

# Fleet & Activity Data in MOVES2010

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MOVES



## Acknowledgements

- David Brzezinski
- Ari Kahan

# Applicability

- This presentation describes fleet and activity defaults in both MOVES2010 and MOVES2010a.
- There are minor differences between the two models.
  - These are detailed in the “MOVES2010 Highway Vehicle Population and Activity Data” report.

## Agenda

- **What is Fleet & Activity Data?**
- **Vehicle Classification & MOVES**
- **County and Project-Level Fleet & Activity**
- **National Scale Fleet & Activity**
  - Total Activity
  - Source Bin Distributions
  - Operating Mode Distributions
- **Future Steps and More Information**

Definitions and Concepts

# WHAT IS FLEET & ACTIVITY DATA?

# What is Activity Data?

- **“Activity Basis”**
  - Expresses how much of an emission process happens in a given area and time.



## What is Activity Data?

- “Operating Mode”
  - Distinguish emission-relevant types of operation.
  - Operating Mode Distributions (OMD) allocate the total Activity Basis to the operating modes

Operating Modes for Running Emissions

	Speed Class (mph)		
	1-25	25-50	50 +
30 +	16	30	40
27-30			
24-27		29	39
21-24		28	38
18-21			
15-18			37
12-15		27	
9-12	15	25	
6-9	14	24	35
3-6	13	23	
0-3	12	22	33
< 0	11	21	

## Emission Processes & Activity

Emission Process	Activity Basis	Operating Modes
Running Exhaust	Source Hours Operating (SHO)	Vehicle Specific Power (VSP) bins
Start Exhaust	Starts	Soak time bins
Extended Idle Exhaust	SH Extended Idle (SHEI)	Single mode
Crankcase	na (chained to start, running & idling emissions)	na
Brakewear	SHO	VSP bins
Tirewear	SHO	Speed bins

# Emission Processes & Activity (cont.)

Emission Process	Activity Basis	Operating Modes
Evap Permeation	Source Hours (SH)	Running, Hot soak, Cold Soak
Evap Fuel Vapor Venting	SH	Running, Hot soak, Cold Soak
Evap Fuel Leaks	SH	Running, Hot soak, Cold Soak
Evap Refueling Losses	na (chained to fuel consumption)	na

# What is Fleet Data?

- **What kinds of vehicles are being modeled?**
  - Mix of cars, trucks, motorcycles, etc.
  - Mix of fuels & engine technologies
  - Mix of ages & model years
  - Mix of regulatory classes



Definitions and Concepts

# VEHICLE CLASSIFICATION & MOVES

# Vehicle Types in MOVES

- **HPMS Vehicle Type**
  - Highway Performance Monitoring System
  - Vehicles classified mostly by tires/axles
  - Used by FHWA for vehicle miles (VMT) reporting
- **MOVES Source Type**
  - Derived from HPMS
  - Each source type may have different activity

