

# **Appendix I-Mobile Input Parameters**

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# Analysis Notes

## MOVES-Based On-Road Emissions Estimates for the El Paso Metropolitan Planning Organization (EPMPO) Destino 2045 MTP Update

18 April 2018

The Texas A&M Transportation Institute (TTI) performed the following emissions analysis described as “Scenario 2” for the EPMPO’s Destino 2045 Metropolitan Transportation Plan (MTP) Update. Scenario 2 is one of three TDM scenarios involving the inclusion or omission of an FM1110 roadway project in 2020, 2030, 2040 and 2045 emissions analysis years. Scenario 2 (S2) omits the FM1110 roadway project for all years.<sup>1</sup> The EPMPO provided TTI the Travel Demand Model (TDM) data sets for the analyses on April 5, 2018.

TTI performed the S2 analysis to update the prior Destino 2045 MTP emissions analysis, performed by TTI, February 2018 (and referred to in this discussion as “prior analysis”). Except for the new TDM data for S2, all methods, procedures, and all other emissions modeling data used by TTI were consistent with the prior analysis.<sup>2</sup>

TTI used EPA’s MOVES2014a on-road model (November 2016 release), the current AP-42 paved road re-suspended dust model, the S2 Destino TDM (with 2012 TDM validation year), and TTI’s emissions estimation utilities.<sup>3</sup> TTI produced 2020, 2030, 2040, 2045, summer and winter weekday particulate-matter-up-to-10-microns-in-diameter (PM<sub>10</sub>) estimates for El Paso County; part of Dona Ana County, NM in the TDM; and 2020 carbon monoxide (CO) estimates for the TDM CO zones (traffic analysis zones comprising the CO maintenance area boundary).

### **SCOPE OF EMISSIONS ANALYSIS**

- 1. Methodology:** *Vehicle exhaust, evaporative, tire wear, and brake wear emissions:* Detailed, hourly, disaggregate, MOVES rates-per-activity, TDM link-based method with the most recent version of MOVES.<sup>4</sup>  
*Paved road re-suspended dust:* 24-hour, by road type using the EPA’s AP-42 re-suspended dust model.<sup>5</sup>
- 2. Analysis Year:** 2020, 2030, 2040, 2045.
- 3. Seasonal Period:** *Summer:* June through August weekday (average Monday through Friday).  
*Winter:* December through February weekday.

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<sup>1</sup> TTI documented Scenario 1 and Scenario 3 analyses separately. Scenario 1 includes FM1110 roadway project in all years. Scenario 3 excludes FM1110 project in 2020 and includes FM1110 project thereafter.

<sup>2</sup> “Analysis Notes, MOVES-Based On-road Mobile Source Emissions Estimates for the El Paso Metropolitan Planning Organization (EPMPO) Destino 2045 MTP Update”, TTI, March 1, 2018.

<sup>3</sup> All emissions models and TTI utilities used for this analysis are the same as TTI used in the prior analysis.

<sup>4</sup> EPA’s November 2016 MOVES2014a update is, for practical purposes, the latest on-road release. (A more recent, December 2017, MOVES2014a update does not change on-road, but only updates non-road post-processors.)

<sup>5</sup> AP-42 paved road re-suspended model provided in “AP-42, Fifth Edition, Volume 1, Chapter 13: Miscellaneous Sources, 13.2.1 Paved Roads” (EPA, January 2011, <https://www3.epa.gov/ttn/chief/ap42/ch13/index.html>).

- 4. Geography:** Areas modeled within the El Paso regional TDM include El Paso County (summer); El Paso CO zones and El Paso non-CO zones (comprising El Paso County - winter 2020); and Dona Ana zones (summer and winter).<sup>6</sup>
- 5. Pollutants:** CO, PM<sub>10</sub>.<sup>7</sup>
- 6. Sources:** Gasoline- and diesel-powered MOVES source use types (SUT).

**Table 1. Modeled Emissions Sources.**

SUT	Gasoline	Diesel
Motorcycle	X	-
Passenger Car	X	X
Passenger Truck	X	X
Light Commercial Truck	X	X
Intercity Bus	-	X
Transit Bus	-	X
School Bus	X	X
Refuse Truck	X	X
Single Unit Short-Haul Truck	X	X
Single Unit Long-Haul Truck	X	X
Motor Home	X	X
Combination Short-Haul Truck	X	X
Combination Long-Haul Truck	-	X

- 7. Tools:** MOVES and TTI’s MOVES-based inventory development utilities<sup>8</sup> were used: RatesCalc – produces and/or compiles emissions rate tables from MOVES output; EmsCalc – calculates hourly link emissions for a county (or coded sub-county area) using the estimated link VMT and speeds, VMT mixes, off-network activity, and emissions factors from RatesCalc (or MOVES or RatesAdj); TransVMT – estimates the on-road fleet VMT and operational speeds for use in air quality analyses (input to EmsCalc), based on TDM data sets; VMTmixBuild – formats gasoline and diesel MOVES source type (vehicle type) VMT mix input to EmsCalc; OffNetActCalc – calculates source-hours-parked (SHP), source-hours-extended-idling (SHI), auxiliary power unit (APU) usage hours, and starts inputs to EmsCalc; VehpopulationBuild – calculates vehicle population estimates input to

<sup>6</sup> The El Paso TDM traffic analysis zones (TAZ) within the El Paso CO maintenance area are labeled “CO zones” and the remaining El Paso County TAZs are “non-CO zones.” Only part of Dona Ana County is in the El Paso TDM.

<sup>7</sup> PM<sub>10</sub> is comprised of MOVES-based direct vehicle primary total exhaust, brake wear, tire wear, and AP-42-based re-suspended dust from paved roads. Although not reported in the emissions summary totals, summer and winter VOC and NO<sub>x</sub> emissions were estimated as well as summer CO emissions.

<sup>8</sup> TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUtil User’s Guide, TTI, August 2016.

OffNetActCalc based on vehicle registration data and other factors; and MOVESfleetInputBuild – produces sourcetypeagedistribution and avft (i.e., fuel fractions) table inputs to MOVES, based on vehicle registration data, MOVES default data, and VMT mix estimates.

## **DEVELOPMENT OF ON-ROAD FLEET LINK-VMT AND SPEEDS**

**8. Travel Demand Models:** TTI received new, scenario-specific Destino TDM data sets (i.e., trip matrices and four-time-period, non-directional, average non-summer weekday traffic [ANSWT] assignments) from the EPMPO April 5, 2018. Data sets included the 2012 validation year, 2020, 2030, 2040, and 2045 future analysis years. TTI post-processed the data sets to form average seasonal weekday, county, hourly, directional, Highway Performance Monitoring System (HPMS)-consistent, network link VMT and volumes, and added intrazonal link VMT estimates, coded for county and sub-county areas. Method details are found in *MOVES2014a-Based Travel Demand Model Link Emissions Estimation Method* (TTI, August 2016).

**9. Adjustments to TDM VMT:** The ANSWT network link volumes and VMT and added intrazonal link VMT were factored to be consistent with HPMS VMT, to reflect seasonal weekday activity, to allocate by hour, and to allocate by direction of travel. Seasonal weekday and hourly distribution factors were developed using the latest available multi-year, El Paso County aggregate Texas Department of Transportation (TxDOT) Automatic Traffic Recorder [ATR] traffic count data (2007 – 2016).<sup>9</sup>

- a. Historical Analysis Year HPMS Consistency and Seasonal Weekday Adjustments (No historical year emission analysis was required):  
HPMS consistency: When required, the historical year TDM total ANSWT link VMT is adjusted to the seasonal (summer or winter) VMT using county-level VMT control totals. The VMT control total is county total, annual average daily traffic (AADT) HPMS VMT (from TxDOT’s Roadway Inventory Annual Reports, adjusted to the seasonal weekday form (using seasonal factor described below)).  
Seasonal adjustment: Two county-level seasonal (summer and winter) weekday factors are produced and applied to the county-level AADT HPMS VMT to develop the historical year VMT control totals. These factors are calculated as the ratio of the average seasonal weekday-to-AADT ATR counts.
- b. 2020, 2030, 2040, 2045 Future Year HPMS Consistency and Seasonal Adjustments:  
HPMS consistency: TTI updated and applied the HPMS adjustment factor to total ANSWT link VMT for each year. The validation year HPMS adjustment factor is 2012 HPMS VMT (first adjusted to ANSWT using the 2012 ANSWT/AADT ATR count ratio) to 2012 validation year total ANSWT link VMT. See Table 4 in Attachment 1, Page 11.<sup>10</sup>  
Seasonal adjustment: Two county-level seasonal (summer and winter) weekday factors were produced and used with the 2020, 2030, 2040, and 2045 analysis years. These factors were calculated as the ratio of the seasonal weekday-to-ANSWT counts. See Table 5 in Attachment 1, Page 11.

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<sup>9</sup> All the ATR-based factors used were from the prior analysis.

<sup>10</sup> The EPMPO-provided TDM data included an updated 2012 validation-year TDM dataset, thus TTI updated the future year HPMS adjustment factor.

- c. **Seasonal Weekday Hourly VMT Distribution:**  
County level, seasonal weekday, hourly travel factors were developed and used to allocate the 24-hour link VMT/volume estimates to each hour of the day – a single set was used for all analysis years. In order to maintain VMT proportions within each of the four time periods, the hourly fractions were normalized within each time period. See Table 6 in Attachment 1, Page 12.
- d. **Directional Factors:**  
Directional factors were applied to link volumes/VMT by time-of-day period. A single set of directional split factors by TDM network functional class and area type was used for both seasons and all years. These are the same factors applied in the prior El Paso conformity analysis.

**10. Hourly Congested Speeds:** TTI estimated directional, hourly operational link speeds using the TTI speed model, which estimates delay on each link as function of volume-to-capacity, and applies it to the link’s estimated free-flow speed. TTI estimated the local streets category link average operational speeds represented by the centroid connector links, as centroid connector TDM input speeds; and represented as added intrazonal links, as the zone’s average centroid connector input speed.

### **DEVELOPMENT OF VMT MIX**

**11. VMT Mix:** Using latest available classification counts (2005-2014) and associated year-end registration data (2013), TTI estimated the El Paso County time-of-day (AM Peak, Mid-Day, PM Peak, Overnight) VMT mixes by the four MOVES road types. No seasonal adjustments are made for VMT mix. The methodology is described in *Developing MOVES Source Use Types and VMT Mix for Conformity Analysis* (TTI, August 2016).

### **OFF-NETWORK ACTIVITY**

**12. Vehicle Population Estimates:** The El Paso County vehicle population estimates were based on Texas Department of Motor Vehicles (TxDMV) registration data, vehicle population factors derived from the VMT mix, and VMT-based growth estimates for future years where registration data is not available. No vehicle population estimates were developed for Dona Ana. Dona Ana was essentially treated as an extension of El Paso throughout this analysis. With the TxDMV registration data being the basis of the El Paso County vehicle population estimates, the vehicle population estimates only vary by analysis year, not by season (the same analysis year vehicle population estimates were used for both summer and winter off-network activity categories).

- a. **Historical Analysis Year Vehicle Population Estimates (Not required):**  
TxDmv registration data: El Paso County historical analysis year vehicle population estimates are based on the analysis year TxDMV mid-year registration data for El Paso County. This registration data is aggregated into vehicle registration categories (motorcycles, passenger cars, trucks less than or equal to 8,500 pounds gross vehicle rating [GVWR], trucks greater than 8,500 pounds and less than or equal to 19,500 pounds GVWR, and trucks greater than 19,500 pounds GVWR).

Vehicle population factors: Since the TxDMV registration data does not include each SUT/fuel type combination (fuel types are not included, as well as many of the heavy-duty vehicle categories that are grouped by GVWR), vehicle population factors were developed using the analysis year 24-hour VMT mix. These factors were applied to vehicle registrations aggregated by category to split each category into each SUT/fuel type combination included in the analysis.

VMT-based growth estimates: For historical analysis years (i.e., registration data exists), VMT-based growth estimates are typically not required.

b. 2020, 2030, 2040, 2045 Future Analysis Year Vehicle Population Estimates:

TxDmv registration data: As described for historical vehicle population estimates, the registration data were aggregated by vehicle registration category. Since registration data were not available for future year analyses, the most recent mid-year TxDMV registration data sets (2014) were used.

Vehicle population factors: As described for historical vehicle population estimates, vehicle population factors developed using the analysis year 24-hour VMT mix were applied to vehicle registrations aggregated by category to split each category into each SUT/fuel type combinations included in the analysis; thus creating the base (2014) vehicle population estimates.

