Draft MOVES2009 Highway Vehicle Population and Activity Data

United States
Environmental Protection
Agency

Draft MOVES2009 Highway Vehicle Population and Activity Data

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

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1. Introduction

The Environmental Protection Agency's MOVES (Motor Vehicle Emission Simulator) is a new set of modeling tools for estimating emissions produced by on-road (cars, trucks, motorcycles, etc.) and nonroad (backhoes, lawnmowers, etc) mobile sources. This report partially documents the Draft MOVES2009 version, released in April 2009. Draft MOVES2009 estimates greenhouse gases (GHG), criteria pollutants and selected air toxics from highway vehicles. When finalized, MOVES2009 will serve as a replacment for MOBILE6.2

The primary vehicle classification in MOVES is "SourceType." (Also sometimes called "SourceUseType").The MOVES SourceTypes are listed in Table 1-1, along with the associated DOT Highway Performance Monitoring System (HPMS) vehicle classes.

To estimate emissions accurately, we must use accurate estimates of vehicle populations and activity. This paper documents the sources and calculations used to produce the default population and activity data in the DRAFT MOVES2009 database used to compute national level emissions.[a] In particular, this paper will describe the data used to fill the tables and fields listed in Table 1-2.

Table 1-1. MOVES SourceTypes

SourceType ID	SourceType	HPMS Vehicle Class
11	Motorcycles	Motorcycles
21	Passenger Cars	Passenger Cars
31	Passenger Trucks (primarily personal use)	Other Two-Axle/Four Tire, Single Unit
32	Light Commercial Trucks (other use)	Other Two-Axle/Four Tire, Single Unit
41	Intercity Buses (non-school, non-transit)	Buses
42	Transit Buses	Buses
43	School Buses	Buses
51	Refuse Trucks	Single Unit
52	Single Unit Short-haul Trucks	Single Unit
53	Single Unit Long-haul Trucks	Single Unit
54	Motor Homes	Single Unit
61	Combination Short-haul Trucks	Combination
62	Combination Long-haul Trucks	Combination

"Long-haul" trucks are defined as trucks for which most trips are 200 miles or more.

[a] For many uses, local inputs are required. EPA is currently developing draft technical guidance to describe these requirements.

Table 1-2. MOVES Database Elements Covered in This Report

Database Table Name*	Fields
SourceTypeYear	sourceTypePopulation salesGrowthFactor migrationRate
SourceTypeModelYear	ACPenetrationFraction
SourceTypeAge	survivalRate relativeMAR functioningACFraction
SourceTypeAgeDistribution	ageFraction
SourceBinDistribution*	sourceBinActivityFraction
SourceUseType	rollingTerm rotatingTerm dragTerm sourceMass
RoadTypeDistribution	roadTypeVMTFraction
AvgSpeedDistribution	avgSpeedFraction
HPMSVtypeYear	HPMSBaseYearVMT baseYearOffNetVMT VMTGrowthFactor
MonthVMTFraction	monthVMTFraction
DayVMTFraction	dayVMTFraction
HourVMTFraction	hourVMTFraction
DriveSchedule	averageSpeed
DriveScheduleSecond	speed
DriveScheduleAssociation	sourceTypeID roadTypeID driveScheduleID isRamp
SourceTypeHour	idleSHOFactor
ZoneRoadType	SHOAllocFactor
Zone	idleAllocFactor startAllocFactor SHPAllocFactor
SCCVTypeDistribution	SCCVTypeFraction

MonthGroupHour	AC Activity Terms (A, B & C)
SampleVehicleDay	dayID sourceTypeID
SampleVehicleTrip	priorTripID keyontime keyOffTime
SampleVehiclePopulation	stmyFuelEngFraction stmyFraction

*See also Table 7-1, listing tables and fields used by the SourceBinGenerator.

2. Data Sources

A number of organizations collect data relevant to this report. The most important sources used to populate the vehicle population and activity portions of MOVES database are described here. These sources are referred to throughout this document by the abbreviated name given in this description, but the reference citation is only given here.

2.1. VIUS(and TIUS)

Until 2002, the U.S. Census Bureau conducted the Vehicle Inventory and Use Survey (VIUS)[1] to collect data on the physical characteristics and activity of U.S. trucks every five years. The survey is a sample of private and commercial trucks that were registered in the U.S. as of July of the survey year. The survey excludes automobiles, motorcycles, government-owed vehicles, ambulances, buses, motor homes and nonroad equipment. For MOVES, VIUS provides information to characterize trucks by SourceType and to estimate age distributions. Draft MOVES2009 uses data from both the 1997 and 2002[2] surveys. Before 1997, VIUS was known as TIUS (Truck Inventory and Use Survey). To populate the 1990 base year, we used data from the 1992 TIUS.[3].

Note that Census Bureau has discontinued the VIUS survey. We request comments on alternate data sources or approaches for determining truck populations in the future.

2.2. Polk NVPP® and TIP®

R.L. Polk & Co. is a private company providing automotive information services. The company maintains two databases relevant for MOVES: the National Vehicle Population Profile (NVPP®)[4] and the Trucking Industry Profile (TIP®Net) Vehicles in Operation database.[5] The first focuses on light-duty cars and trucks, the second focuses on medium and heavy-duty trucks. Both compile data from state vehicle registration lists. For Draft MOVES2009, EPA used the 1999 NVPP® and TIP®.

2.3. FHWA *Highway Statistics*

Each year the Federal Highway Administration's (FHWA) Office of Highway Policy Information publishes *Highway Statistics*. This volume summarizes a vast amount of roadway and vehicle data from the states and other sources. For MOVES, we will use data on vehicle registrations and vehicle miles traveled (VMT), summarized in four tables. [6] [7] [8] [9]. Hereafter, references will be to FHWA MV-1, MV-10, VM-1, and VM-2. For the 1999 base year, we used the 1999 statistics; for the 1990 base year, we used 1990 numbers.

2.4. FTA National Transit Database

The Federal Transit Administration (FTA) summarizes financial and operating data from U.S. mass transit agencies in the National Transit Database (NTD).[10] For Draft MOVES2009, we used 1999 data from the report, "Age Distribution of Active Revenue Vehicle Inventory: Details by Transit Agency."

2.5. School Bus Fleet Fact Book

The School Bus Fleet 1999 Fact Book includes estimates, by state, of number of school buses and total miles traveled.[11] The Fact Book is published by Bobit Publications.

2.6. MOBILE6

In some cases, we have been able to use data from MOBILE6 with only minor adaptation. The MOBILE6 data is documented in technical reports, particularly M6.FLT.002 "Update of Fleet Characterization Data for Use in MOBILE6 - Final Report."[12] Additional MOBILE6 documentation is available on the web at http://www.epa.gov/otaq/m6.htm

2.7. Annual Energy Outlook & National Energy Modeling System

The Annual Energy Outlook (AEO) [13,14] describes Department of Energy forecasts for future energy consumption. The National Energy Modeling System (NEMS) is used to generate these projections based on economic and demographic projections. For Draft MOVES2009 we used *AEO2006* to forecast VMT growth and vehicle sales growth. For the final MOVES2009, we propose updating these results with more recent forecasts.

2.8. Transportation Energy Data Book

Each year, Oak Ridge National Laboratory produces the DOE Transportation Energy Data Book (TEDB). This book summarizes transportation and energy data from a variety of sources. For MOVES2004, we relied on Edition 22, published in September 2002[15] and Edition 23, published in October 2003.[16] For Draft MOVES2009 we updated sales growth based on Edition 27, published in 2008.[17] and updated 1990 values using Edition 13, published in 1993.

2.9. Oak Ridge National Laboratory Light-duty Vehicle Database

Oak Ridge National Laboratory Center for Transportation Analysis has compiled a database of light-duty vehicle information which combines EPA Test vehicle data and Ward's Automotive Inc. data spanning 1976 – 2001.[18] We used this database to determine weight distributions for light trucks by model year.

3. SourceTypeYear

The SourceTypeYear table stores three data fields—**SourceTypePopulation, SalesGrowthFactor**, and **Migration Rate**. Each field is described below in terms of what information it contains, the sources of the data used for the field, and, when applicable, certain data points used in determining the field parameters.

3.1. 1999 SourceTypePopulation

The SourceTypePopulation field stores the total population of vehicles by SourceType for a given base year and domain. For Draft MOVES2009, this is the entire United States in 1999. An additional base year is 1990. Some of the values are taken directly from the indicated sources; other values needed to be derived from the available data.

SourceTypePopulation provides base year populations and provides the basis for Total Activity Generator calculation of populations in calendar years after the base year. These populations are, in turn, used to generate travel fractions by age and SourceType and to allow allocation of VMT by age.

The primary sources for calendar year 1999 vehicle population data are the FHWA *Highway Statistics* Tables MV-1 and MV-10 and the Polk NVPP® and TIP® databases. The Transportation Energy Data Book (TEDB) explains three factors that account for differences between the two sources:

1. Polk data includes only vehicles that were registered on July 1 of 1999. FHWA data includes all vehicles that have been registered at any time throughout the year and thus may include vehicles that were retired during the year or may double count vehicles registered in two or more states.
2. Polk and FHWA may differ in how they classify some minivans and SUVs as trucks or automobiles. (This difference is less important since 1990).
3. FHWA includes all non-military Federal vehicles. Polk data includes only those Federal vehicles that are registered within a state.

Also, FHWA data is available for Puerto Rico, but Puerto Rico does not appear to be included in our Polk data set. MOVES will cover Puerto Rico and the Virgin Islands. In addition, Polk collects data on Gross Vehicle Weight (GVW) class 3 vehicles in both the NVPP® and TIP® databases, but the values are not the same. Polk staff recommended using the TIP® values.[19] Finally, our 1999 Polk data set includes school buses and motor homes (which can be counted separately), but does not include "non-school buses."

Motorcycle population estimates were available from both FHWA registration data and from the Motorcycle Industry Council. The MIC estimate is based on 1998 sales estimates, adjusted to subtract noped sales (nopeds are similar to mopeds, but lack pedals) and to account for scrappage.

The Department of Transportation's National Household Transportation Survey (NHTS) combines the previous National Personal Transportation Survey and the American Travel Survey to collect data on personal travel patterns and includes data on motorcycles, personal trucks and automobiles.[20] Data from the 2001 survey is included in Table 3-1, but is not used in MOVES because it is two years newer than the FHWA and Polk data, and it excludes non-household vehicles. Values from the five data sources are compared in Table 3-1.

Table 3-1. Vehicle Population Comparisons 1999

Data Source	Motorcycles	Automobiles	Trucks (total)	Buses (total)	Motor Homes
FHWA MV-1 (w Puerto Rico and publically ownedvehicles)	4,173,869	134,480,432	83,178,092	732,189	na
FHWA MV-10 (w/o Puerto Rico and publically owned vehicles)		131,076,551	81,060,369		
Polk NVPP® & TIP®	na	126,868,744	80,323,528*	na	902,949
NHTS (2001)	4,951,747	115,914,908	80,499,939		1,446,469
MIC (1998)[21]	4,605,439				

*Excluding motor homes and NVPP® GVW3 trucks.

For automobiles and trucks, it is possible to do a direct comparison of Polk and FHWA data. To estimate the MOVES population, we adjust the FHWA data to account for double-counting by multiplying the total FHWA population by the ratio of the Polk population to the FHWA population without public vehicles and Puerto Rican vehicles.

$$\text{Adjusted Population} = \text{FHWA}_{\text{w public \& PR}} * (\text{Polk}/\text{FHWA}_{\text{w/o public \& PR}})$$

This leads to the values in Table 3-2.[b]

Table 3-2. Adjusted Vehicle Populations

	Population (Draft MOVES2009)	Population (proposed for final MOVES2009)
Automobiles	130,163,354	130,163,354
Trucks (total)	83,348,540	83,007,993

For MOVES, total trucks are sub-classified into seven SourceTypes. The proportion of total trucks in each subtype was estimated using VIUS responses for Axle Arrangement, Primary Area of Operation, Body Type and Major Use as detailed in Table 3-3a and Table 3.3b.

With these definitions and with vehicles that lack AREAOP codes assigned proportionally to the corresponding SourceTypes, we computed the distributions in Table 3-4.

[b] There was an error in the calculation of the value for total trucks used in Draft MOVES2009. We plan to correct this error in the final version of MOVES2009 as indicated here.

These distributions were multiplied by the total truck population from Table 3-2 to derive population values for MOVES.

Table 3-3a. VIUS 1997 Codes Used for Distinguishing Truck SourceTypes.

SourceType	Axle Arrangement	Primary Area of Operation	Body Type	Major Use
Passenger Trucks	2 axle/4 tire (AXLRE= 1,5,6,7)	any	any	personal transportation (MAJUSE=20)
Light Commercial Trucks	2 axle/4 tire (AXLRE= 1,5,6,7)	any	any	any but personal transportation
Refuse Trucks	Single Unit (AXLRE = 2-4, 8-16)	off-road, local or short-range (AREAOP <=4)	garbage hauler (BODTYP=30)	Any
Single Unit Short-haul Trucks	Single Unit (AXLRE = 2-4, 8-16)	off-road, local or short-range (AREAOP <=4)	any except garbage hauler	Any
Single Unit Long-haul Trucks	Single Unit (AXLRE = 2-4, 8-16)	long-range (AREAOP >=5)	any	Any
Combination Short-haul Trucks	Combination (AXLRE >=17)	off-road, local or medium (AREAOP <=4)	any	Any
Combination Long-haul Trucks	Combination (AXLRE >=17)	long-range (AREAOP >=5)	any	Any

Table 3-3b. VIUS 2002 Codes Used for Distinguishing Truck SourceTypes.

SourceType	Axle Arrangement	Primary Area of Operation	Body Type	Operator Classification
Passenger Trucks	axle_config in (1,6,7,8)	any	any	opclass=5
Light Commerical Trucks	axle_config in (1,6,7,8)	any	any	opclass<>5
Refuse Trucks	axle_config in (2,3,4,5,9,10,11,12,13,14,15,16,17,18,19,20)	trip_primary in (1,2,3,4)	bodytype=21	any
Single Unit Short-Haul Trucks	axle_config in (2,3,4,5,9,10,11,12,13,14,15,16,17,18,19,20)	trip_primary in (1,2,3,4)	Any except bodytype=21	any
Single Unit Long-Haul Trucks	axle_config in (2,3,4,5,9,10,11,12,13,14,15,16,17,18,19,20)	trip_primary in (5,6) Long Range	any	any
Combination Short-Haul Trucks	axle_config>=21	trip_primary in (1,2,3,4)	sample_strata=5 Combination Trucks	any
Combination Long_Haul Trucks	axle_config>=21	trip_primary in (5,6) Long Range	sample_strata=5 Combination Trucks	any

Table 3-4. 1999 Truck SourceType Distribution and Populations

SourceType	Percent	Population (Draft MOVES2009)	Population (final MOVES2009)
Passenger Trucks	68.90%	57,424,819	57,190,192
Light Commercial Trucks	23.02%	19,184,642	19,106,257
Refuse Trucks	0.11%	88,970	88,607
Single Unit Short-haul Trucks	5.39%	4,489,140	4,470,798
Single Unit Long-haul Trucks	0.32%	265,520	264,435
Combination Short-haul Trucks	1.31%	1,088,815	1,084,366
Combination Long-haul Trucks	.97%	806,633	803,337
Total	100.00%	83,348,540	83,007,993

For buses, we needed to distribute the total buses from FHWA to the three MOVES classes. Additional information on bus numbers was available from the FTA NTD, Polk TIP®, and the School Bus Fleet Fact Book, and the American Bus Association "Motorcoach Census 2000".[22] The FTA NTD provides population numbers for a variety of transit options. To determine the number of transit buses, we summed their counts for Articulated Motor Buses, Motor Bus Class A, B & C, and Double Decked buses.

Table 3-5. 1999 Bus Population Comparisons

Data Source	Total Buses	Intercity Buses	Transit Buses	School Buses
FHWA MV-1	732,189			
FHWA MV-10 (excludes PR)	728,777			592,029*
FTA NTD			55,706	
APTA[23] ***			75,087	
Polk TIP®				460,178
School Bus Fleet Fact Book				429,086
Motorcoach Census**		44,200		

* Includes some church & industrial buses.
** Includes Canada.
*** Includes trolleybuses.

As Table 3-5 shows, estimates of bus populations vary. We chose to use the FHWA value because it includes church and industrial buses that we believe have activity patterns more similar to school buses than to intercity buses. To calculate the number of buses for the categories needed for MOVES, we used the FHWA school bus value and the FTA transit bus value. We assigned the remaining total FHWA buses (732,189-592,029-55,706 = 84,454) to the intercity category. Note this value substantially exceeds the estimate of intercity buses provided by the Motorcoach Census. We request comment on ways to improve our national bus population estimates.

For motorcycles we used the 1999 FHWA value from table MV-1. For comparison, Table 3-1 also shows the 1998 population as estimated by the Motorcycle Industry Council based on sales and estimated scrappage rates, and the 2001 population estimated by the 2001 NHTS. The FHWA population estimates are noticeably lower than the other estimates. If time and resources allow, EPA may investigate this further for future versions of the MOVES model.

For motor homes we used the population from the Polk TIP® database. In Table 3-1, this value is compared to the estimate from the 2001 NHTS. As for motorcycles, the FHWA registration count is noticeably lower than the household survey estimate. This could reflect population growth in the years between the estimates, or it may reflect difference in the way motor homes are defined in the two studies, or be an artifact of the method used to extrapolate from the NHTS sample to the national population estimate. If time and resources allow, EPA may investigate this further for future versions of the MOVES model.

Table 3-6 summarizes the 1999 vehicle populations used in Draft MOVES2009.

Table 3-6. 1999 SourceType Populations in Draft MOVES2009

SourceType ID	SourceType	1999 Population
11	Motorcycles	4,173,869
21	Passenger Cars	130,163,354
31	Passenger Trucks	57,424,800
32	Light Commercial Trucks	19,184,600
41	Intercity Buses	84,454
42	Transit Buses	55,706
43	School Buses	592,029
51	Refuse Trucks	88,607
52	Single Unit Short-haul Trucks	4,489,140
53	Single Unit Long-haul Trucks	265,520
54	Motor Homes	902,949
61	Combination Short-haul Trucks	1,088,820
62	Combination Long-haul Trucks	806,633

3.2. 1990 SourceTypePopulation

Because SIPs require estimates of 1990 emissions, the MOVES database includes a 1990 base year. The SourceTypePopulation inputs for 1990 were developed using methods and data similar to those used for 1999.

The primary sources for calendar year 1990 vehicle population data are the FHWA Highway Statistics Tables MV-200, VM- 201A, MV-10 and the Polk NVPP® databases. As in 1999, the FHWA and Polk data differ in how vehicles are counted. (See previous section.) Additionally, the 1990 Polk data does not include buses and motor homes. The National Personal Transportation Survey includes data on personal trucks, automobiles and motorcycles.

Data on motorcycles were also obtained from the Motorcycle Statistical Annual published by the Motorcycle Industry Council. Values from all four sources are compared in Table 3-1.

Registration data on vehicles registered in Puerto Rico for year 1990 was obtained from FHWA's Highway Statistics 1990.

Table 3-7. 1990 Vehicle Population Comparisons

Data Source	Motorcycles	Automobiles	Trucks (total)	Buses (total)	Motor Homes
FHWA(w/ Puerto Rico and Publicly owned vehicles)[1]	4,278,286	135,022,124	54,673,458	629,943	na
FHWA (w/o Puerto Rico and w/ Publicly owned vehicles)[2]	4,259,461	133,700,497	54,470,430	626,987	na
Polk NVPP®	na	123,276,600	56,023,000[3]	na	na
NPTS (1990)[4]	2,089,523	120,712,000	37,110,000	na	821,000
Motorcycle Industry Council[5]	4,310,000	na	na	na	na

[1] Data on Puerto Rico was obtained from Highway Statistics 1990, published by the FHWA.
[2] For these numbers, used data from FHWA Highway Statistics TableVM-201A, April 1997 and Table MV-200 (state motor vehicle registrations, by years 1990-1995).
[3] As published in TEDB edition 23. Does not include Puerto Rico and publicly –owned vehicles.
[4] 1990 NPTS special report on travel modes- Chapter3, the demography of the US Vehicle Fleet. The motorcycle number is calculated using the appendix table and the proportion of MCs from Table 20 of the 2001 NHTS Summary of Travel Trends.
[5] The Motorcycle number was obtained as a sum of on-highway and dual motorcycles for year 1990 as published in the 1999 Motorcycle Statistical Annual.

For MOVES, total trucks are sub-classified into seven SourceTypes. The proportion of total trucks in each subtype was estimated using TIUS92 responses for Axle Arrangement, Primary Area of Operation, Body Type and Major Use as detailed in Table 3-8.

With these definitions and with vehicles that lack AREAOP codes assigned proportionally to the corresponding SourceTypes, we computed the distributions in Table 3-9. These distributions were multiplied by the total truck population from Table 3-7 to derive population values for MOVES.

Table 3-8. TIUS92 Codes Used for Distinguishing Truck SourceTypes.

SourceType	Axle Arrangement	Primary Area of Operation	Body Type	Major Use
Passenger Trucks	2 axle/4 tire (AXLRE= 1,5,6,7)	any	Any	personal transportation (MAJUSE=20)
Light Commercial Trucks	2 axle/4 tire (AXLRE= 1,5,6,7)	any	Any	any but personal transportation
Refuse Trucks	Single Unit (AXLRE = 2-4, 8-16)	off-road, local or short-range (AREAOP <=4)	garbage hauler (BODTYP=30)	any
Single Unit Short-haul Trucks	Single Unit (AXLRE = 2-4, 8-16)	off-road, local or short-range (AREAOP <=4)	any except garbage hauler	any
Single Unit Long-haul Trucks	Single Unit (AXLRE = 2-4, 8-16)	long-range (AREAOP >=5)	any	any
Combination Short-haul Trucks	Combination (AXLRE >=17)	off-road, local or medium (AREAOP <=4)	Any	any
Combination Long-haul Trucks	Combination (AXLRE >=17)	long-range (AREAOP >=5)	Any	any

Table 3-9. 1990 Truck SourceType Distribution and Populations

SourceType	Percent	Population
Passenger Trucks	67.32%	37,713,840
Light Commercial Trucks	24.07%	13,483,198
Refuse Trucks	0.11%	59,037
Single Unit Short-haul Trucks	6.12%	3,426,459
Single Unit Long-haul Trucks	0.23%	128,776
Combination Short-haul Trucks	1.35%	758,091
Combination Long-haul Trucks	0.81%	453,599
Total	100.00%	56,023,000

For buses, we needed to distribute the total buses from FHWA to the three MOVES classes. Additional information on bus numbers was available from the American Public Transit Association (APTA) Fact Book, the School Bus Fleet Fact Book, and the Transportation Energy Data Book.

Table 3-10. 1990 Bus Population Comparisons

Data Source	Total Buses	Intercity Buses	Transit Buses	School Buses
FHWA (w/o PR and with Publicly-owned Vehicles)*	626,9871	20,6802		545,7223
FHWA (w/o PR and w/o Publicly-owned Vehicles)	275,4931			
APTA 1991 Transit Fact Book			60,585	
TEDB**		58,141	59,753	508,261
School Bus Fleet Fact Book***				391,714

* FHWA Highway Statistics, Summary to 1995, Table MV-200
** Transportation Energy Data Book : Edition 13, March 1993, Table 3.29. 1990 buses. "Intercity Buses" is sum of "Intercity Bus" and "Other;" "School Buses" includes other non-revenue buses.
*** Average of school years 1989-90 and 1990 -91, School Bus Fleet Fact Books 1990 and 1991.

Table 3-11 summarizes the 1990 vehicle populations used in Draft MOVES2009. For motor homes we used the only available data from NPTS. We used the TEDB data for buses. For trucks the TIUS data was used; the remaining values were based on FHWA data.

Table 3-11. 1990 SourceType Populations in Draft MOVES2009

SourceType ID	SourceType	1990 Population
11	Motorcycles	4,278,286
21	Passenger Cars	135,022,124
31	Passenger Trucks	37,713,840
32	Light Commercial Trucks	13,483,198
41	Intercity Buses	58,141
42	Transit Buses	59,753
43	School Buses	508,261
51	Refuse Trucks	59,037
52	Single Unit Short-haul Trucks	3,426,459
53	Single Unit Long-haul Trucks	128,776
54	Motor Homes	821,000
61	Combination Short-haul Trucks	758,091
62	Combination Long-haul Trucks	453,599

3.3. SalesGrowthFactor

The SalesGrowthFactor field stores a multiplicative factor indicating changes in sales by SourceType for calendar years after the base year. It determines the number of new vehicles added to the vehicle population each year, and is expressed relative to the previous year's sales. For example, "1" means no change from previous year sales levels, "1.02" means a two percent increase in sales, and "0.98" means a two percent decrease in sales. SalesGrowthFactor is used in the Total Activity Generator calculation of source type populations for calendar years after the base year-- in Draft MOVES2009, years 2000 through 2050.

