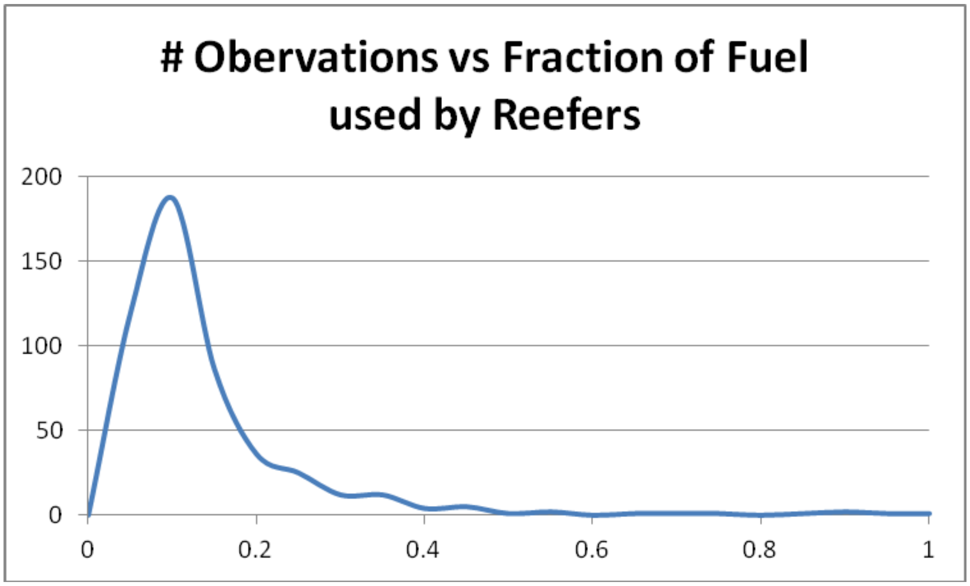


Table 11. Reefer Fuel Consumption Validation Ranges

	Min	Max	% of Obs	Comments
Range 1^	>0	0.18%	4.8%	Set to include ~5% of obs
Range 2	0.18%	1.45%	5.2%	Set to include ~5% of obs
Range 3	1.45%	24.25%	81.1%	Max value set at average + 1 sigma
Range 4	24.25%	36.90%	4.8%	between 1 and 2 sigma from average
Range 5*	36.90%	<100%	4.0%	2+ sigma from avg

^ Note - reefer fuel consumption cannot = 0 - absolute error

* Note - reefer fuel consumption cannot = 100% - absolute error

Basis - all diesel reefer fleets, 2013 reporting year

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

Data Processing

Except as noted above, the validation range recommendations are based upon a distributional analysis performed on the 2011 Truck Partner input and performance data. Fleet level data was input into SAS and grouped by truck class, bin category, and fuel type combinations. If a particular combination had less than 20 fleets, it was aggregated to the next “higher” level until at least 20 fleets were included. This process resulted in 26 groupings, as shown in Table 12. 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, Moving, Package, (Groups 5, 7, 8, and 9).

Table 12. Truck Fleet Groupings Used for Distributional Analysis

Group #	Name	# Fleets
1	2B_Mixed	90
2	3_Mixed	67
3	4_Mixed	59
4	5_Mixed	49
5	6_LTL/Dry Van_Diesel	52
6	6_Mixed	98
7	6_Moving	24
8	6_Package_Diesel	29
9	6_TL/Dry Van_Diesel	29
10	7_LTL/Dry Van_Diesel	56
11	7_Mixed	129
12	7_TL/Dry Van_Diesel	31
13	8A_LTL/Dry Van_Diesel	57
14	8A_Mixed	164
15	8A_Refrigerated_Diesel	24
16	8A_TL/Dry Van_Diesel	70
17	8B_AutoCarrier_Diesel	22
18	8B_Dray_Diesel	84
19	8B_Flatbed_Diesel	150
20	8B_Heavy/Bulk_Diesel	29
21	8B_LTL/Dry Van_Diesel	95
22	8B_Mixed	463
23	8B_Refrigerated_Diesel	408
24	8B_Specialized_Diesel	61
25	8B_TL/Dry Van_Diesel	719
26	8B_Tanker_Diesel	74
	Sum	**3,133**

ERG then performed a distributional assessment 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)
- Percent Biofuel
- Percent Average Used Cargo Volume
- 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 13.

Table 13. 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 Average Used Cargo Volume	0	100
Percent Urban Operation	0	100
Percent Highway Operation	0	100
Average Idle Hours	0	Mean + 3*std.dev

Using these criteria ERG identified 49 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 14.

Table 14. Values Flagged as Outliers

Group	Value	Mean	Parameter
1	121,133	30,058	Mi/Veh
1	121,108	30,058	Mi/Veh
3	86,827	25,894	Mi/Veh
7	111,401	31,584	Mi/Veh
9	124,685	33,782	Mi/Veh
10	115,287	38,540	Mi/Veh
12	118,006	37,498	Mi/Veh
14	166,342	38,957	Mi/Veh
14	143,660	38,957	Mi/Veh
15	184,305	45,563	Mi/Veh
16	113,448	38,336	Mi/Veh
18	157,713	54,525	Mi/Veh
20	185,244	54,430	Mi/Veh
20	186,529	54,430	Mi/Veh

Group	Value	Mean	Parameter
32	228,151	94,557	Mi/Veh
32	209,269	94,557	Mi/Veh
32	205,840	94,557	Mi/Veh
3	18.9	10.0	MPG
4	30	11.5	MPG
19	8	6.3	MPG
20	8.7	6.3	MPG
20	9	6.3	MPG
32	7.8	6.0	MPG
32	7.9	6.0	MPG
32	7.9	6.0	MPG
1	1,560	345	Avg Idle hrs/yr
1	1,785	345	Avg Idle hrs/yr
3	1,267	328	Avg Idle hrs/yr
7	1,462	441	Avg Idle hrs/yr
8	1,825	414	Avg Idle hrs/yr
8	1,680	414	Avg Idle hrs/yr
10	1,500	473	Avg Idle hrs/yr
10	1,505	473	Avg Idle hrs/yr
12	1,615	350	Avg Idle hrs/yr
14	1,835	494	Avg Idle hrs/yr
14	1,825	494	Avg Idle hrs/yr
14	2,077	494	Avg Idle hrs/yr
15	1,440	346	Avg Idle hrs/yr
16	1,400	430	Avg Idle hrs/yr
16	1,505	430	Avg Idle hrs/yr
18	2,574	694	Avg Idle hrs/yr
19	2,071	443	Avg Idle hrs/yr
19	2,050	443	Avg Idle hrs/yr
20	2,100	525	Avg Idle hrs/yr
20	2,000	525	Avg Idle hrs/yr
20	1,986	525	Avg Idle hrs/yr
32	3,024	918	Avg Idle hrs/yr
32	3,410	918	Avg Idle hrs/yr
33	2,816	853	Avg Idle hrs/yr

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 MPG appear normally distributed. Examples for Class 8b TL/Dry Van Diesel fleets are shown in Figures 4 and 5.

Figure 4. Annual Miles Per Vehicle Distribution, Class 8b TL/Dry Van Diesel Fleets

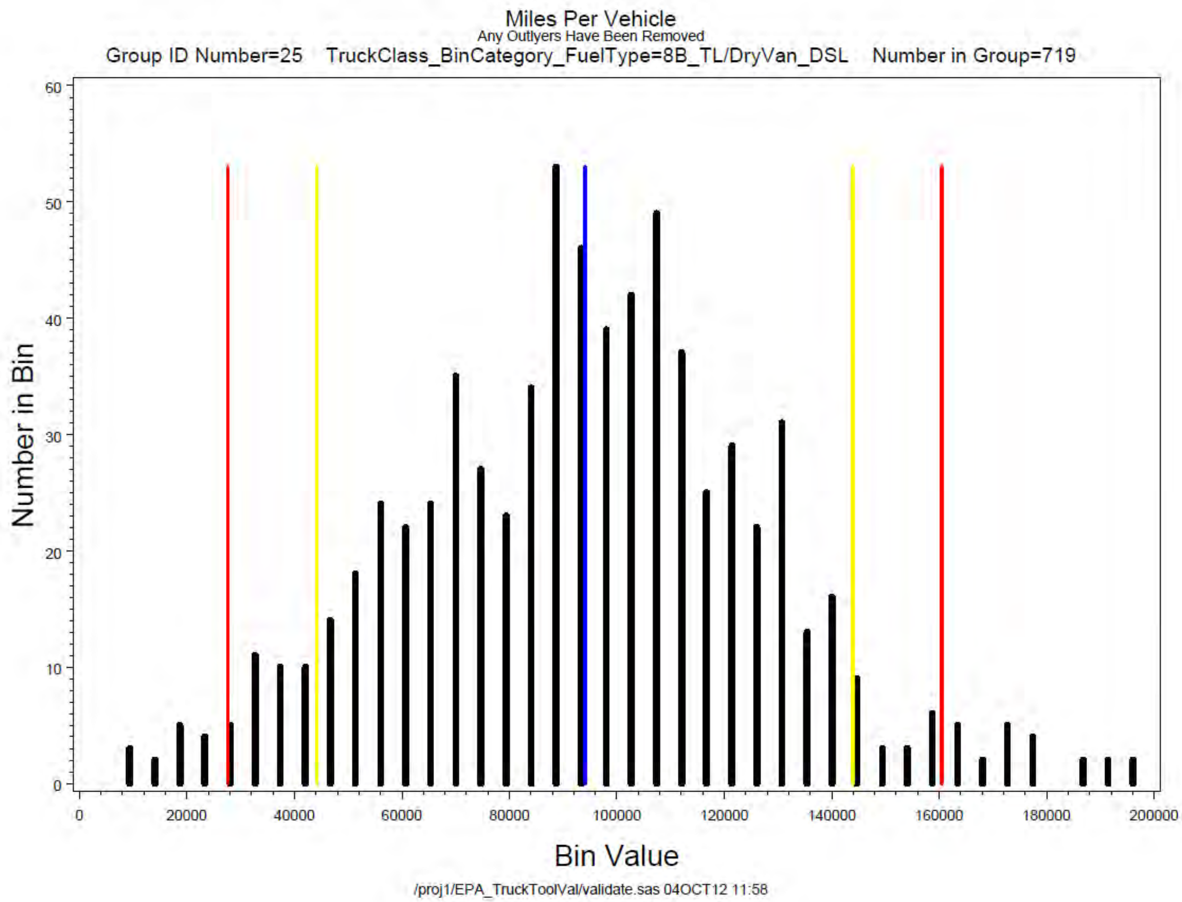
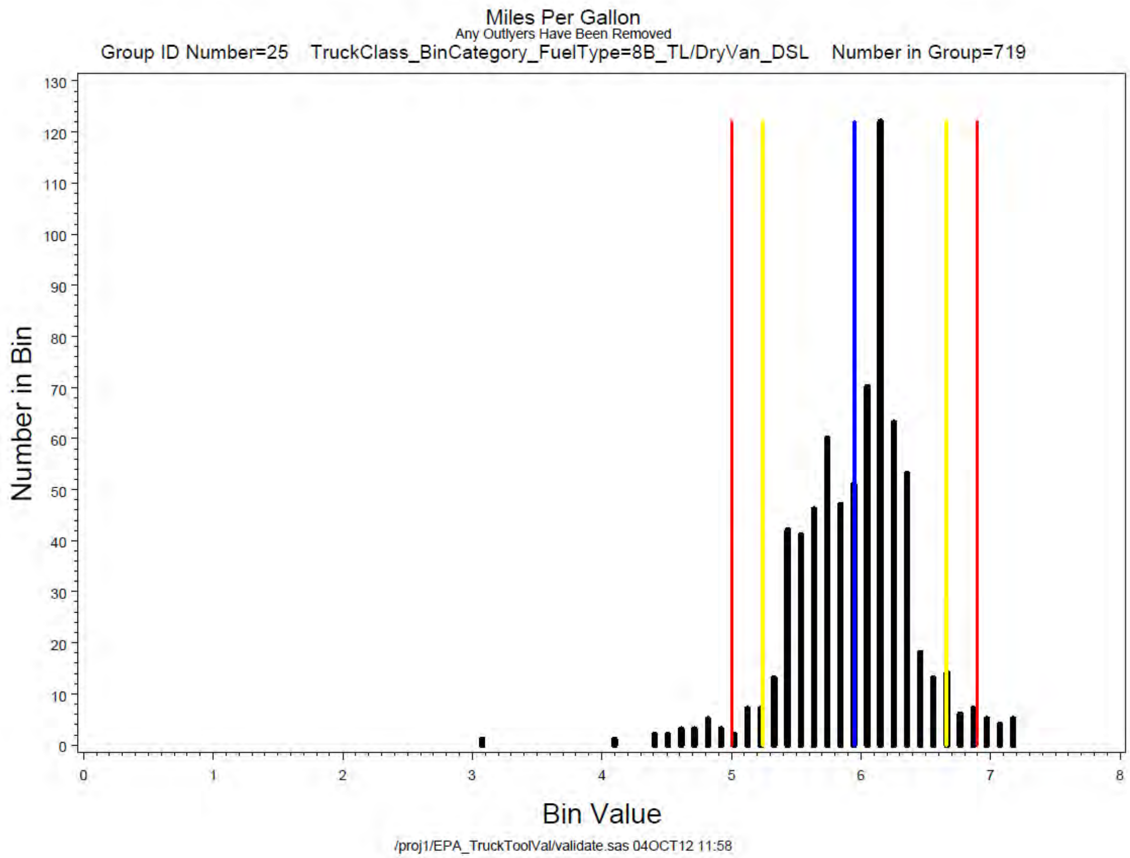


Figure 5. Miles per Gallon Distribution, Class 8b TL/Dry Van Diesel Fleets



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% biodiesel.[32] Finally, % Urban and % Highway Operation data showed no clear distributions, with values ranging from 0 % to 100 %.

Based on this preliminary assessment, red and yellow flag areas were defined for each fleet group/metric combination as shown in Table 15.

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

Table 15. "Red" and "Yellow" Flag Criteria

Metric	Low Red Flag	Low Yellow Flag	High Yellow Flag	High Red Flag
Miles per Vehicle	Mean – 2StD^	Mean-1.5StD^	Mean+1.5StD	Mean+2StD
MPG	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
% Revenue Miles	variable^^	variable^^	None	None
% Empty Miles	1	5	variable^^	variable^^
% Biofuel	None	None	None	None
% Average Used Cargo Volume	Mean – 2StD	Mean-1.5StD	variable*	variable*
% Urban Operation	None	None	None	None
% Highway Operation	None	None	None	None
Average Idle Hours	Mean – 2StD^	Mean-1.5StD^	Mean+1.5StD	Mean+2StD

^ If the calculated values are < 0 for a particular fleet category/metric combination, an alternate cutoff is applied based on expert judgment.
* Cutoffs developed based on expert judgment.
^^ Values selected in consultation with SmartWay support staff.

For six of the metrics,[33] 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 10-15% of the values for these metrics being flagged as either red or yellow for partner attention (although the flag rates associated with % Revenue and % Empty Miles is substantially higher). Selecting cutoffs at this level of stringency is intended to identify likely input errors without unduly burdening the large majority of Truck Tool users with unnecessary data checks and text explanations. Tables 16-21 present the actual yellow and red flag values for each fleet group/metric combination, given the decision criteria presented in Table 15. Tables 22-27 present the number of observations that would be flagged with yellow and red warnings for these combinations.

[33] Standard deviations are only used on the low end to determine red/yellow cutoffs for the % Average Used Cargo Volume metric, due to a number of carriers utilizing 100% of available space. Upper end cutoffs are based on expert judgment for LTL categories.

Table 16. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Miles per Vehicle

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	2,000	4,000	28,884	62,834	74,151
2	3_Mixed	6,000	8,000	30,479	62,193	72,764
3	4_Mixed	2,000	6,000	27,133	55,662	65,171
4	5_Mixed	2,000	4,000	29,922	60,351	70,494
5	6_LTL/Dry Van_Diesel	3,000	9,000	32,000	61,481	71,308
6	6_Mixed	5,000	10,000	35,838	68,836	79,835
7	6_Moving	3,000	8,000	33,908	68,107	79,506
8	6_Package_Diesel	7,376	14,188	34,622	55,057	61,869
9	6_TL/Dry Van_Diesel	5,000	10,000	33,738	69,723	81,718
10	7_LTL/Dry Van_Diesel	5,000	10,000	43,040	85,533	99,697
11	7_Mixed	4,000	8,000	36,778	69,979	81,046
12	7_TL/Dry Van_Diesel	2,000	6,000	31,764	65,241	76,399
13	8A_LTL/Dry Van_Diesel	4,000	10,000	49,990	94,443	109,260
14	8A_Mixed	4,000	8,000	52,847	102,878	119,555
15	8A_Refrigerated_Diesel	10,000	20,000	66,376	120,026	137,909
16	8A_TL/Dry Van_Diesel	4,000	7,433	74,532	141,631	163,997
17	8B_AutoCarrier_Diesel	39,712	49,944	80,640	111,335	121,567
18	8B_Dray_Diesel	4,000	12,344	56,782	101,219	116,032
19	8B_Flatbed_Diesel	34,715	47,250	84,858	122,465	135,001
20	8B_Heavy/Bulk_Diesel	7,717	23,515	70,909	118,303	134,101
21	8B_LTL/Dry Van_Diesel	16,801	30,898	73,188	115,477	129,574
22	8B_Mixed	12,171	29,882	83,016	136,150	153,861
23	8B_Refrigerated_Diesel	38,363	55,515	106,968	158,422	175,573
24	8B_Specialized_Diesel	1,705	23,589	89,242	154,895	176,780
25	8B_TL/Dry Van_Diesel	27,591	44,207	94,054	143,902	160,518
26	8B_Tanker_Diesel	32,467	44,793	81,769	118,745	131,071

Table 17. Yellow/Red Criteria by Fleet Group/Metric Combination
Miles per Gallon[34]

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	4.6	6.7	12.9	19.1	21.1
2	3_Mixed	5.0	6.3	10.2	14.1	15.4
3	4_Mixed	5.4	6.4	9.3	12.2	13.1
4	5_Mixed	4.5	5.5	8.4	11.4	12.4
5	6_LTL/Dry Van_Diesel	5.7	6.3	8.0	9.7	10.3
6	6_Mixed	5.2	5.8	7.8	9.7	10.3
7	6_Moving	5.8	6.2	7.3	8.5	8.9
8	6_Package_Diesel	6.1	6.7	8.7	10.6	11.3
9	6_TL/Dry Van_Diesel	4.9	5.6	7.7	9.8	10.5
10	7_LTL/Dry Van_Diesel	5.6	6.1	7.6	9.1	9.6
11	7_Mixed	4.5	5.2	7.3	9.4	10.1
12	7_TL/Dry Van_Diesel	5.3	5.9	7.7	9.4	10.0
13	8A_LTL/Dry Van_Diesel	5.3	5.5	6.3	7.0	7.2
14	8A_Mixed	4.4	4.8	6.2	7.6	8.1
15	8A_Refrigerated_Diesel	4.8	5.0	5.9	6.7	7.0
16	8A_TL/Dry Van_Diesel	5.0	5.3	6.3	7.3	7.6
17	8B_AutoCarrier_Diesel	4.2	4.5	5.2	5.8	6.1
18	8B_Dray_Diesel	4.9	5.1	5.8	6.5	6.7
19	8B_Flatbed_Diesel	4.4	4.7	5.7	6.6	6.9
20	8B_Heavy/Bulk_Diesel	3.4	3.8	5.0	6.3	6.7
21	8B_LTL/Dry Van_Diesel	5.1	5.4	6.0	6.7	6.9
22	8B_Mixed	4.8	5.0	5.8	6.6	6.9
23	8B_Refrigerated_Diesel	4.8	5.1	5.7	6.4	6.6
24	8B_Specialized_Diesel	3.8	4.3	5.5	6.8	7.2
25	8B_TL/Dry Van_Diesel	5.0	5.2	5.9	6.7	6.9
26	8B_Tanker_Diesel	4.8	5.0	5.8	6.6	6.9

