MOVES Design & Data Needs

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Overview

- What is MOVES?
- Understanding MOVES Design
- Fleet & Activity Inputs

MOVES

- **MOtor Vehicle Emission Simulator**
- **State-of-the-art emission modeling framework**
- **Will replace current models (MOBILE & NONROAD) and expand capabilities**
- **Designed to allow easier incorporation of large amounts of in-use data from a variety of sources**
  - MOBILE structure limited our ability to incorporate new emissions data

MOVES – What's different from MOBILE6?

- **Inventory estimation**
  - VMT incorporated in calculation rather than post-processed
  - There is still an option for g/mi output
- **Designed for analysis at multiple scales**
- **Emission rates based on operating modes rather than driving cycles**
- **Software framework**
- **New data and methodologies**

Understanding MOVES Design

- **Emission Processes**
- **Emission Rates**
- **Modal Emissions**
  - Running Emissions
  - Starts
  - Evaporative Emissions

MOVES Emission Processes

- **Running**
- **Start**
- **Extended Idle ("hoteling")**
- **Evaporative Processes**
  - Permeation, Vapor Venting, Leaks, Refueling
- **Crankcase**
- **Tire Wear**
- **Brake Wear**
- **Life Cycle Processes**
  - Well-To-Pump

Emission Rates in MOVES

- **Two database tables**
  - EmissionRate
  - EmissionRateByAge
- **Each stores emissions by:**
  - sourcebin (characteristics of vehicle)
  - operating mode (characteristics of driving)

Running Emissions Design

- **Group activity and emissions into "bins"**
  - Vehicle Specific Power (VSP) & Instantaneous Speed
    - Accounts for speed, acceleration, grade, road load
- **Any driving pattern can be modeled**
  - Adds flexibility compared to MOBILE
- **Allows direct use of data from many sources**
  - Laboratory, I/M programs, RSD
- **Provides common emission rates for all scales**
- **Independent validation has shown good results**

Operating Modes for Running Exhaust Emissions

VSP Class (kW/tonne)	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	

For coast and cruise,

13 modes retained from MOVES2004, *plus*

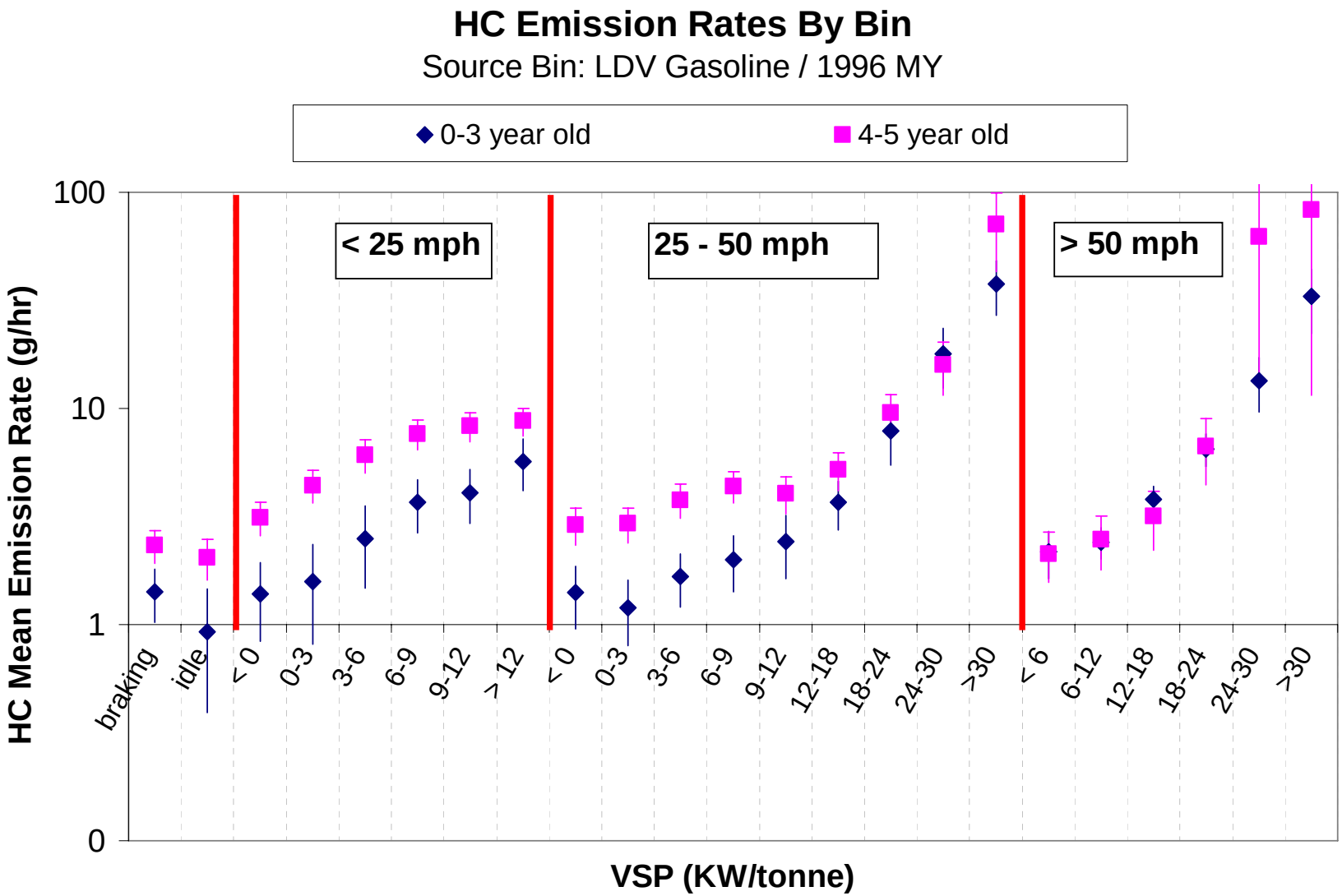
8 modes added for MOVES2006.