VMT-based growth estimates: For each analysis year, VMT-based growth estimates were calculated by dividing the El Paso County analysis year summer Weekday VMT by the El Paso County 2014 summer Weekday VMT. These growth estimates were applied to the base vehicle population estimates to scale the base estimates up to the analysis year.

### 13. Source Hours Parked (SHP) Estimates:

- a. Summer and Winter El Paso County: For each inventory scenario (i.e., analysis year and season), hourly SHP by vehicle type (SUT/fuel type combination) was estimated as a function of total hours (hours a vehicle exists) minus the vehicle type's hours of operation on roads (source hours operating [SHO]). Since the SHP was calculated on an hourly basis, the total number of hours (of each vehicles existence) within the time period is equal to the vehicle population. The hourly SHO, which is the same as the vehicle hours of travel (VHT), was calculated by applying the analysis year VMT mix to the link VMT and dividing the link VMT by the associated link speed.
- b. Winter El Paso CO Zones and Non-CO Zones: For each analysis year, the hourly county-level winter SHP estimates by SUT/fuel type were distributed to CO zones and Non-CO zones using hourly CO split and hourly Non-CO split factors by SUT/fuel type. These split factors were calculated as the inverse of the VHT. For example, if 30 percent of the El Paso County VHT for a given hour and SUT/fuel type were in the CO zones, then 70 percent of the El Paso County SHP will be in the CO zones and 30 percent will be in the Non-CO zones.
- c. Dona Ana: For each inventory scenario, the hourly SHP by vehicle type for the Dona Ana area was calculated by scaling the El Paso County activity based on the ratio of the Dona Ana VMT to the El Paso County VMT; thus treating Dona Ana as an extension of El Paso.

#### **14. Vehicle Starts Estimates:**

- a. Summer and Winter El Paso County: Engine starts were based on the MOVES national default starts per vehicle and the county-level vehicle population estimates. For each inventory scenario, the hourly vehicle type starts were calculated as the product of the MOVES default weekday starts/vehicle by the county-level vehicle population estimates.
- b. Winter El Paso CO Zones and Non-CO Zones: For each analysis year, the county-level winter vehicle starts by SUT/fuel type were distributed to the CO zones and Non-CO zones based on the distribution of vehicle trips (taken from the analysis year trip matrices) between the two areas. For example, if 30 percent of the El Paso County vehicle trips were in the CO zones, then 30 percent of the El Paso County vehicle starts will be in the CO zones and 70 percent of the county-level starts will be in the Non-CO zones.
- c. Dona Ana: For each inventory scenario, the hourly vehicle starts in the Dona Ana area were calculated by scaling the El Paso County activity based on the ratio of the Dona Ana VMT to the El Paso County VMT; thus treating Dona Ana as an extension of El Paso.

#### **15. Hotelling, Extended Idle (or Source Hours Idling, SHI), and APU Hours:**

- a. Summer and Winter El Paso County: For each inventory scenario, the Weekday hotelling activity was based on information from the Texas Commission on Environmental Quality (TCEQ) *Extended Idle Study* (ERG, 2004). This study established a base 24-hour 2004 hotelling activity by Texas county. The 2004 base hotelling activity from this study for El Paso County was scaled to each inventory scenario (analysis year/season) weekday based on the ratio of the 24-hour inventory scenario weekday combination long-haul truck VMT to the combination long-haul truck VMT from a 2004 base year (as truck VMT increases, so does the hotelling activity). The inventory scenario 24-hour hotelling activity was distributed to each hour of the day using hourly factors, which were created as the inverse of the hourly VHT fractions calculated from the inventory scenario link VMT and speeds. The hotelling activity was then disaggregated into each category (SHI and APU hours) using proportions developed using model year travel fractions (calculated based on the source type age distribution and relative mileage accumulation rates used in the MOVES runs) and the MOVES default hotelling activity distribution.
- b. Winter El Paso CO Zones and Non-CO Zones: Since the CO zones are primarily in the downtown area, all winter hotelling, SHI, and APU hours activity were assumed to occur outside the CO zones, with all of the winter hotelling, SHI, and APU hours activity occurring in the Non-CO zones.
- c. Dona Ana: For each inventory scenario, the hourly hotelling, SHI, and APU hours for the Dona Ana area were calculated by scaling the El Paso County activity based on the ratio of the Dona Ana VMT to the El Paso County VMT; thus treating Dona Ana as an extension of El Paso.

## **DEVELOPMENT OF EMISSIONS FACTORS**

**16. Background:** TTI developed emissions rates using MOVES2014a and the TTI post-processing utility, RatesCalc, for preparing MOVES2014a-based emissions rates for input to TTI's external inventory calculation utility, EmsCalc. El Paso County summer weekday and winter weekday emissions rates were produced for each analysis year. These emissions rates were used to estimate emissions for all of the El Paso TDM modeling areas.<sup>11</sup>

These on-road emissions rates were developed in terms of mass per activity unit: miles for roadway-based processes; SHP, starts, SHI, and APU hours for off-network processes. All of these activity-based rates were directly output by MOVES, except for parked vehicle evaporative emissions rates based in SHP. TTI used the RatesCalc utility to calculate emissions rates in terms of rate/SHP (as a conversion of MOVES rate/vehicle output) using the data in the county (local) input database (CDB) used in the MOVES emissions rates run and the MOVES default database. The RatesCalc utility combined the rate/distance, rate/hour (SHI and APU hours), and rate/start emissions rates tables from MOVES output, and the calculated rate/SHP emissions rates table into a final database of rates look-up tables for input to the EmsCalc utility. For additional details on the RatesCalc processing of MOVES output, see Attachment 2.

Table 2 lists the emissions processes with associated activity basis and emissions rate units. The emissions factors were developed by pollutant, speed, process, hour, road type, and SUT/FT. The MOVES-based emissions factors include PM from exhaust, tire wear and brake wear, whereas the paved road re-suspended dust estimates were calculated separately using the EPA's AP-42 model (see Item 20).

**Table 2. On-Road Fleet Emissions Rates Modeled by Process and Activity Factor.**

<b>Emissions Process</b>	<b>Activity<sup>1</sup></b>	<b>Emissions Factor Units<sup>2</sup></b>
Running Exhaust Crankcase Running Exhaust	VMT	mass/mile (mass/mi)
Brake Wear	VMT	mass/mi
Tire Wear	VMT	mass/mi
Start Exhaust Crankcase Start Exhaust	starts	g/start
Extended Idle Exhaust Crankcase Extended Idle Exhaust	SHI	mass/shi
Auxiliary Power Exhaust	APU Hours	mass/APU hour
Evaporative Permeation Evaporative Fuel Vapor Venting Evaporative Fuel Leaks	VMT, SHP	mass/mi, mass/shp

<sup>1</sup> The amount of travel on roads (VMT), SHP, vehicle starts, SHI and APU hours are the basic activity factors. SHI and APU hours are for combination long-haul trucks only. Evaporative (hydrocarbon) permeation, fuel vapor venting, and fuel leaks occur both during operation and while parked.

<sup>11</sup> TTI used the emission rates from the prior analysis.



**17. MOVES Model Inputs:** All of the user-specified model settings and inputs for each run were contained in a MOVES run specification (MRS) and a CDB (the latest model default database “MOVESDB20161117” was also used). See Attachment 2 for details on the MRS files and CDBs developed and used to estimate the summer weekday and winter weekday emissions factors each analysis year.

**18. Emissions Factor Post-Processing:** No emissions rate adjustments were required and therefore no emissions rate adjustments via post-processing were performed.

**19. Emissions Controls Modeling:** Table 3 shows the modeling approaches used for the emissions control strategies. Unless otherwise stated, the control strategy was modeled in all years and both seasons.

**Table 3. Emissions Modeling Strategies and Approaches.**

Strategy	Approach
Federal Motor Vehicle Control Program Standards	MOVES defaults.
Federal Heavy-Duty Diesel Engines Rebuild and 2004 Pull-Ahead Programs to Mitigate NO <sub>x</sub> Off-Cycle Effects	MOVES defaults.
Gasoline Fuel – Tier 2/Tier 3 sulfur standards, Low Summer Reid Vapor Pressure (RVP), Winter Oxygenate	Locality-specific user-developed inputs to MOVES. TTI produced summer 2020 and later conventional gasoline inputs consistent with pertinent federal and state rules, based on a combination of El Paso fuel sample data and MOVES defaults or other expected future year values. Fuel formulations are provided in Attachment 2.
Federal Low Sulfur Diesel Fuel	Locality-specific user inputs to MOVES. Diesel sulfur input values were set for consistency with the applicable federal diesel sulfur standards. Diesel formulations are provided in Attachment 2.
Inspection and Maintenance (I/M) Program	Locality-specific user-developed I/M coverage inputs to MOVES. TTI developed El Paso I/M Program inputs to MOVES using the available MOVES I/M parameters pertaining to the domain of subject I/M vehicles, consistent with current program descriptions and latest I/M modeling protocols. Attachment 2 provides a summary of the I/M program input parameters used.

**20. PM<sub>10</sub> Emissions Factors for Re-Suspended Dust from Paved and Unpaved Roads:**

- a. *Paved Roads:* Re-suspended dust emissions factors from paved roads (i.e., TDM and intrazonal links) were developed according to equation (2) in AP-42 section 13.2.1 (EPA, January 2011). The input parameters are PM<sub>10</sub> particle size multiplier, road surface silt loading, average vehicle weight, days with at least 0.01 inches precipitation for the seasonal period, and number of days in the seasonal averaging period. The PM<sub>10</sub> particle size multiplier from the referenced EPA AP-42 guidance was used. The road surface silt loading values were consistent with the PM<sub>10</sub> State Implementation Plan (SIP). The average vehicle weight values were updated to reflect the current VMT mix (Item 11).

Since the climate data used in the MOVES analysis is required to be consistent with the SIP, the days with at least 0.01 inches precipitation for the seasonal period and number of days in the seasonal averaging period used were consistent with prior El Paso MTP analyses. Because control programs (i.e., street sweeping) affect the road surface silt loading and controlled silt loading values are not available, no control programs were included in the development of the re-suspended dust emissions factors for this analysis and were not necessary since the PM<sub>10</sub> emissions did not exceed the PM<sub>10</sub> emissions budget. While the PM<sub>10</sub> nonattainment area was initially determined using the city limits at the time, conformity is demonstrated at the county level. Further refinement to include only the emissions within the city limits was not necessary since the PM<sub>10</sub> emissions at the county level did not exceed the PM<sub>10</sub> emissions budget.

- b. *Unpaved Roads*: No unpaved road emissions factor analyses were performed under the assumption that there were no unpaved roads in any of the new TDM networks.

**Attachment 1**  
**Adjustments to TDM VMT**

**Table 4. HPMS Factor.**

<b>2012 HPMS VMT</b>	<b>AADT-to-ANSWT Factor</b>	<b>HPMS-Based ANSWT VMT</b>	<b>2012 TDM VMT</b>	<b>HPMS Factor</b>
15,151,926	1.08815	16,487,568	17,815,876	0.925442459

**Table 5. 2020, 2030, 2040, 2045 Analysis Years TDM (ANSWT) Seasonal Weekday Factors.**

<b>Season</b>	<b>Seasonal Weekday Factor</b>
Summer	0.95645
Winter	0.99560

**Table 6. Seasonal Weekday Hourly VMT Distributions.**

Time-Period	Hour	Summer Fractions		Winter Fractions	
		24-Hour-Period	Four-Period <sup>1</sup>	24-Hour-Period	Time-Period <sup>1</sup>
AM Peak	7:00 a.m.	0.010574	0.041778	0.008995	0.038565
	8:00 a.m.	0.006826	0.026970	0.006132	0.026290
	9:00 a.m.	0.005587	0.022074	0.005099	0.021861
Mid-Day	10:00 a.m.	0.005148	0.020340	0.004707	0.020181
	11:00 a.m.	0.007328	0.028953	0.006712	0.028777
	12:00 p.m.	0.018190	0.071869	0.016062	0.068864
	1:00 p.m.	0.037314	0.147428	0.037315	0.159984
	2:00 p.m.	0.063690	0.343596	0.068041	0.354998
	3:00 p.m.	0.065525	0.353496	0.067692	0.353177
PM Peak	4:00 p.m.	0.056148	0.302908	0.055933	0.291825
	5:00 p.m.	0.052431	0.182905	0.053120	0.181671
	6:00 p.m.	0.055021	0.191940	0.056178	0.192130
	7:00 p.m.	0.058244	0.203184	0.059164	0.202342
Overnight	8:00 p.m.	0.059400	0.207216	0.060609	0.207284
	9:00 p.m.	0.061561	0.214755	0.063325	0.216573
	10:00 p.m.	0.066592	0.242258	0.070744	0.250248
	11:00 p.m.	0.071780	0.261132	0.075082	0.265593
	12:00 a.m.	0.074417	0.270726	0.075244	0.266165
	1:00 a.m.	0.062091	0.225884	0.061626	0.217994
	2:00 a.m.	0.046914	0.185357	0.045080	0.193277
	3:00 a.m.	0.037489	0.148119	0.034568	0.148207
	4:00 a.m.	0.032499	0.128404	0.029574	0.126795
	5:00 a.m.	0.026365	0.104168	0.022956	0.098421
	6:00 a.m.	0.018866	0.074540	0.016042	0.068778

<sup>1</sup> To maintain VMT proportions within the four periods, the hourly fractions were normalized within each period.