[34] 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 18. Yellow/Red Criteria by Fleet Group/Metric Combination
% Revenue Miles

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	55	60	84.9	N/A	N/A
2	3_Mixed	50	60	84.4	N/A	N/A
3	4_Mixed	50	60	87.8	N/A	N/A
4	5_Mixed	50	60	85.7	N/A	N/A
5	6_LTL/Dry Van_Diesel	50	60	89.7	N/A	N/A
6	6_Mixed	55	65	82.8	N/A	N/A
7	6_Moving	55	65	84.5	N/A	N/A
8	6_Package_Diesel	55	65	95.5	N/A	N/A
9	6_TL/Dry Van_Diesel	55	65	86.1	N/A	N/A
10	7_LTL/Dry Van_Diesel	55	65	90.4	N/A	N/A
11	7_Mixed	55	65	83.6	N/A	N/A
12	7_TL/Dry Van_Diesel	55	65	84.4	N/A	N/A
13	8A_LTL/Dry Van_Diesel	55	60	90.5	N/A	N/A
14	8A_Mixed	55	60	82.6	N/A	N/A
15	8A_Refrigerated_Diesel	55	60	81.8	N/A	N/A
16	8A_TL/Dry Van_Diesel	55	60	87.1	N/A	N/A
17	8B_AutoCarrier_Diesel	50	55	70.6	N/A	N/A
18	8B_Dray_Diesel	55	60	84.9	N/A	N/A
19	8B_Flatbed_Diesel	60	65	81.6	N/A	N/A
20	8B_Heavy/Bulk_Diesel	50	55	65.1	N/A	N/A
21	8B_LTL/Dry Van_Diesel	60	70	90.3	N/A	N/A
22	8B_Mixed	50	60	85.6	N/A	N/A
23	8B_Refrigerated_Diesel	60	70	87.7	N/A	N/A
24	8B_Specialized_Diesel	55	60	64.5	N/A	N/A
25	8B_TL/Dry Van_Diesel	55	65	87.4	N/A	N/A
26	8B_Tanker_Diesel	45	50	66.8	N/A	N/A

Table 19. Yellow/Red Criteria by Fleet Group/Metric Combination
% Empty Miles

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	1	5	14.3	40	45
2	3_Mixed	1	5	18.9	40	50
3	4_Mixed	1	5	13.4	40	50
4	5_Mixed	1	5	24.0	40	50
5	6_LTL/Dry Van_Diesel	1	5	9.6	40	50
6	6_Mixed	1	5	19.0	40	50
7	6_Moving	1	5	15.0	40	50
8	6_Package_Diesel	1	5	18.5	40	50
9	6_TL/Dry Van_Diesel	1	5	12.1	40	50
10	7_LTL/Dry Van_Diesel	1	5	17.0	40	45
11	7_Mixed	1	5	15.4	40	45
12	7_TL/Dry Van_Diesel	1	5	4.5	40	45
13	8A_LTL/Dry Van_Diesel	1	5	17.1	40	45
14	8A_Mixed	1	5	18.5	40	45
15	8A_Refrigerated_Diesel	1	5	12.0	40	45
16	8A_TL/Dry Van_Diesel	1	5	15.5	40	45
17	8B_AutoCarrier_Diesel	1	5	18.2	45	50
18	8B_Dray_Diesel	1	5	21.2	40	45
19	8B_Flatbed_Diesel	1	5	11.3	40	45
20	8B_Heavy/Bulk_Diesel	1	5	16.8	50	60
21	8B_LTL/Dry Van_Diesel	1	5	20.7	35	45
22	8B_Mixed	1	5	14.2	45	50
23	8B_Refrigerated_Diesel	1	5	11.3	40	45
24	8B_Specialized_Diesel	1	5	32.0	45	50
25	8B_TL/Dry Van_Diesel	1	5	22.4	45	50
26	8B_Tanker_Diesel	30	40	18.6	65	75

Table 20. Yellow/Red Criteria by Fleet Group/Metric Combination
Average Used Cargo Volume %

Group	Name	Low Red	Low Yellow	Mean	High Yellow^	High Red^
1	2B_Mixed	30	40	69.7	N/A	N/A
2	3_Mixed	37	47	74.8	N/A	N/A
3	4_Mixed	37	47	75.7	N/A	N/A
4	5_Mixed	39	48	77.1	N/A	N/A
5	6_LTL/Dry Van_Diesel	48	54	74.0	90	95
6	6_Mixed	46	54	77.3	N/A	N/A
7	6_Moving	36	42	59.8	80	90
8	6_Package_Diesel	53	60	83.1	N/A	N/A
9	6_TL/Dry Van_Diesel	40	49	76.3	N/A	N/A
10	7_LTL/Dry Van_Diesel	52	58	77.1	90	95
11	7_Mixed	43	51	75.0	N/A	N/A
12	7_TL/Dry Van_Diesel	49	56	80.1	N/A	N/A
13	8A_LTL/Dry Van_Diesel	55	61	79.5	90	95
14	8A_Mixed	48	56	80.5	N/A	N/A
15	8A_Refrigerated_Diesel	40	50	77.5	N/A	N/A
16	8A_TL/Dry Van_Diesel	50	58	81.0	N/A	N/A
17	8B_AutoCarrier_Diesel	69	75	91.4	N/A	N/A
18	8B_Dray_Diesel	55	63	85.7	N/A	N/A
19	8B_Flatbed_Diesel	62	69	87.2	N/A	N/A
20	8B_Heavy/Bulk_Diesel	60	67	88.4	N/A	N/A
21	8B_LTL/Dry Van_Diesel	58	64	81.3	90	95
22	8B_Mixed	55	62	82.6	N/A	N/A
23	8B_Refrigerated_Diesel	58	65	85.0	N/A	N/A
24	8B_Specialized_Diesel	61	69	90.1	N/A	N/A
25	8B_TL/Dry Van_Diesel	59	65	85.2	N/A	N/A
26	8B_Tanker_Diesel	63	69	89.1	N/A	N/A

^ “N/A” indicates calculated flag value > 100. Any value ≤ 100 is acceptable for these group/metric combinations. Other values based on expert judgment.

Table 21. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Average Idle Hours per Truck

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	50	100	323	693	817
2	3_Mixed	40	100	371	778	914
3	4_Mixed	50	100	364	695	806
4	5_Mixed	50	100	420	808	937
5	6_LTL/Dry Van_Diesel	50	80	311	574	662
6	6_Mixed	50	80	425	875	1,025
7	6_Moving	20	40	275	519	601
8	6_Package_Diesel	10	20	305	741	887
9	6_TL/Dry Van_Diesel	20	50	514	1,217	1,451
10	7_LTL/Dry Van_Diesel	70	100	326	578	662
11	7_Mixed	60	100	413	825	963
12	7_TL/Dry Van_Diesel	20	70	288	523	601
13	8A_LTL/Dry Van_Diesel	50	100	384	762	888
14	8A_Mixed	40	100	574	1,268	1,499
15	8A_Refrigerated_Diesel	100	200	713	1,538	1,813
16	8A_TL/Dry Van_Diesel	40	80	629	1,391	1,645
17	8B_AutoCarrier_Diesel	300	400	1,154	2,278	2,653
18	8B_Dray_Diesel	100	200	672	1,377	1,612
19	8B_Flatbed_Diesel	100	200	911	1,735	2,010
20	8B_Heavy/Bulk_Diesel	100	200	601	1,102	1,270
21	8B_LTL/Dry Van_Diesel	100	200	518	1,048	1,225
22	8B_Mixed	100	200	782	1,636	1,921
23	8B_Refrigerated_Diesel	100	200	843	1,705	1,993
24	8B_Specialized_Diesel	100	220	760	1,613	1,897
25	8B_TL/Dry Van_Diesel	100	200	912	1,786	2,077
26	8B_Tanker_Diesel	100	150	826	1,745	2,051

Table 22. Number of Values Flagged by Fleet Group/Metric Combination
Annual Miles per Vehicle

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	4	3	7	2
2	3_Mixed	6	2	1	4
3	4_Mixed	1	5	2	3
4	5_Mixed	3	0	1	2
5	6_LTL/Dry Van_Diesel	0	0	3	3
6	6_Mixed	6	5	4	3
7	6_Moving	1	1	0	1
8	6_Package_Diesel	0	0	0	2
9	6_TL/Dry Van_Diesel	2	2	1	1
10	7_LTL/Dry Van_Diesel	1	2	0	4
11	7_Mixed	4	1	3	5
12	7_TL/Dry Van_Diesel	2	0	1	0
13	8A_LTL/Dry Van_Diesel	0	1	1	4
14	8A_Mixed	4	3	11	3
15	8A_Refrigerated_Diesel	0	1	1	0
16	8A_TL/Dry Van_Diesel	1	1	6	1
17	8B_AutoCarrier_Diesel	1	1	0	0
18	8B_Dray_Diesel	0	2	4	4
19	8B_Flatbed_Diesel	4	7	6	3
20	8B_Heavy/Bulk_Diesel	0	2	3	0
21	8B_LTL/Dry Van_Diesel	2	2	5	3
22	8B_Mixed	4	27	20	13
23	8B_Refrigerated_Diesel	14	19	10	11
24	8B_Specialized_Diesel	0	3	2	4
25	8B_TL/Dry Van_Diesel	19	31	20	22
26	8B_Tanker_Diesel	2	2	3	2
	Sum	81	123	115	100
		2.6%	3.9%	3.7%	3.2%

Table 23. Number of Values Flagged by Fleet Group/Metric Combination
Miles per Gallon

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	1	2	4	3
2	3_Mixed	0	3	1	2
3	4_Mixed	3	0	0	1
4	5_Mixed	0	2	1	1
5	6_LTL/Dry Van_Diesel	0	4	3	0
6	6_Mixed	4	0	5	1
7	6_Moving	0	0	3	0
8	6_Package_Diesel	1	1	1	0
9	6_TL/Dry Van_Diesel	1	0	1	1
10	7_LTL/Dry Van_Diesel	2	4	0	1
11	7_Mixed	3	2	3	1
12	7_TL/Dry Van_Diesel	0	2	1	1
13	8A_LTL/Dry Van_Diesel	1	5	0	1
14	8A_Mixed	3	5	4	8
15	8A_Refrigerated_Diesel	0	2	0	2
16	8A_TL/Dry Van_Diesel	2	1	2	2
17	8B_AutoCarrier_Diesel	0	0	0	1
18	8B_Dray_Diesel	3	4	5	0
19	8B_Flatbed_Diesel	2	4	3	1
20	8B_Heavy/Bulk_Diesel	1	3	2	0
21	8B_LTL/Dry Van_Diesel	3	2	0	2
22	8B_Mixed	15	15	7	7
23	8B_Refrigerated_Diesel	13	10	29	5
24	8B_Specialized_Diesel	3	1	1	0
25	8B_TL/Dry Van_Diesel	22	14	20	21
26	8B_Tanker_Diesel	3	2	2	1
	Sum	86	88	99	63
		2.7%	2.8%	3.2%	2.0%

Table 24. Number of Values Flagged by Fleet Group/Metric Combination
Revenue Miles

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	6	3	N/A	N/A
2	3_Mixed	1	5	N/A	N/A
3	4_Mixed	0	2	N/A	N/A
4	5_Mixed	0	1	N/A	N/A
5	6_LTL/Dry Van_Diesel	0	1	N/A	N/A
6	6_Mixed	7	9	N/A	N/A
7	6_Moving	1	2	N/A	N/A
8	6_Package_Diesel	0	1	N/A	N/A
9	6_TL/Dry Van_Diesel	2	2	N/A	N/A
10	7_LTL/Dry Van_Diesel	2	3	N/A	N/A
11	7_Mixed	11	9	N/A	N/A
12	7_TL/Dry Van_Diesel	2	2	N/A	N/A
13	8A_LTL/Dry Van_Diesel	1	0	N/A	N/A
14	8A_Mixed	16	4	N/A	N/A
15	8A_Refrigerated_Diesel	2	1	N/A	N/A
16	8A_TL/Dry Van_Diesel	4	1	N/A	N/A
17	8B_AutoCarrier_Diesel	1	2	N/A	N/A
18	8B_Dray_Diesel	7	6	N/A	N/A
19	8B_Flatbed_Diesel	4	8	N/A	N/A
20	8B_Heavy/Bulk_Diesel	1	7	N/A	N/A
21	8B_LTL/Dry Van_Diesel	2	5	N/A	N/A
22	8B_Mixed	1	19	N/A	N/A
23	8B_Refrigerated_Diesel	13	14	N/A	N/A
24	8B_Specialized_Diesel	25	5	N/A	N/A
25	8B_TL/Dry Van_Diesel	10	21	N/A	N/A
26	8B_Tanker_Diesel	1	5	N/A	N/A
	Sum	120	138	0	0
		3.8%	4.4%	0.0%	0.0%

Table 25. Number of Values Flagged by Fleet Group/Metric Combination
Empty Miles

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	21	14	3	6
2	3_Mixed	19	4	5	1
3	4_Mixed	18	8	2	0
4	5_Mixed	13	1	1	0
5	6_LTL/Dry Van_Diesel	14	12	1	0
6	6_Mixed	23	10	9	0
7	6_Moving	6	0	0	0
8	6_Package_Diesel	18	4	0	0
9	6_TL/Dry Van_Diesel	7	5	2	0
10	7_LTL/Dry Van_Diesel	15	12	1	2
11	7_Mixed	26	15	1	11
12	7_TL/Dry Van_Diesel	8	2	1	3
13	8A_LTL/Dry Van_Diesel	16	11	0	1
14	8A_Mixed	27	17	2	18
15	8A_Refrigerated_Diesel	3	1	1	3
16	8A_TL/Dry Van_Diesel	13	6	2	4
17	8B_AutoCarrier_Diesel	1	1	2	0
18	8B_Dray_Diesel	12	13	7	16
19	8B_Flatbed_Diesel	6	5	1	3
20	8B_Heavy/Bulk_Diesel	1	1	0	0
21	8B_LTL/Dry Van_Diesel	10	24	3	1
22	8B_Mixed	60	59	15	1
23	8B_Refrigerated_Diesel	27	51	7	11
24	8B_Specialized_Diesel	2	2	5	0
25	8B_TL/Dry Van_Diesel	43	103	9	3
26	8B_Tanker_Diesel	4	0	0	0
	Sum	413	381	80	84
		13.2%	12.2%	2.6%	2.7%

Table 26. Number of Values Flagged by Fleet Group/Metric Combination
Average Used Cargo Volume %

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	2	4	N/A	N/A
2	3_Mixed	2	4	N/A	N/A
3	4_Mixed	2	1	N/A	N/A
4	5_Mixed	0	5	N/A	N/A
5	6_LTL/Dry Van_Diesel	1	4	3	3
6	6_Mixed	5	3	N/A	N/A
7	6_Moving	0	0	3	0
8	6_Package_Diesel	1	3	N/A	N/A
9	6_TL/Dry Van_Diesel	0	1	N/A	N/A
10	7_LTL/Dry Van_Diesel	3	2	4	6
11	7_Mixed	3	14	N/A	N/A
12	7_TL/Dry Van_Diesel	0	2	N/A	N/A
13	8A_LTL/Dry Van_Diesel	3	4	10	5
14	8A_Mixed	6	9	N/A	N/A
15	8A_Refrigerated_Diesel	1	2	N/A	N/A
16	8A_TL/Dry Van_Diesel	1	7	N/A	N/A
17	8B_AutoCarrier_Diesel	2	0	N/A	N/A
18	8B_Dray_Diesel	7	5	N/A	N/A
19	8B_Flatbed_Diesel	7	9	N/A	N/A
20	8B_Heavy/Bulk_Diesel	3	0	N/A	N/A
21	8B_LTL/Dry Van_Diesel	5	4	5	11
22	8B_Mixed	28	12	N/A	N/A
23	8B_Refrigerated_Diesel	22	10	N/A	N/A
24	8B_Specialized_Diesel	4	2	N/A	N/A
25	8B_TL/Dry Van_Diesel	35	30	N/A	N/A
26	8B_Tanker_Diesel	6	1	N/A	N/A
	Sum	149	138	25	25
		4.8%	4.4%	0.8%	0.8%

Table 27. Number of Values Flagged by Fleet Group/Metric Combination
Average Annual Idle Hours per Truck

Group #	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	3	4	2	5
2	3_Mixed	2	7	7	2
3	4_Mixed	0	1	3	4
4	5_Mixed	1	2	2	1
5	6_LTL/Dry Van_Diesel	0	2	3	3
6	6_Mixed	6	2	3	6
7	6_Moving	0	2	1	0
8	6_Package_Diesel	1	1	2	1
9	6_TL/Dry Van_Diesel	1	1	0	2
10	7_LTL/Dry Van_Diesel	0	4	2	2
11	7_Mixed	2	2	1	8
12	7_TL/Dry Van_Diesel	1	1	3	0
13	8A_LTL/Dry Van_Diesel	0	5	1	3
14	8A_Mixed	3	3	3	13
15	8A_Refrigerated_Diesel	0	2	1	2
16	8A_TL/Dry Van_Diesel	1	4	4	5
17	8B_AutoCarrier_Diesel	1	0	1	1
18	8B_Dray_Diesel	1	5	9	2
19	8B_Flatbed_Diesel	0	1	15	6
20	8B_Heavy/Bulk_Diesel	0	1	1	2
21	8B_LTL/Dry Van_Diesel	3	6	3	7
22	8B_Mixed	15	10	21	31
23	8B_Refrigerated_Diesel	8	15	29	21
24	8B_Specialized_Diesel	0	2	0	6
25	8B_TL/Dry Van_Diesel	8	6	72	23
26	8B_Tanker_Diesel	2	1	7	3
	Sum	59	90	196	159
		1.9%	2.9%	6.3%	5.1%

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 we have 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.[35] 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 dataset (prior to cleaning) are presented in Table 28.