PLUS
One mode each for
idle, and
decel/braking

Gives a total of
23 opModes

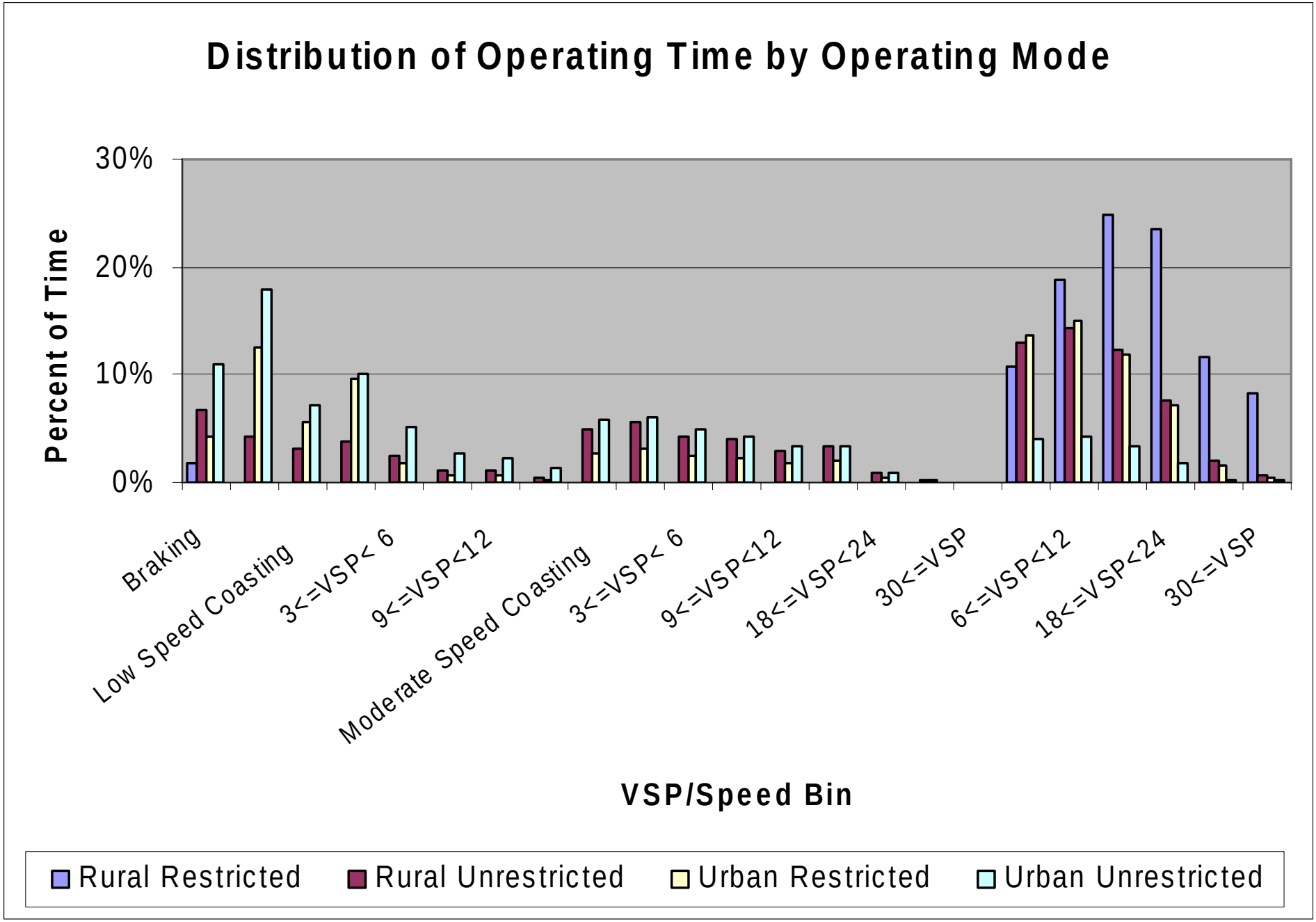
But…

Heavy Duty maxes out around 18 kW/tonne.