Note that the sales growth factors are not used in the calculation of county-level or project level emissions, where users must input local vehicle populations for each year that is modeled. For MOVES2004, SalesGrowthFactor estimates were derived from actual sales data from TEDB23 (2003), whose primary source is Ward's Motor Vehicle Facts and Figures, and from sales projections from *AEO2004*. For Draft MOVES2009, the sales data for passenger cars and light trucks were updated to account for actual sales data and updated sales forecasts, but rates for the remaining sourcetypes were not changed. Beyond 2030, the SalesGrowthFactor was set to the 2030 value. For the final MOVES2009, we anticipate updating sales information, at least for the dominant sourcetypes.

The data sources and methodologies by source type are described below:

- Passenger Cars and Passenger Trucks: SalesGrowthFactors for calendar year 2000 through 2005 were derived from total sales numbers reported in the TEDB26 Table 4.5. Factors for calendar years 2006 through 2030 were derived from new car sales estimates presented in *AEO2006* Supplemental Table 45, generated by NEMS.
- Motorcycles: SalesGrowthFactors for calendar year 2000 and 2001 were computed from sales values in the Motorcycle Industry Council Statistical Annual.[24] SalesGrowthFactors for years 2006 through 2030 were set equal to passenger car growth factors.
- Commercial Trucks: SalesGrowthFactors for calendar year 2000 through 2005 were derived from total light truck sales numbers reported in the TEDB26 Table 4.6. Factors for Calendar year 2002 through 2030 differ from passenger trucks. It is possible that they were mistakenly retained from an earlier version of the model. We plan to investigate this further for the final MOVES2009. .
- Buses, Single Unit Trucks & Motor Homes: Calendar years 2000-2001 were based on sales as reported in TEDB23 Table 5.3 (gross weight range 10,000-33,000 lbs). Years 2004 through 2030 were calculated from medium-duty truck sales projections from *AEO200*6Supplemental Table 55.
- Combination Trucks, Refuse Trucks: Calendar years 2000-2001 were based on sales as reported in TEDB23 Table 5.3 (gross weight range 33,001 and greater pounds). Years 2004 through 2030 were calculated from heavy-duty truck sales projections found in *AEO2006* Supplemental Table 55.

The resulting SalesGrowthFactors by source type are shown in Table 3-12:

Table 3-12. SalesGrowthFactor by Calendar Year and Source Type

Calendar Year	Motorcycles	Passenger Cars	Passenger Trucks	Light Comm. Trucks	Buses, Single Unit Trucks & Motor Homes	Combination Trucks
2000	1.017	1.017	1.039	1.039	0.963	0.809
2001	0.952	0.952	1.037	1.037	0.850	0.660
2002	0.970	0.962	1.001	1.001	0.882	0.923
2003	1.015	0.939	1.026	1.026	1.067	1.042
2004	1.013	0.986	1.047	1.047	1.170	1.310
2005	1.039	1.021	0.991	0.991	1.082	1.130
2006	1.059	1.059	0.905	0.998	1.001	1.010
2007	0.997	0.997	1.059	1.047	1.001	0.940
2008	0.987	0.987	1.031	1.007	1.003	0.990
2009	0.985	0.985	1.043	1.039	1.026	1.000
2010	0.980	0.980	1.042	0.994	0.992	1.000
2011	1.005	1.005	1.016	1.015	0.997	0.990
2012	0.996	0.996	1.017	0.983	0.986	1.000
2013	0.991	0.991	1.011	0.996	1.000	1.010
2014	0.989	0.989	1.015	1.011	1.029	1.020
2015	0.994	0.994	1.008	1.019	1.035	1.020
2016	1.001	1.001	1.012	1.022	1.025	1.020
2017	1.002	1.002	1.017	1.016	1.015	1.020
2018	1.005	1.005	1.019	1.015	1.010	1.000
2019	1.004	1.004	1.015	1.009	0.995	0.980
2020	1.007	1.007	1.013	1.011	0.997	0.980
2021	1.007	1.007	1.018	1.012	1.006	1.000
2022	1.009	1.009	1.019	1.015	1.012	1.010
2023	1.009	1.009	1.021	1.015	1.015	1.010
2024	1.009	1.009	1.021	1.016	1.018	1.020
2025	1.008	1.008	1.020	1.015	1.018	1.020
2026	1.010	1.010	1.021	1.016	1.016	1.020
2027	1.008	1.008	1.020	1.015	1.012	1.010
2028	1.007	1.007	1.016	1.012	1.006	1.000
2029	1.008	1.008	1.018	1.014	1.010	1.010
2030+	1.008	1.008	1.017	1.013	1.013	1.010

3.3. MigrationRate

The MigrationRate field stores a yearly multiplicative factor used to estimate how many vehicles join or leave the population of a SourceType in the given domain in a given year. We expect this field may be useful when modeling emissions on relatively small geographic scale.

For the default MOVES database, the domain is the entire U.S. and we are using a simplifying assumption of no migration: that is, a migration rate of 1.

4. SourceTypeModelYear

SourceTypeModelYear stores the field **ACPenetrationFraction,** which is the fraction of vehicles equipped with air conditioning, by source type and model year. ACPenetrationRate is used in the calculation of the A/C adjustment.

Default values in Draft MOVES2009 were taken from MOBILE6. [25] Market penetration data by model year were gathered from Ward's Automotive Handbook for light-duty vehicles and light-duty trucks for model years 1972 through the 1995 for cars and 1975-1995 for light trucks. Rates in the first few years of available data are quite variable, so values for early model years were estimated by applying the 1972 and 1975 rates for cars and trucks, respectively. Projections beyond 1995 were developed by calculating the average yearly rate of increase in the last five years of data and applying this rate until a predetermined cap was reached. A cap of 98% was placed on cars and 95% on trucks under the assumption that there will always be vehicles sold without air conditioning, more likely on trucks than cars. For MOVES, the light-duty vehicle rates were applied to passenger cars, and the light-duty truck rates were applied to all other sourcetypes (except motorcycles, for which AC penetration is assumed to be zero).

Table 4.1. AC Penetration Fractions in Draft MOVES2009

	Motorcycles	Passenger Cars	All Trucks and Buses
1972-and-earlier	0	0.592	0.287
1973	0	0.726	0.287
1974	0	0.616	0.287
1975	0	0.631	0.287
1976	0	0.671	0.311
1977	0	0.720	0.351
1978	0	0.719	0.385
1979	0	0.694	0.366
1980	0	0.624	0.348
1981	0	0.667	0.390
1982	0	0.699	0.449
1983	0	0.737	0.464
1984	0	0.776	0.521
1985	0	0.796	0.532
1986	0	0.800	0.544
1987	0	0.755	0.588
1988	0	0.793	0.640
1989	0	0.762	0.719
1990	0	0.862	0.764
1991	0	0.869	0.771
1992	0	0.882	0.811
1993	0	0.897	0.837
1994	0	0.922	0.848
1995	0	0.934	0.882
1996	0	0.948	0.906
1997	0	0.963	0.929
1998	0	0.977	0.950
1999+	0	0.980	0.950

5. SourceTypeAge

Three fields comprise SourceTypeAge in Draft MOVES2009: **SurvivalRate, Relative MAR**, and **FunctioningACFraction**. Each one is described below, including data sources and some relevant data points used in the model.

5.1. SurvivalRate

The SurvivalRate field describes the fraction of vehicles of a given SourceType and Age) that remain on the road one year to the next. SurvivalRate is used in the Total Activity Generator in the calculation of source type populations by age in calendar years after the base year. In MOVES, a separate SurvivalRate is applied to each age in each SourceType fleet. These SurvivalRates in MOVES are used for all model years in a SourceType in all calendar years.

SurvivalRates for Motorcycles were calculated based on regression of data provided by the Motorcycle Industry Council (MIC).[26]

Survival rates for Passenger Cars, Passenger Trucks and Light Commercial Trucks came from NHTSA's survivability Table 3 and Table 4.[27] These survival rates are based on a detailed analysis of Polk vehicle registration data from 1977 to 2002. We modified these rates to fit them into the MOVES format:

- NHTSA rates for Light Trucks were used for both MOVES Passenger Trucks and MOVES Light Commercial Trucks.

- MOVES calculates emissions to age 30 for both cars and trucks, but NHSTA car rates were available only to age 25, so we extrapolated car rates to age 30 using the estimated survival rate equation in section 3.1 of the NHTSA report.

- According to the NHTSA methodology, NHTSA "age= 1" corresponds to MOVES "ageid =2," so the survival fractions were shifted accordingly.

- Because MOVES requires survival rates for MOVES ages < 2, the survival rates for age 0 and age 1 were interpolated using a linear interpolation and assuming that the survival rate prior to age 0 is 1.

- NHTSA defines survival rate as the ratio of the number of vehicles remaining in the fleet at a given year as compared to a base-line year. MOVES calculations require a value that is the ratio of a given year to the previous year, so we transformed the NHTSA rates to MOVES rates using this ratio.

- Because MOVES ageid= 30 is intended to represent all ages 30-and-greater, the survival rate for ageid=30 was set to 0.3.

- Quantitatively the formula used to derive the MOVES Survival rates was:

MOVES Survival Rate (ageid =0) = 1 - (1-NHTSA Survival Rate (age =2)/3)
MOVES Survival Rate (ageid =1) = 1 - (1- 2* NHTSA Survival Rate (age =2)/3)

MOVES Survival Rate (age = 2 through 29) =
NHTSA Survival Rate (age = n-1)/ NHTSA Survival Rate (age = n-2)
MOVES Survival Rate (age = 30) = 0.3

The data for all other SourceTypes came from the Transportation Energy Data Book (TEDB22, unchanged for version 23). We used the Heavy-Duty rates for the 1980 model year (TEDB22, Table 6.11, same as TEDB26 Table 3.10). The 1990 model year rates were not used because they were significantly higher than the other model years in the analysis (e.g. 45 percent survival rate for 30 year-old trucks), and seemed unrealistically high. While limited data exists to confirm this judgment, a snapshot of 5-year survival rates can be derived from VIUS 1992 and 1997 results for comparison. According to VIUS, the average survival rate for model years 1988-1991 between the 1992 and 1997 surveys was 88 percent. The comparable survival rate for 1990 model year Heavy-Duty vehicles from TEDB was 96 percent, while the rate for 1980 model year trucks was 91 percent. This comparison lends credence to the decision that the 1980 model year survival rates are more in line with available data.

TEDB22 does not include scrappage rates for GVWR 10,000-26,000 vehicles, so it was necessary to apply the Heavy-Duty rates to predominantly Medium-Duty use types.

The TEDB survival rates were transformed into MOVES format in the same way as the NHTSA rates. Survival rates for all "age 30" sourcetypes[c] were set to 0.3. This is assumed to be the fraction of all vehicles 30-and-older that survive an additional year.

SurvivalRates used in Draft MOVES2009 are shown in Table 5-1.

[c]Except motorcycles. See note below Table 5-1.

Table 5-1. SurvivalRate by Age and SourceType

Age	Motorcycles	Passenger Cars	Passenger Trucks Light Comm. Trucks	All Other SourceTypes
0	0.990	0.997	0.991	1.000
1	0.990	0.997	0.991	1.000
2	0.980	0.997	0.991	1.000
3	0.970	0.993	0.986	1.000
4	0.960	0.990	0.981	0.990
5	0.960	0.986	0.976	0.980
6	0.950	0.981	0.970	0.980
7	0.940	0.976	0.964	0.970
8	0.930	0.971	0.958	0.970
9	0.920	0.965	0.952	0.970
10	0.920	0.959	0.946	0.960
11	0.910	0.953	0.940	0.960
12	0.900	0.912	0.935	0.950
13	0.890	0.854	0.929	0.950
14	0.890	0.832	0.913	0.950
15	0.880	0.813	0.908	0.940
16	0.870	0.799	0.903	0.940
17	0.860	0.787	0.898	0.930
18	0.850	0.779	0.894	0.930
19	0.850	0.772	0.891	0.920
20	0.840	0.767	0.888	0.920
21	0.830	0.763	0.885	0.920
22	0.820	0.760	0.883	0.910
23	0.820	0.757	0.880	0.910
24	0.810	0.757	0.879	0.910
25	0.800	0.754	0.877	0.900
26	0.790	0.754	0.875	0.900
27	0.780	0.567	0.875	0.900
28	0.780	0.752	0.873	0.890
29	0.770	0.752	0.872	0.890
30	0.760*	0.300	0.300	0.300

* In draft MOVES2009, we neglected to set the age 30 motorcycle survival rate to 0.30. We plan to fix this in the final MOVES2009.

We request comment on the survival rates used in MOVES and the possibility of updating them.

5.2. Relative MAR

The Relative Mileage Accumulation Rate (Relative MAR) is listed for each MOVES SourceType and Age. The Relative MAR is computed as the annual MAR divided by the highest MAR within the HPMS vehicle class. This allows MOVES to maintain a constant MAR ratio between ages and between the sourcetypes that make up each HPMS vehicle type even as vehicle populations and the total VMT for an HPMS vehicle class changes over time. Table 1-2 (previous) lists the groupings of the MOVES SourceTypes within the six HPMS Vehicle Classes. The following discussion refers to the Source Type ID numbers found in this table.

For many SourceTypes, the annual MARs were derived from the MARs developed for MOBILE6. These were mapped from the MOBILE6 Vehicle Classes to the MOVES

SourceTypes. We then used regression to smooth these initial MARs and to extend the MARs from 25 to 30 ages.

5.2.1. Motorcycles

The MARs for motorcycles (category 11) were set to equal those in MOBILE6.

5.2.2. Passenger Cars, Passenger Trucks and Light Commerical Trucks

The MARs for passenger cars, passenger trucks and light commercial trucks (categories 21, 31 & 32) were taken from the NHTSA report on survivability and mileage schedules.[28] In the NHTSA analysis, annual mileage by age was determined for cars and for trucks using data from the National Household Travel Survey.   In this NHTSA analysis, vehicles that were less than one year old at the time of the survey were classified as "age 1", etc. NHTSA used cubic regression to smooth the VMT by age estimates.

We used NHTSA's regression coefficients to extrapolate mileage to ages not covered by the report. We divided each age's mileage by the NHTSA "age 1" mileage to determine a relative MAR. For consistency with MOVES age categories, we then shifted the relative MARs such that the NHTSA "age1" ratio was used for MOVES age 0, etc.   We used NHTSA's light truck VMT to determine relative MARS for both passenger trucks and light commercial trucks.

5.2.3. Heavy Trucks

The initial MARs for truck categories 51, 52, 53, 61, and 62 in MOVES were calculated based on weighting fractions assigned to the MOBILE6 truck classes.   We used VIUS 1997 values for Gross Vehicle Weight (PKGVW) to determine weighting fractions by model year. To separate Light-Duty Trucks 1 and Light-Duty Trucks 2, which are distinguished by Loaded Vehicle Weights, we used information from the Oak Ridge National Lab Light Duty Vehicle database. To separate Class 2a and 2b trucks, we used information from the Oak Ridge National Laboratory Report by Davis and Truitt.[29] The initial MARs for the MOVES truck categories were then calculated as the product of the weighting fractions and the MARs from MOBILE6.

5.2.3. Buses

For the School Buses (category 43) the initial MARs were taken from the MOBILE6 value for diesel school buses (HDDBS).   As in MOBILE6, the same annual MAR was used for each age. The MOBILE6 value of 9,939 miles per year came from the 1997 School Bus Fleet Fact Book.

For Transit Buses (category 42), the initial MARs were taken from the MOBILE6 values for diesel transit buses (HDDBT).   This mileage data was obtained from the 1994 Federal Transportation Administration survey of transit agencies. [30]

For Intercity Buses (category 41), the initial MARs were taken from Motorcoach Census 2000.[31] The data did not distinguish vehicle age, so the same MAR was used for each age. This MAR is high compared to transit and school buses. We are not sure if this simply reflects the very different type of driving done by these buses, or if it indicates a problem . We welcome comments with ideas for validating or improving this estimate.

5.2.4. Motor Homes

For motor homes (category 54), the initial MARs were taken from an independent research study[32] conducted in October 2000 among members of the Good Sam Club. The members are active recreation vehicle (RV) enthusiasts who own motor homes, trailers and trucks. The average annual mileage was estimated to be 4,566 miles. The data did not distinguish vehicle age, so the same MAR was used for each age.

5.2.5. Calculating Relative MARs for motorcycles, trucks and buses.

In order to smooth the data and to extend the MARs from the 25 ages in MOBILE6 to the 30 ages in MOVES, we used statistical regression to determine the curves that best fit the data for years starting in 1997 and going back to 1973 (ages 1 to 25). Table 5-2 presents the resulting regression equations for each MOVES category. Note, as in MOBILE6, the motorcycle values were estimated as a linear function to age 12. Ages 13 through 30 are then estimated as a constant.

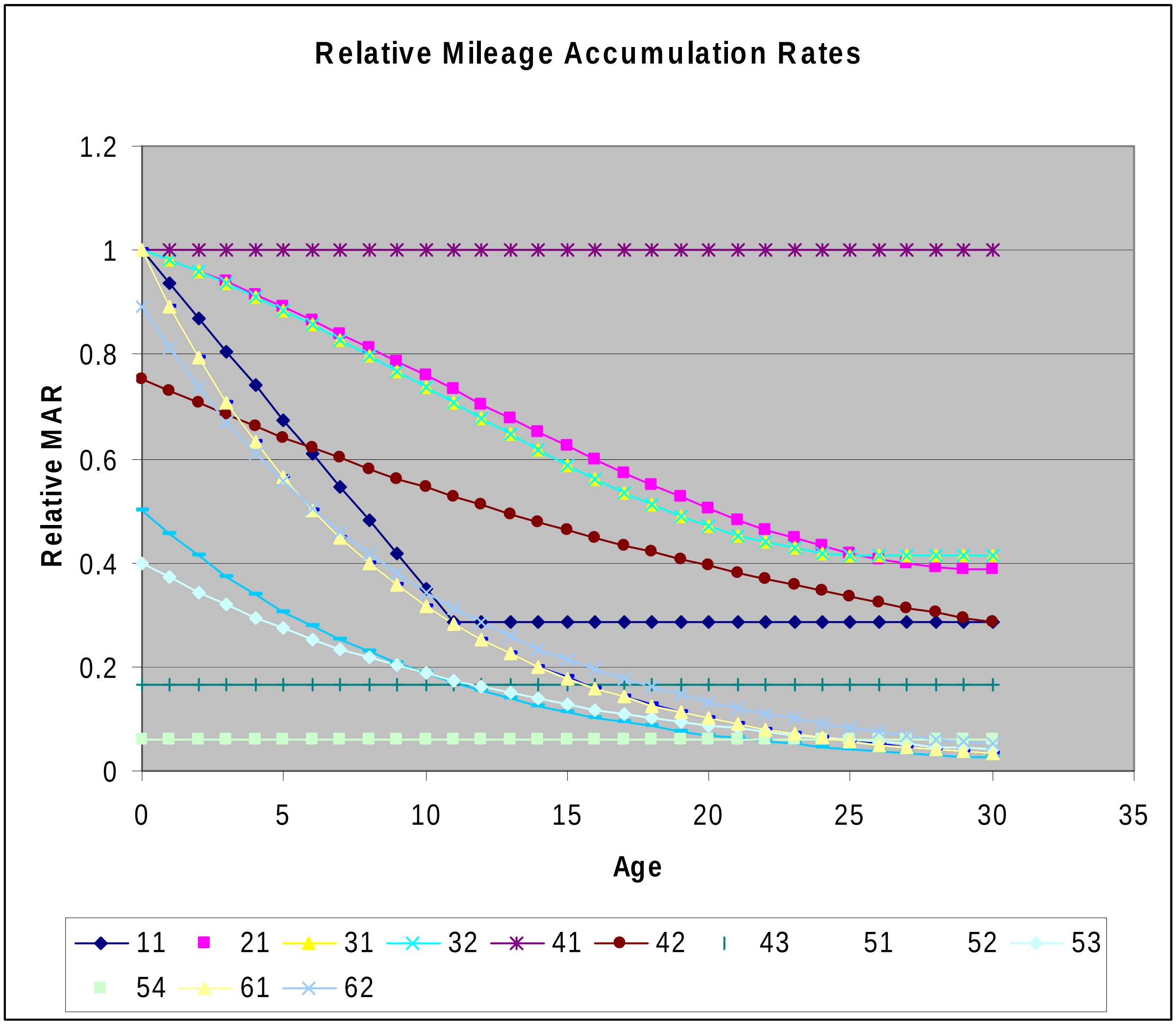
Table 5.2. Equations for Calculating Annual Mileage Accumulation Rates used in MOVES

MOVES Source Type	Source Type ID	Regression Equation	R^2 from Regression
Motorcycles	11	na	na*
Refuse Trucks	51	$y=0.8674e^{-0.1148x}$	0.904
Single Unit Short-haul Trucks	52	$y=0.4289e^{-0.0990x}$	0.990
Single Unit Long-haul Trucks	53	$y=0.3339e^{-0.0762x}$	0.864
Motor Homes	54	y=0.0457	na
Intercity Buses	41	y=0.6000	na
Transit Buses	42	$y=0.46659e^{-0.0324x}$	na*
School Buses	43	y=0.0994	na
Combination Short-haul Trucks	61	$y=0.0016x^2-0.0762x+0.9655$	0.977
Combination Long-haul Trucks	62	$y=0.0021x^2-0.0887x+1.0496$	0.879

* For Motorcycles and Transit Buses, the equations from MOBILE6 were used

The values calculated from the equations were then used to calculate the relative MARs by computing the ratio of the value for each SourceType and age to the highest value within the HPMS class. For example, all of the bus values are relative to each other. The relative MARs for all sourcetypes are illustrated in Figure 5.1

Figure 5.1. Relative Mileage Accumulation Rates in Draft MOVES2009



5.3. FunctioningACFraction

The FunctioningACFraction field indicates the fraction of the air-conditioning equipped fleet with fully functional A/C systems, by source type and vehicle age. A value of 1 means all systems are functional. This is used in the calculation of total energy to account for vehicles without functioning A/C systems. Default estimates were developed for all source types using the "unrepaired malfunction" rates used for 1992-and-later model years in MOBILE6.[33] These were applied to all source types except motorcycles, which were assigned a value of zero for all years.

Table 5-3. FunctioningACFraction by Age (All Use Types Except Motorcycles)

Age	FunctioningAC Fraction
0	1
1	1
2	1
3	1
4	0.99
5	0.99
6	0.99
7	0.99
8	0.98
9	0.98
10	0.98
11	0.98
12	0.98
13	0.96
14	0.96
15	0.96
16	0.96
17	0.96
18	0.95
19	0.95
20	0.95
21	0.95
22	0.95
23	0.95
24	0.95
25	0.95
26	0.95
27	0.95
28	0.95
29	0.95
30	0.95

6. SourceTypeAgeDistribution

The age distribution of for each sourcetype is stored in the SoruceTypeAgeDistribution table. Because sales are not constant, these distributions vary by calendar year. MOVES uses age distributions for the base year combined with sales and scrappage information to compute the age distribution in the calendar year selected for analysis.

This section first describes how the age distributions were determined for the primary default base year of 1999, and then for the 1990 base year. Age distributions for the 1999 base year are summarized in table 6-1. Age distributions for the 1990 base year are available in the SourceTypeAgeDistribution table.

6.1. 1999 Motorcycles

To determine age fractions for motorcycles, we began with Motorcycle Industry Council estimates of the number of motorcycles in use by model year in 1998. We used the estimates of sales growth and survival rates to grow these population estimates to 1999, then computed age fractions. These fractions are summarized in Table 6.1.

6.2. 1999 Passenger Cars

We considered three approaches to determine age fractions for passenger cars.