Table 28. Maximum and Minimum Miles per Gallon

Group #	Name	Min	Mean	Max
1	2B_Mixed	2.0	12.9	21.6
2	3_Mixed	5.4	10.2	30.0[36]
3	4_Mixed	5.0	9.3	14.9
4	5_Mixed	4.8	8.4	13.7
5	6_LTL/Dry Van_Diesel	5.7	8.0	10.3
6	6_Mixed	4.2	7.8	10.4
7	6_Moving	6.4	7.3	8.9
8	6_Package_Diesel	5.7	8.7	10.8
9	6_TL/Dry Van_Diesel	4.4	7.7	11.6
10	7_LTL/Dry Van_Diesel	5.6	7.6	9.8
11	7_Mixed	1.2	7.3	11.9
12	7_TL/Dry Van_Diesel	5.8	7.7	10.8
13	8A_LTL/Dry Van_Diesel	4.9	6.3	8.0
14	8A_Mixed	2.8	6.2	9.0
15	8A_Refrigerated_Diesel	4.9	5.9	7.1
16	8A_TL/Dry Van_Diesel	4.4	6.3	8.3
17	8B_AutoCarrier_Diesel	4.5	5.2	6.3
18	8B_Dray_Diesel	4.7	5.8	6.6
19	8B_Flatbed_Diesel	0.6	5.7	7.0
20	8B_Heavy/Bulk_Diesel	3.4	5.0	6.4
21	8B_LTL/Dry Van_Diesel	4.4	6.0	7.1
22	8B_Mixed	3.0	5.8	7.3
23	8B_Refrigerated_Diesel	4.3	5.7	7.1
24	8B_Specialized_Diesel	2.8	5.5	6.8
25	8B_TL/Dry Van_Diesel	3.1	5.9	7.9
26	8B_Tanker_Diesel	3.8	5.8	7.0

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

[36] Value for a hybrid electric truck. Hybrids are subject to separate validation ranges for the 2015 version of the Truck Tool as discussed below. The maximum value for non-hybrid Class 3 diesel trucks was 14.4 mpg.

[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) and for this reason no absolute lower bound is used 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 Model were used. Background on the PERE modeling exercise is provided in Appendix E.

Absolute maximum miles per gallon estimates were developed for conventional diesel trucks using the PERE model, and are shown in Table 29 by truck class.

Table 29. 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 all substantially higher than the maximum value observed for non-hybrid diesel trucks in the 2011 Truck Tool data.

Non-Diesel MPG

The 2011 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.[37] 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

[37] Delorme, A. et. al., *Impact of Advanced Technologies on Medium-Duty Trucks Fuel Efficiency*, Argonne National Laboratory, 2010-01-1929.

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 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 28 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),[38] thereby adjusting mpg values for volumetric energy density. Table 30 presents the corresponding upper bound MPG values for non-diesel vehicles by truck class.

Table 30. 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 in order 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 E.

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

[38] https://www.afdc.energy.gov/afdc/prep/popups/gges.html

relative fraction of highway versus urban driving. Therefore the MPG ranges used for validation of hybrid fuel economy are calculated using the following steps.

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

Gal/Mi - 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

Gal/Mi – 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

Gal/Mi – Highway

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
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. The average value for Class 2b trucks was assumed to equal the mi/kWhr value estimates for large SUVs in EPA's MARKAL model

(3.01). The values for Class 4 and 6 electric trucks (1.43 and 1.00 respectively) were taken from Calstart's E-Truck Task Force Business Case Calculator. Values for Class 3 and 5 trucks were based on simple averages of the Class 2b, 4, and 6 values. Given the lack of available data for the heavier truck classes, values for Class 7 (0.75), Class 8a (0.5) and Class 8b (0.4) were based on engineering judgment.

Once average mi/kWhr estimates were derived, "red" and "yellow" ranges were established 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).

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 Biodiesel

While the maximum observed blend level for biodiesel was 20 percent, B100 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 dataset (prior to cleaning) are presented in Table 31.

Table 31. Maximum and Minimum Observed Payloads (Short Tons)

Group #	Name	Min	Mean	Max
1	2B_Mixed	0.1	1.0	1.9[39]
2	3_Mixed	0.1	1.7	3.0
3	4_Mixed	0.5	2.4	4.0
4	5_Mixed	1.3	3.1	5.3
5	6_LTL/Dry Van_Diesel	0.9	4.6	6.3
6	6_Mixed	0.9	4.5	6.5
7	6_Moving	2.5	3.6	4.9
8	6_Package_Diesel	2.0	4.2	6.0
9	6_TL/Dry Van_Diesel	0.9	4.1	6.9

[39] Three extreme outliers for Class 2b trucks were dropped for the purposes of establishing maximum upper bounds: 16.0, 13.0 and 5.0 tons.

Group #	Name	Min	Mean	Max
10	7_LTL/Dry Van_Diesel	1.8	6.0	8.7
11	7_Mixed	1.1	6.0	20.0
12	7_TL/Dry Van_Diesel	4.5	6.4	12.7
13	8A_LTL/Dry Van_Diesel	6.0	10.6	15.0
14	8A_Mixed	1.9	11.3	24.0
15	8A_Refrigerated_Diesel	6.3	13.3	21.0
16	8A_TL/Dry Van_Diesel	3.8	11.4	20.0
17	8B_AutoCarrier_Diesel	9.3	19.6	24.5
18	8B_Dray_Diesel	15.0	20.5	24.5
19	8B_Flatbed_Diesel	14.8	23.2	33.3
20	8B_Heavy/Bulk_Diesel	20.0	27.6	40.0
21	8B_LTL/Dry Van_Diesel	7.8	18.2	27.9
22	8B_Mixed	7.5	20.3	33.1
23	8B_Refrigerated_Diesel	13.2	20.9	27.5
24	8B_Specialized_Diesel	7.3	24.4	37.0
25	8B_TL/Dry Van_Diesel	6.5	18.9	50.0
26	8B_Tanker_Diesel	17.5	24.6	34.6

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, note that standard payload limitations can be waived by obtaining permits for heavy loads, or by avoiding over-the-road operation.[40] Accordingly, the absolute upper bound payload levels were set equal to 3 times the maximum observed values shown in Table 31.

However, no absolute lower-bound payload value was set, to allow for light package and specialty deliveries. Therefore the only low end constraint is the requirement that payloads be > 0.

Average Volume

The maximum and minimum observed volumes from the dataset (prior to cleaning) are presented in Table 32.

[40] One SmartWay Truck Partner indicated unusually high payloads for their Class 2b truck fleet, but noted they only use their trucks in terminal operations.

Table 32. Maximum and Minimum Observed Volumes (cubic feet)

Group #	Name	Min	Mean	Max
1	2B_Mixed	1	343	1,000
2	3_Mixed	1	498	940
3	4_Mixed	54	659	1,185
4	5_Mixed	141	1,215	1,894
5	6_LTL/Dry Van_Diesel	693	1,375	1,115
6	6_Mixed	336	1,324	878
7	6_Moving	141	1,382	1,894
8	6_Package_Diesel	300	1,398	1,800
9	6_TL/Dry Van_Diesel	693	1,255	1,521[41]
10	7_LTL/Dry Van_Diesel	693	1,687	3,765
11	7_Mixed	267	1,601	3,521
12	7_TL/Dry Van_Diesel	728	1,581	3,521
13	8A_LTL/Dry Van_Diesel	1,000	3,272	3,852
14	8A_Mixed	1	2,862	6,302
15	8A_Refrigerated_Diesel	1	2,759	3,780
16	8A_TL/Dry Van_Diesel	1,454	3,410	3,848
17	8B_AutoCarrier_Diesel	2,844	4,424	8,350
18	8B_Dray_Diesel	1,516	2,387	3,892
19	8B_Flatbed_Diesel	2,341	3,485	5,000
20	8B_Heavy/Bulk_Diesel	1,000	3,114	4,824
21	8B_LTL/Dry Van_Diesel	2,205	3,615	4,925
22	8B_Mixed	1,991	3,565	4,896
23	8B_Refrigerated_Diesel	3,171	3,721	4,068
24	8B_Specialized_Diesel	450	2,604	5,843
25	8B_TL/Dry Van_Diesel	1,159	3,740	6,316
26	8B_Tanker_Diesel	702	1,210	4,004

Maximum volumes are extremely difficult to define given the presence of non-uniform body styles, oversized loads, etc. Accordingly a simple upper bound was set at 3 times the maximum observed values shown above.

However, no absolute lower-bound volume value was set, to allow for small package and specialty deliveries. Therefore the only low end constraint is the requirement that volumes be > 0.

Average Used Cargo Volume %

Average used cargo volume % was frequently equal to 100 in the dataset. Accordingly, no upper bound was set for this field. In addition, no absolute lower-bound was set for

[41] One Class 6 LTL fleet with an extreme outlier volume of 12,000 cubic feet was dropped for the purposes of this analysis.

utilization either, to allow for small package and LTL/specialty deliveries. The only requirement is that all values be ≥ 0 and ≤ 100.

The new Truck Tool adds a new Data Source option for Dray carriers allows them to select an industry average used cargo volume % factor, since these carriers may not know how their containers are loaded. To calculate the industry average value the following calculation steps were performed:

1) All truck carriers with a Dray Operation tag were identified from the 2012 Truck Tool submittals - 109 dray carriers with 20,774 trucks. 75.9% of these trucks had a Chassis Body Type tag, 23.2% had a Dry Van tag, and 0.9% had a Mixed tag. No other body type tags were reported for dray carriers. Essentially all of these trucks were Class 8b diesels.

2) All *non*-dray carriers with Chassis, Dry Van, and Mixed Body Type tags were selected, and the average used cargo volume % was calculated for Body Type tag, weighted by the number of trucks. (This approach assumes that none of the average used cargo volume % values reported for Dray carriers were reliable, regardless of their Data Source selection.) There were 229,349 trucks in this data set. The weighted average used cargo volume % values for non-dray carriers were as follows.

Chassis	90.5%
Dry Van	84.8%
Mixed	85.4%

3) The weighted average used cargo volume % values from Step 2 were combined with the body type percentage distribution from Step 1 to obtain a single, industry average for used cargo volume % value for use by Dray carriers of 89.13%. This estimate applies for all truck classes and fuel types, as the data set is very thin for anything other than class 8b diesels. Note that this value will only be used if a Dray Carrier selects the "Industry Average" button on the Activity screen or the default selection on the Data Source screen. Also note that the default option is only available to carriers that specified a non-zero Dray operations percentage in the Fleet Description section - otherwise the Industry Average button will not appear.

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.

Average Annual Idle Hours per Truck

The maximum and minimum observed idle hours from the dataset (prior to cleaning) are presented in Table 33.

Table 33. Maximum and Minimum Observed Idle Hours per Truck

Group #	Name	Min	Mean	Max
1	2B_Mixed	0	323	1,785
2	3_Mixed	20	371	1,267
3	4_Mixed	50	364	1,524
4	5_Mixed	30	420	1,462
5	6_LTL/Dry Van_Diesel	0	311	720
6	6_Mixed	2	425	1,825
7	6_Moving	22	275	576
8	6_Package_Diesel	8	305	1,196
9	6_TL/Dry Van_Diesel	0	514	1,820
10	7_LTL/Dry Van_Diesel	75	326	1,440
11	7_Mixed	55	413	2,077
12	7_TL/Dry Van_Diesel	3	288	598
13	8A_LTL/Dry Van_Diesel	61	384	2,071
14	8A_Mixed	0	574	2,574
15	8A_Refrigerated_Diesel	130	713	2,000
16	8A_TL/Dry Van_Diesel	25	629	2,016
17	8B_AutoCarrier_Diesel	240	1,154	3,380
18	8B_Dray_Diesel	78	672	2,080
19	8B_Flatbed_Diesel	100	911	2,100
20	8B_Heavy/Bulk_Diesel	161	601	1,401
21	8B_LTL/Dry Van_Diesel	61	518	1,675
22	8B_Mixed	0	782	2,475
23	8B_Refrigerated_Diesel	41	843	2,349
24	8B_Specialized_Diesel	140	760	2,200
25	8B_TL/Dry Van_Diesel	17	912	3,410
26	8B_Tanker_Diesel	54	826	2,816

Absolute bounds on idle hours are based on simple operational constraints: a truck can idle no more than 24 hours per day, 7 days a week, or 8,760 hours per year. Zero hours are also acceptable values with explanations.

4.0 Performance Metrics

The Truck Tool allows the user to calculate their emissions performance using a number of different metrics, at different levels of aggregation. Available performance metrics include:

- Grams per mile
- Grams per Payload Ton-Mile
- Grams per Thousand Cubic Foot-Miles
- Grams per Thousand Utilized Cubic Foot-Miles

The Internal Metrics report within the Truck Tool presents the results of 36 calculations (4 x 4 x 3 = 48), which represent the following four calculations for each of the three pollutants (CO_2, NOx, PM_{10} and $PM_{2.5}$) and for each of three different mileage types (total, payload, and loaded). Note that all capitalized fields represent fields in the user interface:

1. **g/mile: ∑ E / M**
   where E = Emissions, M = Miles Driven
2. **g/avg payload ton-mile: ∑ E / (M × AP)**
   where E = Emissions, M = Miles Driven, AP = Average Payload
3. **g/avg cubic foot volume: ∑ E / (M × ACV)**
   where E = Emissions, M = Miles Driven, ACV = Average Cargo Volume
4. **g/avg utilized cubic foot: ∑ E / (M × ACV) / CU**
   where E = Emissions, M = Miles Driven, ACV = Average Cargo Volume, CU = % Cube Utilization

For all four calculations:

Emissions = grams of pollutant (as specified above)
Miles Driven = Total Miles, Payload 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 NOx and PM) for all reporting purposes. Additional aggregation may be reported across truck classes, fuel types, divisions, and at the company level, as specified by the user.

Appendix A: MOVES2014a-based NOx/$PM_{2.5}$ Emission Factors (g/mi)

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1987-2b	2.054	29.723	37.726	18.449	17.094	0.0244	1.2711	2.2732	2.1385	1.1757
1987-3	2.054	29.731	37.783	18.516	17.148	0.0243	1.2722	2.2772	2.1406	1.1779
1987-4	2.062	30.029	38.176	19.603	18.723	0.0281	1.0992	1.7449	1.8929	0.9826
1987-5	2.056	29.847	38.169	19.124	17.773	0.0252	1.2356	2.1686	2.0914	1.1469
1987-6	2.031	30.632	40.246	21.933	19.880	0.0234	1.3420	2.4574	2.2482	1.2929
1987-7	1.953	33.247	46.874	31.328	26.382	0.0205	1.5502	2.9831	2.5652	1.5839
1987-8a	1.878	35.624	53.545	40.543	31.448	0.0171	1.7787	3.5902	2.9327	1.8508
1987-8b	1.788	37.993	59.476	49.106	35.488	0.0137	2.0099	4.1852	3.3206	2.0986
1988-2b	1.725	26.478	32.440	16.516	15.613	0.0212	0.8082	1.1087	0.9246	0.5780
1988-3	2.040	30.186	38.939	20.215	18.544	0.0249	0.9102	1.3377	1.0662	0.6520
1988-4	2.059	29.924	37.966	19.228	18.212	0.0274	0.9609	1.3160	1.1938	0.6753
1988-5	2.025	30.844	40.594	22.610	20.542	0.0245	0.9267	1.3878	1.1014	0.6755
1988-6	2.020	30.943	40.971	23.039	20.723	0.0239	0.9162	1.3974	1.0747	0.6722
1988-7	1.984	32.224	44.361	27.785	24.110	0.0224	0.9289	1.4973	1.0951	0.7047
1988-8a	1.901	34.963	52.011	38.323	30.271	0.0182	0.9441	1.7213	1.1110	0.7596
1988-8b	1.787	37.835	58.970	48.431	35.163	0.0136	0.9601	1.9275	1.1317	0.8041
1989-2b	1.938	30.946	41.279	24.643	21.944	0.0225	0.9059	1.4020	1.0608	0.6778
1989-3	2.042	29.548	37.422	18.313	17.013	0.0255	0.9071	1.2921	1.0658	0.6389
1989-4	2.059	29.899	37.909	19.149	18.123	0.0274	0.9601	1.3138	1.1919	0.6745
1989-5	2.034	30.498	39.851	21.523	19.658	0.0249	0.9252	1.3656	1.0990	0.6685
1989-6	2.009	31.406	42.468	25.058	22.195	0.0235	0.9266	1.4420	1.0938	0.6895
1989-7	2.019	31.145	41.961	24.293	21.679	0.0238	0.9263	1.4276	1.0957	0.6857
1989-8a	1.926	34.397	51.102	36.826	29.443	0.0191	0.9500	1.6968	1.1232	0.7567
1989-8b	1.779	38.112	59.796	49.567	35.658	0.0132	0.9664	1.9539	1.1407	0.8109
1990-2b	1.300	19.972	24.681	12.926	12.039	0.0208	0.8038	1.0871	0.9227	0.5749
1990-3	1.589	22.862	29.089	14.637	13.524	0.0257	0.9245	1.3190	1.0854	0.6498
1990-4	1.587	22.982	29.138	14.310	13.302	0.0261	0.9347	1.3093	1.1040	0.6515
1990-5	1.582	23.217	29.778	15.222	14.098	0.0259	0.9416	1.3339	1.1199	0.6632
1990-6	1.548	24.367	32.840	19.429	17.186	0.0235	0.9409	1.4495	1.1022	0.6944
1990-7	1.545	24.491	33.226	19.958	17.577	0.0233	0.9439	1.4641	1.1088	0.6997
1990-8a	1.452	27.525	41.540	31.509	24.380	0.0175	0.9694	1.7811	1.1402	0.7801
1990-8b	1.358	29.812	47.184	39.701	28.135	0.0126	0.9891	1.9990	1.1667	0.8258
1991-2b	1.318	17.679	21.840	11.603	10.767	0.0311	0.6625	0.7254	0.6133	0.3913
1991-3	1.457	21.072	27.290	13.284	12.356	0.0242	0.8159	0.8847	0.6771	0.4469
1991-4	1.397	23.077	32.316	20.351	17.592	0.0209	0.8435	1.2173	0.8484	0.6058
1991-5	1.472	20.082	25.725	13.457	12.643	0.0311	0.7715	0.8192	0.6780	0.4329
1991-6	1.429	22.107	30.070	17.120	15.370	0.0226	0.8308	1.0639	0.7694	0.5376
1991-7	1.396	23.290	33.348	21.628	18.485	0.0206	0.8489	1.2643	0.8744	0.6269
1991-8a	1.315	25.951	41.193	32.228	24.139	0.0150	0.8878	1.7720	1.1316	0.8002
1991-8b	1.240	27.603	44.794	37.659	26.553	0.0115	0.9066	2.0524	1.2743	0.8860
1992-2b	1.226	15.981	19.482	10.822	10.025	0.0294	0.5792	0.6388	0.5580	0.3571
1992-3	1.407	20.594	26.427	12.948	12.078	0.0234	0.7917	0.8552	0.6592	0.4381
1992-4	1.457	21.068	27.120	13.058	12.163	0.0241	0.8140	0.8814	0.6765	0.4450