**Attachment 2**  
**MOVES Run Specifications (MRS), County Databases (CDB), Outputs, and**  
**Post-Processing**

MOVES Inputs and Output:

- MRS input files: One for each analysis year and season (8).
- CDB inputs: One for each analysis year and season (8).
- The MOVES default input database (MOVESDB20161117).
- MOVES output databases: One per MOVES run.
- MOVES run log output text files: One per MOVES run.

Post-Processing Output:

- Final Rates Databases inputs to EmsCalc (8): For each MOVES output database, TTI used RatesCalc to calculate the mass/SHP off-network evaporative process rates using data from CDB, MOVES default database, and MOVES rateperprofile and ratepervehicle emissions rate output. Using the CDB and MOVES default data, the MOVES vehicle population and SHP calculation process was replicated to provide vehicle population-to-SHP ratios, which were multiplied by the MOVES rate/vehicle output yielding rate/SHP. Rates needed directly from the MOVES output and the SHP-based rates calculated by RatesCalc were tabulated in the RatesCalc output database. The MOVES pollutants specified in the pre-analysis plan were included (i.e., CO, PM<sub>10</sub> total exhaust, PM<sub>10</sub> brakewear, PM<sub>10</sub> tirewear), and VOC and NO<sub>x</sub> were added as well. Four rate tables were included: ttirateperdistance, ttirateperstart, ttirateperhour, and ttiratepershp; containing, respectively, the MOVES rateperdistance, rateperstart, rateperhour (SHI and APU hour-based rates), and the RatesCalc-produced SHP-based rates, each with a column added specifying units. These rates tables were input to EmsCalc emissions calculation utility. The RatesCalc utility is described in more detail in *TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUtil User's Guide* (TTI, August 2016).

Table 7 describes the MOVES2014a run specification files used. Table 8 describes the CDBs built and used for the rates analysis. Table 9, Table 10, and Table 11 summarize the meteorological, fuels, and I/M program inputs used.

**Table 7. MOVES Run Specification Selections by GUI Panel.**

Navigation Panel	Detail Panel <sup>1</sup>	Selection		
Scale <sup>1</sup>	Model; Domain/Scale; Calculation Type	On-Road; County; Emissions Rates		
Time Spans <sup>1</sup>	Time Aggregation Level; Years – Months – Days – Hours	Hour; <Year> - <Month> - Weekday - All		
Geographic Bounds <sup>1</sup>	Region; Selections; Domain Input Database	Zone and Link; El Paso; mvs14a_elp18mtp_<Year><season>_er_CDB_in <sup>1</sup>		
On-Road Vehicle Equipment	SUT/Fuel Combinations	SUT	Gasoline	Diesel
		Motorcycle	X	-
		Passenger Car	X	X
		Passenger Truck	X	X
		Light Commercial Truck	X	X
		Intercity Bus	-	X
		Transit Bus	-	X
		School Bus	X	X
		Refuse Truck	X	X
		Single Unit Short-Haul Truck	X	X
		Single Unit Long-Haul Truck	X	X
		Motor Home	X	X
		Combination Short-Haul Truck	X	X
Combination Long-Haul Truck	-	X		
Road Type	Selected Road Types	Off-Network – Rural Restricted Access – Rural Unrestricted Access – Urban Restricted Access – Urban Unrestricted Access		
Pollutants and Processes <sup>2</sup>	VOC; CO; NO <sub>x</sub> ; Primary Exhaust PM <sub>10</sub> ; Primary PM <sub>10</sub> Brakewear; Primary PM <sub>10</sub> Tirewear	Dependent on pollutant: Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Crankcase Extended Idle Exhaust, Evap Permeation, Fuel Vapor Venting, Fuel Leaks		
Manage Input Data Sets	Additional Input Database Selections	None		
Strategies	Rate Of Progress	Not Applicable		
General Output	Output Database; Units; Activity	mvs14a_elp18mtp_<Year><season>wkd_er_out <sup>1</sup> ; Grams, KiloJoules, Miles; Hotelling Hours, Population, Starts (not adjustable, pre-selected)		
Output Emissions Detail	Always; For All Vehicles/Equipment; On Road	Time: Hour – Location: Link – Pollutant; Fuel Type, Emissions Process; Source Use Type		
Advanced Performance Measures	Aggregation and Data Handling	All check boxes “un-checked”		

<sup>1</sup> County scale allows only one year per run. The years include 2020, 2030, 2040, and 2045. Separate run specifications were used for summer and winter as well, represented in the MRS file by July and January selections. Each MRS file was named similar to its output database, “mvs14a\_elp18mtp\_<Year><season>wkd\_er.mrs.”

<sup>2</sup> Only the pollutants retained in the final rates inputs to the emissions calculations are listed. Other pollutant selections were required as pre-requisites for the pollutants needed. These pollutants include the PM<sub>2.5</sub> species required for MOVES PM<sub>10</sub> calculations, and other hydrocarbon species for the MOVES VOC modeling.



**Table 8. MOVES CDB Input Tables.**

Input Table	Category	Notes
year	Time	Designates analysis year as a base year (base year means that local activity inputs will be supplied rather than forecast by the model).
state	Geography	Identifies the state (Texas) for the analysis.
county	Geography/ Meteorology	Identifies county of analysis with local altitude and barometric pressure. TTI used input data consistent with original MOBILE seasonal “min/max” temperature input data (estimates by TTI).
zonemonthhour	Meteorology	Summer and winter hourly temperature and relative humidity for the county. TTI used input data consistent with original MOBILE “min/max” temperature inputs (estimates by TTI).
roadtype	Activity	Lists the MOVES road types and associated ramp activity fractions. Road type ramp fractions were set to 0.
Hpmsvtypeyear <sup>1</sup>	Activity (Defaults)	TTI used MOVES default national annual VMT by HPMS vehicle category.
roadtypedistribution <sup>1</sup>		TTI used MOVES default road type VMT fractions.
monthvmtfraction <sup>1</sup>		TTI used MOVES default month VMT fractions.
dayvmtfraction <sup>1</sup>		TTI used MOVES default day VMT fractions.
hourvmtfraction <sup>1</sup>		TTI used MOVES default hour VMT fractions.
avg speeddistribution <sup>1</sup>		TTI used MOVES default average speed distributions.
sourcetypeyear <sup>1</sup>	Fleet (Defaults)	TTI used MOVES default national SUT populations.
sourcetypeage- distribution	Fleet	TTI estimated SUT age fractions using TxDMV mid-year county vehicle registration data and MOVES defaults (consistent with the registration data year), as needed. The latest available mid-year registration data were used for future years.
avft	Fleet	TTI estimated SUT fuel fractions using TxDMV vehicle registration data and defaults, where needed. Local data sets used were consistent with sourcetypeagedistribution tables. The avft estimate is also consistent with the analysis VMT mix (i.e., local SUT/fuel type combinations).
zone	Activity	Start, hotelling, and SHP zone allocation factors. County = zone, and all factors were set to 1.0 (required for county scale analyses).
zoneroadtype	Activity	SHO zone/roadtype allocation factors. County = zone, and all factors were set to 1.0 (required for county scale analyses).
fuelsupply	Fuel	The fuel supply (marketshares) were set to indicate one gasoline and one diesel fuel formulation (i.e., marketshares = 1.0) for the county.
fuelformulation	Fuel	For summer and winter gasoline formulations, TTI used a combination of MOVES defaults and gasoline properties estimated from local survey data with adjustments where needed for consistency with pertinent fuel regulations (e.g., summer RVP limit and Tier 3 sulfur standard). The diesel fuel formulations were consistent with federal sulfur standards.
countyyear	Stage II	N/A.
imcoverage	I/M	TTI used locality-specific set-ups, updated for use with MOVES2014a, to represent the I/M program for El Paso County based on current I/M rules, latest modeling protocols, and the available MOVES I/M parameters (in terms of MOVES I/M “teststandards” and associated “imfactors”) for the I/M vehicles.

<sup>1</sup> Use of default activity and population inputs for the MOVES rates mode runs is a basic aspect of the rates-per-activity emissions estimation method, which calculates the emissions inventory estimates via post-processing. The process uses actual, local vehicle activity estimates external to MOVES in the emissions calculations.

**Table 9. Meteorological Inputs to MOVES: Temperature (T) - Fahrenheit, Relative Humidity (RH) - Percent, Barometric Pressure (BP) - Inches of Mercury.**

Hour	Summer			Winter		
	T	RH	BP	T	RH	BP
1	76.4	48.8	26.068	34.3	50.1	26.191
2	74.5	51.8		32.7	53.6	
3	72.9	55.4		31.0	55.0	
4	71.5	59.3		29.9	57.4	
5	70.4	60.9		28.6	58.7	
6	69.0	63.8		27.9	60.0	
7	66.0	67.7		26.0	63.9	
8	68.2	73.0		27.7	62.0	
9	74.0	58.5		34.5	51.9	
10	78.7	50.1		42.9	40.7	
11	83.0	43.0		49.0	33.8	
12	86.3	38.0		54.6	28.1	
13	89.5	33.5		58.0	25.3	
14	92.4	29.1		59.9	23.2	
15	94.3	26.3		62.0	21.3	
16	95.2	24.9		63.0	20.4	
17	97.0	23.2		62.5	21.2	
18	96.0	24.4		59.1	23.8	
19	93.0	27.6		52.8	30.5	
20	90.8	31.1		50.0	33.1	
21	88.3	33.6		44.2	41.9	
22	84.5	39.1		40.8	44.3	
23	82.3	42.8		39.1	46.4	
24	80.1	44.4		37.3	50.5	

Note: Hourly values are consistent with prior MOBILE6 “min/max temperature” command input values used in the original 1990 base year SIP emissions inventories and in prior El Paso MTP regional emissions estimates for conformity. TTI estimated the average hourly temperature values within the original min/max temperature input range (and hourly average relative humidity and barometric pressure values) using hourly weather data from the same dates and location (El Paso International Airport weather station) used for the original min/max temperature estimates.

**Table 10. MOVES Gasoline and Diesel Fuel Formulation Inputs.**

Fuel Formulation Field <sup>1</sup>	2020+ Gasoline		2020+ Diesel
	Summer	Winter	Summer/Winter
fuelFormulationID	17703	17103	30011
fuelSubtypeID	12	12	20
RVP (psi)	7.00	11.36	0
sulfurLevel (ppm)	10.00	10.00	11.00
ETOHVolume (volume %)	9.60	10.00	0
MTBEVolume (volume %)	0.00	0.00	0
ETBEVolume (volume %)	0.00	0.00	0
TAMEVolume (volume %)	0.00	0.00	0
aromaticContent (volume %)	26.67	21.36	0
olefinContent (volume %)	5.50	6.66	0
benzeneContent (volume %)	0.63	0.63	0
e200 (vapor % at 200 deg. F.)	48.74	53.72	0
e300 (vapor % at 200 deg. F.)	87.84	87.38	0
volToWtPercentOxy	0.3653	0.3653	0
BioDieselEsterVolume	\N	\N	\N
CetaneIndex	\N	\N	\N
PAHContent	\N	\N	\N
T50 (deg. F. at 50 % vapor)	206.12	192.22	0
T90 (deg. F. at 90 % vapor)	306.72	309.50	0

<sup>1</sup> Fuel formulations were developed based on local fuel survey data, MOVES defaults, and other accepted values consistent with federal sulfur and benzene standards and the state RVP limit. For 2020+ winter gasoline, the MOVES E10 scenario- and fuel region-specific default was used. The 2020+ winter gasoline formulation is consistent with the El Paso winter oxygenated fuel program. Summer 2020+ gasoline was based on El Paso fuel survey sample data (latest available, summer 2017, TCEQ survey by ERG), with RVP, sulfur, and benzene content values set to the MOVES defaults, reflecting consistency with the regulatory standards. The average diesel sulfur value is an accepted default value consistent with federal low sulfur diesel standard, and also consistent with recent statewide observations (TCEQ summer 2011, 2014 and 2017 statewide retail outlet diesel survey samples).