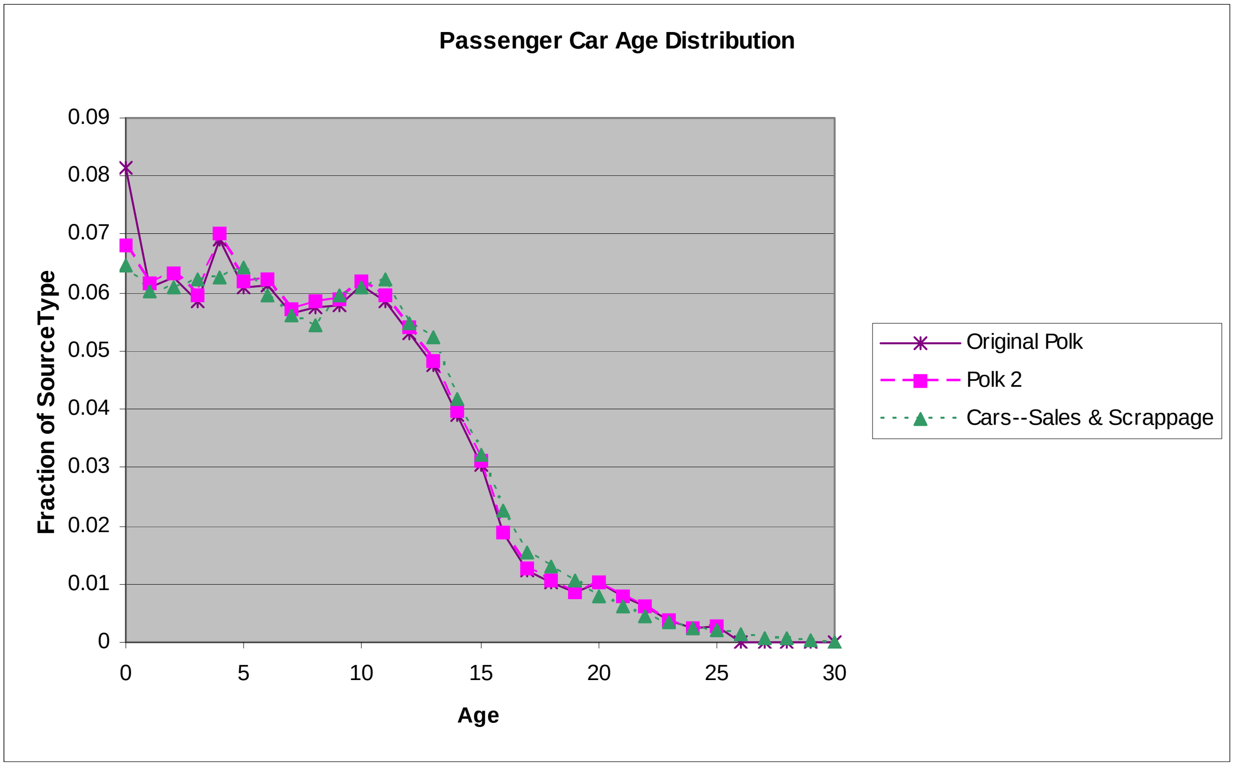
Our original approach (used for MOVES2004 and MOVES Demo) began with Polk NVPP® 1999 data on car registration by model year. This data presents a snapshot of registrations on July 1, 1999, and we needed age fractions as of December 31, 1999. To adjust the values, we used monthly data from the Polk new car database to estimate the number of new cars registered in the months July through December 1999. Model Year 1998 cars were added to the previous estimate of “Age 1” cars and Model Year 1999 and 2000 cars were added to the “Age 0” cars. We then computed fractions by age. However, because this method counts both Model Year 1999 and Model Year 2000 as "Age 0", the Age 0 age fraction is inflated. When the MOVES Total Activity Generator applies growth factors, the number of cars in future years is inflated, and the fraction of passenger cars compared to other source types is skewed. Thus, we rejected this approach.

A second approach was similar to the first, but with only Model Year 1999 vehicles counted as "Age 0" in 1999.

Our third approach used passenger car sales data from Table 4.5 of the TEDB[34] and applied the NHTSA survival fractions, extrapolated to age 30 and shifted such that NHTSA age n = MOVES age n+1. Survival fractions for MOVES age 0 and 1 were interpolated as described in Section 5.1.

Not surprisingly, the age distributions resulting from the three approaches are very similar, as illustrated in Figure 6.1. All show a fairly flat age distribution in the first eleven years followed by a steep decline and a leveling off. The third approach provides a slightly more generic age distribution than the second approach because the direct Polk data approach is for a single year and the NHTSA survival fractions were derived by regression through many years of data. For the Draft MOVES2009 default database, we selected the age distributions generated with the third approach. For future versions of MOVES, we are considering updating these values to better account for more recent data.

Figure 6.1 1999 Age Distributions for Passenger



The passenger car age fractions used in MOVES are summarized in Table 6,1 at the end of this section.

6.3. 1999 Trucks

To determine age fractions for refuse trucks, short-haul and long-haul single unit trucks and short-haul and long-haul combination trucks, we used data from the VIUS database. Vehicles in the VIUS database were assigned to MOVES source types as summarized in Table 3-3a and Table 3.3b.

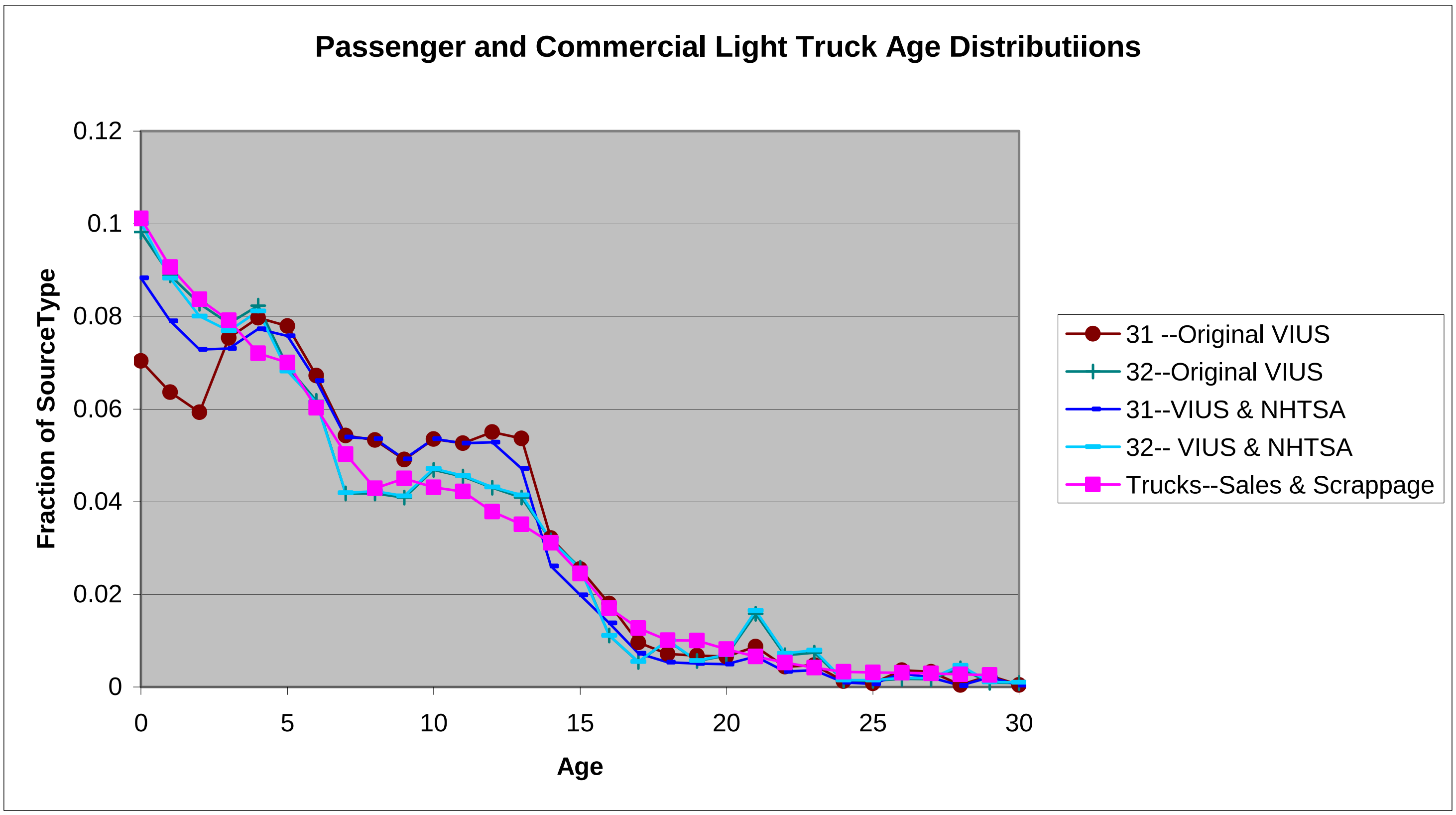
VIUS does not include a model year field and records ages as 0 through 10 and 11-and-greater. Because we needed greater detail on the older vehicles, we followed the practice used for MOBILE6 and determined the model year for some of the older vehicles by using the responses to the VIUS 1997 questions “How did you obtain this vehicle?” (VIUS field “OBTAIN” in VIUS 1997 or "ACQUIREHOW" in VIUS 2002) and “When did you obtain this vehicle?” (VIUS field “ACQYR” in VIUS 1997 or "ACQUIREYEAR" in VIUS 2002) to derive the model year of the vehicles that were obtained new. These derived model years also were used for much of the source bin distribution work described later in this report.

To calculate age fractions, it was important to account for the inconsistent methodologies used for the older and newer vehicles. Thus, for each source type, we adjusted the age 11-and-older vehicle counts by dividing the original count by model year by the fraction of the older vehicles that were coded as “obtained new.” This created an array of adjusted vehicle counts by model year for calendar year 1997. This 1997 array may overestimate the fraction of mid-aged vehicles since the fraction of vehicles purchased new likely declines with time; however, we believe the procedure is reasonable given the limited data available.

We then used the sales growth for 1997 and 1998 from TEDB22 Tables 7.6 and 8.3 and the scrappage rates from TEDB22 Tables 6.10 and 6.11 to grow the population to the 1999 base year and then we calculated age fractions.

Initially, we determined age fractions for passenger trucks and commercial trucks in the same way as other trucks. However, when the new NHTSA survival rates for light duty trucks became available, we reexamined this approach. We compared (1) our original approach with VIUS data for 1997 and the TEDB scrappage rates, (2) a similar approach using VIUS data and NHTSA survival rates, and (3) a "sales and scrappage" approach similar to that used for passenger cars, combining passenger trucks and commercial light trucks and using TEDB sales data. The results of the three approaches are illustrated in Figure 6.2.

Figure 6.2 1999 Age Distributions for Passenger and Light Commercial Trucks



Use of the original VIUS data leads to a dip in 1996 and 1997 passenger trucks that is not reflected by vehicle sales data. The other approaches all create similar trends of fairly steep declines in age fractions until about age 7, a brief leveling off, another steep decline from about age 12 to 17 and a final leveling off. For the MOVES default database, we selected the age distribution generated with the "Sales and Scrappage" approach, which will be applied to both passenger trucks and light commercial trucks. These rates are summarized in Table 6-1.

6.4. 1999 Intercity Buses

We were not able to identify a data source for estimating age distributions of intercity buses. Because the purchase and retirement of these buses is likely to be driven by general economic forces rather than trends in government spending, we will use the age distribution that was derived for short-haul combination trucks, described above. While we believe this choice is reasonable given the lack of data, we welcome suggestions of improved data sources or algorithms to improve the intercity bus age fractions used in future versions of the MOVES database.

6.5. 1999 School Buses and Motor Homes

To determine the age fractions of School Buses and Motor Homes, we used information from the Polk TIP® 1999 database. School Bus and Motor Home counts were available by model year. Unlike the Polk data for passenger cars, these counts reflect registration at the end of the calendar year and, thus, did not require adjustment. We converted model year to age and calculated age fractions. These are summarized in Table 6-1.

6.6. 1999 Transit Buses

To determine the age fractions for Transit Buses, we used data from the Federal Transit Administration database. In particular, we used responses to 1999 Form 408, which included counts of in-use vehicles by year of manufacture.

To properly account for the fraction of Age 0 vehicles at the end of 1999, it was necessary to adjust the counts for model-year-1999 vehicles to account for the different reporting periods of the various transit organizations. The counts were adjusted proportionally depending on the month in which the fiscal year ended. The adjusted counts were used to calculate the age fractions.

Table 6-1. 1999 Age Fractions for MOVES Source Types

source type	11	21	31& 32	42	43	51	52	53	54	61 & 41	62
age											
0	0.0947	0.0646	0.1011	0.0624	0.0794	0.0498	0.0622	0.1697	0.0737	0.0843	0.1668
1	0.0935	0.0602	0.0906	0.0771	0.0660	0.0398	0.0520	0.1419	0.0456	0.0672	0.1331
2	0.0755	0.0610	0.0837	0.0742	0.0647	0.0340	0.0412	0.1124	0.0739	0.0576	0.1140
3	0.0681	0.0624	0.0791	0.0727	0.0594	0.0767	0.0466	0.0585	0.0487	0.0506	0.1140
4	0.0613	0.0626	0.0720	0.0627	0.0798	0.0926	0.0559	0.0609	0.0605	0.0693	0.1186
5	0.0570	0.0642	0.0700	0.0576	0.0406	0.0604	0.0572	0.1017	0.0608	0.0562	0.0804
6	0.0520	0.0597	0.0603	0.0504	0.0511	0.0544	0.0434	0.0783	0.0441	0.0488	0.0643
7	0.0433	0.0562	0.0502	0.0461	0.0435	0.0243	0.0344	0.0185	0.0408	0.0379	0.0403
8	0.0370	0.0543	0.0429	0.0492	0.0585	0.0696	0.0351	0.0138	0.0320	0.0453	0.0304
9	0.0355	0.0596	0.0450	0.0759	0.0696	0.0625	0.0435	0.0686	0.0442	0.0535	0.0315
10	0.0336	0.0608	0.0431	0.0609	0.0419	0.0514	0.0578	0.0748	0.0602	0.0560	0.0320
11	0.0388	0.0622	0.0422	0.0506	0.0526	0.0730	0.0531	0.0517	0.0563	0.0550	0.0290
12	0.0461	0.0549	0.0379	0.0489	0.0556	0.0610	0.0460	0.0129	0.0574	0.0597	0.0080
13	0.0422	0.0522	0.0351	0.0434	0.0512	0.0796	0.0580	0.0031	0.0447	0.0528	0.0087
14	0.0383	0.0419	0.0311	0.0394	0.0464	0.0442	0.0430	0.0064	0.0501	0.0487	0.0115
15	0.0345	0.0320	0.0244	0.0320	0.0374	0.0479	0.0251	0.0067	0.0531	0.0400	0.0062
16	0.0307	0.0226	0.0170	0.0321	0.0144	0.0145	0.0409	0.0000	0.0363	0.0167	0.0013
17	0.0270	0.0155	0.0127	0.0181	0.0111	0.0169	0.0220	0.0032	0.0221	0.0147	0.0011
18	0.0234	0.0129	0.0100	0.0082	0.0136	0.0156	0.0219	0.0024	0.0127	0.0133	0.0035
19	0.0198	0.0105	0.0100	0.0231	0.0138	0.0040	0.0239	0.0000	0.0017	0.0180	0.0012
20	0.0163	0.0080	0.0081	0.0071	0.0118	0.0043	0.0190	0.0002	0.0138	0.0112	0.0010
21	0.0129	0.0060	0.0066	0.0032	0.0104	0.0043	0.0225	0.0101	0.0191	0.0090	0.0006
22	0.0095	0.0045	0.0053	0.0007	0.0107	0.0000	0.0088	0.0006	0.0267	0.0099	0.0010
23	0.0062	0.0034	0.0041	0.0013	0.0073	0.0092	0.0112	0.0011	0.0169	0.0038	0.0000
24	0.0029	0.0026	0.0032	0.0009	0.0092	0.0027	0.0115	0.0005	0.0045	0.0048	0.0009
25	0.0000	0.0019	0.0031	0.0009	0.0000	0.0070	0.0125	0.0000	0.0000	0.0048	0.0003
26	0.0000	0.0014	0.0030	0.0002	0.0000	0.0001	0.0130	0.0021	0.0000	0.0040	0.0003
27	0.0000	0.0008	0.0029	0.0004	0.0000	0.0000	0.0265	0.0000	0.0000	0.0036	0.0000
28	0.0000	0.0006	0.0027	0.0003	0.0000	0.0000	0.0059	0.0000	0.0000	0.0026	0.0002
29	0.0000	0.0005	0.0026	0.0001	0.0000	0.0000	0.0032	0.0000	0.0000	0.0006	0.0000
30	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000

6.7. 1990 Motorcycles

To determine age fractions for motorcycles, we began with Motorcycle Industry Council estimates of the number of motorcycles in use, by model year, in 1990. However, data for individual model years starting from 1978 and earlier were not available. A logarithmic regression curve (R^2 value = 0.82) was fitted to available data, which was then used to extrapolate age fractions for earlier years beginning in 1978.

6.8. 1990 Passenger Cars

To determine age fractions for passenger cars, we began with Polk NVPP® 1990 data on car registration by model year. However, this data presents a snapshot of registrations on July 1, 1990, and we needed age fractions as of December 31, 1990. To adjust the values, we used monthly data from the Polk new car database to estimate the number of new cars registered in the months July through December 1990. Model Year 1989 cars were added to the previous estimate of "Age 1" cars and Model Year 1990 and 1991 cars were added to the "Age 0" cars.

Also the data obtained was lumped together for ages 15+. Hence, regression estimates were used to extrapolate the age fractions for individual ages 15+ based on an exponential curve (R^2 value =0.67) fitted to available data.

6.9. 1990 Trucks

To determine age fractions for passenger trucks, light commercial trucks, refuse trucks, short-haul and long-haul single unit trucks and short-haul and long-haul combination trucks, we used data from the TIUS92 (1992 Truck Inventory and Use Survey) database. Vehicles in the TIUS92 database were assigned to MOVES source types as summarized in Table 3-3.

TIUS92 does not include a model year field and records ages as 0 through 10 and 11-and-greater. Because we needed greater detail on the older vehicles, we followed the practice used for MOBILE6 and determined the model year for some of the older vehicles by using the responses to the TIUS92 questions "How was the vehicle obtained?" (TIUS field "OBTAIN") and "When did you obtain this vehicle?" (TIUS field "ACQYR") to derive the model year of the vehicles that were obtained new.

To calculate age fractions, it was important to account for the inconsistent methodologies used for the older and newer vehicles. Thus, for each source type, we adjusted the age 11-and-older vehicle counts by dividing the original count by model year by the fraction of the older vehicles that were coded as "obtained new." This created an array of adjusted vehicle counts by model year for calendar year 1992. This 1992 array probably overestimates the fraction of mid-aged vehicles since the fraction of vehicles owned by their original owner clearly declines with age; however, we believe the procedure is reasonable given the limited data available.

6.10. 1990 Intercity Buses

As was true for the 1999 base year, we were not able to identify a data source for estimating age distributions of intercity buses. Because the purchase and retirement of these buses is likely to be driven by general economic forces rather than trends in government spending, we will use the age distribution that was derived for short-haul combination trucks, described previously. While we believe this choice is reasonable given the lack of data, we welcome suggestions of improved data sources or algorithms to improve the intercity bus age fractions used in future versions of the MOVES database.

6.11. 1990 School Buses and Motor Homes

Since we were unable to obtain the Polk TIP 1990 database, we used the 1999 age fractions for School Buses and Motor Homes.

6.12. 1990 Transit Buses

For Transit Buses we used the MOBILE 6 age fractions since year 1990 data on transit buses was not available from the Federal Transit Administration database.

7. SourceBinDistribution

The SourceBinDistribution describes the characteristics of a SourceType population as a distribution among SourceBins. These SourceBins classify a vehicle by discriminators relevant for emissions and energy calculations: fuel and engine technology, average vehicle weight and engine displacement, model year group, and regulatory class.

While SourceBinDistributions could be input directly, MOVES usually generates the values in this table using values in a collection of other tables. The SourceBinGenerator input tables are described in Table 7-1.

This section describes how national default information was determined for MOVES. Note that while previous versions of MOVES assigned fractions of vehicles to alternative fuels, for Draft MOVES2009, we simplified the model by providing default fractions only for gasoline and diesel vehicles. We expect to retain this simplified approach for the final MOVES2009. Users wishing to model alternative fuels will still have the option of using the Alternative Vehicle Fuels and Technology strategy to input their own fuel and engine technology fractions.

Table 7-1. Data Tables Used by SourceBinGenerator

Generator Table Name	Key Fields	Additional Fields	Notes
SourceTypePolProcess	SourceTypeID PolProcessID	isSizeWeightReqd isRegClassReqd isMYGroupReqd	Indicates which pollutant-processes the source bin distributions may be applied to and indicates which discriminators are relevant for each sourceType and polProcess (pollutant/process combination)
FuelEngFraction	SourceTypeID ModelYearID FuelTypeID EngTechID	fuelEngFraction	Joint distribution of vehicles with a given fuel type and engine technology. Sums to one for each sourceType & modelYear
SizeWeightFraction	SourceTypeID ModelYearID FuelTypeID EngTechID WeightClassID EngSizeID	sizeWeightFraction	Joint distribution of engine size and weight. Sums to one for each sourceType, modelYear and fuel/engtech combination.
RegClassFraction	SourceTypeID ModelYearID FuelTypeID EngTechID RegClassID	regClassFraction	Fraction of vehicles in a given “Regulatory Class.” Sums to one for each sourceType, modelYear and fuel/engtech combination.
PollutantProcessModelYear	PolProcessID ModelYearID	modelYearGroupID	Assigns model years to appropriate model year groups.
SampleVehiclePopulation	SourceType- ModelYearID FuelTypeID EngTechID RegClassID WeightClassID EngSizeID SCCVTypeID	stmyFuelEngFraction stmyFraction	Includes the fractions found in the FuelEngFraction, RegClassFraction, SizeWeightFraction and SCCVTypeDistribution tables, but also for combinations that do not exist in the existing fleet. This table is only used with the Alternative Vehicle Fuel & Technology Strategy inputs to generate alternate future vehicle fleet source bins.

The MOVES Source Bin Generator code determines which discriminators are relevant for a given pollutant/process combination and multiplies the relevant fractions from the tables listed above to determine the detailed SourceBinDistribution for each combination of Pollutant, Process, SourceType, and Model Year.

More detailed descriptions of the SourceBin Distribution inputs for each SourceType follow. The Inputs for 2000-and-later vehicles of all SourceTypes are described in Section 7.7.

7.1. Motorcycles

For 1999-and-earlier motorcycle characteristics were assigned based on information from EPA motorcycle experts and from the Motorcycle Industry Council.

7.1.1. FuelEngFraction

We assume all motorcycles are powered by conventional gasoline engines.

7.1.2. SizeWeightFraction

The Motorcycle Industry Council "Statistical Annual" provides information on displacement distributions for highway motorcycles for model years 1990 and 1998. These were mapped to MOVES engine displacement categories. Additional EPA certification data was used to establish displacement distributions for model year 2000. We assumed that displacement distributions were the same in 1969 as in 1990, and interpolated between the established values to determine displacement distributions for all model years from 1990 to 1997 and for 1999. Model year 2000 values were intended to be used for all 2000-and-later model years, however in Draft MOVES2009, the 1999 value was used. For final MOVES2009, we intend to replace the current 2000-and-later model year values with those based on the model year 2000 certification data.

We then applied weight distributions for each displacement category as suggested by EPA motorcycle experts. The average weight estimate includes fuel and rider. The weight distributions depended on engine displacement but were otherwise independent of model year. This information is summarized in Table 7-2.

Table 7-2. Motorcycle Engine Size and Average Weight Distributions for Selected Model Years

Displacement Category	1969 MY distribution (assumed)	1990 MY distribution (MIC)	1998 MY distribution (MIC)	2000 MY distribution (certification data)*	Weight distribution (EPA staff)
0-169 cc (1)	0.118	0.118	0.042	0.029	100%: <= 500 lbs
170-279 cc (2)	0.09	0.09	0.05	0.043	50%: <= 500 lbs 50%: 500lbs -700lbs
280+ cc (9)	0.792	0.792	0.908	0.928	30%: 500 lbs-700 lbs 70%: > 700lbs

*Not entered in DraftMOVES2009, but planned for final.

7.1.3. RegClassFraction

All Motorcycles are assigned to the "Motorcycle" (MC) regulatory class.

7.2. Passenger Cars

For base year 1999, passenger car distributions were derived from the 1999 Polk NVPP®. The national files for domestic and imported cars were consolidated into a single file.

7.2.1. FuelEngFraction

The FuelEngFraction table assigns a fraction of each source type and model year to all relevant combinations of fuel type bin and engine technology bin.

The Polk fuel code was converted to the MOVES FuelTypeID using the mapping in Table 6-3. .

Table 7-3. Mapping Polk Fuel Codes to MOVES.

Polk		MOVES	
FUEL_CD	**FUEL_NAME**	**FuelTypeID**	**Fuel Description**
C	DSL TURBO	2	Diesel
D	DIESEL	2	Diesel
E	ELECTRIC	9	Electric
F	GAS TURBO	1	Gasoline
G	GAS	1	Gasoline
N	NATURAL GAS	3	CNG
P	PROPANE	4	LPG
R	METHANOL	6	Methanol
V	CONVERTIBLE	1	Gasoline
X	FLEXIBLE	1	Gasoline

For each model year, the car counts for the MOVES fuels were summed and fractions were computed. While previous versions of MOVES included default values for alternative fueled vehicles, DraftMOVES2009 includes only gasoline and diesel vehicles in the default database. In model years where alternative vehicles were present,

7.2.2. SizeWeightFraction

The Polk cubic displacement values were converted to liters and assigned to the MOVES engine size bins. The weight ID was assigned by adding 300 lbs to the Polk curb weight and grouping into MOVES weight bins. For each fuel type, model year, engine size, and weight bin, the number of cars was summed and fractions were computed. In general, entries for which data was missing were omitted from the calculations. However, because no curb weight data was available from Polk for electric cars, additional analysis was performed. Based on data from the Electric Drive Association on electric vehicle sales[35], two-thirds of electric vehicles were assigned to weight class 35 and one third was assigned to weight class 40. Also, further analysis indicated a likely error in the Polk data (an entry for 1997 gasoline-powered Bentleys with engine size 5099 and weight class 20). This fraction was removed and the 1997 values were renormalized.