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1992-5	1.460	21.224	27.620	13.853	13.020	0.0252	0.8226	0.8526	0.6760	0.4440
1992-6	1.422	22.370	30.696	17.973	15.958	0.0220	0.8345	1.1012	0.7908	0.5537
1992-7	1.401	23.147	32.840	20.962	18.141	0.0211	0.8482	1.2190	0.8559	0.6116
1992-8a	1.302	26.203	41.384	32.697	24.405	0.0147	0.8911	1.7956	1.1459	0.8111
1992-8b	1.236	27.679	44.951	37.903	26.653	0.0114	0.9112	2.0420	1.2739	0.8817
1993-2b	1.402	18.862	23.403	11.935	11.178	0.0297	0.7132	0.7767	0.6397	0.4109
1993-3	1.438	20.559	26.252	12.806	11.971	0.0252	0.7914	0.8540	0.6657	0.4378
1993-4	1.444	21.454	28.091	14.494	13.358	0.0236	0.8190	0.9465	0.7110	0.4813
1993-5	1.457	21.084	27.254	13.325	12.455	0.0246	0.8160	0.8703	0.6763	0.4455
1993-6	1.428	22.134	30.015	17.135	15.440	0.0227	0.8303	1.0568	0.7699	0.5385
1993-7	1.419	22.495	31.214	18.694	16.517	0.0219	0.8353	1.1399	0.8097	0.5742
1993-8a	1.307	26.096	41.237	32.448	24.280	0.0148	0.8877	1.7977	1.1435	0.8120
1993-8b	1.238	27.683	44.976	37.936	26.673	0.0114	0.9095	2.0562	1.2786	0.8867
1994-2b	1.167	17.786	22.134	11.674	10.937	0.0324	1.0305	0.9701	0.6783	0.4837
1994-3	1.381	19.702	24.987	12.627	11.808	0.0394	1.1615	1.1506	0.7888	0.5394
1994-4	1.457	21.074	27.140	13.075	12.175	0.0423	1.2313	1.2324	0.8404	0.5638
1994-5	1.459	21.212	27.705	13.879	12.964	0.0432	1.2692	1.2604	0.8929	0.5873
1994-6	1.438	21.947	29.828	16.713	15.137	0.0401	1.2204	1.4033	0.8995	0.6284
1994-7	1.404	23.119	33.032	21.099	18.135	0.0357	1.1600	1.6220	0.9268	0.6882
1994-8a	1.300	26.369	42.197	33.671	24.824	0.0228	1.0222	2.2410	1.0374	0.8255
1994-8b	1.242	27.610	44.798	37.672	26.569	0.0180	0.9727	2.4363	1.0690	0.8615
1995-2b	1.316	16.247	19.716	10.954	10.160	0.0385	1.0551	0.9932	0.7124	0.4780
1995-3	1.448	20.882	26.984	13.255	12.316	0.0423	1.2463	1.2370	0.8492	0.5674
1995-4	1.444	21.088	27.377	13.926	12.881	0.0419	1.2370	1.2692	0.8555	0.5791
1995-5	1.444	21.695	28.881	15.502	14.249	0.0418	1.2585	1.3437	0.9048	0.6134
1995-6	1.429	22.176	30.327	17.395	15.557	0.0393	1.2158	1.4426	0.8989	0.6363
1995-7	1.410	22.900	32.423	20.245	17.548	0.0368	1.1836	1.5822	0.9249	0.6770
1995-8a	1.307	26.259	41.903	33.258	24.652	0.0235	1.0238	2.2271	1.0316	0.8217
1995-8b	1.247	27.557	44.687	37.501	26.508	0.0183	0.9657	2.4345	1.0616	0.8593
1996-2b	1.314	16.798	20.133	10.952	10.248	0.0395	1.0738	1.0399	0.7334	0.4932
1996-3	1.458	21.076	27.083	13.354	12.385	0.0418	1.2197	1.2448	0.8385	0.5671
1996-4	1.445	21.803	28.675	15.404	14.038	0.0402	1.2029	1.3438	0.8608	0.6018
1996-5	1.437	22.049	29.609	16.940	15.437	0.0405	1.2309	1.4037	0.9196	0.6369
1996-6	1.426	22.646	31.251	18.893	16.676	0.0376	1.1747	1.5174	0.9011	0.6578
1996-7	1.397	23.635	34.142	22.826	19.193	0.0339	1.1360	1.7045	0.9386	0.7086
1996-8a	1.304	26.584	42.306	34.131	25.027	0.0224	1.0059	2.2695	1.0323	0.8289
1996-8b	1.247	27.803	44.871	38.087	26.725	0.0178	0.9656	2.4604	1.0699	0.8650
1997-2b	1.167	13.586	15.766	9.141	8.574	0.0355	0.9495	0.8721	0.6396	0.4258
1997-3	1.426	20.850	26.810	14.016	12.970	0.0412	1.2259	1.2602	0.8481	0.5773
1997-4	1.469	21.263	27.199	13.210	12.265	0.0430	1.2723	1.2397	0.8613	0.5692
1997-5	1.466	21.557	28.007	14.448	13.475	0.0438	1.3022	1.2827	0.9221	0.6015
1997-6	1.454	21.867	28.891	15.548	14.167	0.0412	1.2454	1.3505	0.8846	0.6074
1997-7	1.442	22.377	30.515	17.714	15.795	0.0393	1.2173	1.4582	0.9012	0.6399

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1997-8a	1.333	26.015	40.458	31.515	23.871	0.0256	1.0284	2.1412	1.0014	0.8018
1997-8b	1.265	27.647	44.312	37.195	26.396	0.0189	0.9549	2.4172	1.0460	0.8532
1998-2b	0.979	9.316	10.784	7.613	6.632	0.0305	0.2648	0.3408	0.3774	0.2058
1998-3	1.688	18.203	22.931	13.800	11.415	0.0405	0.4678	0.6647	0.5717	0.3203
1998-4	1.730	18.539	23.524	14.086	11.586	0.0411	0.4755	0.6807	0.5806	0.3244
1998-5	1.732	18.592	23.610	14.329	11.871	0.0425	0.4649	0.6575	0.5944	0.3232
1998-6	1.730	18.576	23.716	14.379	11.834	0.0412	0.4745	0.6839	0.5860	0.3271
1998-7	1.712	19.063	24.941	16.397	13.439	0.0400	0.4890	0.7441	0.6057	0.3524
1998-8a	1.565	22.539	34.787	31.915	22.317	0.0246	0.6376	1.3180	0.7308	0.5116
1998-8b	1.469	24.124	38.386	38.045	24.891	0.0176	0.6957	1.5341	0.7852	0.5598
1999-2b	0.913	7.286	8.214	6.340	4.925	0.0370	0.2849	0.3648	0.4366	0.2216
1999-3	0.930	11.384	12.444	8.905	7.018	0.0430	0.4502	0.6196	0.5855	0.3139
1999-4	0.929	11.617	12.750	9.078	7.128	0.0434	0.4596	0.6380	0.5950	0.3186
1999-5	0.930	11.655	12.875	9.214	7.241	0.0432	0.4609	0.6452	0.5964	0.3209
1999-6	0.925	11.672	12.961	9.438	7.470	0.0435	0.4595	0.6475	0.6051	0.3252
1999-7	0.930	12.138	13.934	10.534	8.375	0.0420	0.4738	0.7058	0.6136	0.3440
1999-8a	0.946	17.975	24.412	23.274	16.442	0.0245	0.6430	1.3455	0.7431	0.5188
1999-8b	0.931	20.220	27.838	27.787	18.554	0.0172	0.7050	1.5659	0.7936	0.5680
2000-2b	0.853	7.912	8.656	6.611	5.287	0.0348	0.3071	0.3893	0.4352	0.2328
2000-3	0.925	11.472	12.568	8.974	7.068	0.0427	0.4536	0.6272	0.5862	0.3153
2000-4	0.930	11.677	12.920	9.240	7.261	0.0431	0.4617	0.6479	0.5956	0.3211
2000-5	0.932	11.725	13.082	9.419	7.409	0.0429	0.4632	0.6569	0.5973	0.3240
2000-6	0.926	11.652	12.947	9.376	7.407	0.0434	0.4594	0.6468	0.6028	0.3237
2000-7	0.929	12.670	14.699	11.474	9.172	0.0407	0.4893	0.7548	0.6217	0.3620
2000-8a	0.936	17.269	22.905	21.517	15.581	0.0270	0.6209	1.2539	0.7244	0.5000
2000-8b	0.932	20.188	27.758	27.693	18.527	0.0175	0.7044	1.5624	0.7933	0.5679
2001-2b	0.913	6.051	7.150	5.574	4.161	0.0373	0.2421	0.3168	0.4119	0.1949
2001-3	0.934	11.378	12.473	8.951	7.069	0.0428	0.4501	0.6230	0.5837	0.3146
2001-4	0.931	11.654	12.800	9.104	7.148	0.0432	0.4608	0.6417	0.5937	0.3190
2001-5	0.932	11.686	12.905	9.218	7.244	0.0431	0.4620	0.6478	0.5948	0.3210
2001-6	0.925	12.095	13.645	10.279	8.230	0.0425	0.4716	0.6902	0.6135	0.3419
2001-7	0.928	12.117	13.752	10.335	8.228	0.0421	0.4727	0.6962	0.6110	0.3413
2001-8a	0.937	18.487	25.022	24.162	16.905	0.0230	0.6559	1.3861	0.7528	0.5298
2001-8b	0.928	20.118	27.692	27.617	18.456	0.0174	0.7010	1.5531	0.7907	0.5645
2002-2b	0.896	5.977	7.044	5.523	4.116	0.0373	0.2409	0.3127	0.4161	0.1946
2002-3	0.902	10.700	11.668	8.514	6.725	0.0443	0.4271	0.5677	0.5890	0.3044
2002-4	0.905	11.137	12.227	8.830	6.915	0.0456	0.4444	0.5984	0.6094	0.3132
2002-5	0.905	11.137	12.227	8.830	6.915	0.0456	0.4444	0.5984	0.6094	0.3132
2002-6	0.902	11.142	12.323	9.039	7.129	0.0458	0.4426	0.6010	0.6178	0.3169
2002-7	0.904	12.064	13.804	10.810	8.670	0.0434	0.4695	0.6931	0.6321	0.3506
2002-8a	0.926	17.133	22.905	21.670	15.635	0.0276	0.6163	1.2481	0.7323	0.5003
2002-8b	0.920	19.925	27.453	27.389	18.316	0.0179	0.6939	1.5314	0.7889	0.5596
2003-2b	0.417	4.168	5.670	4.532	3.193	0.0315	0.2120	0.2730	0.3561	0.1705

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
2003-3	1.287	9.269	9.440	7.185	5.254	0.0393	0.3897	0.5232	0.5273	0.2762
2003-4	1.415	9.715	9.874	7.462	5.407	0.0405	0.4051	0.5509	0.5459	0.2840
2003-5	1.415	9.715	9.874	7.462	5.407	0.0405	0.4051	0.5509	0.5459	0.2840
2003-6	1.412	9.756	9.966	7.579	5.516	0.0407	0.4040	0.5547	0.5532	0.2878
2003-7	1.397	10.071	10.490	8.127	6.037	0.0383	0.4308	0.6471	0.5687	0.3217
2003-8a	1.318	11.696	13.621	11.343	8.223	0.0240	0.5664	1.1606	0.6657	0.4593
2003-8b	1.245	12.556	14.981	12.859	9.011	0.0158	0.6320	1.3996	0.7155	0.5095
2004-2b	0.421	4.195	5.434	4.299	3.071	0.0318	0.2171	0.2778	0.3626	0.1739
2004-3	1.295	9.303	9.451	7.215	5.268	0.0399	0.3877	0.5165	0.5326	0.2757
2004-4	1.411	9.711	9.872	7.494	5.419	0.0411	0.4012	0.5405	0.5494	0.2826
2004-5	1.411	9.711	9.872	7.494	5.419	0.0411	0.4012	0.5405	0.5494	0.2826
2004-6	1.409	9.750	9.957	7.599	5.518	0.0412	0.4007	0.5452	0.5555	0.2861
2004-7	1.395	10.029	10.422	8.085	5.983	0.0391	0.4239	0.6256	0.5688	0.3157
2004-8a	1.318	11.605	13.446	11.192	8.136	0.0252	0.5531	1.1149	0.6589	0.4486
2004-8b	1.242	12.529	14.935	12.834	8.998	0.0163	0.6237	1.3729	0.7108	0.5030
2005-2b	0.375	3.715	5.301	4.162	2.854	0.0338	0.2105	0.2772	0.3716	0.1710
2005-3	1.239	9.081	9.240	7.019	5.162	0.0389	0.3872	0.5208	0.5206	0.2747
2005-4	1.418	9.716	9.873	7.436	5.396	0.0401	0.4080	0.5587	0.5430	0.2850
2005-5	1.418	9.716	9.873	7.436	5.396	0.0401	0.4080	0.5587	0.5430	0.2850
2005-6	1.415	9.760	9.970	7.552	5.502	0.0401	0.4083	0.5659	0.5489	0.2893
2005-7	1.397	10.102	10.540	8.156	6.070	0.0376	0.4359	0.6626	0.5667	0.3249
2005-8a	1.314	11.738	13.695	11.423	8.267	0.0235	0.5680	1.1675	0.6657	0.4598
2005-8b	1.243	12.556	14.982	12.869	9.015	0.0159	0.6289	1.3905	0.7135	0.5069
2006-2b	0.391	3.848	5.561	4.351	2.954	0.0364	0.2222	0.2944	0.3975	0.1807
2006-3	1.240	9.091	9.274	7.053	5.175	0.0395	0.3870	0.5195	0.5252	0.2750
2006-4	1.416	9.715	9.873	7.449	5.402	0.0403	0.4065	0.5547	0.5445	0.2845
2006-5	1.416	9.715	9.873	7.449	5.402	0.0403	0.4065	0.5547	0.5445	0.2845
2006-6	1.414	9.757	9.964	7.554	5.498	0.0403	0.4073	0.5625	0.5496	0.2886
2006-7	1.398	10.077	10.498	8.120	6.033	0.0380	0.4334	0.6538	0.5665	0.3224
2006-8a	1.317	11.692	13.607	11.330	8.216	0.0239	0.5653	1.1565	0.6640	0.4578
2006-8b	1.244	12.548	14.965	12.846	9.005	0.0159	0.6300	1.3931	0.7139	0.5078
2007-2b	0.620	2.516	2.963	2.188	1.621	0.0049	0.0132	0.0167	0.0169	0.0102
2007-3	0.588	5.226	5.312	4.104	2.970	0.0025	0.0172	0.0201	0.0162	0.0106
2007-4	0.585	5.473	5.592	4.313	3.071	0.0021	0.0176	0.0205	0.0161	0.0106
2007-5	0.585	5.473	5.592	4.313	3.071	0.0021	0.0176	0.0205	0.0161	0.0106
2007-6	0.585	5.507	5.669	4.379	3.147	0.0021	0.0177	0.0208	0.0163	0.0108
2007-7	0.546	6.046	6.383	4.956	3.719	0.0020	0.0194	0.0247	0.0174	0.0125
2007-8a	0.350	8.308	9.762	7.650	5.616	0.0018	0.0266	0.0429	0.0228	0.0182
2007-8b	0.255	9.269	10.988	8.670	6.189	0.0016	0.0297	0.0498	0.0249	0.0200
2008-2b	0.655	2.265	2.845	2.064	1.478	0.0053	0.0131	0.0165	0.0174	0.0102
2008-3	0.646	4.750	4.821	3.743	2.727	0.0027	0.0160	0.0179	0.0164	0.0101
2008-4	0.646	5.091	5.192	4.031	2.875	0.0021	0.0165	0.0182	0.0162	0.0101
2008-5	0.646	5.091	5.192	4.031	2.875	0.0021	0.0165	0.0182	0.0162	0.0101

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
2008-6	0.645	5.113	5.235	4.068	2.917	0.0021	0.0165	0.0184	0.0163	0.0102
2008-7	0.625	5.380	5.581	4.347	3.205	0.0021	0.0174	0.0203	0.0168	0.0111
2008-8a	0.453	7.359	8.438	6.621	4.996	0.0019	0.0236	0.0356	0.0210	0.0164
2008-8b	0.285	9.008	10.637	8.411	6.047	0.0016	0.0288	0.0477	0.0244	0.0195
2009-2b	0.506	2.090	2.459	1.835	1.369	0.0040	0.0114	0.0153	0.0152	0.0093
2009-3	0.556	5.213	5.264	4.072	2.969	0.0024	0.0172	0.0204	0.0160	0.0106
2009-4	0.569	5.574	5.698	4.388	3.123	0.0021	0.0179	0.0211	0.0161	0.0107
2009-5	0.569	5.574	5.698	4.388	3.123	0.0021	0.0179	0.0211	0.0161	0.0107
2009-6	0.573	5.590	5.760	4.445	3.199	0.0021	0.0179	0.0213	0.0163	0.0109
2009-7	0.531	6.170	6.528	5.062	3.807	0.0020	0.0198	0.0256	0.0175	0.0128
2009-8a	0.333	8.464	9.963	7.788	5.704	0.0018	0.0271	0.0441	0.0231	0.0186
2009-8b	0.246	9.363	11.100	8.737	6.237	0.0016	0.0300	0.0505	0.0251	0.0202
2010-2b	0.208	0.726	0.953	0.725	0.517	0.0033	0.0094	0.0133	0.0131	0.0081
2010-3	0.237	1.555	1.577	1.185	0.880	0.0022	0.0154	0.0181	0.0145	0.0096
2010-4	0.245	1.673	1.699	1.266	0.924	0.0019	0.0162	0.0190	0.0148	0.0098
2010-5	0.245	1.673	1.699	1.266	0.924	0.0019	0.0162	0.0190	0.0148	0.0098
2010-6	0.245	1.683	1.720	1.293	0.948	0.0019	0.0162	0.0191	0.0150	0.0099
2010-7	0.242	1.753	1.834	1.412	1.060	0.0019	0.0178	0.0227	0.0160	0.0116
2010-8a	0.230	2.074	2.429	2.025	1.465	0.0017	0.0251	0.0405	0.0214	0.0172
2010-8b	0.220	2.218	2.647	2.270	1.591	0.0015	0.0282	0.0474	0.0236	0.0190
2011-2b	0.265	0.859	1.137	0.833	0.575	0.0042	0.0108	0.0140	0.0144	0.0085
2011-3	0.242	1.533	1.571	1.186	0.870	0.0023	0.0148	0.0170	0.0145	0.0092
2011-4	0.238	1.629	1.656	1.248	0.905	0.0019	0.0154	0.0176	0.0145	0.0093
2011-5	0.238	1.629	1.656	1.248	0.905	0.0019	0.0154	0.0176	0.0145	0.0093
2011-6	0.237	1.637	1.672	1.268	0.923	0.0019	0.0154	0.0178	0.0146	0.0095
2011-7	0.236	1.696	1.765	1.364	1.015	0.0019	0.0167	0.0207	0.0155	0.0108
2011-8a	0.228	2.017	2.343	1.949	1.421	0.0017	0.0239	0.0378	0.0206	0.0165
2011-8b	0.218	2.197	2.619	2.247	1.577	0.0015	0.0277	0.0463	0.0233	0.0187
2012-2b	0.265	0.887	1.152	0.846	0.588	0.0042	0.0110	0.0141	0.0145	0.0086
2012-3	0.242	1.551	1.585	1.196	0.876	0.0023	0.0149	0.0171	0.0145	0.0093
2012-4	0.238	1.628	1.653	1.246	0.904	0.0019	0.0154	0.0176	0.0145	0.0093
2012-5	0.238	1.628	1.653	1.246	0.904	0.0019	0.0154	0.0176	0.0145	0.0093
2012-6	0.237	1.637	1.671	1.266	0.922	0.0019	0.0155	0.0179	0.0146	0.0095
2012-7	0.236	1.674	1.728	1.325	0.980	0.0019	0.0163	0.0197	0.0151	0.0103
2012-8a	0.230	1.957	2.253	1.852	1.362	0.0017	0.0225	0.0348	0.0197	0.0155
2012-8b	0.218	2.171	2.575	2.203	1.556	0.0015	0.0270	0.0446	0.0227	0.0182
2013-2b	0.170	0.568	0.738	0.542	0.375	0.0025	0.0066	0.0085	0.0087	0.0052
2013-3	0.150	0.960	0.982	0.742	0.541	0.0013	0.0088	0.0101	0.0086	0.0055
2013-4	0.146	1.003	1.019	0.769	0.557	0.0011	0.0090	0.0103	0.0085	0.0055
2013-5	0.146	1.003	1.019	0.769	0.557	0.0011	0.0090	0.0103	0.0085	0.0055
2013-6	0.146	1.008	1.029	0.781	0.568	0.0011	0.0091	0.0105	0.0086	0.0056
2013-7	0.146	1.034	1.067	0.819	0.606	0.0011	0.0096	0.0116	0.0089	0.0061
2013-8a	0.145	1.237	1.425	1.172	0.864	0.0010	0.0136	0.0211	0.0119	0.0095