*Local I/M Inputs to MOVES*

MOVES adjusts emissions (HC, CO, and NO<sub>x</sub>) at the source-type level to incorporate the benefits of the local I/M program design defined using the MOVES I/M coverage table parameters. TTI produced the I/M coverage input parameters to represent El Paso I/M program designs as specified in the Texas I/M SIP and Texas rules, using the current Texas I/M modeling protocol, and compliance and waiver rates. The El Paso I/M program requires annual emissions testing of gasoline vehicles within a 2-through-24 year vehicle age coverage window (motorcycles, military tactical vehicles, diesel-powered vehicles, and antique vehicles are excluded). A gas cap integrity test is required on all these vehicles, and depending on the model year, the vehicle emissions testing may utilize on-board diagnostics (OBD) or the Two-Speed Idle (2500 RPM/Idle) test. For additional Texas I/M program details, see the current I/M SIP, Revision to the State Implementation Plan Mobile Source Strategies, Inspection and Maintenance State Implementation Plan Revision, TCEQ, February 12, 2014.

**Table 11. MOVES I/M Coverage Table Input Descriptions for El Paso County.<sup>1</sup>**

<b>YearID</b>	<b>Begin Model Year<sup>2</sup></b>	<b>End Model Year<sup>2</sup></b>	<b>Test Standard Description (ID)</b>	<b>Source Use Type (I/M Compliance Factor)<sup>3</sup></b>
2007 through 2019	X	1995	2500 RPM/Idle (12)	Passenger Car (93.12%)
	X	1995	Evp Cap (41)	
	1996	Y	Exh OBD (51)	Passenger Truck (91.26%)
	1996	Y	Evp Cap, OBD (45)	
2020 through 2050	X	Y	Exh OBD (51)	Light Commercial Truck (85.67%)
	X	Y	Evp Cap, OBD (45)	

<sup>1</sup> Common parameters for Texas MOVES imcoverage records not shown include: annual test cycle, gasoline fuel type. The MOVES pollutants and processes affected are exhaust HC, CO, NO<sub>x</sub>, and tank vapor venting HC.

<sup>2</sup> Begin model year (X) and end model year (Y) define the range of model years covered, where “X” and “Y,” respectively, are calculated as YearID – 24, and YearID – 2.

<sup>3</sup> MOVES I/M compliance factors were calculated as a combination of Texas I/M modeling protocol compliance and waiver rates, and the regulatory class coverage adjustments provided in Section 4.10.6 of *MOVES Technical Guidance* (EPA, November 2015), along with the formula: I/M compliance factor = (compliance rate) × (1.0 - waiver rate) × (regulatory class coverage adjustment). Compliance and waiver rates are 96 percent and 3 percent. Regulatory class adjustments are passenger car – 100 percent, passenger truck – 98 percent, and light commercial truck – 92 percent.

**Attachment 3:**  
**Source Type Age and Fuel Engine Fractions Inputs to MOVES**

**El Paso County 2014 Age Distribution Inputs to MOVES**

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUSht	SULhT	MH	CShT	CLhT
0	0.045935	0.053900	0.026733	0.026733	0.055548	0.055650	0.055556	0.064759	0.062455	0.080736	0.064928	0.009782	0.044007
1	0.079804	0.070772	0.037056	0.037056	0.049844	0.049946	0.049851	0.058272	0.060276	0.097975	0.058445	0.015801	0.048909
2	0.069402	0.060117	0.033846	0.033846	0.046005	0.046100	0.046012	0.053507	0.079702	0.150497	0.053673	0.014296	0.050486
3	0.042856	0.046863	0.035079	0.035079	0.042194	0.055697	0.032610	0.028999	0.066630	0.104892	0.039988	0.006772	0.032874
4	0.031289	0.049364	0.034467	0.034467	0.037253	0.034095	0.035647	0.022977	0.037945	0.036093	0.035305	0.010534	0.017742
5	0.080386	0.040653	0.028561	0.028561	0.031054	0.034678	0.042221	0.030317	0.032680	0.034013	0.029436	0.021068	0.031415
6	0.073146	0.064144	0.058164	0.058164	0.039992	0.048516	0.046183	0.023359	0.109659	0.093698	0.037928	0.029345	0.043640
7	0.096114	0.066662	0.060009	0.060009	0.052280	0.047012	0.047736	0.081433	0.047749	0.057695	0.049441	0.044394	0.094086
8	0.078472	0.061945	0.055914	0.055914	0.053395	0.033713	0.055776	0.060642	0.069535	0.064010	0.050348	0.042889	0.070679
9	0.063826	0.060570	0.053565	0.053565	0.055067	0.052559	0.049572	0.057049	0.069717	0.057569	0.051939	0.049661	0.061342
10	0.045602	0.055428	0.061812	0.061812	0.053502	0.043092	0.048835	0.034170	0.053558	0.040882	0.050306	0.036117	0.041119
11	0.054839	0.053694	0.053524	0.053524	0.049301	0.041983	0.041807	0.033378	0.042484	0.033007	0.046365	0.029345	0.032913
12	0.039694	0.051897	0.055451	0.055451	0.046064	0.042452	0.043802	0.024143	0.034858	0.026419	0.043333	0.033860	0.032437
13	0.031455	0.043310	0.053863	0.053863	0.044038	0.048613	0.039741	0.029530	0.035585	0.027473	0.041306	0.051919	0.043530
14	0.024715	0.042587	0.047742	0.047742	0.041777	0.032808	0.043136	0.040271	0.039034	0.021921	0.039197	0.082769	0.052520
15	0.024049	0.033234	0.039570	0.039570	0.040613	0.031807	0.039913	0.057677	0.032498	0.019697	0.037984	0.078254	0.044225
16	0.017142	0.027351	0.033474	0.033474	0.030598	0.037111	0.031314	0.052718	0.018337	0.009478	0.022205	0.055681	0.037120
17	0.011401	0.021668	0.033913	0.033913	0.024835	0.033826	0.029099	0.025424	0.017974	0.010221	0.034115	0.040632	0.028101
18	0.011401	0.016127	0.022415	0.022415	0.020412	0.030975	0.024947	0.032795	0.009259	0.005665	0.020938	0.033860	0.025898
19	0.008405	0.015798	0.023979	0.023979	0.026464	0.025322	0.031789	0.041995	0.014706	0.006044	0.024651	0.048157	0.032080
20	0.007240	0.011279	0.022920	0.022920	0.020257	0.021952	0.015251	0.029313	0.009622	0.003876	0.023297	0.040632	0.020867
21	0.004660	0.008904	0.016038	0.016038	0.016633	0.018163	0.018167	0.013318	0.007081	0.002748	0.015998	0.029345	0.017990
22	0.003911	0.006789	0.013027	0.013027	0.012252	0.015769	0.014653	0.011855	0.005991	0.001875	0.013989	0.024831	0.012870
23	0.003994	0.005559	0.009793	0.009793	0.013801	0.015855	0.018594	0.018450	0.005991	0.002168	0.010346	0.030098	0.014209
24	0.003162	0.004365	0.009074	0.009074	0.015450	0.023149	0.020950	0.013061	0.004720	0.001735	0.013522	0.024078	0.012572
25	0.001831	0.003615	0.008759	0.008759	0.015324	0.017611	0.011953	0.020123	0.005084	0.001442	0.017413	0.017306	0.009605
26	0.002496	0.002877	0.009512	0.009512	0.014173	0.013781	0.014128	0.011515	0.004720	0.001180	0.015355	0.015049	0.007859
27	0.002164	0.002357	0.005600	0.005600	0.014695	0.012718	0.014276	0.010304	0.001452	0.000678	0.014965	0.015801	0.006202
28	0.003828	0.001917	0.007022	0.007022	0.012327	0.010714	0.012460	0.005268	0.003813	0.000875	0.010998	0.016554	0.006083
29	0.002996	0.001624	0.005782	0.005782	0.010701	0.009139	0.010634	0.005263	0.001997	0.000762	0.011609	0.012039	0.005596
30	0.033785	0.014631	0.043334	0.043334	0.014149	0.015191	0.013386	0.008114	0.014887	0.004677	0.020675	0.039127	0.021026

### Texas Statewide 2020 Fuel Engine Fractions Summary<sup>1</sup>

SUT	Fuel Type	Model Year															
		2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.990	0.993	0.999	1.000	0.993	0.995
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.010	0.007	0.001	0.000	0.007	0.005
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.987	0.985	0.977	0.981	0.975	0.979
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.013	0.015	0.023	0.019	0.025	0.021
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.962	0.955	0.941	0.948	0.938	0.946
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.038	0.045	0.059	0.052	0.062	0.054
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.005	0.001	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.998	0.995	0.999	0.997	0.997
SUSHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.371	0.219	0.234	0.274	0.351	0.287	0.256	0.238	0.232
SUSHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.629	0.781	0.766	0.726	0.649	0.713	0.744	0.762	0.768
SULHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.371	0.219	0.234	0.274	0.351	0.287	0.256	0.238	0.232
SULHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.629	0.781	0.766	0.726	0.649	0.713	0.744	0.762	0.768
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.510	0.530	0.540	0.560
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.490	0.470	0.460	0.440
CSHT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.199	0.110	0.057	0.081	0.052	0.058	0.031	0.050	0.051
CSHT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.801	0.890	0.943	0.919	0.948	0.942	0.969	0.950	0.949
CLHT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

**Texas Statewide 2020 Fuel Engine Fractions Summary<sup>1</sup> - (Continued)**

SUT	Fuel Type	Model Year														
		2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.997	0.996	0.996	0.997	0.997	0.998	0.998	0.999	0.999	0.999	1.000	0.999	0.999	0.997	0.999
PC	Diesel	0.003	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.001	0.001	0.003	0.001
PT	Gas	0.982	0.982	0.983	0.989	0.992	0.981	0.993	0.992	0.981	0.995	0.991	0.986	0.985	0.994	0.989
PT	Diesel	0.018	0.018	0.017	0.011	0.008	0.019	0.007	0.008	0.019	0.005	0.009	0.014	0.015	0.006	0.011
LCT	Gas	0.951	0.951	0.956	0.908	0.949	0.929	0.950	0.927	0.971	0.932	0.974	0.974	0.951	0.937	0.984
LCT	Diesel	0.049	0.049	0.044	0.092	0.051	0.071	0.050	0.073	0.029	0.068	0.026	0.026	0.049	0.063	0.016
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.042	0.114	0.147	0.121	0.010	0.090	0.124
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.958	0.886	0.853	0.879	0.990	0.910	0.876
RT	Gas	0.005	0.004	0.005	0.006	0.002	0.169	0.404	0.019	0.012	0.010	0.105	0.031	0.210	0.101	0.204
RT	Diesel	0.995	0.996	0.995	0.994	0.998	0.831	0.596	0.981	0.988	0.990	0.895	0.969	0.790	0.899	0.796
SUSHT	Gas	0.245	0.260	0.268	0.311	0.350	0.348	0.435	0.436	0.427	0.673	0.508	0.519	0.511	0.465	0.539
SUSHT	Diesel	0.755	0.740	0.732	0.689	0.650	0.652	0.565	0.564	0.573	0.327	0.492	0.481	0.489	0.535	0.461
SULHT	Gas	0.245	0.260	0.268	0.311	0.350	0.348	0.435	0.436	0.427	0.673	0.508	0.519	0.511	0.465	0.539
SULHT	Diesel	0.755	0.740	0.732	0.689	0.650	0.652	0.565	0.564	0.573	0.327	0.492	0.481	0.489	0.535	0.461
MH	Gas	0.570	0.590	0.600	0.630	0.660	0.680	0.710	0.740	0.770	0.790	0.820	0.850	0.850	0.850	0.850
MH	Diesel	0.430	0.410	0.400	0.370	0.340	0.320	0.290	0.260	0.230	0.210	0.180	0.150	0.150	0.150	0.150
CShT	Gas	0.052	0.055	0.077	0.084	0.090	0.107	0.134	0.147	0.146	0.275	0.117	0.117	0.160	0.161	0.144
CShT	Diesel	0.948	0.945	0.923	0.916	0.910	0.893	0.866	0.853	0.854	0.725	0.883	0.883	0.840	0.839	0.856
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.