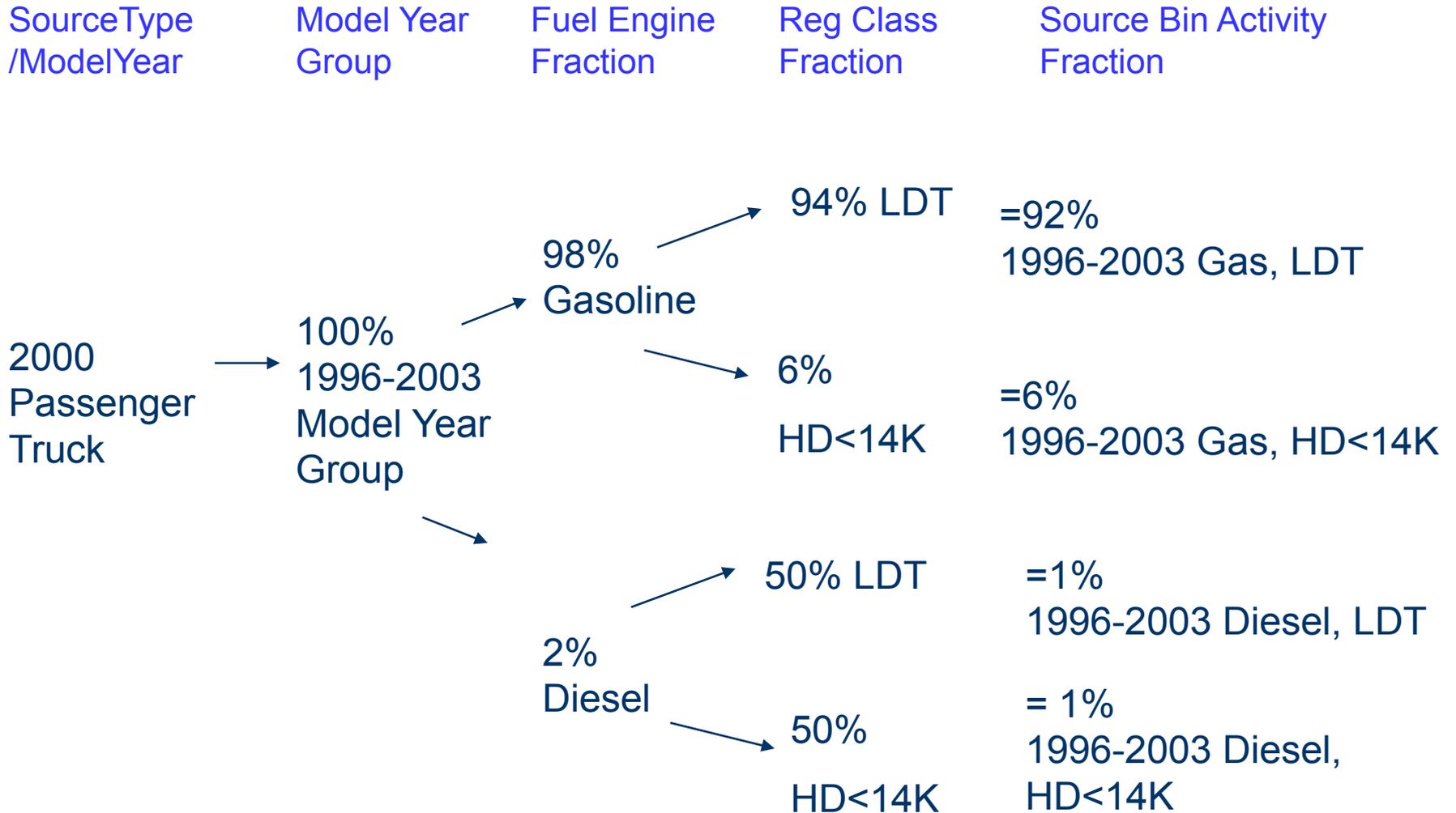
# MOVES Source Types

HPMS Vehicle Type	MOVES Source Type
Motorcycle	Motorcycle
Passenger Car	Passenger Car
Other 4-tire, 2-axle	Passenger Truck Light Commercial Truck
Buses	Intercity Bus Transit Bus School Bus
Single Unit Trucks	Refuse Trucks Short-haul Single Unit Long-haul Single Unit Motorhomes
Combination Trucks	Short-haul Combination Long-haul Combination

# “Under the Hood” Vehicle Grouping

- **MOVES Regulatory Class**
  - Weight-class based groupings
    - MC, LDV, LDT, LHD<14K, LHD> 14K, MHD, HHD
  - Associate with EPA vehicle emission standards
- **MOVES Source Bins**
  - Map to emission rates
  - Determined by
    - Model Year Group
    - Engine Technology & Fueltype (gasoline, diesel, etc.)
    - Regulatory Class
    - Average Weight Class (MOVES2010 only)

# Illustration: Mapping Source Type to Source Bin



# Data for Source Bin Mapping

	MY 1960-2002	MY 2003+
Fuel type and engine technology fraction	Polk registration data, Ward's sales data, VIUS, etc.	Average of recent historical data
Regulatory class fraction	VIUS, ORNL research,	2002 values
Engine size and average weight fraction (MOVES2010 only)	Polk registration data, VIUS, ORNL research, etc.	2002 values

# Vehicle Classification & MOVES (cont)

- **Source Classification Code (SCC)**
  - Used by SMOKE and other systems
  - Encodes information on vehicle type, fueltype, roadtype and emission type
  - Based on VIUS data, etc.