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
2013-8b	0.140	1.395	1.654	1.415	1.000	0.0010	0.0167	0.0275	0.0140	0.0113
2014-2b	0.170	0.569	0.739	0.542	0.375	0.0025	0.0066	0.0085	0.0087	0.0052
2014-3	0.149	0.958	0.980	0.740	0.539	0.0013	0.0088	0.0101	0.0085	0.0054
2014-4	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2014-5	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2014-6	0.146	1.005	1.025	0.778	0.565	0.0011	0.0091	0.0105	0.0086	0.0056
2014-7	0.145	1.028	1.061	0.814	0.598	0.0011	0.0096	0.0115	0.0089	0.0060
2014-8a	0.143	1.212	1.397	1.148	0.833	0.0010	0.0134	0.0208	0.0118	0.0092
2014-8b	0.135	1.349	1.600	1.369	0.947	0.0009	0.0162	0.0268	0.0137	0.0108
2015-2b	0.170	0.570	0.739	0.543	0.375	0.0025	0.0066	0.0085	0.0087	0.0052
2015-3	0.149	0.958	0.980	0.740	0.539	0.0013	0.0088	0.0101	0.0085	0.0054
2015-4	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2015-5	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2015-6	0.146	1.005	1.026	0.778	0.565	0.0011	0.0091	0.0105	0.0086	0.0056
2015-7	0.145	1.028	1.062	0.815	0.599	0.0011	0.0096	0.0115	0.0089	0.0060
2015-8a	0.143	1.214	1.399	1.150	0.834	0.0010	0.0134	0.0208	0.0118	0.0092
2015-8b	0.135	1.349	1.601	1.370	0.947	0.0009	0.0162	0.0268	0.0137	0.0108
2016-2b	0.170	0.568	0.738	0.542	0.374	0.0025	0.0066	0.0085	0.0087	0.0052
2016-3	0.149	0.957	0.980	0.740	0.539	0.0013	0.0088	0.0101	0.0085	0.0054
2016-4	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2016-5	0.146	1.000	1.016	0.766	0.554	0.0011	0.0090	0.0103	0.0085	0.0055
2016-6	0.146	1.005	1.025	0.778	0.565	0.0011	0.0091	0.0105	0.0086	0.0056
2016-7	0.145	1.028	1.061	0.815	0.599	0.0011	0.0096	0.0115	0.0089	0.0060
2016-8a	0.143	1.213	1.398	1.150	0.834	0.0010	0.0134	0.0208	0.0118	0.0092
2016-8b	0.135	1.349	1.601	1.369	0.947	0.0009	0.0162	0.0268	0.0137	0.0108

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1987-2b	0.200	3.460	7.050	7.256	4.611	0.0028	0.0305	0.0846	0.0761	0.0768
1987-3	0.245	8.078	11.850	12.226	8.387	0.0033	0.0550	0.1112	0.0940	0.1839
1987-4	0.245	8.083	11.891	12.276	8.442	0.0033	0.0551	0.1131	0.0957	0.1862
1987-5	0.244	8.210	11.719	11.939	8.071	0.0033	0.0576	0.1111	0.0870	0.1732
1987-6	0.244	8.210	11.719	11.939	8.071	0.0033	0.0576	0.1111	0.0870	0.1732
1987-7	0.244	8.210	11.719	11.939	8.071	0.0033	0.0576	0.1111	0.0870	0.1732
1987-8a	0.240	8.774	12.458	12.696	8.822	0.0032	0.0697	0.1614	0.1240	0.2045
1987-8b	0.184	13.452	18.324	18.840	13.167	0.0027	0.1695	0.5752	0.4344	0.3818
1988-2b	0.204	3.818	7.300	7.525	4.892	0.0041	0.0527	0.0642	0.0841	0.0652
1988-3	0.245	8.102	11.867	12.236	8.393	0.0046	0.1173	0.0914	0.1359	0.1493
1988-4	0.245	8.065	11.953	12.379	8.576	0.0047	0.1160	0.0927	0.1424	0.1580
1988-5	0.244	8.278	11.799	12.033	8.169	0.0045	0.1225	0.0950	0.1273	0.1385
1988-6	0.244	8.271	11.790	12.024	8.160	0.0045	0.1223	0.0945	0.1268	0.1380

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1988-7	0.244	8.222	11.731	11.962	8.094	0.0046	0.1211	0.0914	0.1234	0.1352
1988-8a	0.239	8.908	12.746	12.971	9.044	0.0045	0.1380	0.1410	0.1751	0.1776
1988-8b	0.184	13.452	18.324	18.840	13.167	0.0038	0.2486	0.4355	0.4976	0.3580
1989-2b	0.206	4.223	7.600	7.888	5.230	0.0041	0.0585	0.0655	0.0863	0.0720
1989-3	0.246	8.030	11.749	12.171	8.312	0.0046	0.1153	0.0883	0.1320	0.1458
1989-4	0.246	8.031	11.897	12.336	8.525	0.0047	0.1151	0.0905	0.1402	0.1557
1989-5	0.245	8.065	11.503	11.881	7.993	0.0046	0.1167	0.0867	0.1175	0.1309
1989-6	0.245	8.065	11.503	11.881	7.993	0.0046	0.1167	0.0867	0.1175	0.1309
1989-7	0.245	8.065	11.503	11.881	7.993	0.0046	0.1167	0.0867	0.1175	0.1309
1989-8a	0.220	13.378	19.932	19.781	13.082	0.0045	0.2496	0.4615	0.4939	0.3638
1989-8b	0.220	13.378	19.932	19.781	13.082	0.0045	0.2496	0.4615	0.4939	0.3638
1990-2b	0.133	5.020	7.787	6.473	4.742	0.0014	0.0170	0.0473	0.0835	0.1287
1990-3	0.129	6.147	8.612	6.900	5.345	0.0016	0.0200	0.0394	0.0791	0.1749
1990-4	0.129	6.206	8.860	7.156	5.647	0.0016	0.0206	0.0535	0.0908	0.1908
1990-5	0.129	6.170	8.468	6.699	5.120	0.0016	0.0198	0.0352	0.0722	0.1649
1990-6	0.129	6.170	8.468	6.699	5.120	0.0016	0.0198	0.0352	0.0722	0.1649
1990-7	0.129	6.170	8.468	6.699	5.120	0.0016	0.0198	0.0352	0.0722	0.1649
1990-8a	0.118	10.202	15.355	12.353	8.827	0.0013	0.0461	0.5350	0.3995	0.3981
1990-8b	0.118	10.202	15.355	12.353	8.827	0.0013	0.0461	0.5350	0.3995	0.3981
1991-2b	0.133	4.391	7.514	6.389	4.528	0.0039	0.0746	0.0318	0.0299	0.0569
1991-3	0.129	6.146	8.629	6.921	5.371	0.0043	0.1130	0.0383	0.0309	0.1011
1991-4	0.129	6.257	8.894	7.149	5.612	0.0043	0.1153	0.0480	0.0354	0.1067
1991-5	0.129	6.138	8.512	6.781	5.212	0.0043	0.1130	0.0353	0.0290	0.0978
1991-6	0.129	6.175	8.477	6.701	5.123	0.0043	0.1141	0.0356	0.0284	0.0963
1991-7	0.129	6.175	8.477	6.701	5.123	0.0043	0.1141	0.0356	0.0284	0.0963
1991-8a	0.128	6.561	9.286	7.357	5.715	0.0043	0.1227	0.0664	0.0418	0.1106
1991-8b	0.128	6.561	9.286	7.357	5.715	0.0043	0.1227	0.0664	0.0418	0.1106
1992-2b	0.130	4.723	7.672	6.451	4.653	0.0039	0.0816	0.0320	0.0293	0.0646
1992-3	0.129	6.154	8.695	6.996	5.461	0.0043	0.1130	0.0401	0.0320	0.1029
1992-4	0.129	6.275	8.995	7.259	5.749	0.0043	0.1156	0.0510	0.0370	0.1096
1992-5	0.129	6.125	8.525	6.810	5.246	0.0043	0.1126	0.0352	0.0292	0.0984
1992-6	0.129	6.176	8.480	6.702	5.124	0.0043	0.1142	0.0356	0.0284	0.0963
1992-7	0.129	6.176	8.480	6.702	5.124	0.0043	0.1142	0.0356	0.0284	0.0963
1992-8a	0.127	6.685	9.538	7.561	5.888	0.0043	0.1254	0.0759	0.0460	0.1147
1992-8b	0.127	6.685	9.538	7.561	5.888	0.0043	0.1254	0.0759	0.0460	0.1147
1993-2b	0.129	4.841	7.680	6.471	4.685	0.0039	0.0840	0.0315	0.0284	0.0683
1993-3	0.129	6.062	8.454	6.826	5.263	0.0043	0.1113	0.0351	0.0292	0.0990
1993-4	0.129	6.082	8.566	6.931	5.392	0.0043	0.1115	0.0370	0.0306	0.1015
1993-5	0.130	6.054	8.444	6.820	5.258	0.0043	0.1111	0.0344	0.0290	0.0989
1993-6	0.129	6.065	8.282	6.648	5.060	0.0043	0.1120	0.0344	0.0274	0.0957
1993-7	0.129	6.065	8.282	6.648	5.060	0.0043	0.1120	0.0344	0.0274	0.0957
1993-8a	0.129	6.144	8.450	6.782	5.187	0.0043	0.1137	0.0407	0.0301	0.0987
1993-8b	0.129	6.144	8.450	6.782	5.187	0.0043	0.1137	0.0407	0.0301	0.0987

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1994-2b	0.105	4.306	7.164	6.337	4.425	0.0021	0.0158	0.0492	0.1240	0.0706
1994-3	0.127	6.053	8.470	6.778	5.246	0.0026	0.0225	0.0848	0.1867	0.1154
1994-4	0.127	6.156	8.788	7.080	5.583	0.0026	0.0230	0.0914	0.2021	0.1296
1994-5	0.127	5.967	8.414	6.789	5.286	0.0026	0.0217	0.0830	0.1878	0.1174
1994-6	0.127	6.059	8.316	6.580	5.029	0.0026	0.0228	0.0820	0.1762	0.1060
1994-7	0.127	6.059	8.316	6.580	5.029	0.0026	0.0228	0.0820	0.1762	0.1060
1994-8a	0.116	10.022	15.085	12.135	8.671	0.0023	0.0506	0.2321	0.4497	0.2567
1994-8b	0.116	10.022	15.085	12.135	8.671	0.0023	0.0506	0.2321	0.4497	0.2567
1995-2b	0.109	4.273	7.112	6.290	4.395	0.0023	0.0218	0.0305	0.0372	0.0684
1995-3	0.127	6.020	8.352	6.668	5.126	0.0027	0.0312	0.0285	0.0360	0.1114
1995-4	0.127	6.024	8.476	6.816	5.299	0.0027	0.0311	0.0318	0.0386	0.1154
1995-5	0.127	5.992	8.373	6.719	5.191	0.0027	0.0309	0.0278	0.0364	0.1126
1995-6	0.127	6.049	8.298	6.575	5.023	0.0027	0.0315	0.0284	0.0348	0.1094
1995-7	0.127	6.049	8.298	6.575	5.023	0.0027	0.0315	0.0284	0.0348	0.1094
1995-8a	0.116	10.022	15.084	12.135	8.671	0.0025	0.0561	0.3331	0.1760	0.2124
1995-8b	0.116	10.022	15.084	12.135	8.671	0.0025	0.0561	0.3331	0.1760	0.2124
1996-2b	0.092	3.076	4.725	4.596	3.205	0.0030	0.0171	0.0464	0.0201	0.0581
1996-3	0.127	6.016	8.407	6.731	5.202	0.0032	0.0252	0.0421	0.0189	0.1105
1996-4	0.127	6.018	8.505	6.853	5.351	0.0032	0.0253	0.0457	0.0199	0.1132
1996-5	0.127	5.973	8.414	6.783	5.277	0.0032	0.0251	0.0405	0.0190	0.1118
1996-6	0.127	6.067	8.329	6.583	5.033	0.0032	0.0253	0.0415	0.0180	0.1074
1996-7	0.127	6.067	8.329	6.583	5.033	0.0032	0.0253	0.0415	0.0180	0.1074
1996-8a	0.116	10.022	15.084	12.135	8.671	0.0029	0.0418	0.4210	0.0837	0.1748
1996-8b	0.116	10.022	15.084	12.135	8.671	0.0029	0.0418	0.4210	0.0837	0.1748
1997-2b	0.094	2.636	4.206	3.932	2.861	0.0010	0.0092	0.0285	0.0378	0.0353
1997-3	0.127	6.045	8.380	6.669	5.125	0.0012	0.0129	0.0265	0.0437	0.0634
1997-4	0.127	5.998	8.469	6.826	5.324	0.0012	0.0128	0.0266	0.0464	0.0669
1997-5	0.127	5.997	8.395	6.734	5.210	0.0012	0.0128	0.0253	0.0447	0.0648
1997-6	0.127	6.069	8.332	6.584	5.034	0.0012	0.0129	0.0264	0.0423	0.0617
1997-7	0.127	6.069	8.332	6.584	5.034	0.0012	0.0129	0.0264	0.0423	0.0617
1997-8a	0.116	10.022	15.084	12.135	8.671	0.0010	0.0270	0.2327	0.1480	0.1380
1997-8b	0.116	10.022	15.084	12.135	8.671	0.0010	0.0270	0.2327	0.1480	0.1380
1998-2b	0.100	1.499	3.180	3.447	2.105	0.0013	0.0098	0.0260	0.0269	0.0285
1998-3	0.241	3.808	5.874	6.139	3.951	0.0016	0.0203	0.0479	0.0614	0.0801
1998-4	0.237	4.004	6.477	6.451	4.266	0.0015	0.0227	0.0712	0.0698	0.0900
1998-5	0.247	3.549	5.166	5.810	3.601	0.0016	0.0175	0.0200	0.0524	0.0695
1998-6	0.247	3.586	5.166	5.781	3.576	0.0016	0.0176	0.0204	0.0516	0.0683
1998-7	0.247	3.586	5.166	5.781	3.576	0.0016	0.0176	0.0204	0.0516	0.0683
1998-8a	0.212	5.298	9.136	7.686	5.014	0.0013	0.0365	0.1767	0.1036	0.1121
1998-8b	0.212	5.298	9.136	7.686	5.014	0.0013	0.0365	0.1767	0.1036	0.1121
1999-2b	0.117	1.689	3.342	3.644	2.256	0.0004	0.0055	0.0235	0.0145	0.0384
1999-3	0.247	3.581	5.207	5.820	3.609	0.0005	0.0096	0.0128	0.0181	0.0915
1999-4	0.246	3.618	5.353	5.898	3.694	0.0005	0.0098	0.0202	0.0200	0.0944

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1999-5	0.247	3.536	5.142	5.805	3.590	0.0005	0.0094	0.0089	0.0179	0.0917
1999-6	0.247	3.536	5.143	5.806	3.591	0.0005	0.0094	0.0089	0.0179	0.0917
1999-7	0.247	3.560	5.133	5.781	3.568	0.0005	0.0094	0.0090	0.0172	0.0901
1999-8a	0.245	3.682	5.481	5.944	3.741	0.0005	0.0101	0.0273	0.0210	0.0951
1999-8b	0.245	3.682	5.481	5.944	3.741	0.0005	0.0101	0.0273	0.0210	0.0951
2000-2b	0.118	1.620	3.304	3.591	2.203	0.0004	0.0042	0.0218	0.0190	0.0327
2000-3	0.247	3.542	5.117	5.786	3.567	0.0005	0.0056	0.0088	0.0209	0.0743
2000-4	0.247	3.533	5.126	5.799	3.579	0.0005	0.0056	0.0088	0.0211	0.0748
2000-5	0.247	3.527	5.128	5.804	3.584	0.0005	0.0056	0.0087	0.0212	0.0751
2000-6	0.247	3.527	5.128	5.804	3.585	0.0005	0.0056	0.0087	0.0212	0.0751
2000-7	0.248	3.545	5.114	5.781	3.562	0.0005	0.0057	0.0088	0.0209	0.0741
2000-8a	0.247	3.546	5.117	5.783	3.564	0.0005	0.0057	0.0090	0.0209	0.0742
2000-8b	0.247	3.546	5.117	5.783	3.564	0.0005	0.0057	0.0090	0.0209	0.0742
2001-2b	0.090	1.115	2.400	2.637	1.680	0.0002	0.0039	0.0209	0.0161	0.0240
2001-3	0.234	3.397	4.907	5.501	3.404	0.0002	0.0037	0.0094	0.0572	0.0853
2001-4	0.235	3.377	4.912	5.520	3.421	0.0002	0.0036	0.0094	0.0572	0.0859
2001-5	0.235	3.366	4.906	5.524	3.424	0.0002	0.0036	0.0090	0.0572	0.0861
2001-6	0.235	3.365	4.906	5.524	3.424	0.0002	0.0036	0.0090	0.0572	0.0862
2001-7	0.234	3.404	4.904	5.493	3.397	0.0002	0.0037	0.0093	0.0572	0.0850
2001-8a	0.234	3.408	4.916	5.499	3.404	0.0002	0.0037	0.0099	0.0572	0.0852
2001-8b	0.234	3.408	4.916	5.499	3.404	0.0002	0.0037	0.0099	0.0572	0.0852
2002-2b	0.076	1.058	2.155	2.382	1.548	0.0006	0.0062	0.0130	0.0106	0.0120
2002-3	0.234	3.407	4.916	5.498	3.405	0.0007	0.0102	0.0107	0.0161	0.0301
2002-4	0.234	3.390	4.918	5.513	3.417	0.0007	0.0102	0.0107	0.0163	0.0304
2002-5	0.234	3.380	4.913	5.517	3.420	0.0007	0.0101	0.0106	0.0163	0.0305
2002-6	0.234	3.380	4.913	5.518	3.421	0.0007	0.0101	0.0106	0.0163	0.0305
2002-7	0.234	3.413	4.915	5.493	3.400	0.0007	0.0102	0.0107	0.0161	0.0300
2002-8a	0.234	3.415	4.922	5.496	3.404	0.0007	0.0102	0.0108	0.0161	0.0301
2002-8b	0.234	3.415	4.922	5.496	3.404	0.0007	0.0102	0.0108	0.0161	0.0301
2003-2b	0.081	1.110	2.276	2.501	1.616	0.0003	0.0039	0.0143	0.0102	0.0146
2003-3	0.234	3.407	4.916	5.498	3.404	0.0004	0.0068	0.0062	0.0194	0.0426
2003-4	0.234	3.392	4.918	5.512	3.416	0.0004	0.0067	0.0062	0.0196	0.0430
2003-5	0.234	3.382	4.914	5.516	3.419	0.0004	0.0067	0.0061	0.0196	0.0432
2003-6	0.234	3.381	4.914	5.516	3.419	0.0004	0.0067	0.0061	0.0196	0.0432
2003-7	0.234	3.413	4.915	5.493	3.400	0.0004	0.0068	0.0062	0.0193	0.0425
2003-8a	0.234	3.415	4.922	5.496	3.404	0.0004	0.0068	0.0064	0.0194	0.0426
2003-8b	0.234	3.415	4.922	5.496	3.404	0.0004	0.0068	0.0064	0.0194	0.0426
2004-2b	0.063	0.865	1.516	1.694	1.158	0.0006	0.0044	0.0097	0.0099	0.0089
2004-3	0.234	3.408	4.916	5.497	3.404	0.0007	0.0090	0.0079	0.0209	0.0225
2004-4	0.234	3.395	4.919	5.509	3.414	0.0007	0.0090	0.0080	0.0211	0.0227
2004-5	0.234	3.387	4.914	5.513	3.416	0.0007	0.0090	0.0079	0.0212	0.0228
2004-6	0.234	3.386	4.914	5.513	3.417	0.0007	0.0090	0.0079	0.0212	0.0228
2004-7	0.234	3.413	4.915	5.493	3.400	0.0007	0.0090	0.0079	0.0208	0.0224