### Texas Statewide 2030 Fuel Engine Fractions Summary<sup>1</sup>

SUT	Fuel Type	Model Year															
		2030	2029	2028	2027	2026	2025	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUSHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SUSHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
SULHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SULHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
CShT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
CLHT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

**Texas Statewide 2030 Fuel Engine Fractions Summary<sup>1</sup> - (Continued)**

SUT	Fuel Type	Model Year														
		2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.990	0.993	0.999	1.000	0.993	0.995	0.997	0.996	0.996	0.997	0.997
PC	Diesel	0.012	0.012	0.012	0.012	0.010	0.007	0.001	0.000	0.007	0.005	0.003	0.004	0.004	0.003	0.003
PT	Gas	0.980	0.980	0.980	0.980	0.987	0.985	0.977	0.981	0.975	0.979	0.982	0.982	0.983	0.989	0.992
PT	Diesel	0.020	0.020	0.020	0.020	0.013	0.015	0.023	0.019	0.025	0.021	0.018	0.018	0.017	0.011	0.008
LCT	Gas	0.947	0.947	0.947	0.947	0.962	0.955	0.941	0.948	0.938	0.946	0.951	0.951	0.956	0.908	0.949
LCT	Diesel	0.053	0.053	0.053	0.053	0.038	0.045	0.059	0.052	0.062	0.054	0.049	0.049	0.044	0.092	0.051
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.002	0.002	0.005	0.001	0.003	0.003	0.005	0.004	0.005	0.006	0.002
RT	Diesel	0.997	0.997	0.997	0.997	0.998	0.998	0.995	0.999	0.997	0.997	0.995	0.996	0.995	0.994	0.998
SUSht	Gas	0.396	0.371	0.219	0.234	0.274	0.351	0.287	0.256	0.238	0.232	0.245	0.260	0.268	0.311	0.350
SUSht	Diesel	0.604	0.629	0.781	0.766	0.726	0.649	0.713	0.744	0.762	0.768	0.755	0.740	0.732	0.689	0.650
SULht	Gas	0.396	0.371	0.219	0.234	0.274	0.351	0.287	0.256	0.238	0.232	0.245	0.260	0.268	0.311	0.350
SULht	Diesel	0.604	0.629	0.781	0.766	0.726	0.649	0.713	0.744	0.762	0.768	0.755	0.740	0.732	0.689	0.650
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.510	0.530	0.540	0.560	0.570	0.590	0.600	0.630	0.660
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.490	0.470	0.460	0.440	0.430	0.410	0.400	0.370	0.340
CShT	Gas	0.094	0.199	0.110	0.057	0.081	0.052	0.058	0.031	0.050	0.051	0.052	0.055	0.077	0.084	0.090
CShT	Diesel	0.906	0.801	0.890	0.943	0.919	0.948	0.942	0.969	0.950	0.949	0.948	0.945	0.923	0.916	0.910
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

### Texas Statewide 2040 Fuel Engine Fractions Summary<sup>1</sup>

SUT	Fuel Type	Model Year															
		2040	2039	2038	2037	2036	2035	2034	2033	2032	2031	2030	2029	2028	2027	2026	2025
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUSHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SUSHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
SULHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SULHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
CShT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

**Texas Statewide 2040 Fuel Engine Fractions Summary<sup>1</sup> - (Continued)**

SUT	Fuel Type	Model Year														
		2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.990
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.010
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.987
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.013
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.962
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.038
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998
SUSHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.371	0.219	0.274
SUSHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.629	0.781	0.726
SULHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.371	0.219	0.274
SULHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.629	0.781	0.726
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.199	0.110	0.081
CShT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.801	0.890	0.919
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

### Texas Statewide 2045 Fuel Engine Fractions Summary<sup>1</sup>

SUT	Fuel Type	Model Year															
		2045	2044	2043	2042	2041	2040	2039	2038	2037	2036	2035	2034	2033	2032	2031	2030
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUSHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SUSHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
SULHT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SULHT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
CShT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

**Texas Statewide 2045 Fuel Engine Fractions Summary<sup>1</sup> - (Continued)**

SUT	Fuel Type	Model Year														
		2029	2028	2027	2026	2025	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.010
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUShT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SUShT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
SULhT	Gas	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396	0.396
SULhT	Diesel	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
CShT	Diesel	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<sup>1</sup> Conventional internal combustion engine technology only.

**APPENDIX B:  
EMISSIONS ESTIMATION UTILITIES FOR MOVES-BASED EMISSIONS  
INVENTORIES**





## **TTI EMISSIONS ESTIMATION UTILITIES FOR MOVES2014A-BASED EMISSIONS INVENTORIES**

The following is a summary of utilities developed by TTI (written in the Visual Basic programming language) for producing detailed, link-based, hourly, and 24-hour emissions estimates for on-road mobile sources using the latest version of EPA's MOVES model (MOVES2014a). These utilities produce inputs used with the MOVES model, make special adjustments to the emissions factors (when required), and multiply them with travel model link-based or Highway Performance Monitoring System (HPMS)-based (virtual link) activity estimates to produce emissions at user-specified temporal and spatial scales.

The main utilities for calculating hourly and 24-hour emissions using MOVES are TRANSVMT, VirtualLinkVMT, VehPopulationBuild, OffNetActCalc, MOVESactivityInputBuild, MOVESfleetInputBuild, RatesCalc, RatesAdj, and EmsCalc. The TRANSVMT and VirtualLinkVMT prepare the link VMT and speeds activity input. The VehPopulationBuild utility builds the vehicle population used to calculate the off-network activity. The OffNetActCalc utility builds the SHP, starts, SHI, and APU hours required to estimate emissions using the rate-per-activity emissions rates produced by the RatesCalc or RatesAdj utilities. The MOVESactivityInputBuild and MOVESfleetInputBuild utilities build inputs used in MOVES. The RatesCalc utility assembles the emissions rates from the MOVES output in terms of rate-per-activity, including rate-per-SHP for the evaporative emissions processes. The RatesAdj utility makes special adjustments to the emissions rates when required. The EmsCalc utility calculates emissions by hourly time periods, producing a tab-delimited summary file (including 24-hour totals), hourly link emissions output files (optional), and an optional tab-delimited summary file by MOVES source classification code (SCC).

A process flow diagram follows the utility descriptions.

### **TRANSVMT**

The TRANSVMT utility post-processes travel demand models (TDMs) to produce hourly, on-road vehicle, seasonal and day-of-week specific, directional link VMT, and speed estimates. The TRANSVMT utility processes a TDM traffic assignment by multiplying the link volumes by the appropriate HPMS, seasonal, or other VMT factors. Hourly factors are then used to distribute the link VMT to each hour in the day. The TTI speed model is used to estimate the operational time-of-day link speeds for each direction. Since intrazonal links are not included in the TDM, special intrazonal links are created and the VMT and speeds for these special links are estimated using the intrazonal trips from the trip matrix and the zonal radii. The link VMT and speeds produced by TRANSVMT are subsequently input to the EmsCalc utility for applying the MOVES-based emissions factors (as well as with other utilities to develop off-network activity estimates).

### **VirtualLinkVMT**

The VirtualLinkVMT utility post-processes county HPMS average annual daily traffic (AADT) VMT, centerline miles, and lane miles by functional classification and area type (from the Texas Department of Transportation's [TxDOT's] annual Roadway Inventory Functional Classification Record [RIFCREC]) to produce hourly, on-road vehicle fleet, seasonal and day-of-week specific

actual or projected VMT, and directional operational speed estimates. These estimated VMT and speeds are produced for up to 42 directional HPMS functional classification/area type combinations, or “links.” The VirtualLinkVMT utility was developed for use in areas that do not have TDM networks, as well as for inventory applications for which network link-based detail is not required. The main inputs to VirtualLinkVMT are:

- County HPMS data sets, which include AADT VMT, centerline miles, and lane miles by HPMS area type and functional class;
- County-level VMT control totals;
- Hourly VMT distributions; and
- Speed model inputs to include volume/delay equation parameters adapted for HPMS, and free-flow speeds and lane capacities by HPMS functional classification and area type.

VirtualLinkVMT initially scales the county HPMS AADT VMT at the link level to the appropriate VMT (e.g., uses a county-level VMT control total-to-AADT ratio to produce seasonal, day-of-week specific VMT). Hourly factors and directional split factors are applied to the adjusted VMT on each link to estimate the hourly, directional VMT (and volumes) by HPMS link. Congested speed models, each for the high- and low-capacity links, are used to estimate the hourly operational speeds by direction for each link. The operational speeds are based on volume/capacity (v/c)-derived directional delay (minutes/mile) applied to the estimated free-flow speeds for each link. The virtual link VMT and speeds produced using the VirtualLinkVMT utility are an input to the emissions calculation utility, EmsCalc (as well as with other utilities to develop off-network activity estimates).

### **VehPopulationBuild**

The VehPopulationBuild utility builds the sourcetypeyear data files in a format consistent with the MOVES input database table and the SUT/fuel type population input file (can be used with the EmsCalc utility to estimate emissions or the OffNetActCalc utility to estimate starts and SHP) using the VMT mix and the Texas Department of Motor Vehicles (TxDMV) registration data sets. The TxDMV registration data sets are three sets of registration data (an age registration data file, a gas trucks registration data file, and a diesel trucks registration data file) that list 31 years of registration data. The primary inputs to this utility are:

- County ID file, which specifies the county for which the output will be calculated;
- Age registration data file, which lists 31 years of registration data for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, Total Trucks <=8500, Gas Trucks >8500, Diesel Trucks >8500, Total Trucks >8500, and Total All Trucks vehicle categories;
- Gas trucks registration data file, which lists 31 years of registration data for the Gas >8500, Gas >10000, Gas >14000, Gas >16000, Gas >19500, Gas >26000, Gas >33000, Gas >60000, and Gas Totals gas truck categories;
- Diesel trucks registration data file, which lists 31 years of registration data for the Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000, Diesel >19500, Diesel >26000, Diesel >33000, Diesel >60000, and Diesel Totals diesel truck categories;

- VMT mix by TxDOT district, MOVES SUT, and MOVES fuel type;
- TxDOT district name file, which specifies the VMT mix TxDOT district;
- MOVES default database;
- Population factor file (optional); and
- Year ID file (optional, only used if population factors are used), which specifies the year for calculating the output.

For the desired county (from the county ID file), the age registration data (for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, and Total Trucks <=8500 vehicle categories) are saved in an age registration data array. The gas truck registration data (for the Gas >8500, Gas >10000, Gas >14000, Gas >16000, Gas >19500, Gas >26000, Gas >33000, and Gas >60000 gas truck categories) are saved in the gas truck section of the diesel/gas registration data array. The diesel truck registration data (for the Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000, Diesel >19500, Diesel >26000, Diesel >33000, and Diesel >60000 diesel truck categories) are saved in the diesel truck section of the diesel/gas registration data array. The age registration data array and the diesel/gas registration data array are combined to form the registration category data array (seven categories for 31 years of data and the total) using the combinations in Table 1.

**Table 1. Registration Categories.**

Registration Category	Vehicle Category	Data Location
1	Passenger Vehicle	Age registration data array
2	Motorcycles	
3	Total Trucks <=8500	
4	Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000	Diesel/gas registration data array
5	Diesel >19500, Diesel >26000, Diesel >33000, Diesel >60000	
6	Gas >8500, Gas >10000, Gas >14000, Gas >16000	
7	Gas >19500, Gas >26000, Gas >33000, Gas >60000	

The registration category data array is used to fill the SUT population array (by SUT and fuel type) for all vehicles except long-haul trucks. Each SUT/fuel type combination is assigned the total registrations from one or more of the registration categories in the registration category data array. Table 2 shows the SUTs and their associated registration category in the registration category data array.