7.2.3. RegClassFraction

All Passenger Cars were assigned to the "Light-Duty Vehicle" (LDV) regulatory class.

7.3. Trucks

This section describes how default Source Bin information was compiled for Passenger Trucks, Light Commercial Trucks, Single-Unit Short-haul and Long-haul Trucks, and Combination Short-haul and Long-haul Trucks. Source Bin information for Buses, Refuse Trucks, and Motor Homes are described in separate sections following.

The Vehicle Inventory and Use Survey (VIUS) conducted by the Census Bureau was the primary source for information on truck distributions. Information from the 1997 and 2002 VIUS was supplemented with information from MOBILE6 and from the Oak Ridge National Laboratory Light Duty Vehicle database.

VIUS records were assigned to SourceTypes as described above in Table 3-3. Not all SourceTypes had data for all model years, and no data was available beyond model year 2002. For years where no vehicles or only a few vehicles were surveyed by VIUS, we duplicated fractions from the nearest available model year. The 2002 VIUS was used 1986 and later model years and 1997 VIUS information was only used for the older model years not surveyed in the 2002 VIUS. In the Draft MOVES2009 release, the oldest model year observed diesel fractions were applied to the older model years for combination trucks only. These older model years for the other truck categories were assumed to have no diesel trucks.

7.3.1. FuelEngFraction

The VIUS ENGTYP field was converted to the MOVES FuelTypeID using the mapping in Table 7-4. Note, it was not possible to distinguish LPG and CNG vehicles using VIUS. Based on historical data, we assigned the pre-1990 LPG/LNG vehicles to LPG and the 1990-and-later vehicles to CNG. While these vehicles form a very small portion of the national fleet, we would like to update this assignment if better information becomes available. Also, it was not possible to identify the fuel used for the VIUS category "Other." Vehicles in this category were omitted from the analysis and model year results were renormalized. For the Draft MOVES2009 release, all non-gasoline trucks were set to be diesel fuel, so that the default fleet contains only gasoline and diesel fuel trucks.

Table 7-4. Mapping VIUS ENGTYP to MOVES FuelTypeID

VIUS		MOVES	
1	Leaded gasoline	1	Gasoline
2	Unleaded gasoline	1	Gasoline
3	Diesel	2	Diesel
4	Liquefied gas (petroleum (LPG) or natural (LNG))	3 or 4	CNG or LPG
5	Other		None

All 1999-and-earlier trucks were assigned to EngTechID “1" (conventional).

Table 7-5 summarizes the pre-1999 diesel fractions for MOVES general truck categories by model year. The gasoline fractions can be estimated as one minus the diesel fractions listed here.

For light trucks, fuel distribution information is also available from Polk. While the Polk data cannot easily be mapped to the truck SourceTypes used in MOVES, if future resources allow, it would be instructive to compare the Polk distributions to the combined passenger truck and light commercial truck distributions. This could help estimate the uncertainty in the fuel fraction estimates for these vehicles. The Census Bureau has discontinued the VIUS project, so it will be necessary to use Polk data or other sources for this type of information for future updates of these factors.

Table 7-5. Diesel Fractions for Trucks

Source Type	Passenger Trucks 31	Light Commerical Trucks 32	Single-Unit Short-haul Trucks 52	Single-Unit Long-haul Trucks 53	Combination Short-haul Trucks 61	Combination Long-haul Trucks 62
Model Year						
1969	0.00000	0.00000	0.00000	0.00000	0.73282	1.00000
1970	0.00000	0.00000	0.00000	0.00000	0.73282	1.00000
1971	0.00000	0.00000	0.06238	0.00000	0.73282	1.00000
1972	0.00000	0.00000	0.01695	0.00000	0.73282	1.00000
1973	0.00000	0.00906	0.04465	0.00000	0.73282	1.00000
1974	0.00000	0.08203	0.02377	0.00000	0.73282	1.00000
1975	0.00000	0.02876	0.02130	0.47356	0.73282	1.00000
1976	0.00000	0.00000	0.06518	1.00000	0.73282	1.00000
1977	0.00000	0.00000	0.32805	1.00000	0.73282	1.00000
1978	0.00000	0.00000	0.01731	0.06120	0.73282	1.00000
1979	0.01392	0.04185	0.11083	1.00000	0.73282	1.00000
1980	0.00000	0.05726	0.15791	1.00000	0.73282	1.00000
1981	0.03557	0.03149	0.16825	0.20453	0.96590	1.00000
1982	0.00000	0.29896	0.19327	0.87629	0.94257	1.00000
1983	0.04182	0.15086	0.67378	1.00000	0.92500	1.00000
1984	0.00000	0.21648	0.57100	1.00000	0.91464	1.00000
1985	0.01633	0.17784	0.52692	0.99148	0.89852	1.00000
1986	0.03626	0.07360	0.28809	0.31785	0.96279	0.99427
1987	0.00000	0.04131	0.50033	0.82097	0.99402	1.00000
1988	0.00562	0.11345	0.48870	0.89909	0.98549	1.00000
1989	0.00833	0.04988	0.51855	0.40003	1.00000	1.00000
1990	0.00826	0.05767	0.60288	0.82450	1.00000	1.00000
1991	0.02875	0.08897	0.66240	0.91614	1.00000	1.00000
1992	0.01429	0.13401	0.57597	1.00000	1.00000	1.00000
1993	0.02557	0.04579	0.62871	0.41192	1.00000	1.00000
1994	0.01917	0.06397	0.62889	0.89764	1.00000	1.00000
1995	0.00792	0.09397	0.65834	0.45123	1.00000	1.00000
1996	0.02474	0.06139	0.64296	0.88378	1.00000	1.00000
1997	0.02167	0.12999	0.68158	0.56891	1.00000	1.00000
1998	0.00654	0.04804	0.61441	0.61159	1.00000	1.00000
1999	0.03755	0.11866	0.73754	0.67638	1.00000	1.00000

7.3.2. SizeWeightFraction

Engine size distributions for trucks were determined using the VIUS 2002 database. The VIUS database categorizes engine size by fuel type and the categories do not exactly match the MOVES categories. We mapped from the VIUS engine size categories to the MOVES engine size categories as described in Table 7-6. For comparison, the engine size ranges for both the VIUS and MOVES categories are listed in cubic inches displacement.

Table 7-6. Mapping VIUS Engine Size Categories to MOVES EngSizeID

Fuel Type	VIUS Fuel_CID code	VIUS CID Range	MOVES EngSizeID Code	MOVES CID Range
Gasoline	1,2	1-129	20	1-122
Gasoline	3,4	130-149	2025	122-153
Gasoline	5,6	150-179	2530	153-183
Gasoline	7,8	180-209	3035	183-214
Gasoline	9,10	210-239	3540	214-244
Gasoline	11,12	240-299	4050	244-305
Gasoline	13-18	300 & Up	5099	305 & Up
Diesel	20	1-249	3540	214-244
Diesel	21	250-299	4050	244-305
Diesel	22-36	300 & Up	5099	305 & Up
Propane	38-41	All	5099	305 & Up
Alcohol	43	1-229	3035	183-214
Alcohol	44	230-269	3540	214-244
Alcohol	45	270-339	4050	244-305
Alcohol	46	340 & Up	5099	305 & Up
Other	48	1-99	20	1-122
Other	49	100-149	2025	122-153
Other	50	150-199	2530	153-183
Other	51	200-249	3540	214-244
Other	52	250-299	4050	244-305
Other	53-56	300 & Up	5099	305 & Up
Fuel Not Reported	58-61	All	5099	305 & Up
Vehicle Not In Use	63-66	All	5099	305 & Up
All	19,37,42,47,57,62,67	Unknown	0	Unknown

Determining weight categories for light trucks was fairly complicated. The VIUS 1997 data combines information from two different survey forms. The first form was administered for VIUS “strata” 1 and 2 trucks: pickup trucks, panel trucks, vans (including mini-vans), utility type vehicles (including jeeps) and station wagons on truck chassis. The second form was administered for all other trucks. While both surveys requested information on engine size, only the second form requested detailed information on vehicle weight. Thus for strata 1 and 2 trucks, VIUS classifies the trucks only by broad average weight category (AVGCK): 6,000 lbs or less, 6,001-10,000 lbs, 10,001-14,000lbs, etc. To determine a more detailed average engine size and weight distribution for these vehicles, we used the Oak Ridge National Laboratory (ORNL) light-duty vehicle database to correlate engine size with vehicle weight distributions by model year.

In particular, for Source Types 31 and 32 (Passenger Trucks and Light Commercial Trucks):

- VIUS 1997 trucks of the SourceType in strata 3, 4, and 5 were assigned to the appropriate MOVES weight class based on VIUS detailed average weight information.
- VIUS 1997 trucks of the SourceType in strata 1 and 2 were identified by enginesizeID and broad average weight category.
- Strata 1 and 2 trucks in the heavier (10,001-14,000 lbs, etc) VIUS 1997 broad categories were matched one-to-one with the MOVES weight classes.
- For trucks in the lower broad categories (6,000 lbs or less and 6001-10,000 lbs), we used VIUS 1997 to determine the fraction of trucks by model year and fuel type that fell into each engine size/broad weight class combination (the “VIUS fraction”)
- We assigned trucks in the ORNL light duty vehicle database to a weightclassID by adding 300lbs to the recorded curb weight and determining the appropriate MOVES weight class.
- For the trucks with a VIUS 1997 average weight of 6,000 lbs or less, we multiplied the VIUS 1997 fraction by the fraction of trucks with a given weightclassID among the trucks in the ORNL database that had the given engine size and an average weight of 6,000 lbs or less.   Note, the ORNL database did not provide information on fuel type, so the same distributions were used for all fuels.
- Because the ORNL database included only vehicles with a GVW up to 8500 lbs, we did not use it to distribute the trucks with a VIUS 1997 average weight of 6,001-10,000 lbs. Instead these were distributed equally among the MOVES WeightClassIDs 70, 80, 90 and 100.

Source Types 52 and 53 (Long- and Short-haul Single Unit Trucks) also included some trucks in VIUS 1997 strata 1 and 2, thus a similar algorithm was applied.

- VIUS 1997 trucks of the Source Type in strata 3, 4, and 5 were assigned to the appropriate MOVES weight class based on VIUS 1997 detailed average weight information.
- VIUS 1997 trucks of the Source Type in strata 1 and 2 were identified by enginesizeID and broad average weight category.
- Strata 1 and 2 trucks in the heavier (10,001-14,000 lbs, etc) VIUS 1997 broad categories were matched one-to-one with the MOVES weight classes.
- For trucks in the lower broad categories (6,000 lbs-or-less and 6001-10,000 lbs), we used VIUS 1997 to determine the fraction of trucks by model year and fuel type that fell into each engine size/broad weight class combination (the “VIUS fraction”)

- We did not believe the ORNL light duty vehicle database adequately represented single unit trucks. Thus, the trucks with a VIUS 1997 average weight of 6,000 lbs or less and an engine size less than 5 liters were distributed equally among the MOVES weight classes 20, 25, 30, 35, 40, 45, 50, and 60. Because no evidence existed of very light trucks among the vehicles with larger engines (5 liter or larger), these were equally distributed among MOVES weight classes 40, 45, 50 and 60.
- The trucks with a VIUS 1997 average weight of 6,001-10,000 lbs were distributed equally among the MOVES weight classes 70, 80, 90 and 100.

SourceTypes 61 and 62 (Long- and Short-haul combination trucks) did not include any vehicles of VIUS 1997 strata 1 or 2. Thus we used the detailed VIUS 1997 average weight information and engine size information to assign engine size and weight classes for all of these trucks.

The VIUS 2002 contains an estimate of the average weight (vehicle weight plus cargo weight) of 1998-2002 model year vehicle or vehicle/trailer combination as it was most often operated when carrying a typical payload during 2002. These estimates were used to determine the MOVES weightClassID categories for these trucks. Table 7.7 shows the weight ranges used for each weightClassID. Any vehicles without a non-zero value for the average weight and without a weight classification in the WeightAvgCK field were excluded from the analysis for determining the average weight distributions.

Since there is a smaller number of gasoline trucks among the single unit and refuse trucks, all model years (1998-2002) were combined to determine a single weight distribution to use for these model years.

The average weight distributions for light duty trucks (sourceTypeID = 31, 32) and none of the average weight distributions for any trucks for model years before 1998 were updated and the VIUS 1997 estimates were retained.

In cases where distributions were missing (no survey information), distributions from a nearby model year with the same source type was used. Weight distributions for all 2003 and newer model years were set to be the same as for the 2002 model year for each source type.

Table 7-7. Mapping VIUS Average Weight to MOVES WeightClassID

Where WeightAvg is not zero:	
weightClassID	**WeightAvg Range**
20	1-2000
25	2000-2499
30	2500-2999
35	3000-3499
40	3500-3999
45	4000-4499
50	4500-4999
60	5000-5999
70	6000-6999
80	7000-7999
90	8000-8999
100	9000-9999
140	10000-13999
160	14000-15999
195	16000-19499
260	19500-25999
330	26000-32999
400	33000-39999
500	40000-49999
600	50000-59999
800	60000-79999
1000	80000-99999
1300	100000-129999
9999	130000 & Up
Where WeightAvg is zero:	
weightClassID	**WeightAvgCK**
140	4 (10000-14000)
160	5 (14000-16000)
195	6 (16000-19500)

7.3.3. RegClassFraction

Trucks were split between the regulatory classes “Light-Duty Trucks” (LDT) and “Heavy-Duty Trucks” (HDT) based on gross vehicle weight (GVW) (the maximum weight that a truck is designed to carry.)

In particular, we used the VIUS response “PKGVW” in VIUS 1997 and ADM_GVW in VIUS 2002 and the Davis & Truit report on Class 2b Trucks[36] to determine GVW fractions by fuel type. The VIUS fields are intended to identify the Polk weight class. Work for MOBILE6 using the VIUS precursor, TIUS 1992 indicated that the PKGVW measure in VIUS is problematic. TIUS PKGVW is taken from the truck VIN, but is not always consistent with the indicated average and maximum weight. (For example, the reported “maximum weight” often exceeded the PKGVW.) These problems were also seen in VIUS. However, “maximum weight” was not available for smaller trucks, and the other measures of weight reported in VIUS were not consistent with the need for an indicator of the relevant emission standards. When the

PKGVW led to unusual results, for example, particularly high fraction of LDT among combination trucks, we checked additional VIUS fields to determine if the PKGVW was mistaken. In some cases, the PKGVW was manually revised to a higher value and fractions were recomputed. In other cases, the PKGVW was consistent with the other fields, and the difference reflected the fact that our SourceType categories are based on axle counts and trailer configurations rather than weight. For example, a 6-tire (“dually”) pickup that regularly pulls a trailer is classified as a “Combination Truck,” although it is in the LDT regulatory class. Some model years had relatively high fractions of such trucks. It is likely these high values indicate a problem with small sample size for the model year, but they were left unchanged for now.

Also, because the split between the LDT and HDT regulatory class is at 8500 lbs, it was necessary to split the Polk GVW Class 2 into class 2a (6001-8500 lbs) and class 2b (8501-10,000 lbs). Davis & Truitt[37] report that, on average, 23.3 percent of Class 2 trucks are in Class 2b; 97.4 percent of Class 2a trucks are powered by gasoline, and 76 percent of Class 2b trucks are powered by gasoline. From this information, we estimate that 19.2 percent of gasoline-powered Class 2 trucks are Class 2b and that 73.7 percent of diesel-powered class 2 trucks are Class 2b.

Table 7.8. Light Truck Class 2 Weight Distribution

	Class 2a	**Class 2b**	
Fuel Type	**6001-8500 lbs. GVWR**	**8501-10000 lbs. GVWR**	**Class 2b Fraction**
Gasoline	74.7%	17.7%	19.2%
Diesel	2.0%	5.6%	73.7%
Any	76.7%	23.3%	

The regulatory class fractions for trucks are listed below in Table 7-9 and Table 7-10. Fractions of LDT for gasoline- and diesel-fueled vehicles are provided separately. The remaining trucks are classified as HDT. Entries of “#N/A” indicate that no vehicles of that SourceType and FuelType were surveyed in that model year. Values for alternative-fuel vehicles are available in the MOVES database. All 1986 and newer model year data was obtained from VIUS 2002. The pre-1986 model year values are from VIUS 1997.

Table 7-9. Fraction of Light-Duty Trucks among Gasoline-Fueled Trucks

Model Year	SourceType					
	Passenger Trucks 31	Light Commercial Trucks 32	Single-Unit Short-haul Trucks 52	Single-Unit Long-haul Trucks 53	Combination Short-haul Trucks 61	Combination Long-haul Trucks 62
1967	0.902303	#N/A	#N/A	#N/A	#N/A	#N/A
1968	0.879238	#N/A	#N/A	#N/A	#N/A	#N/A
1969	1	#N/A	0.109337	#N/A	#N/A	#N/A
1970	0.983681	#N/A	0.046808	#N/A	#N/A	#N/A
1971	0.956315	#N/A	0.38324	#N/A	#N/A	#N/A
1972	0.957791	0.74768	0.683527	#N/A	#N/A	#N/A
1973	0.953535	0.59472	0.300171	0	#N/A	#N/A
1974	0.946371	0.65248	0.132987	0	#N/A	#N/A
1975	0.966522	0.724827	0.134558	0	#N/A	#N/A
1976	0.951185	0.883189	0.125404	#N/A	#N/A	#N/A
1977	0.887739	0.793622	0.061817	#N/A	#N/A	#N/A
1978	0.847443	0.809907	0.45065	0.62437	#N/A	#N/A
1979	0.863942	0.776929	0.255077	#N/A	#N/A	#N/A
1980	0.897151	0.74161	0.171485	#N/A	0	#N/A
1981	0.959489	0.893686	0.304625	0.643456	0	#N/A
1982	0.939455	0.719863	0.544875	0	0	#N/A
1983	0.95116	0.903414	0.494159	#N/A	0	#N/A
1984	0.937822	0.86782	0.332359	#N/A	0	#N/A
1985	0.933322	0.869615	0.253229	0.808384	0	#N/A
1986	0.926321	0.818333	0.317167	0.429721	0	#N/A
1987	0.951630	0.897109	0.458448	0	0	#N/A
1988	0.949331	0.890861	0.421998	0	0	#N/A
1989	0.951473	0.891322	0.525825	0	0	#N/A
1990	0.950769	0.911313	0.508253	0	0	#N/A
1991	0.958130	0.887311	0.405240	0	#N/A	#N/A
1992	0.953552	0.905625	0.453636	0.624370	0	#N/A
1993	0.953891	0.908697	0.672601	0	#N/A	#N/A
1994	0.950555	0.872257	0.510745	0	0	#N/A
1995	0.945395	0.877733	0.453314	0	0	#N/A
1996	0.948863	0.861956	0.515149	0	0	#N/A
1997	0.950000	0.877692	0.447634	0	#N/A	#N/A
1998	0.947357	0.891901	0.412569	0	0	#N/A
1999	0.930476	0.870745	0.366611	0	0.082522	#N/A
2000	0.937397	0.884837	0.615046	0	#N/A	#N/A
2001	0.935546	0.880982	0.537060	0.429721	0	#N/A
2002	0.945155	0.897487	0.587987	0	#N/A	#N/A

Table 7-10. Fraction of Light-Duty Trucks among Diesel-fueled Trucks

Model Year	SourceType					
	Passenger Trucks 31	**Light Commercial Trucks 32**	**Single-Unit Short-haul Trucks 52**	**Single-Unit Long-haul Trucks 53**	**Combination Short-haul Trucks 61**	**Combination Long-haul Trucks 62**
1967	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1968	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1969	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1970	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1971	#N/A	#N/A	0	#N/A	#N/A	#N/A
1972	#N/A	#N/A	0	#N/A	#N/A	#N/A
1973	#N/A	0	0	#N/A	#N/A	#N/A
1974	#N/A	0	0	#N/A	#N/A	#N/A
1975	#N/A	0	0	0	#N/A	#N/A
1976	#N/A	#N/A	0	0	#N/A	#N/A
1977	#N/A	0	0	0	#N/A	#N/A
1978	#N/A	0	0	0	#N/A	#N/A
1979	0	0.072135	0	0	#N/A	#N/A
1980	#N/A	0.397873	0	0	0.009394	#N/A
1981	0.892664	0.118825	0	0	0	#N/A
1982	#N/A	0.271488	0.047107	0	0	#N/A
1983	0.54614	0.232866	0.219283	#N/A	0	#N/A
1984	0.262872	0.243221	0.019513	0	0	0
1985	0.259661	0.231416	0.041111	0	0.006796	0
1986	0.456608	0.351492	0.021218	0.028255	0	0
1987	0.951630	0.088341	0.129185	0	0	0
1988	0.254950	0.210368	0.054122	0.068212	0	0
1989	0.260932	0.144417	0.031919	0	0	0
1990	0.260713	0.062091	0	0	0	0
1991	0.261741	0.176872	0.111821	0.184952	0	0
1992	0.262386	0.222906	0.042603	0.029801	0	0
1993	0.262899	0.149897	0.156027	0.538647	0	0
1994	0.298405	0.159601	0.073051	0.042628	0	0
1995	0.308964	0.200670	0.117612	0	0	0
1996	0.289104	0.211153	0.113798	0.084009	0	0
1997	0.261310	0.356162	0.120503	0	0	0
1998	0.263000	0.142366	0.017443	0	0	0
1999	0.260865	0.214650	0.155014	0	0	0
2000	0.358104	0.216855	0.171699	0.298503	0	0
2001	0.234050	0.342721	0.120036	0.188003	0	0
2002	0.282868	0.262352	0.085967	0	0	0

7.4. Buses

Because buses are not included in VIUS and because the Polk data we had for school buses was incomplete, the source bin fractions for buses is based on a variety of data sources and assumptions. Values for transit buses, school buses, and intercity buses were calculated separately.

7.4.1. FuelEngFraction

We followed the Energy Information Administration (EIA) in assigning all intercity buses to conventional diesel engines (*AEO2006, Supplemental Table 34*).

The National Transit Database (NTD) responses to form 408 (Revenue Vehicle Information Form) included information classifying transit buses to a variety of fuel types by model year.   The mapping from NTD fuel types to MOVES fuel types is summarized in Table 7-11.   The resulting fractions by model year are summarized in Table 7-10.

Table 7-11. Mapping National Transit Database Fuel Types to MOVES Fuel Types

NTD code	NTD description	MOVES Fuel ID	MOVES Fuel Description
BF	Bunker fuel	na	
CN	Compressed natural gas	3	CNG
DF	Diesel fuel	2	diesel
DU	Dual fuel	2	diesel
EB	Electric battery	9	electric
EP	Electric propulsion	9	electric
ET	Ethanol	5	ethanol
GA	Gasoline	1	gasoline
GR	Grain additive	na	
KE	Kerosene	na	
LN	Liquefied natural gas	3	CNG
LP	Liquefied petroleum gas	4	LPG
MT	Methanol	6	methanol
OR	Other	na	

Table 7-12. Fuel Fractions for Transit Buses

Model Year	Gasoline	Diesel	CNG	LPG	Ethanol	Methanol	Electric
1969	0	1	0	0	0	0	0
1970	0	1	0	0	0	0	0
1971	0	1	0	0	0	0	0
1972	0	1	0	0	0	0	0
1973	0	1	0	0	0	0	0
1974	0	1	0	0	0	0	0
1975	0	1	0	0	0	0	0
1976	0	1	0	0	0	0	0
1977	0	1	0	0	0	0	0
1978	0	1	0	0	0	0	0
1979	0.033981	0.966019	0	0	0	0	0
1980	0	1	0	0	0	0	0
1981	0.002088	0.997912	0	0	0	0	0
1982	0.001894	0.992424	0	0	0	0	0.005682
1983	0	1	0	0	0	0	0
1984	0.001603	0.998397	0	0	0	0	0
1985	0	0.999565	0.000435	0	0	0	0
1986	0.00079	0.996447	0.002764	0	0	0	0
1987	0.001402	0.998598	0	0	0	0	0
1988	0.002377	0.997623	0	0	0	0	0
1989	0.00113	0.998306	0	0	0.000565	0	0
1990	0.002941	0.990271	0.006787	0	0	0	0
1991	0.003134	0.978064	0.018106	0	0	0	0.000696
1992	0.010769	0.933903	0.046417	0.000743	0	0.005941	0.002228
1993	0.003061	0.918707	0.07551	0.00068	0.001361	0	0.00068
1994	0.010711	0.900625	0.084796	0.000893	0	0	0.002975
1995	0.009555	0.835108	0.153153	0	0	0	0.002184
1996	0.017963	0.881825	0.097613	0.000709	0	0	0.001891
1997	0.012702	0.810162	0.174365	0.000462	0	0	0.002309
1998	0.012003	0.838409	0.1487	0	0	0	0.000889
1999	0.005998	0.878041	0.113296	0	0	0	0.002666

All 1999-and-earlier electric buses were assigned to EngTechID “30" (electric only). All other 1999-and-earlier buses were assigned to EngTechID “1" (conventional).