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2004-8a	0.234	3.415	4.922	5.496	3.404	0.0007	0.0090	0.0080	0.0209	0.0224
2004-8b	0.234	3.415	4.922	5.496	3.404	0.0007	0.0090	0.0080	0.0209	0.0224
2005-2b	0.046	0.523	1.042	1.167	0.771	0.0006	0.0039	0.0098	0.0090	0.0074
2005-3	0.234	3.408	4.916	5.498	3.404	0.0007	0.0090	0.0079	0.0209	0.0225
2005-4	0.234	3.393	4.919	5.511	3.415	0.0007	0.0090	0.0079	0.0211	0.0227
2005-5	0.234	3.384	4.914	5.515	3.418	0.0007	0.0090	0.0079	0.0212	0.0228
2005-6	0.234	3.383	4.914	5.515	3.418	0.0007	0.0090	0.0079	0.0212	0.0228
2005-7	0.234	3.413	4.915	5.493	3.400	0.0007	0.0090	0.0079	0.0208	0.0224
2005-8a	0.234	3.415	4.923	5.497	3.404	0.0007	0.0090	0.0081	0.0209	0.0224
2005-8b	0.234	3.415	4.923	5.497	3.404	0.0007	0.0090	0.0081	0.0209	0.0224
2006-2b	0.048	0.544	0.994	1.138	0.777	0.0006	0.0041	0.0098	0.0093	0.0078
2006-3	0.234	3.410	4.916	5.496	3.403	0.0007	0.0090	0.0080	0.0209	0.0224
2006-4	0.234	3.399	4.919	5.506	3.412	0.0007	0.0090	0.0080	0.0210	0.0226
2006-5	0.234	3.392	4.914	5.509	3.413	0.0007	0.0090	0.0079	0.0211	0.0227
2006-6	0.234	3.391	4.914	5.509	3.413	0.0007	0.0090	0.0079	0.0211	0.0227
2006-7	0.234	3.413	4.915	5.493	3.400	0.0007	0.0090	0.0079	0.0208	0.0224
2006-8a	0.234	3.415	4.922	5.496	3.404	0.0007	0.0090	0.0080	0.0209	0.0224
2006-8b	0.234	3.415	4.922	5.496	3.404	0.0007	0.0090	0.0080	0.0209	0.0224
2007-2b	0.034	0.421	0.763	0.892	0.617	0.0005	0.0033	0.0080	0.0074	0.0061
2007-3	0.234	3.409	4.916	5.497	3.403	0.0006	0.0074	0.0065	0.0172	0.0185
2007-4	0.234	3.396	4.918	5.508	3.413	0.0006	0.0074	0.0065	0.0174	0.0187
2007-5	0.234	3.388	4.914	5.512	3.416	0.0006	0.0074	0.0065	0.0174	0.0187
2007-6	0.234	3.387	4.914	5.512	3.416	0.0006	0.0074	0.0065	0.0174	0.0188
2007-7	0.234	3.413	4.915	5.493	3.400	0.0006	0.0074	0.0065	0.0171	0.0184
2007-8a	0.234	3.415	4.921	5.496	3.403	0.0006	0.0074	0.0066	0.0172	0.0185
2007-8b	0.234	3.415	4.921	5.496	3.403	0.0006	0.0074	0.0066	0.0172	0.0185
2008-2b	0.020	0.214	0.497	0.590	0.377	0.0005	0.0033	0.0080	0.0076	0.0062
2008-3	0.070	1.023	1.475	1.649	1.021	0.0006	0.0074	0.0065	0.0172	0.0185
2008-4	0.070	1.021	1.476	1.651	1.023	0.0006	0.0074	0.0066	0.0173	0.0186
2008-5	0.070	1.019	1.474	1.652	1.023	0.0006	0.0074	0.0065	0.0173	0.0186
2008-6	0.070	1.019	1.474	1.652	1.023	0.0006	0.0074	0.0065	0.0173	0.0186
2008-7	0.070	1.024	1.475	1.648	1.020	0.0006	0.0074	0.0065	0.0171	0.0184
2008-8a	0.070	1.024	1.476	1.649	1.021	0.0006	0.0074	0.0066	0.0172	0.0185
2008-8b	0.070	1.024	1.476	1.649	1.021	0.0006	0.0074	0.0066	0.0172	0.0185
2009-2b	0.007	0.144	0.307	0.388	0.267	0.0004	0.0029	0.0071	0.0067	0.0055
2009-3	0.070	1.023	1.475	1.649	1.021	0.0005	0.0066	0.0059	0.0154	0.0165
2009-4	0.070	1.019	1.475	1.652	1.023	0.0005	0.0066	0.0058	0.0155	0.0167
2009-5	0.070	1.017	1.474	1.653	1.024	0.0005	0.0066	0.0058	0.0155	0.0167
2009-6	0.070	1.017	1.474	1.653	1.024	0.0005	0.0066	0.0058	0.0156	0.0167
2009-7	0.070	1.024	1.475	1.648	1.020	0.0005	0.0066	0.0058	0.0153	0.0165
2009-8a	0.070	1.024	1.476	1.649	1.021	0.0005	0.0066	0.0059	0.0154	0.0165
2009-8b	0.070	1.024	1.476	1.649	1.021	0.0005	0.0066	0.0059	0.0154	0.0165
2010-2b	0.006	0.128	0.280	0.361	0.248	0.0004	0.0029	0.0071	0.0066	0.0054

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2010-3	0.070	1.023	1.475	1.649	1.021	0.0005	0.0066	0.0058	0.0154	0.0165
2010-4	0.070	1.019	1.475	1.652	1.023	0.0005	0.0066	0.0058	0.0155	0.0167
2010-5	0.070	1.017	1.474	1.653	1.024	0.0005	0.0066	0.0058	0.0155	0.0167
2010-6	0.070	1.017	1.474	1.653	1.024	0.0005	0.0066	0.0058	0.0156	0.0167
2010-7	0.070	1.024	1.475	1.648	1.020	0.0005	0.0066	0.0058	0.0153	0.0165
2010-8a	0.070	1.024	1.476	1.648	1.021	0.0005	0.0066	0.0059	0.0154	0.0165
2010-8b	0.070	1.024	1.476	1.648	1.021	0.0005	0.0066	0.0059	0.0154	0.0165
2011-2b	0.006	0.131	0.258	0.327	0.228	0.0004	0.0027	0.0064	0.0062	0.0053
2011-3	0.057	0.823	1.186	1.326	0.812	0.0005	0.0059	0.0052	0.0138	0.0148
2011-4	0.057	0.821	1.187	1.328	0.814	0.0005	0.0059	0.0052	0.0138	0.0149
2011-5	0.057	0.820	1.186	1.329	0.815	0.0005	0.0059	0.0052	0.0139	0.0149
2011-6	0.057	0.820	1.186	1.329	0.815	0.0005	0.0059	0.0052	0.0139	0.0149
2011-7	0.057	0.824	1.186	1.326	0.812	0.0005	0.0059	0.0052	0.0137	0.0148
2011-8a	0.057	0.824	1.188	1.326	0.812	0.0005	0.0059	0.0053	0.0137	0.0148
2011-8b	0.057	0.824	1.188	1.326	0.812	0.0005	0.0059	0.0053	0.0137	0.0148
2012-2b	0.007	0.150	0.277	0.350	0.246	0.0004	0.0028	0.0064	0.0064	0.0056
2012-3	0.057	0.823	1.186	1.326	0.812	0.0005	0.0059	0.0052	0.0138	0.0148
2012-4	0.057	0.822	1.187	1.328	0.814	0.0005	0.0059	0.0053	0.0138	0.0149
2012-5	0.057	0.821	1.186	1.328	0.814	0.0005	0.0059	0.0052	0.0138	0.0149
2012-6	0.057	0.821	1.186	1.328	0.814	0.0005	0.0059	0.0052	0.0138	0.0149
2012-7	0.057	0.824	1.186	1.326	0.812	0.0005	0.0059	0.0052	0.0137	0.0148
2012-8a	0.057	0.824	1.188	1.326	0.812	0.0005	0.0059	0.0053	0.0137	0.0148
2012-8b	0.057	0.824	1.188	1.326	0.812	0.0005	0.0059	0.0053	0.0137	0.0148
2013-2b	0.006	0.130	0.206	0.259	0.192	0.0002	0.0018	0.0041	0.0040	0.0035
2013-3	0.057	0.823	1.186	1.326	0.812	0.0003	0.0038	0.0033	0.0088	0.0094
2013-4	0.057	0.822	1.187	1.328	0.814	0.0003	0.0038	0.0034	0.0088	0.0095
2013-5	0.057	0.821	1.186	1.328	0.814	0.0003	0.0038	0.0033	0.0088	0.0095
2013-6	0.057	0.821	1.186	1.328	0.814	0.0003	0.0038	0.0033	0.0088	0.0095
2013-7	0.057	0.824	1.186	1.326	0.812	0.0003	0.0038	0.0033	0.0088	0.0094
2013-8a	0.057	0.824	1.188	1.326	0.812	0.0003	0.0038	0.0034	0.0088	0.0094
2013-8b	0.057	0.824	1.188	1.326	0.812	0.0003	0.0038	0.0034	0.0088	0.0094
2014-2b	0.006	0.131	0.208	0.261	0.193	0.0002	0.0018	0.0041	0.0040	0.0035
2014-3	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2014-4	0.056	0.820	1.184	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0094
2014-5	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095
2014-6	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095
2014-7	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2014-8a	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094
2014-8b	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094
2015-2b	0.006	0.130	0.208	0.261	0.193	0.0002	0.0018	0.0041	0.0040	0.0035
2015-3	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2015-4	0.056	0.820	1.184	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0094
2015-5	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2015-6	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095
2015-7	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2015-8a	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094
2015-8b	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094
2016-2b	0.006	0.128	0.206	0.259	0.191	0.0002	0.0018	0.0041	0.0040	0.0035
2016-3	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2016-4	0.056	0.820	1.184	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0094
2016-5	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095
2016-6	0.056	0.819	1.183	1.325	0.812	0.0003	0.0038	0.0033	0.0088	0.0095
2016-7	0.056	0.822	1.184	1.323	0.810	0.0003	0.0038	0.0033	0.0087	0.0094
2016-8a	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094
2016-8b	0.056	0.822	1.185	1.324	0.811	0.0003	0.0038	0.0034	0.0087	0.0094

Note – highlighted cells are set equal to the row above (MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore 8bs are set equal to 8as).

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1987-2b	0.217	3.756	7.654	7.877	5.006	0.0028	0.0305	0.0846	0.0761	0.0768
1987-3	0.266	8.769	12.864	13.273	9.105	0.0033	0.0550	0.1112	0.0940	0.1839
1987-4	0.266	8.775	12.909	13.327	9.165	0.0033	0.0551	0.1131	0.0957	0.1862
1987-5	0.265	8.913	12.722	12.962	8.762	0.0033	0.0576	0.1111	0.0870	0.1732
1987-6	0.265	8.913	12.722	12.962	8.762	0.0033	0.0576	0.1111	0.0870	0.1732
1987-7	0.265	8.913	12.722	12.962	8.762	0.0033	0.0576	0.1111	0.0870	0.1732
1987-8a	0.260	9.526	13.524	13.783	9.577	0.0032	0.0697	0.1614	0.1240	0.2045
1987-8b	0.199	14.604	19.893	20.453	14.294	0.0027	0.1695	0.5752	0.4344	0.3818
1988-2b	0.221	4.145	7.925	8.170	5.311	0.0041	0.0527	0.0642	0.0841	0.0652
1988-3	0.266	8.796	12.883	13.283	9.112	0.0046	0.1173	0.0914	0.1359	0.1493
1988-4	0.266	8.755	12.977	13.439	9.311	0.0047	0.1160	0.0927	0.1424	0.1580
1988-5	0.265	8.987	12.809	13.064	8.869	0.0045	0.1225	0.0950	0.1273	0.1385
1988-6	0.265	8.979	12.800	13.054	8.858	0.0045	0.1223	0.0945	0.1268	0.1380
1988-7	0.265	8.926	12.735	12.986	8.787	0.0046	0.1211	0.0914	0.1234	0.1352
1988-8a	0.259	9.671	13.838	14.082	9.818	0.0045	0.1380	0.1410	0.1751	0.1776
1988-8b	0.199	14.604	19.893	20.453	14.294	0.0038	0.2486	0.4355	0.4976	0.3580
1989-2b	0.224	4.584	8.251	8.563	5.678	0.0041	0.0585	0.0655	0.0863	0.0720
1989-3	0.267	8.718	12.755	13.213	9.024	0.0046	0.1153	0.0883	0.1320	0.1458
1989-4	0.267	8.718	12.915	13.392	9.255	0.0047	0.1151	0.0905	0.1402	0.1557
1989-5	0.266	8.755	12.488	12.899	8.677	0.0046	0.1167	0.0867	0.1175	0.1309
1989-6	0.266	8.755	12.488	12.899	8.677	0.0046	0.1167	0.0867	0.1175	0.1309
1989-7	0.266	8.755	12.488	12.899	8.677	0.0046	0.1167	0.0867	0.1175	0.1309
1989-8a	0.239	14.524	21.639	21.475	14.202	0.0045	0.2496	0.4615	0.4939	0.3638
1989-8b	0.239	14.524	21.639	21.475	14.202	0.0045	0.2496	0.4615	0.4939	0.3638
1990-2b	0.145	5.450	8.454	7.027	5.148	0.0014	0.0170	0.0473	0.0835	0.1287

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1990-3	0.140	6.674	9.349	7.491	5.802	0.0016	0.0200	0.0394	0.0791	0.1749
1990-4	0.140	6.738	9.619	7.769	6.131	0.0016	0.0206	0.0535	0.0908	0.1908
1990-5	0.140	6.698	9.193	7.272	5.558	0.0016	0.0198	0.0352	0.0722	0.1649
1990-6	0.140	6.698	9.193	7.272	5.558	0.0016	0.0198	0.0352	0.0722	0.1649
1990-7	0.140	6.698	9.193	7.272	5.558	0.0016	0.0198	0.0352	0.0722	0.1649
1990-8a	0.128	11.075	16.670	13.410	9.583	0.0013	0.0461	0.5350	0.3995	0.3981
1990-8b	0.128	11.075	16.670	13.410	9.583	0.0013	0.0461	0.5350	0.3995	0.3981
1991-2b	0.145	4.767	8.157	6.936	4.916	0.0039	0.0746	0.0318	0.0299	0.0569
1991-3	0.140	6.672	9.368	7.514	5.831	0.0043	0.1130	0.0383	0.0309	0.1011
1991-4	0.140	6.793	9.656	7.762	6.093	0.0043	0.1153	0.0480	0.0354	0.1067
1991-5	0.140	6.663	9.241	7.362	5.658	0.0043	0.1130	0.0353	0.0290	0.0978
1991-6	0.140	6.704	9.203	7.275	5.562	0.0043	0.1141	0.0356	0.0284	0.0963
1991-7	0.140	6.704	9.203	7.275	5.562	0.0043	0.1141	0.0356	0.0284	0.0963
1991-8a	0.139	7.123	10.082	7.987	6.205	0.0043	0.1227	0.0664	0.0418	0.1106
1991-8b	0.139	7.123	10.082	7.987	6.205	0.0043	0.1227	0.0664	0.0418	0.1106
1992-2b	0.141	5.127	8.329	7.003	5.051	0.0039	0.0816	0.0320	0.0293	0.0646
1992-3	0.140	6.681	9.439	7.595	5.929	0.0043	0.1130	0.0401	0.0320	0.1029
1992-4	0.140	6.813	9.765	7.880	6.241	0.0043	0.1156	0.0510	0.0370	0.1096
1992-5	0.140	6.650	9.255	7.393	5.696	0.0043	0.1126	0.0352	0.0292	0.0984
1992-6	0.140	6.705	9.206	7.276	5.562	0.0043	0.1142	0.0356	0.0284	0.0963
1992-7	0.140	6.705	9.206	7.276	5.562	0.0043	0.1142	0.0356	0.0284	0.0963
1992-8a	0.138	7.258	10.355	8.208	6.392	0.0043	0.1254	0.0759	0.0460	0.1147
1992-8b	0.138	7.258	10.355	8.208	6.392	0.0043	0.1254	0.0759	0.0460	0.1147
1993-2b	0.140	5.256	8.337	7.025	5.087	0.0039	0.0840	0.0315	0.0284	0.0683
1993-3	0.141	6.581	9.178	7.410	5.713	0.0043	0.1113	0.0351	0.0292	0.0990
1993-4	0.141	6.603	9.300	7.525	5.853	0.0043	0.1115	0.0370	0.0306	0.1015
1993-5	0.141	6.572	9.167	7.404	5.708	0.0043	0.1111	0.0344	0.0290	0.0989
1993-6	0.140	6.584	8.991	7.217	5.494	0.0043	0.1120	0.0344	0.0274	0.0957
1993-7	0.140	6.584	8.991	7.217	5.494	0.0043	0.1120	0.0344	0.0274	0.0957
1993-8a	0.140	6.670	9.173	7.363	5.631	0.0043	0.1137	0.0407	0.0301	0.0987
1993-8b	0.140	6.670	9.173	7.363	5.631	0.0043	0.1137	0.0407	0.0301	0.0987
1994-2b	0.114	4.674	7.777	6.879	4.804	0.0021	0.0158	0.0492	0.1240	0.0706
1994-3	0.138	6.571	9.195	7.358	5.695	0.0026	0.0225	0.0848	0.1867	0.1154
1994-4	0.137	6.683	9.541	7.687	6.061	0.0026	0.0230	0.0914	0.2021	0.1296
1994-5	0.138	6.478	9.134	7.371	5.739	0.0026	0.0217	0.0830	0.1878	0.1174
1994-6	0.137	6.578	9.028	7.143	5.459	0.0026	0.0228	0.0820	0.1762	0.1060
1994-7	0.137	6.578	9.028	7.143	5.459	0.0026	0.0228	0.0820	0.1762	0.1060
1994-8a	0.126	10.880	16.376	13.174	9.414	0.0023	0.0506	0.2321	0.4497	0.2567
1994-8b	0.126	10.880	16.376	13.174	9.414	0.0023	0.0506	0.2321	0.4497	0.2567
1995-2b	0.118	4.638	7.721	6.829	4.772	0.0023	0.0218	0.0305	0.0372	0.0684
1995-3	0.138	6.535	9.067	7.239	5.565	0.0027	0.0312	0.0285	0.0360	0.1114
1995-4	0.138	6.540	9.202	7.400	5.753	0.0027	0.0311	0.0318	0.0386	0.1154
1995-5	0.138	6.505	9.090	7.295	5.636	0.0027	0.0309	0.0278	0.0364	0.1126