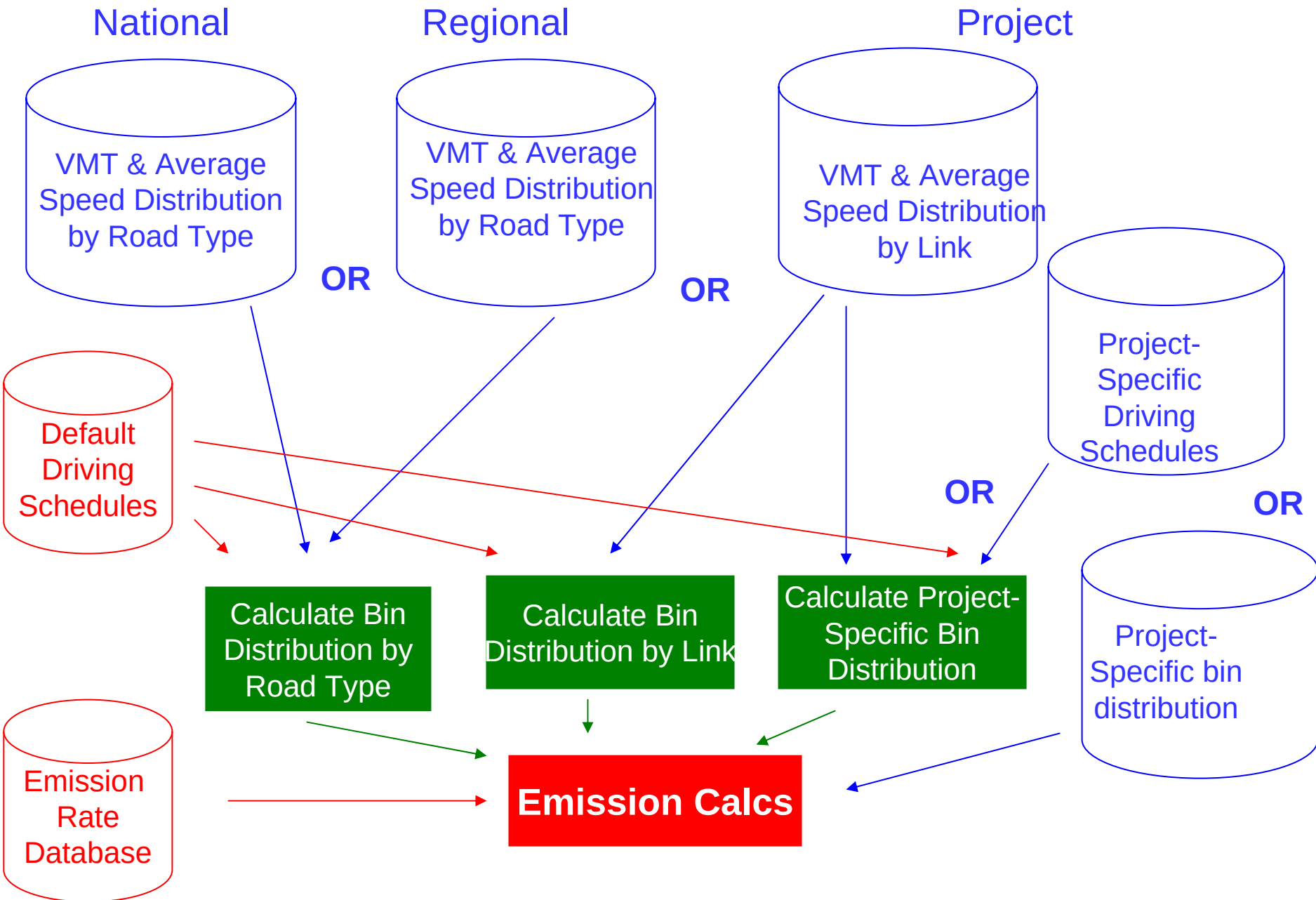

HC Emission Rates By Bin
Source Bin: LDV Gasoline / 1996 MY
0-3 year old
4-5 year old
< 25 mph
25 - 50 mph
> 50 mph
HC Mean Emission Rate (g/hr)
100
10
1
0
braking
idle
< 0
0-3
3-6
6-9
9-12
> 12
< 0
0-3
3-6
6-9
9-12
12-18
18-24
24-30
>30
< 6
6-12
12-18
18-24
24-30
>30
VSP (KW/tonne)