SCC	Description
220100100X	Light Duty Gasoline Vehicles (LDGV)
220102000X	Light Duty Gasoline Trucks 1 & 2
220104000X	Light Duty Gasoline Trucks 3 and 4
220107000X	Heavy Duty Gasoline Vehicles 2B--8B and Gasoline Buses
220108000X	Motorcycles (MC)
223000100X	Light Duty Diesel Vehicles (LDDV)
223006000X	Light Duty Diesel Trucks 1 thru 4 (LDDT)
223007100X	Heavy Duty Diesel Vehicles (HDDV) Class 2B
223007200X	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5
223007300X	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7
223007400X	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B
223007500X	Heavy Duty Diesel Buses (School and Transit)

County & Project Scale

# LOCAL INPUTS FOR MOVES FLEET & ACTIVITY VALUES

# Fleet & Activity at County Scale

- Enter by County and Year
- Users can enter local data on:
  - VMT
  - Vehicle population
  - Vehicle age distributions
  - Average Speed Distribution
  - Road Type Distribution
  - Ramp Fraction
  - Diesel Fraction
- See **MOVES** technical guidance for more information on local inputs

# Fleet & Activity at Project Scale

- Entered by link and hour
- Users can enter data on:
  - VMT
  - Vehicle population
  - Vehicle age distributions
  - Operating mode distributions\*
  - Diesel fractions
- \* Users choice on how to indicate operating modes for driving vehicles:
  - Average speed (uses default driving cycles)
  - Driving cycle (computes op mode distribution)
  - Operating mode distribution
- See guidance and training materials for more info.

National Scale

# MOVES FLEET & ACTIVITY DEFAULTS

# National Scale Total Activity Generator (TAG)

- The national scale TAG estimates activity basis for each county in the U.S. based on data available for entire nation.
- Result is activity for each
  - Emission process
  - Source type
  - Road type
  - Hour
  - Zone (county)

# TAG inputs & sources--Population

TAG Input	Principal Data Sources (see report for details)
Base Year Population	Federal Highway Administration (FHWA) (MV-1) and R. L. Polk registration data; Vehicle In-Use Survey (VIUS) information on truck subtypes
Sales Growth Rates	Transportation Energy Data Book (Ward's) and Dept. of Energy Annual Energy Outlook (AEO). (LD from AEO 2009, HD from AEO 2006 (MOVES2010) or AEO 2010 (MOVES2010a))
Scrappage Rates	FHWA and Oak Ridge Natl. Lab analysis of ownership data
Age Distributions	Polk registration data, VIUS data on truck ages
Allocation to county	Use VMT allocation

# 1999 Vehicle Populations

SourceType ID	SourceType	1999 Population
11	Motorcycles	4,173,870
21	Passenger Cars	130,163,000
31	Passenger Trucks	57,190,200
32	Light Commercial Trucks	19,106,300
41	Intercity Buses	84,454
42	Transit Buses	55,706
43	School Buses	592,029
51	Refuse Trucks	88,607
52	Single Unit Short-haul Trucks	4,470,800
53	Single Unit Long-haul Trucks	264,435
54	Motor Homes	902,949
61	Combination Short-haul Trucks	1,084,370
62	Combination Long-haul Trucks	803,337

# TAG inputs & sources--VMT

TAG Input	Principal Data Sources (see report for details)
Base year VMT	FHWA (VM-1)
Relative mileage accumulation rates	MOBILE6 (VIUS), National Highway Traffic Safety Administration (NHTSA) analysis (based on National Household Travel Survey data)
VMT growth rates	FHWA (VM-1), AEO (for LD from AEO 2009; for HD from AEO 2006 for MOVES2010, from AEO 2009 for MOVES 2010a)
Allocation to roadtype	FHWA (VM-1, VM-2)
Allocation to month, day & hour	FHWA research study (1996)
Allocation to county	National Emission Inventory (based on FHWA data)

## TAG: Conversion of VMT to Activity Basis

Activity Basis	Calculation	Primary Source Data
Source Hours Operating (SHO)	VMT * Average Speed	Average speed from MOBILE6 (Urban) and CalTrans (Rural)
Starts	Trips Per Vehicle * Population	Trips per vehicle from instrumented vehicles
Extended Idle(SHEI) (Long haul comb. trucks only)	Rest hours/Driving Hours * SHO	Federal regulations, national survey of truck idling, data from instrumented vehicles
Source Hours (SH)	Population * 24	
Source Hours Parked (SHP)	SH-SHO	

# Instrumented Vehicle Studies

Location	Study Years	Vehicle Types	# Vehicles
Atlanta, GA; Baltimore, MD; Spokane, WA	1992	Passenger cars & trucks	321
Minneapolis	2004-2005	Passenger cars & trucks	133
Knoxville	2000-2001	Passenger cars & trucks	377
Las Vegas	2004-2005	Passenger cars & trucks	350
California	1997-1998	Heavy Trucks	120
Houston	2002	Heavy Trucks	4