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1995-6	0.138	6.567	9.009	7.138	5.453	0.0027	0.0315	0.0284	0.0348	0.1094
1995-7	0.138	6.567	9.009	7.138	5.453	0.0027	0.0315	0.0284	0.0348	0.1094
1995-8a	0.126	10.880	16.376	13.174	9.414	0.0025	0.0561	0.3331	0.1760	0.2124
1995-8b	0.126	10.880	16.376	13.174	9.414	0.0025	0.0561	0.3331	0.1760	0.2124
1996-2b	0.100	3.340	5.129	4.990	3.480	0.0030	0.0171	0.0464	0.0201	0.0581
1996-3	0.138	6.531	9.127	7.308	5.647	0.0032	0.0252	0.0421	0.0189	0.1105
1996-4	0.138	6.533	9.233	7.440	5.809	0.0032	0.0253	0.0457	0.0199	0.1132
1996-5	0.138	6.484	9.134	7.364	5.729	0.0032	0.0251	0.0405	0.0190	0.1118
1996-6	0.137	6.586	9.042	7.147	5.464	0.0032	0.0253	0.0415	0.0180	0.1074
1996-7	0.137	6.586	9.042	7.147	5.464	0.0032	0.0253	0.0415	0.0180	0.1074
1996-8a	0.126	10.880	16.376	13.174	9.414	0.0029	0.0418	0.4210	0.0837	0.1748
1996-8b	0.126	10.880	16.376	13.174	9.414	0.0029	0.0418	0.4210	0.0837	0.1748
1997-2b	0.102	2.862	4.566	4.269	3.106	0.0010	0.0092	0.0285	0.0378	0.0353
1997-3	0.138	6.563	9.098	7.240	5.564	0.0012	0.0129	0.0265	0.0437	0.0634
1997-4	0.138	6.512	9.194	7.411	5.780	0.0012	0.0128	0.0266	0.0464	0.0669
1997-5	0.138	6.510	9.113	7.311	5.657	0.0012	0.0128	0.0253	0.0447	0.0648
1997-6	0.137	6.588	9.046	7.148	5.465	0.0012	0.0129	0.0264	0.0423	0.0617
1997-7	0.137	6.588	9.046	7.148	5.465	0.0012	0.0129	0.0264	0.0423	0.0617
1997-8a	0.126	10.880	16.376	13.174	9.414	0.0010	0.0270	0.2327	0.1480	0.1380
1997-8b	0.126	10.880	16.376	13.174	9.414	0.0010	0.0270	0.2327	0.1480	0.1380
1998-2b	0.108	1.628	3.452	3.742	2.286	0.0013	0.0098	0.0260	0.0269	0.0285
1998-3	0.262	4.134	6.377	6.665	4.290	0.0016	0.0203	0.0479	0.0614	0.0801
1998-4	0.257	4.347	7.031	7.003	4.631	0.0015	0.0227	0.0712	0.0698	0.0900
1998-5	0.268	3.853	5.608	6.307	3.909	0.0016	0.0175	0.0200	0.0524	0.0695
1998-6	0.268	3.893	5.608	6.276	3.883	0.0016	0.0176	0.0204	0.0516	0.0683
1998-7	0.268	3.893	5.608	6.276	3.883	0.0016	0.0176	0.0204	0.0516	0.0683
1998-8a	0.231	5.752	9.919	8.344	5.444	0.0013	0.0365	0.1767	0.1036	0.1121
1998-8b	0.231	5.752	9.919	8.344	5.444	0.0013	0.0365	0.1767	0.1036	0.1121
1999-2b	0.127	1.834	3.628	3.956	2.450	0.0004	0.0055	0.0235	0.0145	0.0384
1999-3	0.268	3.887	5.653	6.318	3.918	0.0005	0.0096	0.0128	0.0181	0.0915
1999-4	0.267	3.927	5.811	6.403	4.011	0.0005	0.0098	0.0202	0.0200	0.0944
1999-5	0.268	3.839	5.583	6.302	3.898	0.0005	0.0094	0.0089	0.0179	0.0917
1999-6	0.268	3.839	5.583	6.303	3.898	0.0005	0.0094	0.0089	0.0179	0.0917
1999-7	0.268	3.865	5.573	6.276	3.873	0.0005	0.0094	0.0090	0.0172	0.0901
1999-8a	0.265	3.998	5.950	6.453	4.061	0.0005	0.0101	0.0273	0.0210	0.0951
1999-8b	0.265	3.998	5.950	6.453	4.061	0.0005	0.0101	0.0273	0.0210	0.0951
2000-2b	0.128	1.759	3.587	3.898	2.392	0.0004	0.0042	0.0218	0.0190	0.0327
2000-3	0.269	3.845	5.556	6.281	3.872	0.0005	0.0056	0.0088	0.0209	0.0743
2000-4	0.269	3.835	5.565	6.295	3.886	0.0005	0.0056	0.0088	0.0211	0.0748
2000-5	0.269	3.829	5.567	6.301	3.891	0.0005	0.0056	0.0087	0.0212	0.0751
2000-6	0.269	3.829	5.567	6.301	3.892	0.0005	0.0056	0.0087	0.0212	0.0751
2000-7	0.269	3.849	5.552	6.276	3.868	0.0005	0.0057	0.0088	0.0209	0.0741
2000-8a	0.269	3.850	5.556	6.278	3.869	0.0005	0.0057	0.0090	0.0209	0.0742

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2000-8b	0.269	3.850	5.556	6.278	3.869	0.0005	0.0057	0.0090	0.0209	0.0742
2001-2b	0.096	1.193	2.568	2.823	1.798	0.0002	0.0042	0.0226	0.0175	0.0261
2001-3	0.251	3.635	5.251	5.887	3.643	0.0003	0.0040	0.0102	0.0621	0.0926
2001-4	0.251	3.615	5.257	5.907	3.661	0.0003	0.0040	0.0102	0.0621	0.0933
2001-5	0.251	3.603	5.251	5.912	3.664	0.0003	0.0039	0.0098	0.0621	0.0935
2001-6	0.251	3.602	5.251	5.912	3.665	0.0003	0.0039	0.0098	0.0621	0.0935
2001-7	0.251	3.643	5.248	5.879	3.636	0.0003	0.0040	0.0101	0.0621	0.0923
2001-8a	0.251	3.648	5.262	5.885	3.643	0.0003	0.0040	0.0107	0.0621	0.0924
2001-8b	0.251	3.648	5.262	5.885	3.643	0.0003	0.0040	0.0107	0.0621	0.0924
2002-2b	0.081	1.132	2.307	2.549	1.656	0.0007	0.0068	0.0142	0.0115	0.0130
2002-3	0.251	3.646	5.262	5.885	3.644	0.0008	0.0111	0.0116	0.0175	0.0327
2002-4	0.251	3.628	5.263	5.900	3.657	0.0008	0.0110	0.0116	0.0177	0.0330
2002-5	0.251	3.618	5.259	5.905	3.661	0.0008	0.0110	0.0115	0.0177	0.0331
2002-6	0.251	3.617	5.259	5.906	3.661	0.0008	0.0110	0.0115	0.0177	0.0331
2002-7	0.251	3.653	5.261	5.879	3.639	0.0007	0.0111	0.0116	0.0175	0.0326
2002-8a	0.251	3.655	5.268	5.882	3.643	0.0007	0.0111	0.0117	0.0175	0.0327
2002-8b	0.251	3.655	5.268	5.882	3.643	0.0007	0.0111	0.0117	0.0175	0.0327
2003-2b	0.086	1.188	2.436	2.677	1.729	0.0003	0.0043	0.0155	0.0111	0.0159
2003-3	0.251	3.647	5.262	5.884	3.644	0.0004	0.0073	0.0068	0.0210	0.0463
2003-4	0.251	3.630	5.264	5.899	3.656	0.0004	0.0073	0.0068	0.0212	0.0467
2003-5	0.251	3.620	5.259	5.904	3.659	0.0004	0.0073	0.0066	0.0213	0.0469
2003-6	0.251	3.619	5.259	5.904	3.660	0.0004	0.0073	0.0066	0.0213	0.0469
2003-7	0.251	3.653	5.261	5.879	3.639	0.0004	0.0073	0.0067	0.0210	0.0462
2003-8a	0.251	3.655	5.268	5.883	3.643	0.0004	0.0074	0.0070	0.0210	0.0462
2003-8b	0.251	3.655	5.268	5.883	3.643	0.0004	0.0074	0.0070	0.0210	0.0462
2004-2b	0.067	0.925	1.622	1.813	1.239	0.0006	0.0048	0.0105	0.0108	0.0096
2004-3	0.251	3.648	5.262	5.884	3.643	0.0007	0.0098	0.0086	0.0227	0.0244
2004-4	0.251	3.634	5.264	5.897	3.654	0.0007	0.0098	0.0086	0.0229	0.0246
2004-5	0.251	3.624	5.259	5.900	3.656	0.0007	0.0097	0.0085	0.0230	0.0247
2004-6	0.251	3.624	5.259	5.900	3.657	0.0007	0.0097	0.0085	0.0230	0.0247
2004-7	0.251	3.653	5.261	5.879	3.639	0.0007	0.0098	0.0086	0.0226	0.0243
2004-8a	0.251	3.655	5.268	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0244
2004-8b	0.251	3.655	5.268	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0244
2005-2b	0.049	0.560	1.115	1.248	0.826	0.0006	0.0043	0.0106	0.0098	0.0080
2005-3	0.251	3.647	5.262	5.884	3.643	0.0007	0.0098	0.0086	0.0227	0.0244
2005-4	0.251	3.632	5.264	5.898	3.656	0.0007	0.0098	0.0086	0.0229	0.0247
2005-5	0.251	3.622	5.259	5.902	3.658	0.0007	0.0097	0.0085	0.0230	0.0248
2005-6	0.251	3.621	5.259	5.903	3.658	0.0007	0.0097	0.0085	0.0230	0.0248
2005-7	0.251	3.653	5.261	5.879	3.639	0.0007	0.0098	0.0086	0.0226	0.0243
2005-8a	0.251	3.655	5.269	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0244
2005-8b	0.251	3.655	5.269	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0244
2006-2b	0.051	0.583	1.064	1.218	0.831	0.0006	0.0044	0.0107	0.0101	0.0084
2006-3	0.251	3.649	5.262	5.883	3.642	0.0007	0.0098	0.0086	0.0227	0.0244

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2006-4	0.251	3.638	5.265	5.893	3.651	0.0007	0.0098	0.0086	0.0228	0.0246
2006-5	0.251	3.630	5.259	5.896	3.653	0.0007	0.0097	0.0086	0.0229	0.0247
2006-6	0.251	3.629	5.259	5.896	3.653	0.0007	0.0097	0.0086	0.0229	0.0247
2006-7	0.251	3.653	5.261	5.879	3.639	0.0007	0.0098	0.0086	0.0226	0.0243
2006-8a	0.251	3.655	5.268	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0243
2006-8b	0.251	3.655	5.268	5.883	3.643	0.0007	0.0098	0.0087	0.0227	0.0243
2007-2b	0.037	0.451	0.816	0.955	0.660	0.0005	0.0035	0.0087	0.0081	0.0066
2007-3	0.251	3.648	5.262	5.883	3.643	0.0006	0.0080	0.0071	0.0187	0.0201
2007-4	0.251	3.634	5.264	5.896	3.653	0.0006	0.0080	0.0071	0.0188	0.0203
2007-5	0.251	3.626	5.259	5.899	3.656	0.0006	0.0080	0.0070	0.0189	0.0203
2007-6	0.251	3.625	5.259	5.900	3.656	0.0006	0.0080	0.0070	0.0189	0.0204
2007-7	0.251	3.653	5.261	5.879	3.639	0.0006	0.0080	0.0071	0.0186	0.0200
2007-8a	0.251	3.655	5.267	5.882	3.642	0.0006	0.0080	0.0072	0.0186	0.0200
2007-8b	0.251	3.655	5.267	5.882	3.642	0.0006	0.0080	0.0072	0.0186	0.0200
2008-2b	0.021	0.229	0.532	0.631	0.404	0.0005	0.0036	0.0087	0.0082	0.0068
2008-3	0.075	1.095	1.579	1.765	1.092	0.0006	0.0080	0.0071	0.0187	0.0201
2008-4	0.075	1.092	1.579	1.767	1.095	0.0006	0.0080	0.0071	0.0188	0.0202
2008-5	0.075	1.090	1.578	1.768	1.095	0.0006	0.0080	0.0071	0.0188	0.0202
2008-6	0.075	1.090	1.578	1.768	1.095	0.0006	0.0080	0.0071	0.0188	0.0202
2008-7	0.075	1.096	1.578	1.764	1.092	0.0006	0.0080	0.0071	0.0186	0.0200
2008-8a	0.075	1.096	1.580	1.765	1.093	0.0006	0.0080	0.0072	0.0187	0.0200
2008-8b	0.075	1.096	1.580	1.765	1.093	0.0006	0.0080	0.0072	0.0187	0.0200
2009-2b	0.008	0.154	0.329	0.416	0.286	0.0005	0.0032	0.0077	0.0073	0.0060
2009-3	0.075	1.095	1.578	1.765	1.093	0.0005	0.0072	0.0064	0.0167	0.0180
2009-4	0.075	1.091	1.579	1.768	1.095	0.0005	0.0072	0.0063	0.0168	0.0181
2009-5	0.075	1.089	1.578	1.769	1.096	0.0006	0.0072	0.0063	0.0169	0.0182
2009-6	0.075	1.088	1.578	1.769	1.096	0.0006	0.0072	0.0063	0.0169	0.0182
2009-7	0.075	1.096	1.578	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2009-8a	0.075	1.096	1.580	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2009-8b	0.075	1.096	1.580	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2010-2b	0.007	0.136	0.300	0.386	0.266	0.0005	0.0031	0.0077	0.0071	0.0058
2010-3	0.075	1.095	1.578	1.765	1.093	0.0005	0.0072	0.0064	0.0167	0.0180
2010-4	0.075	1.091	1.579	1.768	1.095	0.0005	0.0072	0.0063	0.0168	0.0181
2010-5	0.075	1.089	1.578	1.769	1.096	0.0006	0.0072	0.0063	0.0169	0.0182
2010-6	0.075	1.088	1.578	1.769	1.096	0.0006	0.0072	0.0063	0.0169	0.0182
2010-7	0.075	1.096	1.578	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2010-8a	0.075	1.096	1.579	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2010-8b	0.075	1.096	1.579	1.764	1.092	0.0005	0.0072	0.0064	0.0167	0.0179
2011-2b	0.007	0.140	0.276	0.350	0.244	0.0004	0.0030	0.0070	0.0067	0.0057
2011-3	0.061	0.881	1.270	1.419	0.869	0.0005	0.0064	0.0057	0.0149	0.0161
2011-4	0.061	0.879	1.270	1.422	0.872	0.0005	0.0064	0.0057	0.0150	0.0162
2011-5	0.061	0.877	1.270	1.422	0.872	0.0005	0.0064	0.0056	0.0151	0.0162
2011-6	0.061	0.877	1.270	1.422	0.872	0.0005	0.0064	0.0056	0.0151	0.0162

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2011-7	0.060	0.881	1.269	1.419	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2011-8a	0.060	0.882	1.271	1.420	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2011-8b	0.060	0.882	1.271	1.420	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2012-2b	0.007	0.160	0.296	0.374	0.264	0.0004	0.0031	0.0069	0.0069	0.0060
2012-3	0.060	0.881	1.270	1.419	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2012-4	0.061	0.880	1.271	1.421	0.871	0.0005	0.0064	0.0057	0.0150	0.0161
2012-5	0.061	0.878	1.270	1.421	0.871	0.0005	0.0064	0.0057	0.0150	0.0162
2012-6	0.061	0.878	1.270	1.421	0.871	0.0005	0.0064	0.0057	0.0150	0.0162
2012-7	0.060	0.881	1.269	1.419	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2012-8a	0.060	0.882	1.271	1.420	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2012-8b	0.060	0.882	1.271	1.420	0.869	0.0005	0.0064	0.0057	0.0149	0.0160
2013-2b	0.006	0.139	0.221	0.277	0.205	0.0003	0.0019	0.0044	0.0044	0.0038
2013-3	0.060	0.881	1.270	1.419	0.869	0.0003	0.0041	0.0036	0.0095	0.0102
2013-4	0.061	0.880	1.271	1.421	0.871	0.0003	0.0041	0.0036	0.0096	0.0103
2013-5	0.061	0.878	1.270	1.421	0.871	0.0003	0.0041	0.0036	0.0096	0.0103
2013-6	0.061	0.878	1.270	1.421	0.871	0.0003	0.0041	0.0036	0.0096	0.0103
2013-7	0.060	0.881	1.269	1.419	0.869	0.0003	0.0041	0.0036	0.0095	0.0102
2013-8a	0.060	0.882	1.271	1.420	0.869	0.0003	0.0041	0.0037	0.0095	0.0102
2013-8b	0.060	0.882	1.271	1.420	0.869	0.0003	0.0041	0.0037	0.0095	0.0102
2014-2b	0.006	0.140	0.223	0.280	0.207	0.0003	0.0019	0.0044	0.0044	0.0038
2014-3	0.060	0.879	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2014-4	0.060	0.878	1.268	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0102
2014-5	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2014-6	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2014-7	0.060	0.880	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2014-8a	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102
2014-8b	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102
2015-2b	0.006	0.139	0.222	0.279	0.207	0.0003	0.0019	0.0044	0.0044	0.0038
2015-3	0.060	0.879	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2015-4	0.060	0.878	1.268	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0102
2015-5	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2015-6	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2015-7	0.060	0.880	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2015-8a	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102
2015-8b	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102
2016-2b	0.006	0.137	0.220	0.277	0.204	0.0003	0.0019	0.0044	0.0044	0.0038
2016-3	0.060	0.879	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2016-4	0.060	0.878	1.268	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0102
2016-5	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2016-6	0.060	0.876	1.266	1.418	0.869	0.0003	0.0041	0.0036	0.0095	0.0103
2016-7	0.060	0.880	1.267	1.416	0.867	0.0003	0.0041	0.0036	0.0095	0.0102
2016-8a	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102
2016-8b	0.060	0.880	1.269	1.417	0.868	0.0003	0.0041	0.0036	0.0095	0.0102

Note – highlighted cells are set equal to the row above (MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore 8bs are set equal to 8as).