**Table 2. SUT/Registration Category Correlation.**

SUT	Registration Category
11	2
21	1
31, 32	3
41, 42, 43, 51, 52, 54	4 + 6
61	5 + 7

SUT population factors are calculated by SUT/fuel type using the data from the VMT mix input for all SUTs except motorcycles (SUT 11) and the long-haul trucks (SUTs 53 and 62) and saved in the SUT population factors array. For SUT 21, the fuel type VMT mix is divided by the total VMT mix for SUT 21. For SUT 31, the fuel type VMT mix is divided by the total VMT mix for SUTs 31 and 32. The same process applies to SUT 32. For SUT 41, the fuel type VMT mix is divided by the total VMT mix for SUTs 41, 42, 43, 51, 52, and 54. The same process applies to SUTs 42, 43, 51, 52, and 54. For SUT 61, the fuel type VMT mix is divided by the total VMT mix for SUT 61.

For SUT 11, the SUT population factor for fuel type 1 (gasoline) is set 1 with all other factors set to 0. For SUT 53, the SUT population factors by fuel type are calculated by dividing the fuel type VMT mix for SUT 53 by the fuel type VMT mix for SUT 52. For SUT 62, the SUT population factors by fuel type are calculated by dividing the fuel type VMT mix for SUT 62 by the fuel type VMT mix for SUT 61, therefore creating a ratio of long-haul and short-haul trucks.

The SUT population factors and the population factor (if desired) are applied to the SUT population array for all SUTs except SUT 53 and 62. For SUT 53, the SUT population factors for SUT 53 are applied to the SUT population array for SUT 52. For SUT 62, the SUT population factors for SUT 62 are applied to the SUT population array for SUT 61.

Using the appropriate MySQL code, a new sourcetypeyear database table is created. The data in the SUT population array is aggregated by fuel type and used to fill the sourcetypeyear database table, along with the yearID, salesGrowthFactor, and migrationrate. For the yearID, the year of the registration data is used, unless a population factor is used, in which case the year from the year ID input is used. The salesGrowthFactor and migrationrate for each SUT is set 1. A text format of this database table is written by the utility as well. The SUT/fuel type population input file is written using the SUT population array.

### **OffNetActCalc**

The OffNetActCalc calculates the analysis scenario (i.e., year, season, day type) SHP, starts, SHI, and APU hours by hour, SUT, and fuel type used to estimate emissions using the EmsCalc utility. The SHI and APU hours are only calculated for SUT 62, fuel type 2 (CLhT\_Diesel). The SHP is calculated using either the TDM or the virtual link-based link VMT and speeds (same as used in the distance-based emissions estimation), the 24-hour or time period VMT mix (by roadway type and SUT/fuel type), and the SUT/fuel type population (from the

VehiclePopulationBuild utility). The starts activity is calculated using the SUT/fuel type population and the starts per vehicle (typically the MOVES default). The SHI and APU hours are a function of hotelling hours. This utility has two options for calculating the hotelling hours. Using the first option, the analysis scenario 24-hour hotelling hours is calculated using a user-supplied extended idle factor to the source hours operating (SHO). However, this method of estimating the hotelling hours as a direct function of the SHO does not consider the availability of locations where extended idling may occur. The second option (and suggested method) uses base data (24-hour hotelling, link VMT and speeds, and VMT mix), the analysis scenario data used to calculate the SHP, and the analysis scenario SHP to calculate the analysis scenario 24-hour hotelling hours.

For the analysis scenario first hourly VMT and speeds input, the utility applies the appropriate VMT mix (either the 24-hour VMT mix or the appropriate time period VMT mix as assigned by the user) to each link that has the desired county code; thus distributing the link VMT to each SUT/fuel type, which is added to the hourly SUT/fuel type VMT. The link VMT by SUT/fuel type is divided by the link speed to calculate the link VHT (or SHO) by SUT/fuel type, which is added to the SUT fuel/type VHT. This calculation process is repeated for each analysis scenario VMT and speeds input; therefore producing the analysis scenario hourly values for VMT by SUT/fuel type and for VHT by SUT/fuel type.

The analysis scenario hourly SUT/fuel type speed, total hours (or source hours), and SHP are then calculated. For each hour and SUT/fuel type, the hourly SUT/fuel type VMT is divided by the hourly SUT/fuel type VHT to calculate the hourly SUT/fuel type speed. The hourly SUT/fuel type total hours are set equal to the SUT/fuel type population. The hourly SUT/fuel type SHP is calculated by subtracting the hourly SUT/fuel type VHT (or SHO) from the hourly SUT/fuel type total hours. If the calculated SHP is negative (i.e., SHO is greater than the total hours), the SHP is set to 0.

To calculate the analysis scenario 24-hour hotelling hours under option 1 (as a direct function of SHO), the utility multiplies the CLhT\_Diesel analysis scenario 24-hour SHO by the user-supplied extended idle factor, which represents the amount of extended idle time that must occur per SHO. For option 2 (as a function of base hotelling data), the utility calculates the base 24-hour CLhT\_Diesel VMT using the base VMT and speeds inputs and the base VMT mix with the same procedure used in the analysis scenario SHP calculations. The 24-hour analysis scenario CLhT\_Diesel VMT is then divided by the 24-hour base CLhT\_Diesel VMT to create a scaling factor, which is then applied to the base 24-hour hotelling hours to calculate the analysis scenario 24-hour hotelling hours.

The utility then calculates the analysis scenario hourly hotelling hours. The analysis scenario hourly CLhT\_Diesel SHO (from the SHP calculation process) is converted to hourly VHT fractions. The hourly hotelling fractions are calculated as the inverse of the hourly VHT fractions. The hourly hotelling fractions are then applied to the analysis scenario 24-hour hotelling hours to calculate the hourly hotelling hours. For each hour, the hourly hotelling hours are then compared to the hourly CLhT\_Diesel SHP. For those hours where the hotelling hours are greater than the SHP, hotelling hours are set to the SHP for that hour.

The utility then calculates the SHI fraction and the APU fraction using the source type age distribution (same distribution used in the MOVES runs), the relative mileage accumulation rates, and the hotelling activity distribution. Travel fractions for SUT 62 (CLhT) by ageID (0 through 30) are calculated by multiplying the age distribution by the appropriate relative mileage accumulation rate, which is then converted into a distribution by dividing the individual travel fraction (ageID 0 through 30) by the sum of the travel fractions. These travel fractions are then applied to the appropriate operating mode fractions from the hotelling activity distribution (operating mode 200) and summed to calculate the SHI fraction. Using a similar process, the APU fraction is calculated using the operating mode fractions for operating mode 201. For each hour the analysis scenario hotelling hours are multiplied by the SHI fraction to calculate the analysis scenario SHI activity and by the APU fraction to calculate the analysis scenario APU hours.

### **MOVESactivityInputBuild**

The MOVESactivityInputBuild utility builds the roadtypedistribution, hourvmtfraction, avgspeeddistribution, roadtype, hpmsvtypeday, sourcetyperedayvmt, year, state, zone, zoneroadtype, monthvmtfraction, and dayvmtfraction data files in a format consistent with the MOVES input database tables using the link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility, the VMT mix, and the MOVES defaults. The utility also has the option of building the sourcetypeage (adjusted to reflect the 24-hour VMT mix), starts, and hotellinghours data files in a format consistent with the MVOES input database tables using the output from the OffNetActCalc utility, along with inputs from the MOVES runs and the MOVES defaults. The primary inputs to this utility are:

- Link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility;
- County ID file which specifies the county number in the link-based hourly VMT and speeds for which the output will be calculated;
- VMT roadway type designations, which lists associations of the link roadway types/area type combination to the VMT mix, emissions rate, and MOVES roadway types (same as used with the EmsCalc utility);
- 24-hour or time period VMT mix by roadway type, MOVES source type, and MOVES fuel type (same as used with the EmsCalc utility);
- Day ID, which specifies the MOVES day ID for calculating the output;
- Year ID, which specifies the year for calculating the output;
- Link/Ramp designations, which designates each link roadway type/area type combination to either ramp or non-ramp;
- MOVES default database;
- Month ID, which specifies the month for calculating the output;
- sourcetypeyear, SUT age, and sourcetypeage inputs from the MOVES runs (optional, only if sourcetypeage table output is to be created);

- Starts output from the OffNetActCalc utility (optional, only if starts table output is to be created); and
- Hotelling, extended idle, and APU hours output from the OffNetActCalc utility (optional, only if hotelling table output is to be created).

For each link in the link-based hourly VMT and speeds in which the county number matches the desired county ID, the link VMT is saved in a VMT summary array based on hour, link functional class, and link area type. The link VHT (link VMT/link speed) is saved in a VHT summary array based on hour, link functional class, link area type, and MOVES average speed bin ID (determined using the MOVES average speed bins and the link speed). The link VHT is also saved in a road type VHT array based on link functional class and link area type, and, if the link is specified as ramp by the link/ramp designations specified by the user, the VHT is additionally saved in the ramp segment of the road type VHT array.

A MOVES roadway type array by MOVES roadway type (roadTypeID codes 2 through 5) is also created using the data in the VMT summary array and VMT roadway type designations. For the link road types designated a MOVES road type of 6 or 8, the VMT is added to MOVES road type 2 in the MOVES roadway type array. For the link road types designated a MOVES road type of 7 or 9, the VMT is added to MOVES road type 4 in the MOVES roadway type array. An hourly VMT array (by MOVES SUT, MOVES roadway type, and hour) is formed using the data in the VMT summary array, the VMT roadway type designations, and the VMT mix. If the time period VMT mix is used, each hour is assigned a time period by the user. Otherwise, the same 24-hour VMT mix is used for all hours. An average speed distribution array (by MOVES SUT, MOVES roadway type, hour, and MOVES speed bin) is created using the VHT summary array and the VMT mix. Using the appropriate MySQL code, the MOVES roadtypedistribution, hourvmtfraction, and avgspeeddistribution default values are extracted and saved for later use.

The VMT in the MOVES roadway type array is used to produce the roadway type distribution array by MOVES SUT and MOVES roadway type. This VMT is converted to a distribution by MOVES SUT (i.e., the total for a SUT over the five MOVES roadway types should equal 1), with the distribution value for MOVES roadway type 0 (Off-Network) equal to 0. The utility writes the tab-delimited roadtypedistribution table output (optional).

The VMT in the hourly VMT array is added to the hourly VMT fraction array (by SUT, MOVES roadway type, and hour) and for those roadway types where the VMT for all hours is greater than 0, this VMT is converted to an hourly distribution. For those roadway types where the VMT is equal to 0, a value of 1 is placed in the first hour, followed by 0 in the remaining hours. The utility writes the tab-delimited hourvmtfraction table output (optional). For those SUTs where the VMT mix is greater than 0, the hourly VMT fraction array is used. Otherwise, the MOVES hourvmtfraction default values are used.

The VHT in the average speed distribution array is converted to a distribution by SUT, MOVES roadway type, hour/day (combination of hour and the day ID specified by the user), and MOVES average speed bin. The utility writes the tab-delimited avgspeeddistribution table

output (optional). For those SUTs where the VMT mix is greater than 0, the average speed distribution array is used. Otherwise, the MOVES avgspeddistribution default values are used.

The VHT in the road type VHT array is converted to a proportion of ramp VHT by dividing the ramp segment of the road type VHT array by the total VHT for the road type in the road type VHT. The utility writes the tab-delimited roadtype table output (optional). If the ramp fraction for roadTypeID 2 is greater than 0, then roadTypeID 6 (with rampFraction equal to 0) and roadTypeID 8 (with rampFraction equal to 1) are also added to the roadtype database table. If the ramp fraction for roadTypeID 4 is greater than 0, then roadTypeID 7 (with rampFraction equal to 0) and roadTypeID 9 (with rampFraction equal to 1) are also added to the roadtype database table.

The VMT in the hourly VMT array is aggregated to create the 24-hour HPMS vehicle type VMT array. Each SUT is assigned an HPMS vehicle type (SUT 11 is HPMS vehicle type 10; SUTs 21, 31 and 32 are HPMS vehicle type 25; SUTs 41, 42, and 43 are HPMS vehicle type 40; SUTs 51, 52, 53, and 54 are HPMS vehicle type 50; and SUTs 61 and 62 are HPMS vehicle type 60). The utility writes the tab-delimited hpmsvtypeday table output (optional).

The VMT in the hourly VMT array is also aggregated by SUT to create the 24-hour SUT VMT array. Using this VMT data, the utility writes the tab-delimited sourcetypedayvmt output table (optional) in a format consistent with the MOVES input.

Using the appropriate MySQL code, the fuel year ID is extracted from the MOVES default year database table for the user-supplied year ID. The tab-delimited year table output is written (optional) using the user-supplied year ID and the extracted fuel year ID. The “isbaseYear” data is written as well (automatically set to “Y”).