# Trip Data in MOVES

- **Data stored in two tables:**
  - SampleVehicleDay table
  - SampleVehicleTrip table
- **Together provide a log of trips from a group of “sample vehicles”.**
  - Record trip start time, trip end time and prior trip ID
- **Allow MOVES to compute starts/hour/vehicle, operating time/hour, cold soaks/hour & hot soaks/hour with appropriate soak time.**
- **Where data not available, sample trips extrapolated from other vehicle types.**

# Operating Mode Distributions

Allocate total activity among emission-relevant operating modes:

Process	Activity Basis	Operating Modes
Running Exhaust	Source Hours Operating (SHO)	Vehicle Specific Power (VSP) or Scaled Tractive Power (STP)
Start Exhaust	Starts	Soak time bins
Extended Idle Exhaust	SH Extended Idle (SHEI)	Single mode
Crankcase	na	na
Brakewear	SHO	VSP bins
Tirewear	SHO	Speed bins
Evaporative Processes	SH	Running, Hot soak, Cold soak

## Op Modes for Running Emissions

- **Based on vehicle power**
  - Light Duty uses Vehicle Specific Power (VSP)
  - Heavy Duty uses Scaled Tractive Power (STP)
- **Grouped into “bins”**
- **Each bin associated with a specific emission rate**

		Speed Class (mph)		
		1-25	25-50	50 +
VSP Class (kW/tonne)	30 +	16	30	40
	27-30			
	24-27		29	39
	21-24		28	38
	18-21			
	15-18			37
	12-15		27	
	9-12	15	25	
	6-9	14	24	35
	3-6	13	23	
	0-3	12	22	33
< 0	11	21		

# Source Data

## Default VSP/STP distributions

- **Based on second-by-second speed and acceleration driving cycles**
  - Different driving cycles are associated with different roadtypes, vehicle types and speeds
  - Cycles developed from variety of sources:
    - Emissions test cycles, California chase car data, instrumented HD & MD trucks
  - MOVES calculates a VSP/STP distribution for each driving cycle
- **MOVES weights together distributions from multiple cycles based on average speed distributions for each road type, source type and hour**
  - Average speed distributions from MOBILE6 (urban) and Cal. chase car data (rural)

# Op Modes for Start Emissions

- **Calculates fractions of Starts with different soak times (time parked prior to start).**
- **Start Distributions vary by**
  - Source type
  - Day
  - Hour
- **Calculations based on instrumented vehicle data saved as**
  - “Sample Vehicle Trips”
  - One distribution for each source type

# Op Modes for Evap. Emissions

- **Fraction of vehicles that are:**
  - Running
  - “Hot soaking”
    - Parked in the last hour and, thus, still warm
  - “Cold soaking”
    - Parked for more than one hour
- **Running fraction is based on SHO/Source Hours ratio**
- **Cold & hot soaking fractions are based on Sample Vehicle data**

## Activity for “Emission Rates”

- **MOVES users can select calculation of “Inventory” results or “Emission Rate” results.**
- **If “Emission Rate” is selected, the MOVES model:**
  1. Fills in activity for all speed bins
  2. Calculates SHO and SHP
  3. Calculates emission inventories
  4. Divides by activity to calculate rates
- **Users must enter reasonable activity inputs, but should not expect activity output to match them.**

In Conclusion

# MOVES FLEET & ACTIVITY DEFAULTS

# Future Improvements?

- **Want to add a new base year to MOVES defaults**
  - Challenges:
    - Polk registration data is expensive
    - VIUS was discontinued
    - FHWA has changed vehicle categories
- **Want to upgrade SCCs**
- **Want to improve default average speed distributions**
- **Want to improve extended idle activity defaults**

## For more information

- **MOVES2010 Highway Vehicle Population and Activity Data**
  - <http://www.epa.gov/otaq/models/moves/420r10026.pdf>
- **MOVES Technical Guidance**
  - <http://www.epa.gov/otaq/models/moves/420b10023.pdf>
- **Conformity Guidance:**
  - Transportation Conformity Guidance for Quantitative PM Hot-Spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas
  - Using MOVES in Project-Level Carbon Monoxide Analyses
  - Both at: <http://www.epa.gov/otaq/stateresources/transconf/policy.htm>.