Appendix B – NOx and PM Idle Factors – g/hr
(MOVES2014a, 2014 Calendar Year, ULSD)

Short Duration Idle Emission Factors (< 60 minutes per idle event)

Pollutant	Fuel	Model Yr	Class 2b	Class 3	Class 4-5	Class 6-7	Class 8a/b
NOx	Gasoline	1987	23.905	15.014	15.015	15.015	15.015
NOx	Gasoline	1988	24.691	15.015	15.015	15.015	15.014
NOx	Gasoline	1989	25.886	15.015	15.015	15.015	15.015
NOx	Gasoline	1990	13.200	7.460	7.460	7.460	7.460
NOx	Gasoline	1991	13.252	7.460	7.460	7.460	7.460
NOx	Gasoline	1992	13.553	7.460	7.460	7.460	7.460
NOx	Gasoline	1993	13.748	7.460	7.460	7.460	7.460
NOx	Gasoline	1994	13.583	7.327	7.327	7.327	7.327
NOx	Gasoline	1995	13.834	7.327	7.327	7.327	7.327
NOx	Gasoline	1996	14.008	7.327	7.327	7.327	7.327
NOx	Gasoline	1997	14.183	7.327	7.327	7.327	7.327
NOx	Gasoline	1998	29.706	15.182	15.182	15.182	15.182
NOx	Gasoline	1999	29.859	15.182	15.182	15.182	15.182
NOx	Gasoline	2000	29.859	15.182	15.182	15.182	15.182
NOx	Gasoline	2001	30.493	15.245	15.245	15.245	15.245
NOx	Gasoline	2002	30.493	15.245	15.245	15.245	15.245
NOx	Gasoline	2003	30.493	15.245	15.245	15.245	15.245
NOx	Gasoline	2004	30.811	15.245	15.245	15.245	15.245
NOx	Gasoline	2005	30.811	15.245	15.245	15.245	15.245
NOx	Gasoline	2006	30.811	15.245	15.245	15.245	15.245
NOx	Gasoline	2007	30.811	15.245	15.245	15.245	15.245
NOx	Gasoline	2008	15.600	4.573	4.573	4.573	4.573
NOx	Gasoline	2009	0.312	4.573	4.573	4.573	4.573
NOx	Gasoline	2010	0.312	4.573	4.573	4.573	4.573
NOx	Gasoline	2011	0.245	2.473	2.473	2.473	2.473
NOx	Gasoline	2012	0.245	2.473	2.473	2.473	2.473
NOx	Gasoline	2013	0.142	2.473	2.473	2.473	2.473
NOx	Gasoline	2014	0.142	2.473	2.473	2.473	2.473
NOx	Gasoline	2015	0.142	2.473	2.473	2.473	2.473
NOx	Gasoline	2016	0.142	2.473	2.473	2.473	2.473
NOx	Diesel	1987	194.959	192.468	192.468	192.467	192.467
NOx	Diesel	1988	201.627	192.468	192.468	192.468	192.468
NOx	Diesel	1989	211.755	192.468	192.468	192.467	192.468
NOx	Diesel	1990	243.086	148.641	148.642	148.641	148.642
NOx	Diesel	1991	220.435	139.753	139.753	139.753	139.753
NOx	Diesel	1992	225.612	139.753	139.754	139.754	139.753
NOx	Diesel	1993	228.977	139.753	139.753	139.754	139.753
NOx	Diesel	1994	230.401	139.754	139.754	139.754	139.753

Pollutant	Fuel	Model Yr	Class 2b	Class 3	Class 4-5	Class 6-7	Class 8a/b
NOx	Diesel	1995	234.800	139.753	139.753	139.753	139.753
NOx	Diesel	1996	237.854	139.753	139.754	139.753	139.753
NOx	Diesel	1997	240.907	139.753	139.753	139.753	139.753
NOx	Diesel	1998	194.878	117.349	117.349	117.349	117.349
NOx	Diesel	1999	195.914	96.535	96.535	96.535	154.804
NOx	Diesel	2000	195.914	96.535	96.535	96.535	154.804
NOx	Diesel	2001	195.914	96.535	96.535	96.535	154.804
NOx	Diesel	2002	195.914	96.535	96.535	96.535	154.804
NOx	Diesel	2003	44.534	45.811	45.811	45.811	56.945
NOx	Diesel	2004	45.005	45.811	45.811	45.811	56.945
NOx	Diesel	2005	45.005	45.811	45.811	45.811	56.945
NOx	Diesel	2006	45.005	45.811	45.811	45.811	56.945
NOx	Diesel	2007	41.620	22.780	22.780	22.780	53.190
NOx	Diesel	2008	41.620	22.780	22.780	22.780	53.190
NOx	Diesel	2009	41.837	22.780	22.780	22.780	53.190
NOx	Diesel	2010	17.765	7.212	8.088	8.088	10.054
NOx	Diesel	2011	17.765	7.212	8.088	7.498	10.054
NOx	Diesel	2012	17.765	7.212	8.088	7.498	10.054
NOx	Diesel	2013	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2014	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2015	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2016	11.566	4.564	4.564	4.777	6.489
PM_{10}	Gasoline	1987	0.361	0.361	0.361	0.361	0.361
PM_{10}	Gasoline	1988	1.118	1.118	1.118	1.118	1.118
PM_{10}	Gasoline	1989	1.118	1.118	1.118	1.118	1.118
PM_{10}	Gasoline	1990	0.353	0.353	0.353	0.353	0.353
PM_{10}	Gasoline	1991	0.392	0.392	0.392	0.392	0.392
PM_{10}	Gasoline	1992	0.392	0.392	0.392	0.392	0.392
PM_{10}	Gasoline	1993	0.392	0.392	0.392	0.392	0.392
PM_{10}	Gasoline	1994	0.128	0.128	0.128	0.128	0.128
PM_{10}	Gasoline	1995	0.153	0.153	0.153	0.153	0.153
PM_{10}	Gasoline	1996	0.356	0.356	0.356	0.356	0.356
PM_{10}	Gasoline	1997	0.283	0.283	0.283	0.283	0.283
PM_{10}	Gasoline	1998	0.169	0.169	0.169	0.169	0.169
PM_{10}	Gasoline	1999	0.082	0.082	0.082	0.082	0.082
PM_{10}	Gasoline	2000	0.036	0.036	0.036	0.036	0.036
PM_{10}	Gasoline	2001	0.030	0.030	0.030	0.030	0.030
PM_{10}	Gasoline	2002	0.096	0.096	0.096	0.096	0.096
PM_{10}	Gasoline	2003	0.056	0.056	0.056	0.056	0.056
PM_{10}	Gasoline	2004	0.058	0.058	0.058	0.058	0.058

Pollutant	Fuel	Model Yr	Class 2b	Class 3	Class 4-5	Class 6-7	Class 8a/b
PM_{10}	Gasoline	2005	0.058	0.058	0.058	0.058	0.058
PM_{10}	Gasoline	2006	0.058	0.058	0.058	0.058	0.058
PM_{10}	Gasoline	2007	0.047	0.047	0.047	0.047	0.047
PM_{10}	Gasoline	2008	0.047	0.047	0.047	0.047	0.047
PM_{10}	Gasoline	2009	0.042	0.042	0.042	0.042	0.042
PM_{10}	Gasoline	2010	0.042	0.042	0.042	0.042	0.042
PM_{10}	Gasoline	2011	0.038	0.038	0.038	0.038	0.038
PM_{10}	Gasoline	2012	0.038	0.038	0.038	0.038	0.038
PM_{10}	Gasoline	2013	0.024	0.024	0.024	0.024	0.024
PM_{10}	Gasoline	2014	0.024	0.024	0.024	0.024	0.024
PM_{10}	Gasoline	2015	0.024	0.024	0.024	0.024	0.024
PM_{10}	Gasoline	2016	0.024	0.024	0.024	0.024	0.024
PM_{10}	Diesel	1987	4.314	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1988	4.314	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1989	4.314	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1990	4.314	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1991	3.801	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1992	3.801	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1993	3.801	4.314	4.314	4.314	4.291
PM_{10}	Diesel	1994	7.981	7.459	7.459	7.459	6.560
PM_{10}	Diesel	1995	7.981	7.459	7.459	7.459	6.560
PM_{10}	Diesel	1996	7.981	7.459	7.459	7.459	6.560
PM_{10}	Diesel	1997	7.981	7.459	7.459	7.459	6.560
PM_{10}	Diesel	1998	7.506	7.082	7.082	7.082	6.274
PM_{10}	Diesel	1999	7.507	7.082	7.082	7.082	6.274
PM_{10}	Diesel	2000	7.506	7.082	7.082	7.082	6.274
PM_{10}	Diesel	2001	7.506	7.082	7.082	7.082	6.274
PM_{10}	Diesel	2002	7.506	7.082	7.082	7.082	6.274
PM_{10}	Diesel	2003	6.385	6.385	6.385	6.385	5.670
PM_{10}	Diesel	2004	6.385	6.385	6.385	6.385	5.670
PM_{10}	Diesel	2005	6.385	6.385	6.385	6.385	5.670
PM_{10}	Diesel	2006	6.385	6.385	6.385	6.385	5.670
PM_{10}	Diesel	2007	0.552	0.229	0.229	0.229	0.229
PM_{10}	Diesel	2008	0.552	0.229	0.229	0.229	0.229
PM_{10}	Diesel	2009	0.552	0.229	0.229	0.229	0.229
PM_{10}	Diesel	2010	0.461	0.191	0.216	0.216	0.216
PM_{10}	Diesel	2011	0.461	0.191	0.216	0.200	0.216
PM_{10}	Diesel	2012	0.461	0.191	0.216	0.200	0.216
PM_{10}	Diesel	2013	0.276	0.115	0.115	0.120	0.134
PM_{10}	Diesel	2014	0.276	0.115	0.115	0.120	0.134

Pollutant	Fuel	Model Yr	Class 2b	Class 3	Class 4-5	Class 6-7	Class 8a/b
PM_{10}	Diesel	2015	0.276	0.115	0.115	0.120	0.134
PM_{10}	Diesel	2016	0.276	0.115	0.115	0.120	0.134

Extended Idle Emission Factors – Class 8b Diesels Only

Engine Model Yr	NOx g/hr	PM_{10} g/hr	$PM_{2.5}$ g/hr
1987	119.147	5.013	4.612
1988	119.599	5.014	4.613
1989	117.933	5.011	4.610
1990	113.640	5.002	4.602
1991	240.242	5.012	4.611
1992	240.636	5.013	4.612
1993	233.769	5.006	4.605
1994	239.541	7.697	7.081
1995	239.103	7.700	7.084
1996	237.158	7.712	7.095
1997	239.506	7.697	7.081
1998	237.408	7.371	6.781
1999	241.362	7.349	6.761
2000	241.989	7.345	6.757
2001	239.294	7.360	6.771
2002	237.723	7.369	6.780
2003	239.341	6.651	6.119
2004	237.077	6.662	6.129
2005	238.326	6.656	6.123
2006	239.046	6.652	6.120
2007	210.121	0.418	0.385
2008	208.658	0.418	0.384
2009	211.705	0.419	0.385
2010	211.265	0.417	0.383
2011	210.133	0.416	0.383
2012	210.133	0.416	0.383
2013	210.132	0.413	0.380
2014	210.133	0.413	0.380
2015	210.132	0.413	0.380
2016	210.132	0.413	0.380

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

From Argonne GREET Model Version 1 2011.

http://greet.es.anl.gov/

1. Electric Generation Mix (From Annual Energy Outlook 2010)

	U.S. Mix
Residual oil	1.0%
Natural gas	22.9%
Coal	46.4%
Nuclear power	20.3%
Biomass	0.2%
Others	9.2%

Biomass Type assumed = 100% forest residue
Others = Hydro, Wind, Geothermal, Solar PV etc.

2. Electric Transmission and Distribution Loss = 8.0%

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

	GREET-Calculated Emission Factors By Fuel-Type Plants (Stationary and Transportation)						
	Oil-Fired	NG-Fired	Coal-Fired	Biomass-Fired: Woody	Biomass-Fired: Herbaceous	Biomass-Fired: Forest Residue	TOTAL based on US Mix
NOx	0.833	0.578	1.058	1.169	1.169	1.169	0.634
PM10	0.157	0.023	0.100	0.135	0.135	0.135	0.054
PM2.5	0.118	0.023	0.050	0.067	0.067	0.067	0.030
CO2	834	505	1,083	1,086	1,016	1,379	627
CO2 in burnt biomass from atmosphere				-1,086	-1,016	-1,379	

Assumes no emissions from nuclear power plants or "Others"

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)

	Total delivered based on US electric generation mix
NOx	0.690
PM10	0.058
PM2.5	0.033
CO2	682

Appendix D
Cargo Volume Literature Review Summary

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
2b	Full Size Pick-up	Pick-up		Chevy	Silverado 2500HD		Cu. Ft	3,644	9,200		http://www.chevrolet.com/vehicles/2010/silverado2500hd/features.do
2b	Full Size Pick-up	Pick-up		Ford	F250		Cu. Ft	2,900	9,400		http://www.fordf150.net/specs/05sd_specs.pdf
2b	Step Van	Budget Cargo Van	step/walk-in	Ford		309	Cu. Ft	3,116	8,600		http://www.budgettruck.com/Moving-Trucks.aspx
2b	Step Van	Step Van	step/walk-in	Freightliner-Sprinter	2500 Standard Roof	318	Cu. Ft	3,469	8,550		http://www.freightlinersprinterusa.com/vehicles/cargo-van/models/specifications.php
2b	Utility Van	Utility/ cargo van	van (basic enclosed)	Ford	E350	237	Cu. Ft	4,239	9,500		http://www.motortrend.com/cars/2008/ford/e_350/specifications/index.html
2b	Utility Van	Uhaul 10' Truck	van (basic enclosed)	GMC		402	Cu. Ft	2,810	8,600		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
2b	Utility Van	Budget 10' Moving Truck	van (basic enclosed)			380	Cu. Ft	3,100	8,600		http://www.budgettruck.com/Moving-Trucks.aspx
2b	Stake Truck	Stake/ platform	flatbed/stake/ platform	Supreme		336	Cu. Ft				
3	Pickup	Pick-up		GMC	Sierra 3500		Cu. Ft	4,566	10,700		http://www.gmc.com/sierra/3500/specsStandard.jsp
3	Step Van	Step Van	step/walk-in	Freightliner-Sprinter	3500 Standard Roof	547	Cu. Ft	4,845	11,030		http://www.freightlinersprinterusa.com/vehicles/cargo-van/models/3500-high-roof-170-wb-6-specs.php
3	Conventional Van	Penske 12' Cargo Van	van (basic enclosed)			450	Cu. Ft	2,600			http://www.pensketruckrental.com/commercial-truck-rentals/moving-vans/12-ft.html
3	City Delivery	Budget 16' Moving Truck				800	Cu. Ft	3,400	11,500		http://www.budgettruck.com/Moving-Trucks.aspx
4	Conventional Van	Uhaul 14' Truck		Ford		733	Cu. Ft	6,190	14,050		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
4	Conventional	Uhaul 17'		Ford		865	Cu. Ft	5,930	14,050		http://www.uhaul.com/Reservations/Eq

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
	l Van	Truck									uipmentDetail.aspx?model=EL
4	Conventional Van	Penske 16' Economy Van				826	Cu. Ft	4,300	15,000		http://www.pensketruckrental.com/commercial-truck-rentals/moving-cargo-vans/16-ft.html
4	City Delivery	Penske 16' Cargo Van				1,536	Cu. Ft	5,100			http://www.pensketruckrental.com/commercial-truck-rentals/moving-cargo-vans/16-ft.html
4	Large Walk-In	Walk-in			W700 Step Van	700	Cu. Ft	5,720	16,000		http://files.harc.edu/Projects/Transportation/FedExReportTask3.pdf
4	Large Walk-In	Walk-in		Eaton Hybrid	W700 Step Van	700	Cu. Ft	5,390	16,000		http://files.harc.edu/Projects/Transportation/FedExReportTask3.pdf
4	UPS	Walk-in		Grumman							http://www.grummanolson.com/index2.htm
4	Stake Truck	Stake/platform	flatbed/stake/platform	GMC	W4500	448	Cu. Ft		14,500		http://www.usedtrucksdepot.com/browse_listdetails.php?manf=GMC&scate=Stake+Truck&catname=Medium+Duty+Trucks&main_id=208
5	Bucket Truck	Bucket truck					Cu. Ft				
5	City Delivery	Uhaul 24' Truck	van (basic enclosed)			1,418	Cu. Ft	6,500	18,000		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
5	City Delivery	Uhaul 26' Truck	van (basic enclosed)			1,611	Cu. Ft	7,400	18,000		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
5	Large Walk-In	Large Walk-in	step/walk-in			670	Cu. Ft		16,000		http://news.van.fedex.com/node/7379
6	Beverage	Beverage		Hackney	6-Bay 52" Performer	588/case capacity = 531 @ 120z cans	Cu. Ft/cases cans	11,601	21,150		http://www.hackneybeverage.com/bodycad5.htm
6	Single Axle Van	Budget 24' Truck	van (basic enclosed)			1,380	Cu. Ft	12,000	25,500		http://www.budgettruck.com/Moving-Trucks.aspx
6	Stake Truck	24' Stake Truck	flatbed/stake/platform	International/ Supreme	24'	672	Cu. Ft		25,900		http://www.usedtrucks.ryder.com/Vehicle/VehicleSearch.aspx?VehicleTypeId=1&VehicleGroupId=5

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
6	Refrigerated /Reefer	24' Kold King Refrigerated	reefer	Supreme	24'	1,521	Cu. Ft				http://www.silvercrowncoach.com/supreme.php?page=product&body=refrigerated&product=21&section=specs
6	Landscape Van	Vanscaper Landscape Van	step/walk-in	Supreme	22'	1,496	Cu. Ft			Note: typical step/walk-ins do not reach this size. This is a speciality vehicle	http://www.silvercrowncoach.com/supreme.php?page=product&body=landscaping&product=30
7	Refuse	Refuse Truck					Cu. Ft				
7	Furniture	Furniture Truck				2,013	Cu. Ft				http://www.hendersonrentals.co.nz/?t=38
7	Beverage	Beverage (delivery body)		Hackney	Hackney 10-Bay-48" Aluminum	1251/ case capacity = 1,100 12 oz cans	Cu. Ft/case cans	23,700	37,733		http://hackneyusa.com/
7	Stake Truck	flatbed/stake/platform	flatbed/stake/platform	Supreme	SH20096	728			33,000		http://www.usedtrucks.ryder.com/Vehicle/VehicleSearch.aspx?VehicleTypeId=1&VehicleGroupId=5
7	Refrigerated /Reefer	28' Kold King Refrigerated	reefer	Supreme	28'	1,774	Cu. Ft				http://www.silvercrowncoach.com/supreme.php?page=product&body=refrigerated&product=21&section=specs
7	Tanker Truck	tank (fluid)	tank (fluid)	Ford	F750 XL	267	Cu. Ft	2,000-4000 GAL	26,000		http://www.truckingauctions.com/browse_listdetails.php?scate=Water%20Tank%20Truck&manf=GMC&catname=Heavy%20Duty%20Trucks
7	Single Axle Van	Freightliner Truck	van (basic enclosed)	Freightliner Business Class (24')	Business Class M2 112	1,552			33,000	Note: front axle lbs 12,000/rear axle 21,000	http://www.truckpaper.com/listingsdetail/detail.aspx?OHID=2379362

Clas s	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
										lbs (each add'l axle approx 12,000 lbs)	

Appendix E
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[42]. 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*[43] 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[44]. 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

[42] 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.
[43] FordF150.net. *F-250/F-350/F-450/F-550 Specifications.* Retrieved from http://www.fordf150.net/specs/05sd_specs.pdf
[44] Kenworth. *Kenworth T170/T270/T370 Body Builders Manual*. Retrieved from http://www.kenworth.com/brochures/2009_Hybrid_Body_Builders_Manual.pdf

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 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 exactly 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[45]. 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

[45] 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.

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.

The final input to the PERE model was the driving cycle. In order 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 E-1.

Table E-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 in order 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.