The available Polk data excluded fuel information on school buses and we were unable to locate any other source for bus fuel fractions. (The Union of Concerned Scientists estimates that about one percent of school buses are fueled by either CNG or propane, but does not provide estimates by model year.[38]) Thus we used the diesel fractions from MOBILE6, which were derived from Polk 1996 and 1997 data. We assigned non-diesel buses to gasoline. These fractions are summarized in Table 7-13. In the future it would be desirable to obtain up-to-date, detailed fuel information for school buses from Polk or some other source.

Table 7-13. Fuel Fractions for School Buses

Model Year	Gasoline	Diesel
1972	1	0
1973	1	0
1974	1	0
1975	0.991272	0.008728
1976	0.99145	0.00855
1977	0.976028	0.023972
1978	0.970936	0.029064
1979	0.95401	0.04599
1980	0.94061	0.05939
1981	0.736056	0.263944
1982	0.674035	0.325965
1983	0.676196	0.323804
1984	0.615484	0.384516
1985	0.484507	0.515493
1986	0.326706	0.673294
1987	0.265547	0.734453
1988	0.249771	0.750229
1989	0.229041	0.770959
1990	0.124036	0.875964
1991	0.089541	0.910459
1992	0.010041	0.989959
1993	0.120539	0.879461
1994	0.147479	0.852521
1995	0.114279	0.885721
1996	0.041539	0.958461

7.4.2. SizeWeightFraction

While the vast majority of buses of all types have engine displacement larger than five liters (EngSizeID=5099), it was difficult to find detailed information on average bus weight.

For intercity buses, we used information from Table II-7 of the FTA 2003 Report to Congress[39] that specified the number of buses in various weight categories. This information is summarized in below in Table 7-14. Note the FTA uses the term “over-the-road bus” to refer to the class of buses roughly equivalent to the MOVES “intercity bus” category. The FTA weight categories were mapped to the equivalent MOVES weight classes.

Table 7-14. FTA Estimate of Bus Weights

Weight (lbs)	MOVES Weight ClassID	MOVES Weight Range (lbs)	Number buses (2000)	Bus type
0-20,000			173,536	school & transit
20,000-30,000			392,345	school & transit
30,000-40,000	400	33,000-40,000	120,721	school & transit & intercity
40,000-50,000	500	40,000-50,000	67,905	intercity
total			754,509	

Using our 1999 bus population estimates (in Table3-1), we were able to estimate the fraction of all buses that were intercity buses and then to estimate the fraction of intercity buses in each weight bin. In particular:

Estimated number of intercity buses in 2000:

754,509 * (84,454/(84,454+55,706+592,029)) = 87,028

Estimated number of intercity buses 30,000-40,000 lbs:

87,028 - 67,905 = 19,123

Estimated intercity bus weight distribution:

Class 400 = 19,123/87,028 = 22%

Class 500 = 67,905/87,028 = 78%

This distribution was used for all model years.

For transit buses, we took average curb weights from Figure II-6 of the FTA Report to Congress[40] and added additional weight to account for passengers and alternative fuels. The resulting in-use weights were all in the range from 33,850 to 40,850. Thus all transit buses were assigned to the weight class "400" (33,000 - 40,000 lbs) for all model years. This estimate could be improved if more detailed weight information for transit buses becomes available.

For school buses, we used information from a survey of California school buses. While this data may not be representative of the national average distribution, it was the best data source available. The California data[41] provided information on number of vehicles by gross vehicle weight class and fuel as detailed in Table 7-15.

Table 7-15. California School Buses

	Gas	Diesel	Other	Total
LHDV	2740	4567	8	7315
MHDV	467	2065	2	2534
HHDV	892	11639	147	12678
Total	4099	18271	157	

To estimate the distribution of average weights among the MOVES weight classes, we assumed that the Light Heavy-Duty (LHDV) school buses were evenly distributed among weightClassIDs 70, 80, 90, 100, and 140. Similarly, we assumed the Medium Heavy-Duty (MHDV) school buses were evenly distributed among weightClassIDs 140, 160, 195, 260, and 330 and the Heavy Heavy-Duty (HHDV) school buses were evenly distributed among weightClassIDs 195, 260, 330, and 440.

The final default weight distributions for buses are summarized in Table 7-16.

7.4.3. RegClassFraction

All buses were assigned to the Heavy-Duty Truck regulatory class.

Table 7-16. Weight Distributions for Buses by Fuel Type

	Intercity Buses (41)	Transit Buses (42)	School Buses (43)	
Weight Class	**Diesel**	**Diesel & Gas**	**Diesel**	**Gas**
70			0.0500	0.1337
80			0.0500	0.1337
90			0.0500	0.1337
100			0.0500	0.1337
140			0.0726	0.1565
160			0.0226	0.0228
195			0.1819	0.0772
260			0.1819	0.0772
330			0.1819	0.0772
400	0.2197	1.0000	0.1593	0.0544
500	0.7800			

7.5. Refuse Trucks

Values for Refuse Trucks (Source Type 51) were computed from information in VIUS.

7.5.1. FuelEngFraction

As for other trucks, we used the VIUS EngTyp field to estimate FuelType and Engine Technology Fractions. The Refuse Trucks classified in VIUS as “CNG or LPG” are assigned to diesel. All Refuse Trucks were assumed to have conventional internal combustion engines.

7.5.2. SizeWeightFraction

Because the sample of Refuse Trucks in VIUS was small, the same SizeWeight distributions were used for model year groups. As for other trucks, the EngineSize group was determined from the VIUS engine size categories and the WeightClass was determined from the VIUS reported average weight.

Table 7-17. Fuel Fractions for Refuse Trucks by Model Year

Model Year	Gasoline	Diesel
1983	0.0155	0.9845
1984	0	1.0000
1985	0.2206	0.7794
1986	0.2132	0.7868
1987	0.1687	0.8313
1988	0	1.0000
1989	0.0231	0.9769
1990	0.1109	0.8891
1991	0	1.0000
1992	0.1120	0.8880
1993	0.0292	0.9708
1994	0.0415	0.9585
1995	0.0119	0.9881
1996	0	1.0000
1997	0.0201	0.9799
1998	0	1.0000
1999	0.0349	0.9651
2000	0.0184	0.9816
2001	0	1.0000
2002	0	1.0000

Table 7-18. Refuse Truck SizeWeight Fractions by Fuel Type

Gasoline							
Engine Size	Weight (lbs.)	Pre-1997	1997 and Newer				
3-3.5L	5000-6000	0.009074	0				
>5L	7000-8000	0.148826	0				
>5L	9000-10000	0.070720	0				
>5L	10000-14000	0.135759	0.324438				
>5L	14000-16000	0.199961	0.593328				
>5L	16000-19500	0.055085	0				
>5L	19500-26000	0.205341	0				
>5L	26000-33000	0.022105	0				
>5L	33000-40000	0.153129	0				
>5L	50000-60000	0	0.082234				
Sum		1.000000	1.000000				
Diesel							
Engine Size	Weight (lbs.)	Pre-1998	1998	1999	2000	2001	2002 and Newer
3.5-4L	10000-14000	0.007758	0	0	0	0	0
4-5L	10000-14000	0	0	0	0	0	0.006614
4-5L	14000-16000	0	0	0	0.015505	0	0
4-5L	16000-19500	0	0	0	0	0.011670	0
>5L	9000-10000	0.006867	0.009593	0	0	0	0
>5L	10000-14000	0.011727	0	0	0	0.019438	0
>5L	14000-16000	0.022960	0	0	0	0	0
>5L	16000-19500	0.063128	0	0.011367	0.047200	0	0
>5L	19500-26000	0.099782	0.035378	0.026212	0.052132	0.018329	0.026079
>5L	26000-33000	0.102077	0.019625	0.067419	0.072106	0.043877	0
>5L	33000-40000	0.237485	0.103922	0.088975	0.085991	0.042678	0.046966
>5L	40000-50000	0	0.283642	0.275467	0.165624	0.266357	0.194716
>5L	50000-60000	0.336484	0.338511	0.326902	0.384612	0.315133	0.474469
>5L	60000-80000	0.111730	0.196424	0.193238	0.176831	0.282517	0.224995
>5L	80000-100000	0	0	0.010420	0	0	0.013081
>5L	100000-130000	0	0.012904	0	0	0	0.013081
Sum		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

7.5.3. RegClassFraction

Using the VIUS data on gross vehicle weight, all Refuse Trucks were classified as Heavy-Duty Trucks.

7.6. Motor Homes

Determining source bin distribution for Motor Homes required a number of assumptions and interpolation due to the lack of detailed information. For each field, the following describes the information available, assumptions made, and how data points were determined.

7.6.1. FuelEngFraction

Detailed information on motor home fuel distribution was not available. Staff of the Recreational Vehicle Industry Association (RVIA) told us that the fraction of diesel motor homes had been relatively constant at 10 to 20 percent for many years.[42] This fraction began to increase steadily in the mid-1990s and is now 40%. Based on this information, we used linear interpolation to estimate the diesel fractions in Table 7-19. The remaining 1999-and-earlier motor homes are assumed to be gasoline-fueled. We assumed all 1999-and-earlier motor homes have conventional internal combustion engines.

Table 7-19. Diesel Fractions for Motor Homes.

Model Year	Fraction Diesel
1993-and-earlier	0.150000
1994	0.177778
1995	0.205556
1996	0.233333
1997	0.261111
1998	0.288889
1999	0.316667

7.6.2. SizeWeightFraction

No detailed information was available on average engine size and weight distributions for motor homes. We assumed all motor home engines were 5 L or larger. As a surrogate for average weight, we used information on gross vehicle weight provided in the Polk TIP® 1999 database by model year and mapped the Polk GVW Class to the MOVES weight bins. These values are likely to overestimate average weight and should be updated if better information becomes available. The Polk TIP® information did not specify fuel type, so we assumed that the heaviest vehicles in the Polk database were diesel-powered and the remainder are powered by gasoline. This led to the weight distributions in Table 7-20 and Table 7-21.

Table 7-20. Weight Fractions for Diesel Motor Homes by Model Year

Polk GVW bin	3	4	5	6	7	8
MOVES weight class	140	160	195	260	330	400
Model Year	Diesel					
1975	0.171431	0.792112	0.029828	0	0.006629	0
1976	0.637989	0.340639	0.018755	0.000436	0.002181	0
1977	0.68944	0.292308	0.012168	0.000277	0.005531	0.000277
1978	0.423524	0.574539	0	0.000387	0.00155	0
1979	0.096922	0.899344	0	0.001067	0.002667	0
1980	0.462916	0.537084	0	0	0	0
1981	0	0.941973	0	0.030174	0	0.027853
1982	0	0.868333	0	0.049	0.03	0.052667
1983	0	0.912762	0.000203	0.014845	0.030096	0.042094
1984	0	0.932659	0.000835	0.009183	0.036732	0.020592
1985	0	0.881042	0.001474	0.010761	0.083285	0.023438
1986	0	0.855457	0.013381	0.022962	0.089534	0.018667
1987	0	0.791731	0.085493	0.022498	0.087164	0.013113
1988	0	0.72799	0.148917	0.015469	0.093335	0.014289
1989	0	0.73298	0.128665	0.043052	0.082792	0.012511
1990	0	0.173248	0.614798	0.043628	0.149939	0.018387
1991	0	0	0.619344	0.063712	0.296399	0.020545
1992	0	0	0.551548	0.01901	0.385085	0.044356
1993	0	0	0.345775	0.471873	0.144844	0.037509
1994	0	0	0.45546	0.354386	0.159622	0.030531
1995	0	0	0.635861	0.163195	0.17468	0.026264
1996	0	0	0.553807	0.229529	0.184208	0.032456
1997	0	0	0.666905	0.193167	0.111299	0.028628
1998	0	0	0.267	0.335069	0.357508	0.040423
1999	0	0	0	0.736656	0.233886	0.029458

Table 7-21. Weight Fractions for Gasoline Motor Homes by Model Year

Polk GVW bin	3	4	5	6	7	8
MOVES weight class	140	160	195	260	330	400
Model Year	Gasoline					
1975	1	0	0	0	0	0
1976	1	0	0	0	0	0
1977	1	0	0	0	0	0
1978	1	0	0	0	0	0
1979	1	0	0	0	0	0
1980	1	0	0	0	0	0
1981	0.747723	0.252277	0	0	0	0
1982	0.732235	0.267765	0	0	0	0
1983	0.714552	0.285448	0	0	0	0
1984	0.641577	0.358423	0	0	0	0
1985	0.692314	0.307686	0	0	0	0
1986	0.720248	0.279752	0	0	0	0
1987	0.606635	0.393365	0	0	0	0
1988	0.459429	0.540571	0	0	0	0
1989	0.551601	0.448399	0	0	0	0
1990	0.543354	0.456646	0	0	0	0
1991	0.612025	0.322022	0.065952	0	0	0
1992	0.54464	0.373999	0.081361	0	0	0
1993	0.583788	0.361277	0.054935	0	0	0
1994	0.481099	0.361146	0.157755	0	0	0
1995	0.52997	0.198479	0.271551	0	0	0
1996	0.435959	0.289453	0.274588	0	0	0
1997	0.221675	0.433334	0.344991	0	0	0
1998	0.288222	0.581599	0.13018	0	0	0
1999	0.170133	0.392451	0.288411	0.149004	0	0

7.6.3. RegClassFraction

We assigned all motor homes to the Heavy-Duty Truck regulatory class.

7.7. SourceBinDistributions for 2000-and-later

MOVES was designed to support a wide variety of future fuels and engine technologies, including compressed natural gas (CNG), liquified petroleum gas (LPG), and conventional internal combustion (CIC) and advanced internal combustion (AIC) engines. In particular, emission rates were developed to support the combinations of fuel and engine technology listed by SourceType in Table 7-22. Note that some fuel types that were supported in earlier versions of MOVES (methanol and hydrogen) are not available in DraftMOVES2009.

The various hybrid types were split into "mild" and "full" categories because there are types of hybrids which get less of an efficiency increase from hybrid design due to larger engines and smaller electrical components. The less efficient designs we called "mild" hybrids (like the early Honda hybrids) to distinguish them from the more efficient, full hybrid designs (like the Toyota Prius). Both of these categories have significantly different energy rates and potentially different market shares. Conventional categories are split from advanced categories for a different reason. There have been significant improvements in internal combustion engines over time. The conventional versus advanced split is a crude accounting of these improvements. All of these technologies are further defined in the report, "Fuel Consumption Modeling of Conventional and Advanced Technology Vehicles in the Physical Emission Rate Estimator (PERE)."[43]

Table 7-22. Supported Fuels and Technologies for 2000-and-later Model Years.

Fuel	Engine Technology	Motor-cycles	Passenger Cars, Light Passenger & Commercial Trucks	Transit & School Buses; Single-Unit Short Haul Trucks & Motor Homes	Intercity Buses	Refuse Trucks	Single Unit Long Haul Trucks	Combination Short & Long Haul Trucks
Gasoline	Conventional IC	X	X	X		X	X	X
Gasoline	Advanced IC		X	X			X	X
Gasoline	CIC Hybrid Mild		X	X				
Gasoline	CIC Hybrid Full		X	X				
Gasoline	AIC Hybrid Mild		X	X				
Gasoline	AIC Hybrid Full		X	X				
Diesel	Conventional IC		X	X	X		X	X
Diesel	Advanced IC		X	X	X		X	X
Diesel	CIC Hybrid Mild		X	X				
Diesel	CIC Hybrid Full		X	X				
Diesel	AIC Hybrid Mild		X	X				
Diesel	Diesel AIC Hybrid Full		X	X		X		
CNG	Conventional IC		X	X		X	X	
LPG	Conventional IC		X	X		X	X	
Ethanol	Conventional IC		X	X		X	X	
Electricity	Electric only		X	X		X		

The inputs for determining default SourceBinDistributions for model years 2000-and-later were generally based on fuel and engine technology projections from AEO2004 and on the 1999 calendar year regulatory class, size and weight distributions used in MOVES.

7.7.1. Motorcycles

We assumed that all 2000-and-later motorcycles were fueled by conventional gasoline engines, with the same size and weight distributions as in 1999. All motorcycles are in the "Motorcycle" regulatory class.

7.7.2. Passenger Cars, Light Passenger Trucks and Light Commercial Trucks

Draft MOVES2009 supports a wide range of fuels and future engine technologies for passenger cars and light trucks.

The FuelEngFractions for these vehicles were determined from AEO2004. Supplemental Table 45 of the AEO2004 lists projected sales by technology type for light duty vehicles. Supplemental Table 56 lists projected technology penetrations for light duty vehicles. These values were mapped to the MOVES fuels and technologies to project fractions for model years 2001 through 2025. Fractions from 2001 were applied to model year 2000. Fractions from 2025 were applied to model years 2026 through 2050.

We analyzed passenger cars and light trucks separately. All vehicles were assigned to either the gasoline or diesel fuel conventional engine technology category for all future years. MOVES contains no projections for the use of hybrid or advanced engine technology or the use of alternative fuels in future calendar years. The resulting fuelEngFractions for conventional gasoline and diesel fueled vehicles are listed in Table 7.23.

We used the size and weight distributions from the 2002 model year for all 2003 and newer model years. The size and weight distribution for 2002 model year gasoline conventional internal combustion engines were used for all 2003 and newer model year technologies and fuel types, other than diesel. The 2003 and newer model year diesel vehicles of all technologies use the size and weight distribution for diesel conventional internal combustion engines of the 2002 model year.

All Passenger Cars were assigned to the Light Duty Vehicle (LDV) regulatory class. Light Trucks were distributed among the Light Duty Truck (LDT) and Heavy Duty Truck (HDT) regulatory classes. We used the 2002 model year regulatory class distribution for gasoline conventional internal combustion vehicles for all 2003 and newer model year technologies and fuel types, other than diesel.. The 2003 and newer model year diesel vehicles of all technologies use the regulatory class distribution for diesel conventional internal combustion vehicles of the 2002 model year.

Table 7.23. Fuel Fractions for 2002 and Newer Passenger Cars and Light Duty Trucks

	Passenger Cars		Passenger Trucks		Commerical Light Trucks	
Model Year	gasoline	diesel	gasoline	diesel	gasoline	diesel
2002	0.9900	0.0100	0.9870	0.0130	0.9870	0.0130
2003	0.9900	0.0100	0.9870	0.0130	0.9870	0.0130
2004	0.9900	0.0100	0.9870	0.0130	0.9870	0.0130
2005	0.9900	0.0100	0.8597	0.0123	0.8597	0.0121
2006	0.9900	0.0100	0.5942	0.0109	0.5823	0.0101
2007	0.9900	0.0100	0.4264	0.0100	0.4234	0.0089
2008	0.9900	0.0100	0.2171	0.0089	0.2122	0.0074
2009	0.9900	0.0100	0.1994	0.0088	0.1935	0.0072
2010	0.9900	0.0100	0.1747	0.0087	0.1727	0.0071
2011 and newer	0.9900	0.0100	0.1658	0.0087	0.1500	0.0070

7.7.3 Buses

Historically, school buses and transit buses have used a wide range of alternative fuels, while intercity buses have been powered almost exclusively by conventional diesel engines. For MOVES we anticipate this trend will continue. Fuel and technology projections were not available from AEO. The MOVES estimates for 1999 distributions of transit and school buses are carried forward to 2050. These distributions are summarized in Table 7.24. Engine size and vehicle weight distributions were also carried forward from 1999. All buses were assigned to the Heavy-Duty Truck regulatory class.

Table 7.24. Fuel and Engine Technology Fractions for 2000-and-later Buses

	Diesel CIC	**Gasoline CIC**
Intercity Buses	1.00000	0
Transit Buses	0.99399	0.00601
School Buses	0.95846	0.04154

7.7.4. Motor Homes and Single Unit Short-haul and Long-haul Trucks

For Motor Homes and Single Unit Short-haul and Long-haul Trucks, MOVES uses the AEO2004 projections for medium duty vehicles. AEO Table 55 lists sales projections for medium-duty freight trucks powered by diesel, gasoline, liquified petroleum gas and compressed natural gas. Furthermore, AEO Table 146 lists technology penetrations for Class 4-6 freight vehicles. All non-gasoline trucks, other than diesel, were assigned to the MOVES gasoline conventional combustion category. All diesel trucks with were assigned to the MOVES diesel conventional internal combustion category. The resulting distributions are summarized in Table 7.25.

We used the engine size and vehicle weight distributions from 2002 for future years. Where a future fuel was not part of the fleet in 2002, we used the 2002 size and weight distribution for gasoline conventional internal combustion vehicles. Where a future diesel engine technology was not part of the source type fleet in 2002, we used the 2002 size and weight distribution for diesel conventional internal combustion vehicles.

Table 7.25. Fuel and Engine Technology Fractions for 2002 and Newer Motor Homes and Single-Unit Short-haul and Long-haul Trucks

	Single Unit Short Haul		Single Unit Long Haul		Motor Home	
Model Year	gasoline	diesel	gasoline	diesel	gasoline	diesel
2002	0.2631	0.7369	0.0627	0.9373	0.2237	0.7763
2003	0.2924	0.7076	0.2924	0.7076	0.2924	0.7076
2004	0.2869	0.7131	0.2869	0.7131	0.2869	0.7131
2005	0.2809	0.7191	0.2809	0.7191	0.2809	0.7191
2006	0.2758	0.7242	0.2758	0.7242	0.2758	0.7242
2007	0.2710	0.7290	0.2710	0.7290	0.2710	0.7290
2008	0.2674	0.7326	0.2674	0.7326	0.2674	0.7326
2009	0.2642	0.7358	0.2642	0.7358	0.2642	0.7358
2010	0.2620	0.7380	0.2620	0.7380	0.2620	0.7380
2011	0.2602	0.7399	0.2602	0.7399	0.2602	0.7399
2012	0.2589	0.7411	0.2589	0.7411	0.2589	0.7411
2013	0.2579	0.7421	0.2579	0.7421	0.2579	0.7421
2014	0.2572	0.7428	0.2572	0.7428	0.2572	0.7428
2015	0.2566	0.7434	0.2566	0.7434	0.2566	0.7434
2016	0.2562	0.7438	0.2562	0.7438	0.2562	0.7438
2017	0.2560	0.7440	0.2560	0.7440	0.2560	0.7440
2018	0.2560	0.7440	0.2560	0.7440	0.2560	0.7440
2019	0.2561	0.7439	0.2561	0.7439	0.2561	0.7439
2020	0.2563	0.7437	0.2563	0.7437	0.2563	0.7437
2021	0.2565	0.7435	0.2565	0.7435	0.2565	0.7435
2022	0.2569	0.7431	0.2569	0.7431	0.2569	0.7431
2023	0.2573	0.7427	0.2573	0.7427	0.2573	0.7427
2024	0.2578	0.7422	0.2578	0.7422	0.2578	0.7422
2025	0.2586	0.7414	0.2586	0.7414	0.2586	0.7414
2026	0.2591	0.7409	0.2591	0.7409	0.2591	0.7409
2027	0.2594	0.7406	0.2594	0.7406	0.2594	0.7406
2028	0.2602	0.7398	0.2602	0.7398	0.2602	0.7398
2029	0.2608	0.7392	0.2608	0.7392	0.2608	0.7392
2030	0.2613	0.7387	0.2613	0.7387	0.2613	0.7387
2031 and Newer	0.1532	0.8468	0.1532	0.8468	0.1532	0.8468

7.7.5. Refuse and Combination Trucks

For Refuse, Short-haul and Long-haul Combination Trucks, MOVES uses the AEO2004 projections for heavy-duty freight trucks. AEO Table 55 lists sales projections for heavy-duty freight trucks powered by diesel, gasoline, liquified petroleum gas and compressed natural gas. All non-gasoline trucks, other than diesel, were assigned to the MOVES gasoline conventional combustion category. All diesel trucks with were assigned to the MOVES diesel conventional internal combustion category.

Furthermore, AEO Table 146 lists technology penetrations for Class 7-8 freight trucks with “higher cylinder pressure”, “improved injection & combustion” and “waste heat/thermal management”. All trucks were assigned to the MOVES the conventional internal combustion categories. The resulting distributions are summarized in Table 7.26.

We used the engine size and vehicle weight distributions from 2002 for future years. Where a future fuel or engine technology was not part of the source type fleet in 2002, we used the 2002 size and weight distribution for diesel conventional internal combustion vehicles.

All Refuse Trucks were assigned to the Heavy-Duty Truck regulatory class. Combination Trucks were distributed among the Light Duty Truck (LDT) and Heavy Duty Truck (HDT) regulatory classes. Where a future fuel or technology was not part of the source type fleet in 2002, we used the regulatory class distribution for diesel conventional internal combustion vehicles.