The utility also produces two tab-delimited summary output files. A tab-delimited VMT summary is output by hour, link road type, and link area type for the user-specified county. A tab-delimited VHT summary is output by hour, link road type, link area type, and MOVES average speed bin for the user-specified county.

The utility creates five other tab-delimited outputs (state, zone, zoneroadtype, monthvmtfraction, and dayvmtfraction tables) using the user-supplied inputs. For the state table (optional), the utility extracts the data from the MOVES default state database table where the state ID is 48 and writes this data to the tab-delimited state table output. For the zone table (optional), the utility extracts the data from the MOVES default zone data for the county ID greater than 48000 and county ID less than 49000 and writes this data to the tab-delimited zone table output with the start allocation factors, idle allocation factors, and SHP allocation factors replaced with values of 1.

For the zoneroadtype table (optional), the utility extracts the MOVES default zoneroadtype data where the zone ID greater than 480000 and zone ID less than 490000 and writes this data to the tab-delimited zoneroadtype table output, with the SHO allocation factors replaced with values of 1. For the monthvmtfraction table (optional), the utility extracts the data from the MOVES default monthvmtfraction table and writes the data to the tab-delimited monthvmtfraction table output with the month VMT fraction set to 1 for the user-supplied month



ID and 0 for all other months. For the dayvmtfraction table (optional), the utility extracts the data from the MOVES default dayvmtfraction table and writes this data to the tab-delimited dayvmtfraction table output with the day VMT fraction is set to 1 for the user-supplied day ID and 0 for all other months.

For the sourcetypeage table output (optional, also needed if the hoteling hours table output is to be created), the utility calculates the adjusted relative mileage accumulation rates (MAR) by multiplying the input relative MAR (categorized by SUT and age from the sourcetypeage input) by the SUT-specific relative MAR adjustment factors (one factor per SUT applied across all age categories). These adjustment factors are calculated using inventory SUT VMT fractions within each HPMS vehicle type and the sum of the SUT-specific normalized travel fractions within each HPMS vehicle type. The inventory SUT VMT fractions within each HPMS vehicle type are calculated by dividing the 24-hour SUT VMT by the 24-hour HPMS vehicle type VMT for the respective SUT.

For the sum of the SUT-specific normalized travel fractions within each HPMS vehicle type, the utility uses the same calculation procedures used by MOVES to calculate the normalized travel fractions. The SUT vehicle population is distributed to each age category using the SUT age distribution input. Using the sum of the vehicle population by HPMS vehicle type, the SUT population fraction for each age category within each HPMS vehicle type is calculated by dividing the SUT vehicle population by age by the sum of the vehicle population by HPMS vehicle type. The utility then calculates the initial travel fractions (by SUT and age) by multiplying the SUT population fraction for each age category within each HPMS vehicle type by the relative MAR input.

These initial travel fractions are then normalized within each HPMS vehicle type to produce the SUT and age-specific normalized travel fractions within each HPMS vehicle type. The utility then calculates the SUT-specific relative MAR adjustment factors by dividing the inventory SUT VMT fractions within each HPMS vehicle type by the sum of the SUT and age-specific normalized travel fractions (i.e., aggregated across the age category for each SUT); resulting in one SUT-specific relative MAR adjustment factor for each SUT.

For the starts table output (optional), the utility aggregates the SUT/fuel type hourly starts input (output from the OffNetActCalc utility) by SUT and multiplies the SUT hourly starts by the SUT age distribution (by SUT) to distribute the hourly SUT starts to each age category. The SUT hourly starts by age are written to the starts table output file, along with the user-supplied monthID, yearID, dayID (used to form the output hourDayID), and zoneID (set using the user-supplied county FIPS code).

For the hoteling hours table output (optional), the utility uses travel fractions specific to SUT 62 to distribute the hourly hoteling hours input (output from the OffNetActCalc utility) to each age category. These travel fractions are calculated by multiplying the SUT 62 age distribution by the calculated relative mileage accumulation rates (MOVES defaults adjusted so to reflect the emissions inventory 24-hour VMT mix) for each age category and dividing by the sum of the product for all the age categories. These travel fractions are multiplied by the hourly hoteling hours input and written to the hoteling hours table output, along with the user-supplied dayID

(used to form the output hourDayID), monthID, yearID, and zoneID (set using the user-supplied county FIPS code).

## **MOVESfleetInputBuild**

The MOVESfleetInputBuild utility builds the sourcetypeagedistribution database table and fuel/engine fraction inputs to MOVES using the TxDOT registration data sets and the MOVES default database tables. The TxDOT registration data sets are three sets of registration data (an age registration data file, a gas trucks registration data file, and a diesel trucks registration data file) that list 31 years of registration data. The primary inputs to this utility are:

- Age registration data file, which lists 31 years of registration data for the Passenger Vehicles, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, Total Trucks <=8500, Gas Trucks >8500, Diesel Trucks >8500, Total Trucks >8500, and Total All Trucks vehicle categories;
- Gas trucks registration data file, which lists 31 years of registration data for the Gas > 8500, Gas > 10000, Gas > 14000, Gas > 16000, Gas > 19500, Gas > 26000, Gas > 33000, Gas > 60000, and Gas Totals gas truck categories;
- Diesel trucks registration data file, which lists 31 years of registration data for the Diesel > 8500, Diesel > 10000, Diesel > 14000, Diesel > 16000, Diesel > 19500, Diesel > 26000, Diesel > 33000, Diesel > 60000, and Diesel Totals diesel truck categories;
- SUT data sources input, which specifies the data source for each SUT to use when building the sourcetypeagedistribution database table;
- Fuel/engine fractions data sources input, which specifies the data source for each SUT to use when building the fuel/engine fractions;
- Default sourcetypeage distribution input;
- MOVES default database; and
- Year ID file (optional, only if year is not the registration data year as in a future year analysis), which specifies the year for calculating the output.

The SUT data sources input lists the data source for each SUT, either a single county, multiple counties, state, or MOVES default. As this input is processed, the utility maintains a list of the input sources. The same applies to the fuel/engine fractions, except data source inputs are only valid for source types 52, 53, and 61 (other are not valid due to data limitations and source type 62 are all considered diesel).

For each county (or state total) in the list of the input sources, the age registration data (for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, and Total Trucks <=8500 vehicle categories) are saved in an age registration data array. The gas truck registration data (for the Gas > 8500, Gas > 10000, Gas > 14000, Gas > 16000, Gas > 19500, Gas > 26000, Gas > 33000, and Gas > 60000 gas truck categories) are saved in the gas truck section of the diesel/gas registration data array. The diesel truck registration data (for the Diesel > 8500, Diesel > 10000, Diesel > 14000, Diesel > 16000, Diesel > 19500, Diesel > 26000, Diesel >

33000, and Diesel > 60000 diesel truck categories) are saved in the diesel truck section of the diesel/gas registration data array.

The age registration data array and the diesel/gas registration data array are combined to create the registration category data array (a total of seven categories for 31 years of data and the total) using the combinations in Table 1 (Registration Categories). The county is compared to the data sources for each SUT in the SUT data sources input. If the county is found for a given source type, then the 31 years of registration data from the source type's corresponding category in the registration category data array are added to the SUT age distribution array. Table 3 shows the source types and their corresponding registration categories.

**Table 3. SUTs/Registration Categories Correlation for SUT Age Distribution.**

SUT	Registration Category
11	2
21	1
31, 32	3
52, 53	4
61, 62	5

A similar process is followed for the fuel/engine fractions array. However, only SUTs 52, 53, 61, and 62 are processed due to data limitations. The registration data are saved in the fuel/engine fractions array based on fuel type. Table 4 shows the SUTs and their corresponding registration categories.

**Table 4. SUTs/Registration Categories Correlation for Fuel/Engine Fractions.**

SUT	Fuel Type	Registration Category
52, 53	Diesel	4
	Gas	6
61	Diesel	5
	Gas	7
62	Diesel	5 + 7
	Gas	None – all are assumed diesel

After processing all of the counties, the data from the default sourcetypeage distribution input are processed and the data for the registration data year are saved in the default age distribution array. For each source type in which the registration data are to be used for the age distribution, the 31 years of registration data in the SUT age distribution array are converted to a distribution by dividing the source type yearly registration data by the source type total registration data. For

each source type in which the defaults are to be used, the defaults values from the default age distribution array are copied to the SUT age distribution array.

The MOVES default fuel/engine fractions are extracted from the MOVES default database (using the appropriate code for MySQL) and saved in the default fuel/engine fractions array. For source types 52, 53, and 61, the source type yearly registration data in the fuel/engine fractions array are converted to fuel/engine fractions by dividing the yearly source type diesel registration data by the sum of the yearly source type diesel registration data and the yearly source type gas registration data.

If the year ID input is used, then these fuel/engine fractions are adjusted to match the year from the year ID input. If the year from the year ID input is greater than the registration data year, then the first fuel/engine fraction is extended to match the year from the year ID input and the appropriate number of years is dropped from the end of the fuel/engine fractions to maintain the appropriate distribution. If the year from the year ID input is less than the registration data year, then the last fuel/engine fraction is extended to match the year from the year ID input and the appropriate number of years is dropped from the beginning of the fuel/engine fractions to maintain the appropriate distribution. For source type 62, all of the fuel/engine fractions in the fuel/engine fractions array are set to a value of 1.

Using the appropriate MySQL code, a new `sourcetypeagedistribution` database table is created and the data from the SUT age distribution array, along with the year ID (either from the registration data or the year ID input), are used to fill the new database table. A text format of this database table may be written as well. Using the appropriate MySQL code, a new `AVFTfuelengfraction` database table is created and the data from the fuel/engine fractions array are used to fill the new database table for SUTs 52, 53, 61, and 62. For all other SUTs, the default fuel/engine fraction array data for the appropriate year (either the registration data year or the year ID input) are used to fill the new database table. A text format of this database table may be written as well.

## **RatesCalc**

The RatesCalc utility calculates emissions rates in terms of rate/SHP for the evaporative emissions processes using the data in the CDB used in the MOVES emissions rates run and the MOVES default database. The utility also creates copies of the `rateperdistance`, `rateperhour`, and `rateperstartemissions` rate tables to include the units for each pollutant. If not specified, emissions rates are assembled for each pollutant and process combination (excluding total energy and the refueling emissions processes) in the MOVES emissions rate tables. The utility also uses the `movesrun` database table, along with a pollutant energy or mass lookup table (mass, TEQ, or gmole), to determine the units of the emissions rates, which are added to the emissions rate tables, which will allow the user to specify any of the units available in MOVES for the MOVES emissions rate run. The type of activity used for the emissions rate calculation is determined by the process, as Table 5 shows.

**Table 5. MOVES2014a Emissions Process and Corresponding Activity for Rate-per-Activity Emissions Rates.**

<b>MOVES2014a Emissions Process</b>	<b>Activity</b>	<b>Emissions Rate Units</b>
Running Exhaust	Miles Traveled	Rate/Mile
Crankcase Running Exhaust	Miles Traveled	Rate/Mile
Start Exhaust	Starts	Rate/Start
Crankcase Start Exhaust	Starts	Rate/Start
Extended Idle Exhaust	Extended Idle Hours	Rate/Extended Idle Hour
Crankcase Extended Idle Exhaust	Extended Idle Hours	Rate/Extended Idle Hour
Auxiliary Power Exhaust	APU Hours	Rate/APU Hour
Evaporative Permeation	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Evaporative Fuel Vapor Venting	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Evaporative Fuel Leaks	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Brake Wear	Miles Traveled	Rate/Mile
Tire Wear	Miles Traveled	Rate/Mile

For the rateperdistance (rate/mile emissions rates) emissions rate table, the utility creates a copy of the emissions rates in the specified output database with the table name `ttirateperdistance`. If specific pollutants are specified, only the emissions rates for those pollutants are copied to the `ttirateperdistance` table. Otherwise, the entire `rateperdistance` table is copied to the `ttirateperdistance` table. The utility also adds a “Units\_Per\_Activity” field to the `ttirateperdistance` table and fills that field based on the pollutants energy or mass designation (mass, TEQ, or gmole). For those pollutants designated as mass, the mass units from the `movesrun` table are added to the “Units\_Per\_Activity” field. For those pollutants designated as gmole, the mass units from the `movesrun` table, along with the text “-mole” (i.e., pound-mole or gram-mole) are added to the “Units\_Per\_Activity” field. For those pollutants designated as TEQ, the text “TEQ” is added to the “Units\_Per\_Activity” field. No unit conversions are performed in this utility. The `rateperstart` and `rateperhour`, emissions rate tables are processed in a similar manner to produce the `ttirateperstart` and `ttirateperhour`, emissions rate tables.