VSP Bin Distributions

- **Fraction of driving time spent in each VSP bin**
- **Could be entered directly**
- **More typically derived from**
  - VMT by sourcetype and roadtype (or link)
  - Average speed distribution on roadtype (or link)
  - Default driving cycles by sourcetype, roadtype and average speed


Distribution of Operating Time by Operating Mode
30%
20%
10%
0%
Percent of Time
Braking
Low Speed Coasting
3<=VSP< 6
9<=VSP<12
Moderate Speed Coasting
3<=VSP< 6
9<=VSP<12
18<=VSP<24
30<=VSP
6<=VSP<12
18<=VSP<24
30<=VSP
VSP/Speed Bin
Rural Restricted
Rural Unrestricted
Urban Restricted
Urban Unrestricted

Applying Modal Binning at Different Scales



Start Emissions Design

- **Start rates = "incremental emissions per start"**
  - Activity is the number of starts by time and place
  - Local inputs can provide finer resolution
- **"Soak Time"**
  - Time parked prior to start
  - Soak time bins defined as operating modes
    - < 6 min, 6-30, 30-60, 60-90, 90-120, 120-360, 360-720, >720
- **Number of starts & soak time distribution calculated within model from instrumented vehicle data**

Evaporative Emissions Design

- **Evaporative Emissions modeled based on**
  - Vehicle Characteristics
  - Fuel Characteristics
  - Vehicle operating mode
    - Operating or Parked
    - Time since key on/ key off

Fleet & Activity Inputs

- **Fleet Data**
  - What kinds of vehicles are in an area?
- **Activity Data**
  - "Activity Basis"
    - Expresses how much of an emission process happens in a given area and time.
  - "Operating Mode"
    - Distinguish emission-relevant types of operation.
    - Operating Mode Distributions allocate the total Activity Basis to the operating modes.

	HPMS Vehicle Type	MOVES SourceTypes
	Motorcycle	Motorcycle
	Passenger Car	Passenger Car
	4-tire/2-axle truck	Passenger Truck Light Commercial Truck
	Buses	Intercity Bus Transit Bus School Bus
	Single Unit Trucks	Refuse Truck Single Unit Short-Haul Truck Single Unit Long-Haul Truck Motorhome
	Combination Truck	Combination Short-Haul Truck Combination Long-Haul Truck

Source Bin Discriminants

- **FuelTypes:**
  - Gasoline, Diesel, CNG, E85, etc.
- **Engine Technologies:**
  - Conventional Internal Combusion, Adv. IC, Full & Moderate Hybrids, Electric, Fuel Cell
- **Model Year Groups (vary with pollutant/process)**
- **Regulatory Classes:**
  - MC, LDV, LDT, LHD<14K, LHD> 14K, MHD, HHD
- **Engine Size bins**
- **Average loaded weight bins**

Example Fleet Data Inputs

- **Vehicle Populations by SourceType & year**
  - Ideally include transient and resident vehicles
- **Age Distributions by SourceType & year**
- **Fuel and Technology distributions**

MOVES Roadtypes

MOVES Roadtype	**HPMS Facility Types**
Off-Network--*Used for starts and evaporative emissions*	*na*
Rural Restricted Access	Rural Interstates
Rural Unrestricted Access	Rural Arterials, Collectors & Locals
Urban Restricted Access	Urban Interstates, Freeways & Expressways
Urban Unrestricted Access	Urban Arterials, Collectors & Locals

Example Activity inputs

- VMT by HPMS vehicle type and year
- Allocation of VMT to roadtype
- Allocation of VMT by month, daytype & hour
- Average speed distribution by vehicle type, roadtype and hour
- Trip time & soak data
- Custom driving cycles

Trip Time & Soak Information

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 model to compute starts/hour, operating time/hour, cold soaks/hour & hot soaks/hour with appropriate soak time.

- **Custom data could be used to better model small scales where trip starts and ends may differ greatly from national average**
  - Guidance and tools still in planning stages
  - Not expected in typical SIP & Conformity modeling

MOVES

Custom Driving Cycles or Bin Distributions

- **Eventually would allow users to model changes in driving behavior**
  - Traffic calming
  - Signal coordination
  - Electronic toll collection
  - Etc.
- **Guidance and tools still in planning stages**
- **Not expected in typical SIP & Conformity modeling**

Feedback Needed!

- **Send comments and questions to:**
  - mobile@epa.gov
- **Download MOVES Demo at:**
  - http://www.epa.gov/otaq/ngm.htm
- **Join MOVES email list at:**
  - http://www.epa.gov/otaq/models/mobilelist.htm