Table 7.26. Fuel and Engine Technology Fractions for Refuse Trucks and Short-haul and Long-haul Combination Trucks

	Refuse Trucks		Combination Short Haul		Combination Long Haul	
Model Year	gasoline	diesel	gasoline	diesel	gasoline	diesel
2002	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
2003	0.0332	0.9668	0.0330	0.9670	0.0330	0.9670
2004	0.0330	0.9670	0.0328	0.9672	0.0328	0.9672
2005	0.0328	0.9672	0.0327	0.9673	0.0327	0.9673
2006	0.0328	0.9672	0.0327	0.9673	0.0327	0.9673
2007	0.0330	0.9670	0.0329	0.9671	0.0329	0.9671
2008	0.0333	0.9667	0.0331	0.9669	0.0331	0.9669
2009	0.0336	0.9664	0.0335	0.9665	0.0335	0.9665
2010	0.0340	0.9660	0.0338	0.9662	0.0338	0.9662
2011	0.0344	0.9656	0.0342	0.9658	0.0342	0.9658
2012	0.0348	0.9652	0.0347	0.9653	0.0347	0.9653
2013	0.0353	0.9647	0.0351	0.9649	0.0351	0.9649
2014	0.0357	0.9643	0.0356	0.9644	0.0356	0.9644
2015	0.0362	0.9638	0.0361	0.9639	0.0361	0.9639
2016	0.0367	0.9633	0.0365	0.9635	0.0365	0.9635
2017	0.0371	0.9629	0.0370	0.9630	0.0370	0.9630
2018	0.0376	0.9624	0.0374	0.9626	0.0374	0.9626
2019	0.0380	0.9620	0.0379	0.9621	0.0379	0.9621
2020	0.0384	0.9616	0.0383	0.9617	0.0383	0.9617
2021	0.0388	0.9612	0.0387	0.9613	0.0387	0.9613
2022	0.0392	0.9608	0.0391	0.9609	0.0391	0.9609
2023	0.0396	0.9604	0.0395	0.9605	0.0395	0.9605
2024	0.0400	0.9600	0.0399	0.9601	0.0399	0.9601
2025	0.0404	0.9596	0.0403	0.9597	0.0403	0.9597
2026	0.0407	0.9593	0.0406	0.9594	0.0406	0.9594
2027	0.0411	0.9589	0.0409	0.9591	0.0409	0.9591
2028	0.0414	0.9586	0.0413	0.9587	0.0413	0.9587
2029	0.0417	0.9583	0.0416	0.9584	0.0416	0.9584
2030	0.0420	0.9580	0.0419	0.9581	0.0419	0.9581
2031 and Newer	0.0164	0.9836	0.0164	0.9836	0.0164	0.9836

8. SourceUseType

The SourceUseType table lists average vehicle mass and three average road load coefficients for each SourceType. The mass is listed in metric tons. The road load coefficients are a rolling term "A," a rotatating term "B," and a drag term "C."

MOVES uses these coefficients to calculate vehicle specific power for each source type according to the equation:

$$VSP = \left(A/M\right)\bullet v + \left(B/M\right)\bullet v^2 + \left(C/M\right)\bullet v^3 + \left(a + g \bullet \sin\theta\right)\bullet v \, .$$

where A, B, and C are the road load coefficients in units of (kiloWatt second)/(meter tonne), (kiloWatt second^2)/(meter^2 tonne), and (kiloWatt second^3)/(meter^3 tonne), respectively. *M* is the mass of the vehicle in *kilograms*, *g* is the acceleration due to gravity (*9.8 meter/ second*^{2}), *v* is the vehicle speed in *meter/second*, *a* is the vehicle acceleration in *meter/second*^{2}, and sinθ is the (fractional) road grade.

The values in the SourceUseType table were averaged from values in the Mobile Source Observation Database (MSOD). The values were weighted using the age and sourcebin distributions described elsewhere in this report. In particular, the average values were computed using the equation:

$$weightedvalue = \frac{\displaystyle\sum_{i=1,\,total\,\#of\;ages}\left\{\beta_i \cdot \left(\frac{\displaystyle\sum_{j=1,\,total\,\#of\;sourcebins}\alpha_j \cdot unweightedvalue}{\displaystyle\sum_{j=1,\,total\,\#of\;sourcebins}\alpha_j}\right)\right\}}{\displaystyle\sum_{i=1,\,total\,\#of\;ages}\beta_i}$$

where the "unweighted value" was either the vehicle mid-point mass or one of the three different road load coefficients determined from the road load–vehicle mass relations described below: α_j were the sourceBinActivityFractions in the MOVES database and β_i were the ageFractions in the MOVES database. Age fractions were matched to model years for calendar year 1999 (i.e., Model Year 1999 corresponds to vehicle ageID of 0; Model Year1969 corresponds to ageID of 30.) Only sourcebins and ages with vehicles in the MSOD were used in these weightings. Thus, the "total number of sourcebins" in the MSOD and "total number of ages" in the MSOD were used to normalize the results.

8.1. SourceMass

The SourceMass was computed as the weighted average of the "mid-point" mass for the Weight Class associated with each sourcebin. Sourcebins not represented in the MSOD were excluded.

Table 8-1. MOVES Weight Classes

Weight ClassID	**Weight Class Name**	**Midpoint Weight**
0	Doesn't Matter	[NULL]
20	weight < 2000 pounds	1000
25	2000 pounds <= weight < 2500 pounds	2250
30	2500 pounds <= weight < 3000 pounds	2750
35	3000 pounds <= weight < 3500 pounds	3250
40	3500 pounds <= weight < 4000 pounds	3750
45	4000 pounds <= weight < 4500 pounds	4250
50	4500 pounds <= weight < 5000 pounds	4750
60	5000 pounds <= weight < 6000 pounds	5500
70	6000 pounds <= weight < 7000 pounds	6500
80	7000 pounds <= weight < 8000 pounds	7500
90	8000 pounds <= weight < 9000 pounds	8500
100	9000 pounds <= weight < 10000 pounds	9500
140	10000 pounds <= weight < 14000 pounds	12000
160	14000 pounds <= weight < 16000 pounds	15000
195	16000 pounds <= weight < 19500 pounds	17750
260	19500 pounds <= weight < 26000 pounds	22750
330	26000 pounds <= weight < 33000 pounds	29500
400	33000 pounds <= weight < 40000 pounds	36500
500	40000 pounds <= weight < 50000 pounds	45000
600	50000 pounds <= weight < 60000 pounds	55000
800	60000 pounds <= weight < 80000 pounds	70000
1000	80000 pounds <= weight < 100000 pounds	90000
1300	100000 pounds <= weight < 130000 pounds	115000
9999	130000 pounds <= weight	130000
5	weight < 500 pounds (for MCs)	350
7	500 pounds <= weight < 700 pounds (for MCs)	600
9	700 pounds <= weight (for MCs)	700

8.2. Road Load Coefficients

The information available on road load coefficients varied by regulatory class.

Motorcycle road load coefficients are typically parameterized [44] with mass dependent A and C terms which take into account rolling resistance and aerodynamic drag. Parameters adopted here are from the UN report:

A = 0.088M and C= 0.26 + 1.94x10-4M

where M is the inertial mass of the motorcycle and driver and has units of metric tonnes.

For vehicles with a weight of 8500 lbs or less, the road load coefficients were derived from the track road load horsepower ($TRLHP_{@50mph)}$ recorded in the MSOD.[45] The calculations applied the following empirical equations:[46]

$$A = 0.7457*(0.35/50*0.447) \quad * \; TRLHP_{@50mph}$$
$$B = 0.7457*(0.10/(50*0.447)^2) \quad * \; TRLHP_{@50mph}$$

$$C \;=\; 0.7457*(0.55/(50*0.447)^3) \;\; * \;\; TRLHP_{@50mph}$$

The rolling resistance was multiplied by a factor of 5.

For the heavier vehicles, no road load parameters were available in the MSOD. Instead EPA used the relationships of road load coefficent to vehicle mass from a study done by V.A. Petrushov,[47] as shown in Table 8-2. The mid-point mass for the sourcebin was used as the vehicle mass.

Table 8-2. Road Load Coefficients for Heavy-Duty Trucks, Buses, and Motor Homes

	8500 to 14000 lbs (3.855 to 6.350 tonne)	**14000 to 33000 lbs (6.350 to 14.968 tonne)**	**>33000 lbs (>14.968 tonne)**	**Buses and Motor Homes**
A(kW*s/m)/ M(tonne)	0.0996	0.0875	0.0661	0.0643
B(kW*s^2/m^2)/ M(tonne)	0	0	0	0
C(kW*s^3/m^3) /M(tonne)	3.40×10^{-4} (mass is the average mass of the weight category)	1.97×10^{-4} (mass is the average mass of the weight category)	1.79×10^{-4} (mass is the average mass of the weight category)	$\frac{3.22}{mass(kg)} + 5.06\times 10^{-5}$
	$\frac{1.47}{mass(kg)} + 5.22\times 10^{-5}$	$\frac{1.93}{mass(kg)} + 5.90\times 10^{-5}$	$\frac{2.89}{mass(kg)} + 4.21\times 10^{-5}$	

In both cases, values of A, B, and C were computed for each SourceBin-associated vehicle in the MSOD and a weighted average was computed as described above. The final SourceMass and road load coefficients for all SourceTypes are listed in Table 8-3.

Table 8-3. SourceUseType Characteristics

Source TypeID	HPMS Vtype ID	SourceType Name	Rolling TermA (kW-s/m)	Rotating TermB (kW-s^2/m^2)	Drag TermC (kW-s^3/m^3)	Source Mass (metric tons)
11	10	Motorcycle	0.0251	0	0.000315	0.285
21	20	Passenger Car	0.156461	0.002002	0.000493	1.478803
31	30	Passenger Truck	0.22112	0.002838	0.000698	1.866865
32	30	Light Commercial Truck	0.235008	0.003039	0.000748	2.059793
41	40	Interstate Bus	1.295151	0	0.003715	19.59371
42	40	Urban Bus	1.0944	0	0.003587	16.55604
43	40	School Bus	0.746718	0	0.002176	9.069885
51	50	Refuse Truck	1.417049	0	0.003572	20.68453
52	50	Single-Unit Commercial Truck	0.561933	0	0.001603	7.641593
53	50	Single-Unit Delivery Truck	0.498699	0	0.001474	6.250466
54	50	Motor Home	0.617371	0	0.002105	6.734834
61	60	Combination Commercial Truck	1.963537	0	0.004031	29.32749
62	60	Combination Delivery Truck	2.081264	0	0.004188	31.40378

For Final MOVES2009, we will add a new field to the SourceUseType table, “fixedMassFactor,” that will serve as the denominator in the Vehicle Specific Power (VSP) equation, which generates a relationship between power and emissions that varies with the fixed mass. (For more on VSP, see the Operating Mode Distribution Generator descriptions in the Software Design and Reference Manual[48]) The fixed mass is fundamental to the calculation of the emission rates in the MOVES emission rate tables. In Final MOVES2009, if a user wishes to do “what if” calculations varying the sourceMass, the fixedMassFactor should remain constant. Such ‘what if” calculations are not possible in Draft MOVES2009, because increasing the source mass would increase both the numerator and the denominator in the VSP equation, leading to an incorrect decrease in emissions and energy consumption.

9. RoadTypeDistribution

MOVES will calculate emissions separately for each road type and for “off-network” activity. The road type codes used in MOVES are listed in Table 9-1. These road types are aggregations of the HPMS functional facility types that are also used for SCC reporting.

Table 9-1. Road Type Codes in MOVES

RoadTypeID	Description	HPMS functional Types	SCCRoadTypeID
1	Off Network	Off Network	1
2	Rural Restricted Access	Rural Interstate	11
3	Rural Unrestricted Access	Rural Principal Arterial, Minor Arterial, Major Collector, Minor Collector & Local	13, 15, 17, 19, 21
4	Urban Restricted Access	Urban Interstate & Urban Freeway/Expressway	23, 25
5	Urban Unrestricted Access	Urban Principal Arterial, Minor Arterial, Collector & Local	27, 29, 31, 33

For each SourceType, the **RoadTypeVMTFraction** field stores the fraction of total VMT that is traveled on each of the 5 roadway types.

For MOVES2009, we used data from 1999 FHWA Highway Statistics, Tables VM-1 and VM-2. VM-1 provides detail on VMT by vehicle type; VM-2 provides detail by HPMS functional type. At the time of this analysis, VM-1 (October 2000) had not been updated, but VM-2 was updated in January 2002. We used the total values from the more recent VM-2 to distribute VMT by facility type and allocated them to vehicle class in proportion to the values in VM-1. We then calculated facility type VMT fractions for each HPMS Vehicle Type. We then aggregated the values to the five MOVES road types.

The FHWA Highway Statistics is currently considered the best available source for national information regarding vehicle miles traveled. However, there are problems and constraints associated with using the (mostly) self-reported data in Highway Statistics. In many cases, locally derived VMT data may be more accurate when modeling local areas.

The VMT distributions in Table 9-2 assume that all VMT reported by HPMS is accumulated on one of the 12 HPMS roadway types and thus one of the four "on-network" MOVES roadtypes.. No VMT is currently assigned to the "off-network" category in the national defaults. See the discussion of BaseYearOffNetVMT in Section 11.2.

Table 9-2. Roadtype Distributions by Sourcetype

RoadType ID	Description	Motorcycles	Passenger Cars	Other 2axle - 4tire vehicles	Buses	Single unit trucks	Combination trucks
1	Off Network	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	Rural Restricted Access	0.1040	0.0834	0.0846	0.1268	0.1149	0.3247
3	Rural Unrestricted Access	0.3161	0.2891	0.3055	0.4821	0.3972	0.2941
4	Urban Restricted Access	0.2177	0.2097	0.2031	0.1385	0.1715	0.2075
5	Urban Unrestricted Access	0.3623	0.4178	0.4068	0.2526	0.3165	0.1737
Total		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

We are currently assuming identical VMT distributions for all SourceTypes within an HPMS Vehicle Type. However the MOVES model is designed to allow roadway type allocation by SourceType and one would expect the different SourceTypes to have different roadway type allocations. For example, the long-haul trucks generally would have a greater fraction of travel on rural restricted access roadways than the short-haul trucks. If such data becomes available we would like to update the database.

10. Average Speed Distribution

The AvgSpeedDistribution table provides the fraction of driving time for each SourceType, Road Type, Day, Hour, and Speed Bin in a field called **AvgSpeedFraction**. The values sum to one for each combination of SourceType, Road Type, Day, and Hour.
For Draft MOVES2009, the urban driving values were derived from the default speed distributions (SVMT) in MOBILE6. The MOBILE6 speed fractions were adapted to MOVES by converting the fraction of miles travelled to the fraction of time used, and by mapping from the MOBILE6 road types to the MOVESroad types, with the MOBILE6 "freeway" values mapped to the MOVES "urban restricted" roadtype and the MOBILE6 "arterial" values mapped to the MOVES "urban unrestricted" roadtype. The time fractions were normalized to sum to one for each hour of the day over all 14 speed bins. The values for the off-network roadway type were set to null. The detailed distributions are available in the MOVES default database. Only urban roadways obtain their values from the default MOBILE6 speed distributions. Average speed used for rural driving relied on recent driving data collected in California under studies performed for the California Department of Transportation (Caltrans). Under these Caltrans driving studies, instrumented "chase cars" were equipped with laser rangefinders mounted behind the front grill of each chase car. The studies were performed in the Sacramento area, the San Francisco Bay area and the San Joaquin Valley. Another driving study was also conducted in the South Coast (i.e., Los Angeles Basin), but was conducted entirely in urbanized areas. Thus, this data was not used for the rural area analysis.

A contractor report describes the analysis done to develop speed distributions from these datasets.[49] The datasets contained driving in both urban and rural areas. In the post-processing that was performed under each of these studies, the type of roadway the vehicle was traveling on during each second was also recorded in the output dataset. Since the datasets contained the Highway Performance Monitoring System (HPMS) Functional Class designation, it was easy to divide the driving data from these studies into rural functional class groups for creating average speed distributions. (The urban area travel in these datasets was discarded for this analysis.)

The average speed was calculated over each link traverse for the individual links in each data set. A link traverse is defined as a one-way driving traverse of the entire extent of a roadway link. A review of the links identified in the data showed that although distances of most links ranged between 0.5 to 5 miles, a few of them were ten miles or longer. These longer links were generally restricted to limited access freeways and highways or remote county roads. In rural areas, the difference in average speeds calculated over conventionally defined links versus longer link sections as identified in the route-based driving studies is not likely to be significant because of the general lack of traffic congestion on these rural roads.

Once the average speed was calculated for each link traverse, it was allocated into one of sixteen speed bins defined by EPA for the purpose of calculating speed distributions for use in MOVES. The MOVES speed bins are shown in Table 10-2.

Table 10-2. MOVES Speed Bin Categories.

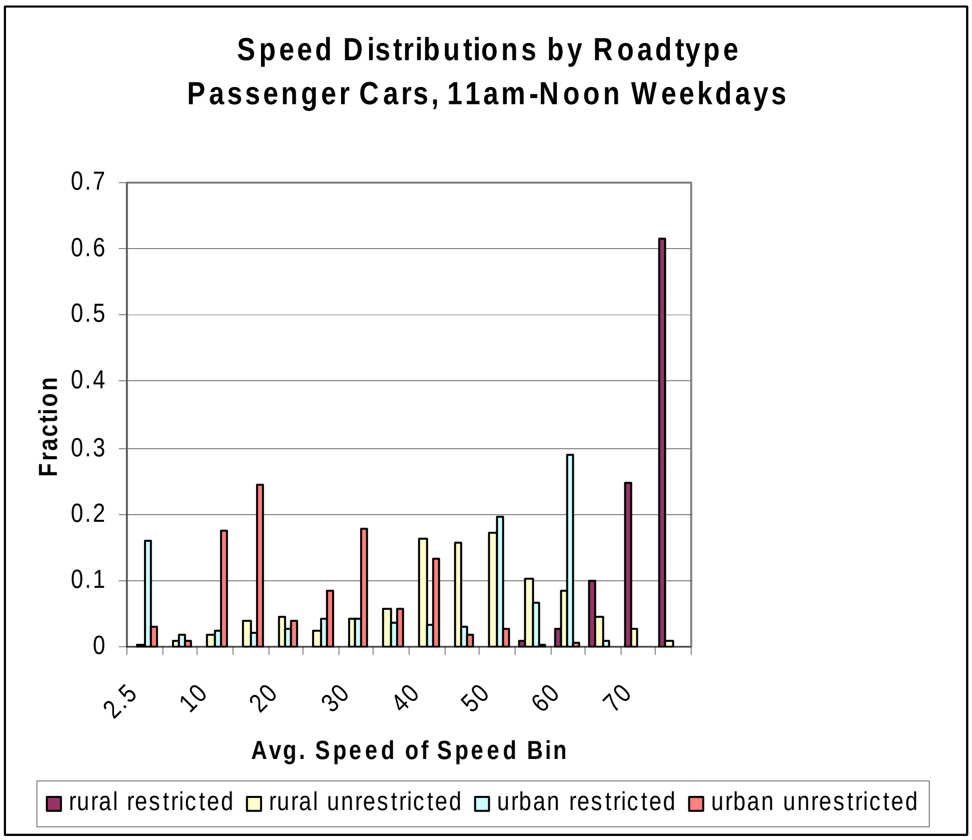
Bin	Average Speed (mph)	Average Speed Range (mph)
1	2.5	speed < 2.5 mph
2	5	2.5 mph <= speed < 7.5 mph
3	10	7.5 mph <= speed < 12.5 mph
4	15	12.5 mph <= speed < 17.5 mph
5	20	17.5 mph <= speed < 22.5 mph
6	25	22.5 mph <= speed < 27.5 mph
7	30	27.5 mph <= speed < 32.5 mph
8	35	32.5 mph <= speed < 37.5 mph
9	40	37.5 mph <= speed < 42.5 mph
10	45	42.5 mph <= speed < 47.5 mph
11	50	47.5 mph <= speed < 52.5 mph
12	55	52.5 mph <= speed < 57.5 mph
13	60	57.5 mph <= speed < 62.5 mph
14	65	62.5 mph <= speed < 67.5 mph
15	70	67.5 mph <= speed < 72.5 mph
16	75	72.5 mph <= speed

To import this information into MOVES, we started with the contractor-provided values of “Time-weighted Distributions (% of time) of California Rural Chase Car Driving Data by Average Link Speed for each HPMS Functional Class.”[50] These values were used directly for the rural restricted access roadtype (2). For the MOVES rural unrestricted access roadtype, the calculation required consolidating values on the five HPMS functional road classes to the single MOVES roadtype. This was done separately for each HPMS Vehicle Class. For each vehicle class, we used the roadtype distribution (see preceding section) to calculate the fraction of VMT on each road class. We then changed to a time-basis by calculating the average speed on each road class, dividing by the average speed and re-nomalizing. We then computed a sum-product of the speed bin fractions and the road class distributions to calculate the weighted-average speed bin distribution for each vehicle class and assigned this distribution to each sourcetype in the HPMS vehicle class.

Our use of the California rural data required a number of assumptions and extrapolations. For Draft MOVES2009, the same rural speed distributions were used for all hours of the day. And, while the California chase car data also only included light-duty vehicles, the resulting speed distributions are also used for heavy-duty vehicles. Also the existing data from the studies used in this analysis were collected entirely in California. Thus, use of these California results to represent national rural speed distributions must include the critical assumption that average speeds within each HPMS functional class do not significantly vary across the U.S on rural roadways.

National default speed distributions are available in the default database for each roadtype, sourcetype and hourday, and are not provided here. However, for illustration, Figure 14.1, shows the speed distributions on different roadtypes for passenger cars for the time period 11 am. to noon on weekdays.

Figure 10.1 Speed Distribution by Roadtype



11. HPMSVTypeYear

Three fields comprise HPMSVTypeYear in Draft MOVES2009: HPMSBaseYearVMT, BaseYearOffNetVMT, and VMTGrowthFactor.

11.1. HPMSBaseYearVMT

The HPMSBaseYearVMT field stores the base year VMT for each HPMS Vehicle Type. This VMT was calculated from the FHWA VM-1 and VM-2 tables as for RoadTypeDistribution, but instead of calculating fractions, we calculated VMT sums by HPMS Vehicle Class.

The resulting VMT for 1999 and 1990 by HPMS Vehicle Class is listed in Table 11-1.

Table 11-1. 1999 VMT by HPMS Vehicle Class

HPMS Vehicle Class	1990 VMT	1999 VMT
Motorcycles	9,557,000,000	10,579,600,000
Passenger Cars	1,408,270,000,000	1,568,640,000,000
Other 2 axle - 4 tire vehicles	574,571,000,000	900,735,000,000
Buses	5,726,000,000	7,657,000,000
Single unit trucks	51,901,000,000	70,273,700,000
Combination trucks	94,341,000,000	132,358,000,000

11.2. BaseYearOffNetVMT

Off Network VMT refers to the portion of activity that is not included in travel demand model networks or any VMT that is not otherwise reflected in the other twelve categories. This field is provided in case it is useful for modeling local areas. However, the reported HPMS VMT values, used to calculate the national averages discussed here, are intended to include all VMT. Thus, for Draft MOVES2009 national defaults, the BaseYearOffNetVMT will be zero for all vehicle types.

11.3. VMTGrowthFactor

The VMTGrowthFactor field stores a multiplicative factor indicating changes in total vehicle miles for calendar years after the base year. Total VMT data are reported according the HPMS vehicle classes discussed previously, i.e. passenger car, other 2-axle / 4-tire vehicle, single-unit truck, combination truck, bus and motorcycle. VMTGrowthFactor is expressed relative to the previous year's VMT; for example, 1 means no change from previous year VMT, 1.02 means a two percent increase in VMT, and 0.98 means a two percent decrease in VMT.

VMTGrowthFactor is used in the Total Activity Generator calculation of VMT for calendar years after the base year, meaning calendar years 2000 through 2050 in Draft MOVES2009. It is important to note that VMTGrowthFactor is a key component for estimates of future activity in MOVES, because the level of total activity in future years for many emission processes is derived from projections of total VMT. For these processes, projections of future populations based on sales growth, survival rates, etc. are only used to allocate total VMT.

Default estimates for VMTGrowthFactor were taken from FHWA *Highway Statistics* for 2000 through 2004, and from AEO2006 for years 2005-and-later. For passenger cars and light-duty trucks, additional calculations were needed to allocate the more aggregate AEO estimates for light-duty vehicles and trucks to the MOVES Source Types.

Calendar year 2000 through 2004 growth factors were derived from estimates of total VMT data as reported by FHWA's *Highway Statistics*, Table VM-1. Total VMT data are reported according the HPMS vehicle classes discussed previously, i.e. passenger car, other 2-axle / 4-tire vehicle, single-unit truck, combination truck, and bus. For these years the growth factors are simply total VMT for the calendar year divided by total VMT from the previous year.

Growth factors for calendar years 2005 through 2030 were calculated in the same manner using NEMS projections of total VMT as reported in *AEO200*6. In the AEO analysis, VMT projections are provided for total Light-Duty (*AEO2006* Supplemental Table 48), total Medium-Duty, and total Heavy-Duty (*AEO2004* Supplemental Table 55). The growth factors derived from the *AEO2006* Medium-Duty VMT estimates were applied to the single-unit truck and bus HPMS vehicle classes. The growth factors derived from the *AEO2006* Heavy-Duty VMT estimates were applied to the combination truck vehicle class.