For the evaporative emissions rates, the utility uses the CDB from the MOVES run and the MOVES default database to replicate the MOVES vehicle population and SHP calculation process. Using the emissions rates from the `rateperprofile` and `ratepervehicle` emissions rate tables, the utility calculates the rate-per-SHP emissions rates by multiplying the emissions rate by the appropriate vehicle population and dividing by the appropriate SHP value. These rate-

per-SHP emissions rates are then saved in the ttiratepershp emissions rate table. Similar to the previous RatesCalc emissions rate tables, the “Units\_Per\_Activity” field is added to the ttiratepershp table and filled based on the pollutants energy or mass designation.

## **RatesAdj**

The RatesAdj utility applies emissions rate adjustments to an emissions rate database table produced by RatesCalc utility (ttirateperdistance, ttirateperstart, ttirateperhour, or ttiratepershp) or by this utility to produce a new emissions rate database table in the same format as the input emissions rate database table. The emissions rate adjustments can be linear adjustments that are applied to all emissions rates or can be applied by SUT, fuel type, pollutant, and process (adjustments may also include roadway type, average speed bin, and hour). The user has the option of selecting which pollutants will be in the new emissions rate database table, along with the output units of the emissions rates. This allows the user to perform any unit conversions between mass units (i.e., pounds to grams or pound-mole to gram-mole) without providing any additional adjustment factors. Unit conversions between unit types (i.e., gram-moles to grams or TEQ to grams) are not performed internally by the utility. These types of conversions must be made using the emissions rate adjustment factors. The utility also has the option for combining multiple emissions rate database tables into one new emissions rate database table, if the input emissions rate database tables are in the same format.

For the first input emissions rate database table, the utility extracts the emissions rates for the specified pollutants (or all the pollutants if not specified) from the input database emissions rate table, applies the emissions rate adjustments (if necessary) and any unit conversion adjustments, and saves these adjusted emissions rates. If more than one emissions rate database table is input, then the utility performs a similar calculation process to the first input emissions rate database table for each input emissions rate database table. If pollutants are found in more than one input emissions rate database table, the adjusted emissions rates are summed to produce one emissions rate.

After processing all of the input emissions rate database tables, the utility creates a new emissions rate database table in the same format as the first input emissions rate database table and writes the adjusted emissions rates to this new emissions rate database table. Using MySQL code, the utility also creates a minimum and maximum emissions rate summary for each input emissions rate table and the output emissions rate table by pollutant, process, and source type/fuel type, which is written to a tab-delimited file specified by the user.

## **EmsCalc**

The EmsCalc utility estimates the hourly link emissions for one user-specified county using the emissions factors (either from RatesCalc or RatesAdj), the 24-hour or time period VMT mix, the hourly link VMT and speeds activity estimates (either from TRANSVMT or VirtualLinkVMT), and the off-network activity (SHP, starts, and SHI). This utility produces a tab-delimited output summary (including hourly and 24-hour totals) and hourly link emissions output files (optional). The primary inputs to EmsCalc are:

- Emissions factors from RatesCalc or RatesAdj;

- Link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility. For each link, the following information is input to EmsCalc: link start node, link end node, link county number, link roadway type number, link area type number, link VMT, and link operational speed estimate;
- 24-hour or time period VMT mix by roadway type, MOVES SUT, and MOVES fuel type;
- Off-network activity (SHP, starts, SHI, and APU hours) by hour and SUT/fuel type;
- VMT roadway type designations, which lists associations of the link roadway types/area type combination to the VMT mix, emissions rate, and MOVES roadway types;
- Pollutants input file, which specifies which pollutant/process combinations for which the emissions calculations will be performed and their respective units in the tab-delimited output;
- SCC input file (optional, only if the activity and emissions by SCC are to be created); and
- SCC pollutants input file (optional, only if the activity and emissions by SCC are to be created).

The emissions estimation can be categorized by two basic types based on the type of emissions factors: the roadway-based emissions and the off-network-based emissions. For the roadway-based emissions (tirateperdistance emissions factors), the VMT for each link is distributed to each of the SUT/fuel type combinations listed in the VMT mix by roadway type (as designated in the VMT roadway type designations). If the time period VMT mix is input, each hour is assigned a time period by the user. Otherwise, the 24-hour VMT mix is used for all hours. For each pollutant/process combination in the pollutants input file, the emissions factors are selected based on the emissions rate roadway type (as designated in the VMT roadway type designations) and the link speed for each SUT/fuel type combinations listed in the VMT mix. For link speeds greater than 75 mph, the emissions factors for 75 mph are used. For link speeds less than 2.5 mph, the emissions factors for 2.5 mph are used. For those link speeds that fall between the 16 MOVES speeds, the emissions factors are interpolated using the emissions factor interpolation methodology in the following section. These SUT/fuel type combination-specific emissions factors are multiplied by the SUT/fuel type combination-specific VMT to estimate the mobile source emissions for that link by SUT/fuel type combination. If the activity and emissions by SCC are to be created, the activity and emissions are also aggregated by SCC using the SCC input file and by SCC pollutant using the SCC pollutants input file (thus allowing the user the option to combine multiple MOVES pollutants into one more aggregate pollutant).

For the off-network emissions, the *tirateperstart*, *tirateperhour*, and *tiratepershp* emissions rates (by SUT/fuel type) are multiplied by the appropriate activity, which is determined by the emissions process (see Table 5). If the activity and emissions by SCC are to be created, the activity and emissions are also aggregated by SCC using the SCC input file and by SCC pollutant using the SCC pollutants input file (thus allowing the user the option to combine multiple MOVES pollutants into one more aggregate pollutant).

The emissions estimates are output in a tab-delimited file (including all of the SUT/fuel type combinations listed in the VMT mix on a single line, separated by a tab character) for the

specified county by pollutant, link roadway type, and SUT/fuel type combination for each of the specified episode time periods. A 24-hour (or total if all 24 hours are not specified) output is also included in the tab-delimited file. Only those pollutant/process combinations in the pollutants input file with tab-delimited output units other than “NONE” will appear in the tab-delimited output file. Prior to output, any unit conversions between mass units (i.e., pounds to grams or pound-mole to gram-mole) are performed by the utility. Unit conversions between unit types (i.e., gram-moles to grams or TEQ to grams) are not performed internally by the utility (these type of unit conversions must be done using the RatesAdj utility). This tab-delimited file also includes hourly and 24-hour summaries of the off-network activity and VMT, VHT, and speed by link road type. Link emissions may also be output by county, pollutant, process, and each SUT/fuel type combination. If specified, the tab-delimited activity and emissions by SCC output file is also created, which lists the activity and emissions for each SCC pollutant by SCC.

#### *Emissions Factor Interpolation Methodology*

To calculate emissions factors for link speeds that fall between two of the 16 MOVES speed bin speeds, an interpolation methodology similar to the methodology used with MOBILE6 is used. This methodology interpolates each emissions factor using a factor developed from the inverse link speed and the inverse high and low bounding speed bin speeds. The following is an example for a link speed of 41.2 mph.



The interpolated emissions factor ( $EF_{\text{Interp}}$ ) is expressed as:

$$EF_{\text{Interp}} = EF_{\text{LowSpeed}} - FAC_{\text{Interp}} H (EF_{\text{LowSpeed}} - EF_{\text{HighSpeed}})$$

Where:

$EF_{\text{LowSpeed}}$  = emissions factor (EF) corresponding to the speed below the link speed;

$EF_{\text{HighSpeed}}$  = EF corresponding to the speed above the link speed; and

$$FAC_{\text{Interp}} = \left( \frac{1}{\text{Speed}_{\text{link}}} - \frac{1}{\text{Speed}_{\text{low}}} \right) \bigg/ \left( \frac{1}{\text{Speed}_{\text{high}}} - \frac{1}{\text{Speed}_{\text{low}}} \right)$$

Given that:

$EF_{\text{LowSpeed}} = 0.7413 \text{ g/mi};$

$EF_{\text{HighSpeed}} = 0.7274 \text{ g/mi};$

$\text{Speed}_{\text{link}} = 41.2 \text{ mph};$

$\text{Speed}_{\text{low}} = 40 \text{ mph};$  and

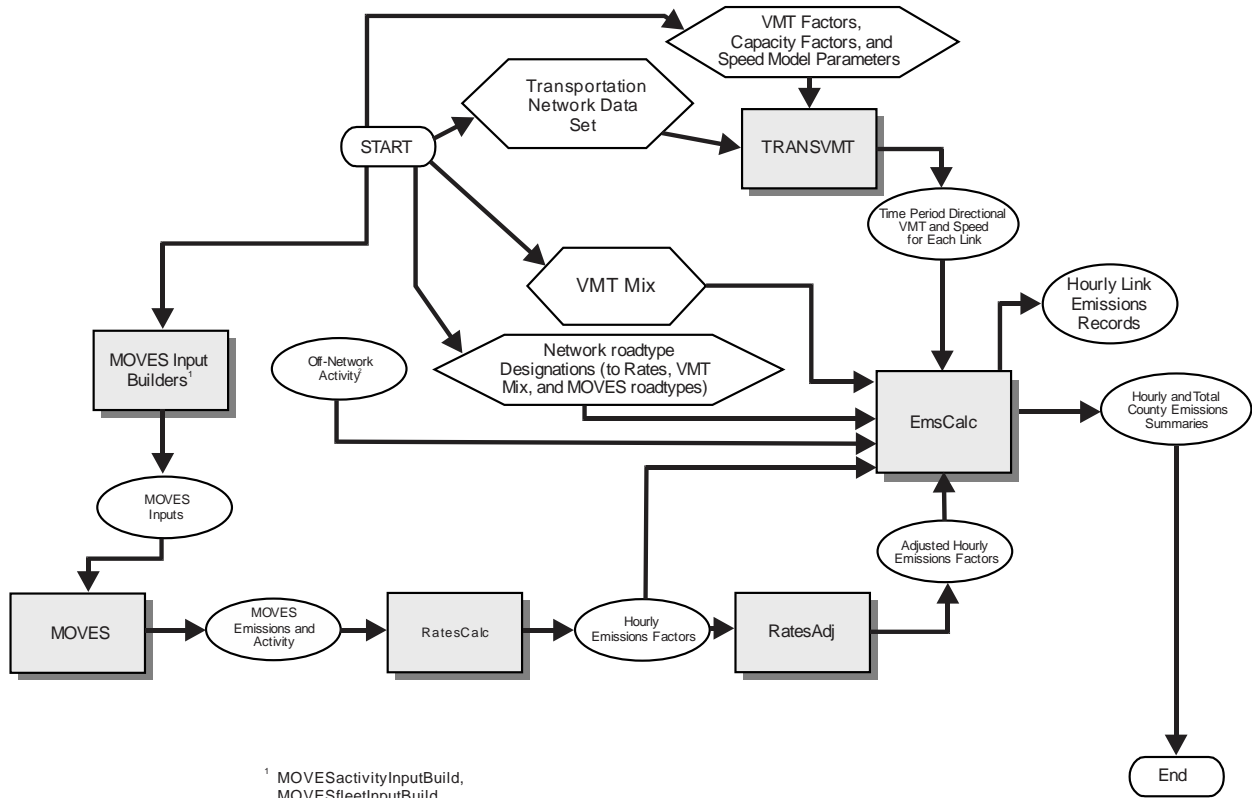
$\text{Speed}_{\text{high}} = 45 \text{ mph}.$

$$FAC_{\text{Interp}} = \left( \frac{1}{41.2\text{mph}} - \frac{1}{40\text{mph}} \right) \bigg/ \left( \frac{1}{45\text{mph}} - \frac{1}{40\text{mph}} \right) = \frac{-0.00073}{-0.00278} = 0.26214;$$

$EF_{\text{Interp}} = 0.7413 \text{ g/mi} - (0.26214) H (0.7413 \text{ g/mi} - 0.7274 \text{ g/mi});$

$= 0.7377 \text{ g/mi}.$

## Travel Demand Model Network Link-Based Hourly MOVES Emissions Estimates



<sup>1</sup> MOVESactivityInputBuild, MOVESfleetInputBuild, MOVESmetInputBuild, and VehPopulationBuild.

<sup>2</sup> VehPopulationBuild, and OffNetActCalc.