Light-Duty VMT as reported in *AEO2006* Supplemental Table 48 applies to total light-duty growth from both cars and trucks; as such they do not reflect the higher growth rate of light trucks relative to passenger cars brought on by steadily increasing sales of light duty trucks. Separate VMTGrowthFactors for the Passenger Car and Other 2-axle/4-wheel Vehicle classes were therefore developed based on estimates of car and light truck populations from *AEO2006*. Using the *AEO2006* estimates of total light-duty VMT and vehicle population (i.e., stock) growth rates listed in AEO Supplemental Table 46, we calculated the "per-vehicle" VMT implied from these estimates (total VMT divided by population). Assuming that per-vehicle VMT growth is the same for cars and light trucks, we multiplied the total light-duty per-vehicle VMT by the car and light truck populations to project separate car and light truck VMT for future years and then computed annual growth rates. Table 11-3 illustrates these calculation steps.

For final MOVES2009, we plan to update these growth factors using updated VMT information and projections.

Table 11-2. VMTGrowthFactor Calculation for Passenger Cars and Light Trucks

Calendar	Vehicle Stock (million) (From AEO2006)			VMT (billion) (From AEO 2006)	Per-Vehicle VMT	VMT by Type (pop * per-vehicle vmt)			
Year	LD Total	LDV	LDT	LD Total	LD Total	LDV Total	Growth	LDT Total	Growth
2004	211.553	130.782	80.771	2632.078	12.442	1627.147		1004.931	
2005	216.805	131.992	84.813	2619.176	12.081	1594.573	0.980	1024.603	1.020
2006	221.645	133.602	88.043	2644.429	11.931	1593.996	1.000	1050.433	1.025
2007	226.700	135.178	91.522	2693.347	11.881	1606.008	1.008	1087.339	1.035
2008	231.613	136.561	95.052	2751.712	11.881	1622.438	1.010	1129.274	1.039
2009	236.476	137.746	98.730	2818.227	11.918	1641.603	1.012	1176.623	1.042
2010	241.264	138.705	102.559	2889.563	11.977	1661.235	1.012	1228.328	1.044
2011	246.004	139.664	106.340	2946.387	11.977	1672.749	1.007	1273.638	1.037
2012	250.608	140.540	110.068	3000.774	11.974	1682.825	1.006	1317.948	1.035
2013	254.971	141.283	113.688	3055.248	11.983	1692.960	1.006	1362.288	1.034
2014	259.118	141.888	117.231	3113.610	12.016	1704.944	1.007	1408.665	1.034
2015	263.028	142.395	120.633	3171.164	12.056	1716.763	1.007	1454.400	1.032
2016	266.797	142.866	123.932	3227.686	12.098	1728.375	1.007	1499.312	1.031
2017	270.473	143.308	127.165	3288.719	12.159	1742.502	1.008	1546.217	1.031
2018	274.100	143.740	130.360	3351.878	12.229	1757.751	1.009	1594.126	1.031
2019	277.634	144.156	133.478	3414.157	12.297	1772.740	1.009	1641.418	1.030
2020	281.091	144.585	136.506	3474.341	12.360	1787.100	1.008	1687.241	1.028
2021	284.535	145.036	139.499	3535.598	12.426	1802.203	1.008	1733.395	1.027
2022	287.982	145.515	142.467	3597.454	12.492	1817.763	1.009	1779.690	1.027
2023	291.469	146.029	145.439	3660.468	12.559	1833.938	1.009	1826.530	1.026
2024	295.016	146.582	148.435	3725.200	12.627	1850.899	1.009	1874.301	1.026
2025	298.626	147.172	151.454	3791.240	12.696	1868.435	1.009	1922.804	1.026
2026	302.333	147.816	154.517	3858.390	12.762	1886.440	1.010	1971.950	1.026
2027	306.124	148.503	157.621	3927.069	12.828	1905.045	1.010	2022.024	1.025
2028	309.952	149.223	160.729	3995.345	12.890	1923.515	1.010	2071.829	1.025
2029	313.854	149.988	163.866	4064.186	12.949	1942.235	1.010	2121.952	1.024
2030	317.825	150.802	167.023	4132.401	13.002	1960.744	1.010	2171.658	1.023

Table 11-3. VMT Growth Factors in Draft MOVES2009

Year	Motorcycles	Passenger Cars	Passenger and Light Comm. Trucks	Buses	Single Unit Trucks	Combination Trucks
2000	0.990	1.021	1.026	0.992	1.004	1.021
2001	0.910	1.012	1.016	0.920	1.025	1.003
2002	0.991	1.019	1.024	0.968	1.048	1.015
2003	1.003	1.008	1.019	0.991	1.025	1.010
2004	1.049	1.020	1.031	0.979	1.043	1.037
2005	0.980	0.980	1.020	0.998	0.998	1.022
2006	1.000	1.000	1.025	1.007	1.007	1.034
2007	1.008	1.008	1.034	1.016	1.016	1.033
2008	1.010	1.010	1.037	1.013	1.013	1.025
2009	1.012	1.012	1.040	1.018	1.018	1.025
2010	1.012	1.012	1.042	1.021	1.021	1.026
2011	1.007	1.007	1.036	1.025	1.025	1.025
2012	1.006	1.006	1.034	1.023	1.023	1.023
2013	1.006	1.006	1.033	1.022	1.022	1.022
2014	1.007	1.007	1.033	1.023	1.023	1.022
2015	1.007	1.007	1.032	1.024	1.024	1.023
2016	1.007	1.007	1.030	1.025	1.025	1.023
2017	1.008	1.008	1.031	1.026	1.026	1.025
2018	1.009	1.009	1.030	1.026	1.026	1.025
2019	1.009	1.009	1.029	1.025	1.025	1.021
2020	1.008	1.008	1.027	1.025	1.025	1.020
2021	1.008	1.008	1.027	1.026	1.026	1.020
2022	1.009	1.009	1.026	1.027	1.027	1.021
2023	1.009	1.009	1.026	1.027	1.027	1.021
2024	1.009	1.009	1.026	1.027	1.027	1.022
2025	1.009	1.009	1.026	1.027	1.027	1.023
2026	1.010	1.010	1.025	1.028	1.028	1.024
2027	1.010	1.010	1.025	1.027	1.027	1.024
2028	1.010	1.010	1.024	1.027	1.027	1.023
2029	1.010	1.010	1.024	1.027	1.027	1.023
2030	1.010	1.010	1.023	1.026	1.026	1.023
2031-2050	1.010	1.010	1.023	1.026	1.026	1.023

12. Temporal Distributions of VMT

MOVES can estimate emissions for every hour of every day of the year. For this reason, for national scale runs ("macroscale") annual VMT estimates need to be allocated to months, days, and hours.

A 1996 report from the Office of Highway Information Management (OHIM)[51] describes analysis of a sample of 5,000 continuous traffic counters distributed through the United States. EPA obtained the data used in the report and used it to generate inputs in the form needed for Draft MOVES2009.

The report does not specify VMT by SourceType or Vehicle Type. Thus, we currently use the same value for all SourceTypes. For Final MOVES2009, we plan to update the MOVES pre-processor tools to aid local areas entering VMT with accurate local temporal distributions.

12.1. MonthVMTFraction

For MonthVMTFraction, we use the data from the OHIM report's Figure 2.2.1 "Travel by Month, 1970-1995," but modified to fit MOVES specifications.

The figure shows VMT/day, normalized to January=1. For MOVES, we need the fraction of total VMT per month, with different values for leap year and non-leap year. We computed the fractions using the report values and the number of days in each month.

Table 12-1. MonthVMTFraction

Month	Normalized VMT/day	MOVES not Leap Year	MOVES Leap Year
January	1.0000	0.0731	0.0729
February	1.0560	0.0697	0.0720
March	1.1183	0.0817	0.0815
April	1.1636	0.0823	0.0821
May	1.1973	0.0875	0.0873
June	1.2480	0.0883	0.0881
July	1.2632	0.0923	0.0921
August	1.2784	0.0934	0.0932
September	1.1973	0.0847	0.0845
October	1.1838	0.0865	0.0863
November	1.1343	0.0802	0.0800
December	1.0975	0.0802	0.0800

12.2. DayVMTFraction

The OHIM report provides VMT percentage values for each day and hour of a typical week for urban and rural roadway types for various regions of the United States for both 1992 and 1995. The data obtained from the OHIM report is not disaggregated by month or SourceType. The same values will be used for every month and SourceType. We used 1995 data (which is very similar to 1992) as it is displayed in Figure 2.3.2 of the OHIM report.

For the DayVMTFraction needed for MOVES2009, we first summed the reported percentages for each day of the week and converted to fractions. Note, the report explains that data for “3am” refers to data collected from 3am to 4am. Thus data labeled “midnight” belongs to the upcoming day. Because MOVES2009 classifies days into two types of days, "weekdays" and "weekend," we then summed the daily fractions to compute fractions for each type of day.

Table 12-2. DayVMTFractions

	Rural	**Urban**
Weekday	0.2788	0.2376
Weekend	0.7212	07624

We assigned the “Rural” fractions to the rural Roadtypes and the “Urban” fractions to the urban Roadtypes. The correct distribution for “Off network” VMT is unknown. Since the majority of U.S. travel is urban, the default DayVMTFraction for "Off network" will be assigned the urban fractions. Note the MOVES2009 default VMT on “Off-network” roadtypes is zero.

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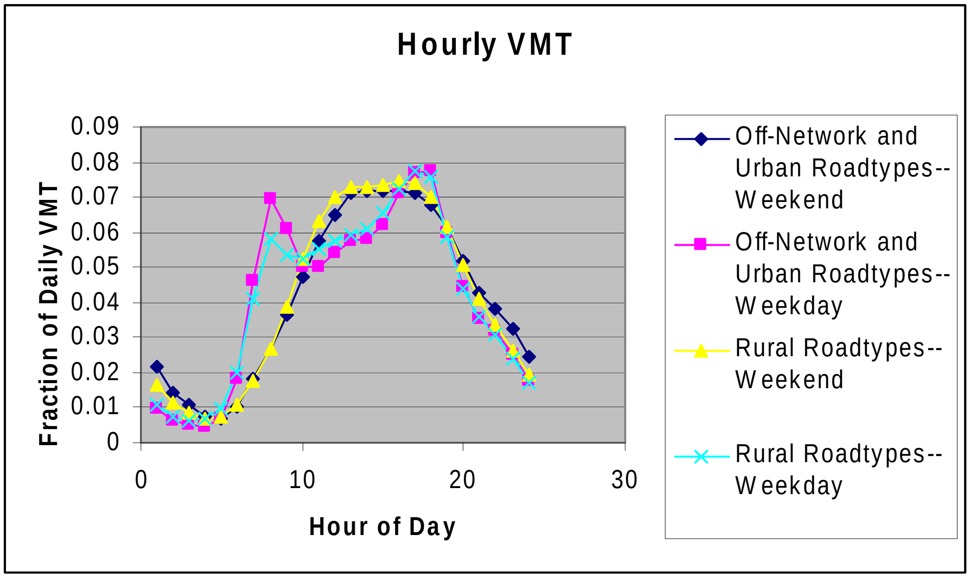
12.3. HourVMTFraction

For HourVMTFraction we used the same data as for DayVMTFraction. We converted the OHIM report data to percent of day by dividing by the DayVMTFraction.

There are separate sets of HourVMTFractions for "Urban" and "Rural" roadway types. Roadway types were assigned as for DayVMTFraction. All SourceTypes use the same HourVMTFraction distributions. The Off-Network roadtype was assigned the “Urban” fractions. Figure 12.1 graphs the hourly VMT fractions.

Figure 12.1 Hourly VMT Fractions in Draft MOVES2009



There is hourly VMT data available from Vehicle Travel Information System(VTRIS) database maintained by FHWA that distinguishes hourly VMT by FHWA vehicle category. Analysis of this data can provide HourVMTfractions differ by sourcetype. We request comment on the relative priority of incorporating this data into MOVES defaults.

13. Driving Schedule Tables

DriveSchedule refers to a second-by-second vehicle speed trajectory. Drive schedules are used in MOVES to determine the operating mode distribution for most MOVES running process emissions and energy consumption.

A key feature of MOVES is the capability to accommodate any number of drive schedules to represent driving patterns across source type, roadway type and average speed. For the national default case, Draft MOVES2009 employs 40 drive schedules, mapped to specific source types and roadway types. The average speed of a driving schedule is used to determine the weighting of that schedule for a given roadtype and sourcetype, based on the average speed distribution. Briefly, for each speed bin in the speed distribution, the MOVES model selects the two associated driving cycles with average speeds that bracket the speed bin's average speed. The Vehicle Specific Power (VSP) distributions determined for each bracketing driving schedule are averaged together, weighted by the proximity of the speed bin average speed to the driving schedule average speeds. In this way, the VSP distribution of any roadtype's speed distribution is determined from the available driving schedules. For more details, see the Operating Mode Distribution Generator sections in the MOVES Software and Design Reference Manual.[52]

For brevity, the entire body of drive schedule information is not presented in this document. The reader is referred to the MOVES database, where three MOVES database tables encompass drive schedule information. **DriveSchedule** provides the drive schedule name, identification number, and the average speed of the drive schedule. **DriveScheduleAssoc** defines the set of schedules which are available for each combination of source use type and road type. This table also indicates which driving schedules describe freeway ramp type driving. **DriveScheduleSecond** contains the second-by-second vehicle trajectories for each schedule. In some cases the vehicle trajectories are not contiguous; that is, they represent several unconnected microtrips.

Table 13-1 shows a complete list of the driving schedules used in the default case and their associated average speed. Note that the speed given in the drive schedule name is just a nominal speed and not used in the MOVES calculations.

Table 13-1. Default MOVES Drive Schedules

Drive Schedule Set	DriveScheduleName(ID)	AverageSpeed (mph)
Light-Duty Non-Freeway	Low Speed 1 (101)	2.5
	New York City (102)	7.1
	Non-Freeway LOS EF (103)	11.6
	Non-Freeway LOS CD (104)	19.2
	Non-Freeway LOS AB (105)	24.8
Light-Duty Freeway	Freeway LOS G (151)	13.1
	Freeway LOS F (152)	18.6
	Freeway LOS E (153)	30.5
	Freeway LOS D (154)	52.9
	Freeway LOS AC (155)	59.7
	Freeway High Speed 1 (156)	63.2
	Freeway High Speed 2 (157)	68.2
	Freeway High Speed 3 (158)	76
	Freeway Ramp (199)	34.6
Medium Heavy-Duty Non-Freeway	5 mph (201)	4.6
	10 mph (202)	10.7
	15 mph (203)	15.6
	20 mph (204)	20.8
	25 mph (205)	24.5
	30 mph (206)	31.5
Medium Heavy-Duty Freeway	30 mph (251)	34.4
	40 mph (252)	44.5
	50 mph (253)	55.4
	60 mph (254)	60.4
	Ramp (299)	31
Heavy Heavy-Duty Non-Freeway	5 mph (301)	5.8
	10 mph (302)	11.2
	15 mph (303)	15.6
	20 mph (304)	19.4
	25 mph (305)	25.6
	30 mph (306)	32.5
Heavy Heavy-Duty Freeway	30 mph (351)	34.3
	40 mph (352)	47.1
	50 mph (353)	54.2
	60 mph (354)	59.4
	Ramp (399)	25.3
Bus Non-Freeway	Low Speed Urban (401)	15*
	30 mph flow (402)	30*
	45 mph flow (403)	45*
Refuse Truck	Refuse Truck Urban (501)	2.2

* Speed represents average of traffic the bus is traveling in, not the average speed of the bus, which is lower due to stops.

14. Drive Schedule Association

The DriveSchedules listed in Table 13-1 are associated with specific SourceTypes and RoadTypes as summarized in Table 14-1. This table is an aggregated representation of the information in DriveScheduleAssociation, which contains a mapping of every schedule to each SourceType across each of the 12 HPMS roadway types.

Table 14-1. Drive Schedule Mapping

Source Use Type	Restricted Access Roadtypes	Unrestricted Access Roadtypes
Motorcycle Passenger Car Passenger Truck Commercial Truck	Light-Duty Freeway Schedules Light-Duty Low Speed 1 New York City Non-Freeway LOS EF	Light-Duty Non-Freeway Schedules Freeway LOS E Freeway LOS D Freeway LOS AC Freeway High Speed 1 Freeway High Speed 2 Freeway High Speed 3 Freeway Ramp
Intercity bus Single Unit Short Haul Single Unit Long Haul Motor Home	Medium Heavy-Duty Freeway Medium Heavy-Duty Non-Freeway	Medium Heavy-Duty Freeway Medium Heavy-Duty Non-Freeway
Transit bus School Bus	Medium Heavy-Duty Freeway Medium Heavy-Duty Non-Freeway	Bus Non-Freeway Medium Heavy-Duty 50mph Freeway Medium Heavy-Duty 60mph Freeway MD Freeway Ramp
Refuse Truck	Heavy Heavy-Duty Freeway Heavy Heavy-Duty Non-Freeway	Refuse Truck Urban
Combination Short Haul Combination Long Haul	Heavy Heavy-Duty Freeway Heavy Heavy-Duty Non-Freeway	Heavy Heavy-Duty Freeway Heavy Heavy-Duty Non-Freeway

The default drive schedules listed in Tables 13-1 and 14-1 were developed from several sources. The majority of the light-duty cycles are identical to those developed for MOBILE6 and documented in report M6.SPD.001.[53] What we now refer to as "non-freeway" schedules are the same as the "arterial" cycles used in MOBILE6; the name change was made to reflect the application of these schedules to all non-freeway operation, including local roadways. The light-duty schedules not included in the MOBILE6 work are Low Speed, New York City, High Speed 2 and High Speed 3. Low Speed is a historic cycle used in the development of speed corrections for MOBILE5 and is meant to represent extreme stop-and-go "creep" driving. The New York City Cycle is a historic test schedule representing congested urban travel with lots of stop-and-go. It is used in EPA's running loss certification test procedure.[54]

High Speed 2 and 3 were developed specifically for MOVES. High Speed 1 was the highest speed schedule in MOBILE6, with an average speed of 63 mph. EPA received many comments with respect to MOBILE6 that this was not sufficient to capture the range of high speed freeway driving in-use. The increase in speed limits as well as improvements in vehicle performance over the past decades dictate the need to represent more extreme driving; High Speed 2 and 3 were developed to represent these conditions. High Speed 2 is a 240-second segment of the US06 certification compliance cycle, with an average speed of 68 mph and a maximum of 80 mph. High Speed 3 is 580-second segment of freeway driving from an in-use vehicle instrumented as part of EPA's On-Board Emission Measurement "Shootout" program,[55] with an average speed of 76 mph and a maximum of 90 mph. The addition of these schedules will serve to increase the capacity of MOVES to reflect the higher speed freeway operation seen on the road today. It should be noted, however, that these schedules are only applied in Draft MOVES2009 if AverageSpeedDistribution contains operation in the highest speed bins; i.e. 70 mph and greater.

Medium-Duty and Heavy-Duty schedules were developed specifically for MOVES, based on work performed for EPA by Eastern Research Group (ERG), Inc. and documented in the report "Roadway-Specific Driving Schedules for Heavy-Duty Vehicles."[56] ERG analyzed data from 150 medium and heavy-duty vehicles instrumented to gather instantaneous speed and GPS measurements. ERG segregated the driving into freeway and non-freeway driving for medium and heavy-duty vehicles, and then further stratified vehicles trips according the pre-defined ranges of average speed covering the range of vehicle operation. ERG characterized representative driving within each speed range, using distributions of vehicle specific power (VSP), speed and acceleration. Driving schedules were then developed for each speed bin by creating combinations of idle-to-idle "microtrips" until the representative target metrics were achieved. The schedules developed by ERG are, thus, not contiguous schedules which would be run on a chassis dynamometer, but are made up of non-continguous "snippets" of driving meant to represent target distributions. For use in MOVES, the highway heavy-duty schedules developed by ERG were modified to isolate operation on freeway ramps. The segments of freeway microtrips identified by ERG as taking place on on-and off-ramps were extracted and used to create medium-duty and heavy-duty ramp schedules (299 and 399). Thus, the schedules which represent on-freeway driving do not contain ramp operation. Another minor modification to the schedules for use in MOVES was made to the time field in order to signify, within a drive schedule, when one microtrip ended and one began. The time field increments two seconds instead of one when each new microtrip begins. This two second increment signifies that these should not be regarded by the model as contiguous operation.

The freeway and non-freeway driving cycles are intended to cover most of the driving on these respective roadtypes. However, some speed distributions for non-freeway roadtypes will include average speeds faster than the fastest non-freeway cycles. The reverse will be true for some freeway speed distributions. In these cases, the model will use appropriate average speed drive schedules from a different roadtype. This mapping is summarized in table 14-1, which illustrates, for example, that low-speed freeway driving is modeled using non-freeway driving schedules. This mapping is appropriate since, when the average speed is very low or very high, the roadtype has little impact on the driving pattern.

For Final MOVES2009 we plan to incorporate additional driving schedules and to replace many of the older driving schedules, which we do not think adequately represent today's vehicles and driving behavior. A contractor has developed 45 driving schedules for light-duty vehicles.[57] These are based on urban and rural data collected in California in 2000 and 2004. The proposed mapping of driving cycles to roadtypes for Final MOVES2009 is summarized in Table 14-2, below. This mapping would apply to passenger cars, passenger trucks and light commercial trucks. We also hope to have additional driving schedules for motorcycles, but they are not available at this time. Other sourcetypes would use the driving schedules currently used in Draft MOVES2009.

Table 14.2 Proposed Drive Schedules for Passenger Cars, Passenger Trucks and Light Commercial Trucks in Final MOVES2009

Rural Restricted Access Roadtype (2)			
ID	**Avgspeed**	**Road Classification**	**DriveScheduleDesc**
158	76.0	LD High Speed Freeway 3	
1009	73.8	Rural Interstate	Final FC01LOSAF Cycle (C10R04-00854)
1010	55.3	Rural Principal Arterial	Final FC02LOSAC Cycle (C15R02-00646)
1011	49.1	Rural Principal Arterial	Final FC02LOSDF Cycle (C10R05-00513)
1012	44.4	Rural Major Arterial	Final FC06LOSAF Cycle (C15R01-00276)
1013	42.5	Rural Minor Arterial	Final FC07LOSAF Cycle (C10R07-00913)
1014	38.6	Rural Collector	Final FC08LOSAF Cycle (C10R05-00330)
1015	30.0	Rural Local	Final FC09LOSAF Cycle (C15R06-00563)
1030	25.4	Urban Principal Arterial	Final FC14LOSC Cycle (C10R04-00104)
1031	21.7	Urban Principal Arterial	Final FC14LOSD Cycle (C15R01-00836)
1032	17.2	Urban Principal Arterial	Final FC14LOSE Cycle (C15R03-00606)
1033	8.7	Urban Principal Arterial	Final FC14LOSF Cycle (C15R05-00424)
102	7.1	LD New York City	
101	2.5	LD Low Speed 1	
Urban Restricted Access Roadtype (4)			
ID	**Avgspeed**	**Road Classification**	**DriveScheduleDesc**
158	76.0	LD High Speed Freeway 3	
1009	73.8	Rural Interstate	Final FC01LOSAF Cycle (C10R04-00854)
1023	66.4	Urban Freeway	Final FC12LOSB Cycle (C15R08-00003)
1024	63.7	Urban Freeway	Final FC12LOSC Cycle (C15R04-00582)
1025	52.8	Urban Freeway	Final FC12LOSD Cycle (C15R09-00037)
1026	43.3	Urban Freeway	Final FC12LOSE Cycle (C15R10-00782)
1014	38.6	Rural Collector	Final FC08LOSAF Cycle (C10R05-00330)
1029	31.0	Urban Principal Arterial	Final FC14LOSB Cycle (C15R07-00177)
1035	29.5	Urban Minor Arterial	Final FC16LOSB Cycle (C15R03-00219)
1034	26.6	Urban Minor Arterial	Final FC16LOSA Cycle (C15R05-00755)
1028	25.5	Urban Principal Arterial	Final FC14LOSA Cycle (C15R03-00651)
1030	25.4	Urban Principal Arterial	Final FC14LOSC Cycle (C10R04-00104)
1036	23.3	Urban Minor Arterial	Final FC16LOSC Cycle (C15R05-00252)
1037	21.9	Urban Minor Arterial	Final FC16LOSD Cycle (C15R02-00561)
1040	21.8	Urban Collector	Final FC17LOSAC Cycle (C15R01-00333)
1031	21.7	Urban Principal Arterial	Final FC14LOSD Cycle (C15R01-00836)
1041	18.6	Urban Collector	Final FC17LOSD Cycle (C15R05-00480)
1032	17.2	Urban Principal Arterial	Final FC14LOSE Cycle (C15R03-00606)
1043	15.7	Urban Local	Final FC19LOSAC Cycle (C15R08-00267)
1038	14.6	Urban Minor Arterial	Final FC16LOSE Cycle (C15R05-00799)
1044	12.0	Urban Local	Final FC19LOSDF Cycle (C15R03-00074)
1042	11.2	Urban Collector	Final FC17LOSEF Cycle (C15R02-00734)
1039	10.5	Urban Minor Arterial	Final FC16LOSF Cycle (C10R02-00249)
1033	8.7	Urban Principal Arterial	Final FC14LOSF Cycle (C15R05-00424)
102	7.1	LD New York City	

Table 14.2 Continued

Rural and Urban Unrestricted Access Roadtypes (3 & 5)			
ID	**Avgspeed**	**Road Classification**	**DriveScheduleDesc**
158	76.0	LD High Speed Freeway 3	
1009	73.8	Rural Interstate	Final FC01LOSAF Cycle (C10R04-00854)
1017	66.4	Urban Interstate	Final FC11LOSB Cycle (C10R02-00546)*
1018	64.4	Urban Interstate	Final FC11LOSC Cycle (C15R09-00849)
1024	63.7	Urban Freeway	Final FC12LOSC Cycle (C15R04-00582)
1019	58.8	Urban Interstate	Final FC11LOSD Cycle (C15R10-00068)
1022	53.9	Urban Freeway	Final FC12LOSA Cycle (C15R02-00501)
1025	52.8	Urban Freeway	Final FC12LOSD Cycle (C15R09-00037)
1020	46.1	Urban Interstate	Final FC11LOSE Cycle (C15R11-00851)
1026	43.3	Urban Freeway	Final FC12LOSE Cycle (C15R10-00782)
1014	38.6	Rural Collector	Final FC08LOSAF Cycle (C10R05-00330)
1029	31.0	Urban Principal Arterial	Final FC14LOSB Cycle (C15R07-00177)
1030	25.4	Urban Principal Arterial	Final FC14LOSC Cycle (C10R04-00104)
1021	20.6	Urban Interstate	Final FC11LOSF Cycle (C15R01-00876)
1027	19.0	Urban Freeway	Final FC12LOSF Cycle (C15R08-00294)
1032	17.2	Urban Principal Arterial	Final FC14LOSE Cycle (C15R03-00606)
1033	8.7	Urban Principal Arterial	Final FC14LOSF Cycle (C15R05-00424)
102	7.1	LD New York City	
101	2.5	LD Low Speed 1	

*1009 was originally characterized as LOSB, but now considered AB.

15. SourceTypeHour

The SourceTypeHour table provides one data field: **IdleSHOFactor.**

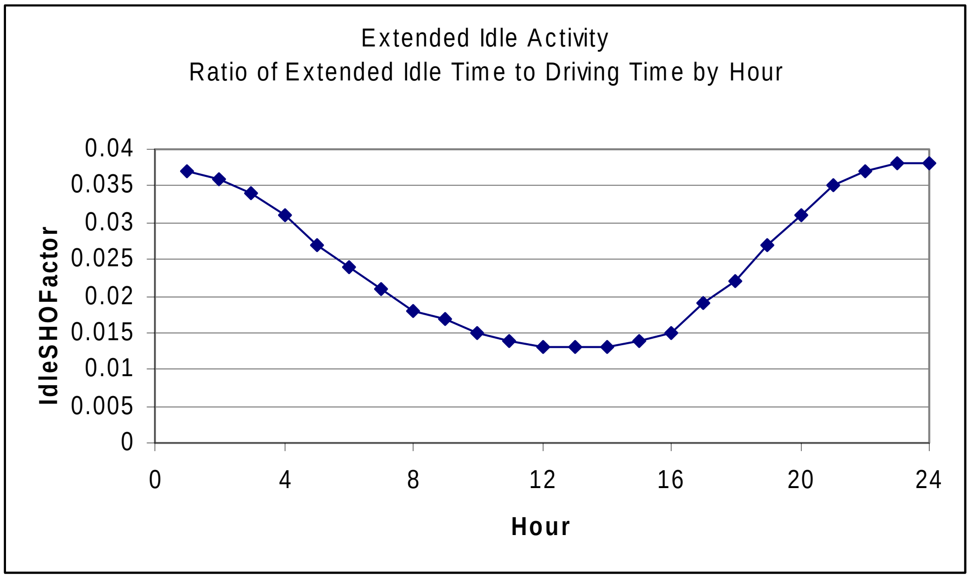
15.1. IdleSHOFactor

The IdleSHOFactor field is the number used to determine the number of hours of extended idling for each Source Type by day of the week and hour of the day. Extended idling, also referred to as "hoteling," is defined as any long period of discretionary idling that occurs during long distance deliveries by heavy-duty trucks. In Draft MOVES2009, only the long haul combination truck sourcetype is assumed to have hoteling activity. All other source use types have hoteling activity fractions set to zero.

No sources exist that directly measure extended idling in order to determine the total hours of extended idling estimated for heavy-duty trucks. However, hoteling mainly occurs among the largest (Class 8) trucks, which are now almost exclusively diesel. A 2004 paper by Lutsey, et al., [58] submitted to the Transportation Research Board, provides some insights on how truck hoteling relates to overall truck activity.

Federal law limits the number of hours which long haul truck drivers can operate each day. These regulations are described in the Federal Register.[59] Using the distribution of truck hoteling duration times (shown in Figure 1 of the Lutsey, et al. paper) and assuming that long haul truck drivers travel an average of 10 hours a day when engaged in hoteling behavior, we can estimate the average duration of hoteling as 5.9 hours for every 10 hours of long-haul truck driving.

However, for MOVES we need to know the fraction of hours spent hoteling versus hours of vehicle operation by time of day. This value can be derived from the known truck activity. In particular, the report, "Roadway-Specific Driving Schedules for Heavy-Duty Vehicles,"[60] combines data from several instrumented truck studies. The data contains detailed information about truck driver behavior; however, none of the trucks in any of the studies was involved in long haul, interstate activity. We assumed that all long haul truck trips have the same hourly truck trip distribution as the heavy heavy-duty trucks in the instrumented studies and that all long haul trips are 10 hours long, and thus deduced an hourly distribution of long haul trip ends. The distribution of hoteling durations from the Lutsey report was applied to these trip-end distributions. From these calculations, we estimated the number of hours of truck operation and hours of truck hoteling. For MOVES, we then calculated the ratio of hoteling hours to truck operation hours for each hour of the day. Weekday data was used for both weekday and weekend fractions.



Note that the Draft MOVES2009 defaults assume no anti-idling measures or truck-stop-electrification efforts. In future versions of MOVES, we intend to make it easier for users to modify the inputs of extended idling behavior to account for new or locally available data on such activity.

16. ZoneRoadType

The **SHOAllocFactor** field is used to determine the hours of vehicle operation in each zone on each of the MOVES roadway types.

While geographic allocations clearly change over time, for national runs using Draft MOVES2009 this table is used for all calendar years. Note that the allocation factors are not used when a user selects the “County” scale. At the “National” scale, users may choose to do multiple runs, with year-specific factors entered for each specific calendar year run.

The spatial allocation of source hours operating distributes the domain-wide estimates of hours of operation to the zones. In draft MOVES2009, the default domain is the nation and the zones are counties. The national source hours of operation (SHO) are calculated from estimates of VMT and speed.

The estimate for the VMT by county comes from the 1999 National Emission Inventory (NEI) analysis documented by Pechan & Associates.[61] These estimates are based on the Highway Performance Monitoring System (HPMS) data collected by the Federal Highway Administration[62] for use in transportation planning and vehicle type breakdowns from the EPA MOBILE6 Emission Factor model.[63] The NEI VMT estimates were incorporated into the National Mobile Inventory Model (NMIM) county database.

To calculate default inputs for Draft MOVES2009, the 1999 NEI VMT estimates were obtained from the NMIM database for each county and HPMS facility type. The average speed estimates were taken directly from Table 8 of the NEI documentation. VMT estimates for each MOVES road type(i) were determined for each county(j) in the nation and the allocation was calculated using the following formula, where k refers to the HPMS facility types within a MOVES road type, and m refers to the VMT for each source type.

$$\text{CountyAllocation}(i,j) = (\text{Sum}(j)((\text{CountyVMT}(i,j,k,m)/\text{Average Speed}(k,m))) / (\text{Sum}(ij)((\text{CountyVMT}(i,j,k,m)/\text{AverageSpeed}(k,m)))$$

The county allocation values for each roadway type sum to one for the nation. Although the data is from 1999 calendar year estimates, the same allocations are used for all calendar years.

17. Zone

In Draft MOVES2009, activity data and meteorological data are assigned to zones rather than counties. By creating and populating their own zones, users may customize geographical boundaries to better represent non-attainment areas and climate differences that do not necessarily follow county boundaries. However, for the national default database, zones and counties are equivalent.

The Zone table provides values for four fields: **CountyID**, **StartAllocFactor**, **IdleAllocFactor,** and **SHPAllocFactor.** CountyID is the identifier for the county in which the zone is located. StartAllocFactor geographically allocates domain-wide start activity. IdleAllocFacor allocates extended idle activity, and SHPAllocFactor allocates time parking (important for evaporative emissions).

While geographic allocations clearly change over time, for national runs using Draft MOVES2009 this table is used for all calendar years. Note that the allocation factors are not used when a user selects the “County” scale. At the “National” scale, users may choose to do multiple runs, with year-specific factors entered for each specific calendar year run.

17.1. StartAllocFactor

The StartAllocFactor distributes the domain-wide estimates of the number of trip starts to the zones. In the default database for Draft MOVES2009, the domain is the nation and the zones are counties. There is no national data on the number of trip starts by county, so for Draft MOVES2009, we have used VMT will to determine this allocation.

The estimate for the VMT by county comes from the 1999 National Emission Inventory (NEI) analysis.[64] The NEI estimates are based on the Highway Performance Monitoring System (HPMS) data collected by the Federal Highway Administration[65] for use in transportation planning and vehicle type breakdowns from the EPA MOBILE6 Emission Factor model.[66] The NEI VMT estimates have been incorporated into the National Mobile Inventory Model county database.

The VMT estimates were obtained from the NMIM database. VMT estimates for each county in each state and the allocation calculated using the following formula, where “i” represents each individual county.

$$CountyAllocation(i) = (CountyVMT(i) / Sum(CountyVMT(i))$$

The county allocation values sum to one for the nation. Although the data is from 1999 estimates, the same allocations will be used for all calendar years.

17.2. IdleAllocFactor

The IdleAllocFactor field stores the factor used to determine the hours of extended idling in each zone in each calendar year.

No sources exist that directly measure extended idling in order to allocate the hours of extended idling estimated for heavy-duty trucks. However, extended idling (or hoteling) occurs primarily on long-haul trips across multiple states, which suggests that travel on rural and urban interstates would best represent long-haul trips. Extended idling mainly occurs among the largest (Class 8) trucks, which are now almost exclusively diesel. Since we have estimates for the amount of rural and urban interstate VMT by Class 8 heavy-duty diesel trucks in each county of the nation, we can use this estimate to create a national allocation factor for extended idling hours.

The actual total demand for overnight parking by trucks has been estimated by the Federal Highway Administration on a state by state basis.[67] These estimates were used to determine the allocation to each State(i) using the following formula:

StateAllocation(i) = StateParkingDemand(i) / Sum(StateParkingDemand(i))

The State allocation values will sum to one for the entire country. This method results in no idling in Washington, D.C., Hawaii, Virgin Islands, or Puerto Rico, which make sense, since none of these areas have VMT associated with rural or urban interstates.

The estimate for the VMT from Class 8 heavy-duty diesel trucks by county comes from the 1999 National Emission Inventory (NEI) analysis.[68] The NEI estimates are based on the Highway Performance Monitoring System (HPMS) data collected by the Federal Highway Administration[69] for use in transportation planning and vehicle type breakdowns from the EPA MOBILE6 Emission Factor model.[70] The NEI VMT estimates have been incorporated into the National Mobile Inventory Model (NMIM) county database.

The VMT estimates were obtained from the NMIM database. VMT estimates for Class 8 heavy-duty diesel trucks on rural and urban interstates were determined for each county in each state and the allocation calculated using the following formula where “j” refers to the counties in each particular state.

IdleAllocFactor(i) = StateAllocation(i) * (CountyVMT(j) / Sum(CountyVMT(j))

The county allocation values will sum to one for the entire country. The sum of the county allocations for a given state will equal the state allocation for that state, as determined earlier.

18. SCC Mappings

For some uses, particularly the preparation of national inventories, modelers will need to produce output aggregated by EPA's Source Category Codes (SCC). The EPA's highway vehicle SCC were derived from MOBILE5 and MOBILE6 and do not directly correspond to the MOVES SourceTypes. For example, depending on its fuel and Gross Vehicle Weight (GVW) limits, a vehicle in the MOVES Passenger Truck category may be coded with one of eight SCCs—including the SCC for a Light-Duty Gasoline Truck 1, a Light-Duty Gasoline Truck 2, a Heavy-Duty Gasoline Truck, a Light-Duty Diesel Truck, or one of the four codes for Heavy-Duty Diesel Vehicle.

The MOVES model is designed to aggregate emissions to the user's choice of SourceType or SCC using the SCCVTypeDistribution table. For each combination of SourceType, Model Year and FuelType, the SCCVTypeDistribution table lists IDs for the possible SCC and the fraction of vehicles assigned to each SCC.

The full SCC also includes a suffix that indicates roadway type. This is a mapping from the MOVES roadtype on which the emissions occur to the HPMS Facility Type used in the SCC codes. This mapping is captured in the SCCRoadTypeDistribution table described below.

18.1. SCCVtypeDistribution

Because the existing SCCs only identify gasoline and diesel-fueled vehicles, it was necessary to map alternatively-fueled vehicles to one of these categories. All alternative-fuel vehicles were mapped to the **diesel** SCC. In the future, SCCs may be revised to explicitly handle alternative fuels.

For most SourceTypes, the mapping to SCCVtype was straightforward. These mappings are summarized in Table 18-1. However, the trucks span a wide range of GVWs and, thus, a wide range of SCCs. We used VIUS values for GVW to determine the truck SCC fractions by model year. To separate Light-Duty Trucks 1 and Light-Duty Trucks 2, which are distinguished by Loaded Vehicle Weights, we used information from the Oak Ridge National Laboratory Light-Duty Vehicle database. And to separate Class 2a and 2b trucks, we used information from Davis and Truitt.[71] The resulting truck mappings are too complex to summarize here, but are available in the MOVES database.

Table 18-1. SCC Mappings for Selected SourceTypes

Source Type ID	SourceType	Fuel Type	SCC-ID	SCC prefix	Abbreviated Description
11	Motorcycle	gasoline	5	2201080	Motorcycles
21	Passenger Car	gasoline	1	2201001	LDGV
21	Passenger Car	other	6	2230001	LDDV
41	Intercity Bus	gasoline	4	2201070	HDGV&B
41	Intercity Bus	other	12	2230075	HDDB
42	Transit Bus	gasoline	4	2201070	HDGV&B
42	Transit Bus	other	12	2230075	HDDB
43	School Bus	gasoline	4	2201070	HDGV&B
43	School Bus	other	12	2230075	HDDB
54	Motor Home	gasoline	4	2201070	HDGV&B
54	Motor Home	other	10	2230073	M-HDDV

18.2. SCCRoadTypeDistribution

Each SCC includes a suffix that indicates the HPMS Facility Class on which the emissions occur. Because MOVES calculations are done for MOVES roadtypes, the **SCCRoadTypeFraction** provides an allocation of emissions on each MOVES roadtype to the appropriate SCCRoadTypes.

Table 18-1. SCC RoadTypes

SCCRoadTypeID	SCCRoadTypeDesc
11	Rural Interstate
13	Rural Principal Arterial
15	Rural Minor Arterial
17	Rural Major Collector
19	Rural Minor Collector
21	Rural Local
23	Urban Interstate
25	Urban Freeway/Expressway
27	Urban Principal Arterial
29	Urban Minor Arterial
31	Urban Collector
33	Urban Local
1	Off-Network

Because roadtype distributions vary geographically, the mapping of MOVES roadTypes to SCCRoadTypes varies by zone (in this case, county). For SCCRoadTypeDistribution we determined the proportion of hours of operation on a given MOVES roadtype within a county that occurred on each SCCRoadType. Hours of operation were estimated by dividing the 1999 National Emission Inventory (NEI) VMT by the 1999 NEI average speed. Both measures were documented by Pechan & Associates.[72] The NEI VMT estimates are based on the Highway Performance Monitoring System (HPMS) data collected by the Federal Highway

Administration[73] for use in transportation planning and vehicle type breakdowns from the EPA MOBILE6 Emission Factor model.[74] The VMT estimates were obtained from the NMIM database for each county and HPMS facility type. The average speed estimates are taken from Table 8 of the NEI documentation.

The SCCRoadType fractions were calculated using the following formula, where i refers to the county, j refers to the MOVES roadtype, k refers to the SCCRoadType within a MOVES road type, and m refers to the VMT for each source type.

SCCRoadTypeFraction(i,j,k) = Sum(j,j,k)(VMT(k,m)/Average Speed(k,m)) / Sum(i,j)((VMT(k,m)/AverageSpeed(k,m))

In cases where a county had no VMT for a given roadtype, the average values were used. The SCCRoadTypeFraction for OffNetwork travel was set to 1 (mapping all "off-network" emissions to this new roadtype. The SCCRoadType fractions for each roadway type will sum to one for each county. Although the data is from 1999 calendar year estimates, the same allocations will be used for all calendar years.

19. MonthGroupHour

ACActivityTerms A, B and C are coefficients for a quadratic equation that calculates air conditioning activity demand as a function of the heat index. These terms are applied in the calculation of the A/C adjustment in the energy consumption calculator. The methodology and the terms themselves were originally derived for MOBILE6 and are documented in the report "Air Conditioning Activity Effects in MOBILE6."[75] They are based on analysis of air conditioning usage data collected in Phoenix, Arizona, in 1994.

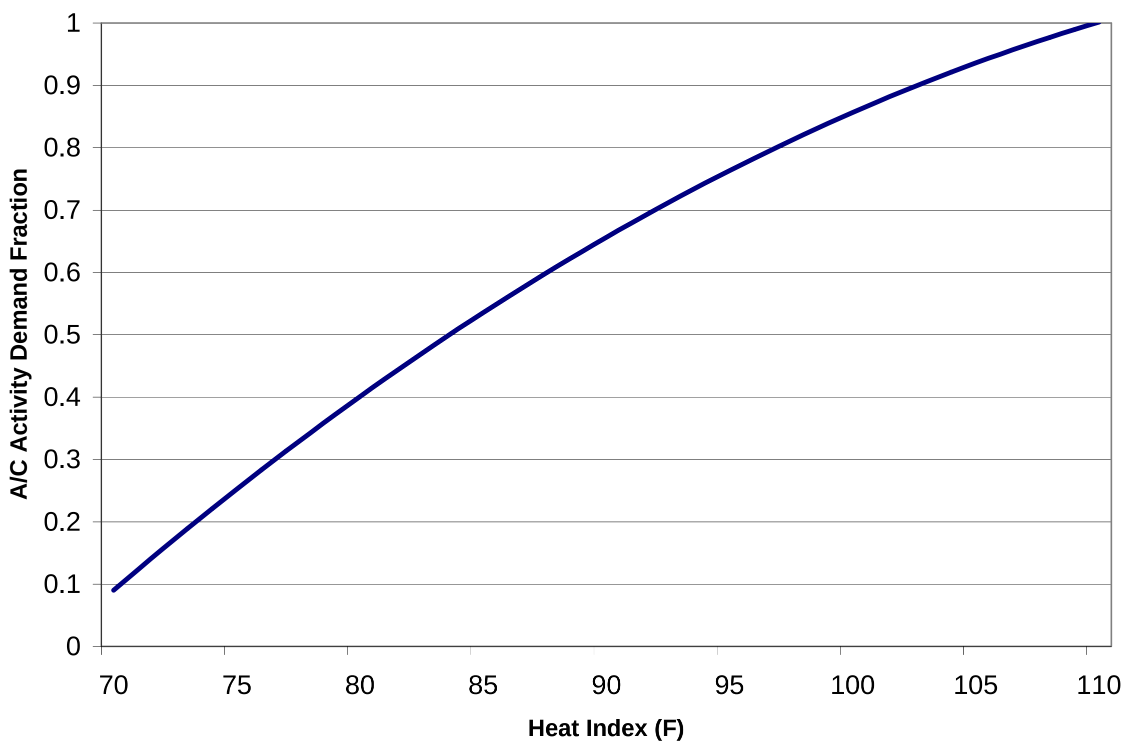
In MOVES, ACActivityTerms are allowed to vary by monthGroup and Hour, in order to provide the possibility of different A/C activity demand functions at a given heat index by season and time of day (this accounts for differences in solar loading observed in the original data). However, for Draft MOVES2009, the default data uses one set of coefficients for all MonthGroups and Hours. These default coefficients represent an average A/C activity demand function over the course of a full day. The coefficients are listed in Table 19.1.

Table 19-1. Air Conditioning Activity Coefficients

A	B	C
-3.63154	0.072465	-0.000276

The A/C activity demand function that results from these coefficients is shown in Figure 19-1. A value of 1 means the A/C compressor is engaged 100 percent of the time; a value of 0 means no A/C compressor engagement.

Figure 19-1: Air Conditioning Activity Demand as a Function of Heat Index



20. Sample Trip Data

To estimate start and evaporative emissions, it is important to estimate the number of starts by time of day, and the duration of time between vehicle trips. (This between-trip duration is often called "soak time." To determine typical patterns of trip starts and ends, MOVES uses information from instrumented vehicles. This data is stored in two tables: SampleVehicleDay and SampleVehicleTrip.

The first table, SampleVehicleDay, lists a "sample population" of vehicles, each with an identifier (vehID), an indication of vehicle type (sourceTypeID), and a "dayID" that indicates whether the vehicle is part of the weekend or weekday vehicle population.

The second table, SampleVehicleTrip, lists the trips made by each of these vehicles. It records the vehID, dayID, a trip number (tripID), the hour of the trip (hourID), the trip number of the prior trip (priorTripID), and the times at which the engine was turned on and off for the trip (keyOnTime and keyOffTime, each recorded in minutes since midnight of the day of the trip). To account for overnight soaks, many first trips reference a prior trip with a null value for keyOnTime and a negative value for keyOffTime. And, to account for vehicles that sit for one or more days without driving, the SampleVehicleDay table includes some vehicles that have no trips in the SampleVehicleTrip table.

The data and processing algorithms used to populate these tables are detailed in two contractor reports.[76,77] The data comes from a variety of instrumented vehicle studies, summarized in Table 20.1. This data was cleaned, adjusted, sampled and weighted to develop a distribution intended to represent average urban activity across the U.S. For vehicle classes that were not represented in the available data, the contractor synthesized trips using trip-per-operating hour information from MOBILE6 and soak time and time-of-day information from sourcetypes that did have data. The application of synthetic trips is summarized in Table 20.2. The resulting trip per day estimates are summarized and compared to MOBILE6 in Table 20.3.

Table 20.1. Source Data for Sample Vehicle Trip Information

Study	Study Area	Study Years	Vehicle Types	Number of Vehicles
3-City	Atlanta, GA; Baltimore, MD; Spokane, WA	**1992**	**Passenger cars & trucks**	**321**
Minneapolis	**Minneapolis/St. Paul, MN**	**2004-2005**	**Passenger cars & trucks**	**133**
Knoxville	**Knoxville, TN**	**2000-2001**	**Passenger cars & trucks**	**377**
Las Vegas	**Las Vegas, NV**	**2004-2005**	**Passenger cars & trucks**	**350**
Battelle	**California, statewide**	**1997-1998**	**Heavy duty trucks**	**120**
TxDOT	**Houston, TX**	**2002**	**Heavy, heavy duty diesel dump trucks**	**4**

Table 20.2. Synthesis of Sample Vehicles for Source Types Lacking Data

SourceType	Based on Direct Data?	Synthesized From
Motorcycles	No	Passenger Cars
Passenger Cars	Yes	n/a
Passenger Trucks	Yes	n/a
Light Commercial Trucks	No	Passenger Trucks
Intercity Buses	No	Combination long-haul trucks
Transit Buses	No	Single-unit short-haul trucks
School Buses	No	Single-unit short-haul trucks
Refuse Trucks	No	Combination short-haul trucks
Single-unit short-haul trucks	Yes	n/a
Single-unit long-haul trucks	No	Combination long-haul trucks
Motor homes	No	Passenger Cars
Combination short-haul trucks	Yes	n/a
Combination long-haul trucks	Yes	n/a

Table 20.2. Starts per Day by SourceType

SourceType	Draft MOVES2009 Weekday	Draft MOVES2009 Weekend	MOBILE6*
Motorcycles	0.78	0.79	1.35
Passenger Cars	5.89	5.30	6.75
Passenger Trucks	5.80	5.06	7.38
Light Commercial Trucks	6.05	5.47	7.38
Intercity Buses	2.77	0.88	6.88
Transit Buses	4.58	3.46	6.88
School Buses	5.75	1.26	6.88
Refuse Trucks	3.75	0.92	6.88
Single-unit short-haul trucks	6.99	1.28	6.88
Single-unit long-haul trucks	4.29	1.29	6.88
Motor homes	0.57	0.57	6.88
Combination short-haul trucks	5.93	1.16	6.88
Combination long-haul trucks	4.29	1.29	6.88

* Note, MOBILE6 distinguished “starts” and “trips.” MOVES does not, but MOVES does include some very short “trips.”

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