

**Consistency in On-Road
Mobile Source Activity
Modeling, with an Application
to Parked Passenger Cars**

Emission Inventories—Applying New Technologies

San Diego, 30 April 2003

Harvey Michaels, David Brzezinski, U.S. EPA, OTAQ

Sue Kimbrough, U.S. EPA, ORD

Outline

- Introduction--VMT and consistency
- Activity bases
- Importance of emissions from parked vehicles
- Consistency in modeling highway mobile source activity
- Hourly estimation of parked car populations in counties
- Conclusions and Discussion
- Summary

Introduction-VMT and Consistency

- Historically, congestion and travel time have driven on-road activity measurements and made VMT the standard activity basis.
- Parking and other non-traveling activity has been modeled as a function of VMT.
 - OK for static situation, where the ratio of parking to VMT is constant.
 - Inconsistencies develop when that ratio shifts.
Example: if a county decreases VMT by carpooling, MOBILE predicts a decrease in all emissions, when, in fact, diurnal emissions will increase.

Introduction (cont.)

- Parked emissions have become relatively more important as regulations have cleaned up exhaust.
- To facilitate consistency, we need logical and appropriate activity bases.
 - Diurnal emissions--time parked, not VMT
 - Nonroad--hours, (VMT won't work)
 - Onroad--for consistency with other sources, hours rather than VMT
- Need consistency between activity measures.
 - E.g., drive less \Rightarrow park more; drive more \Rightarrow park less.

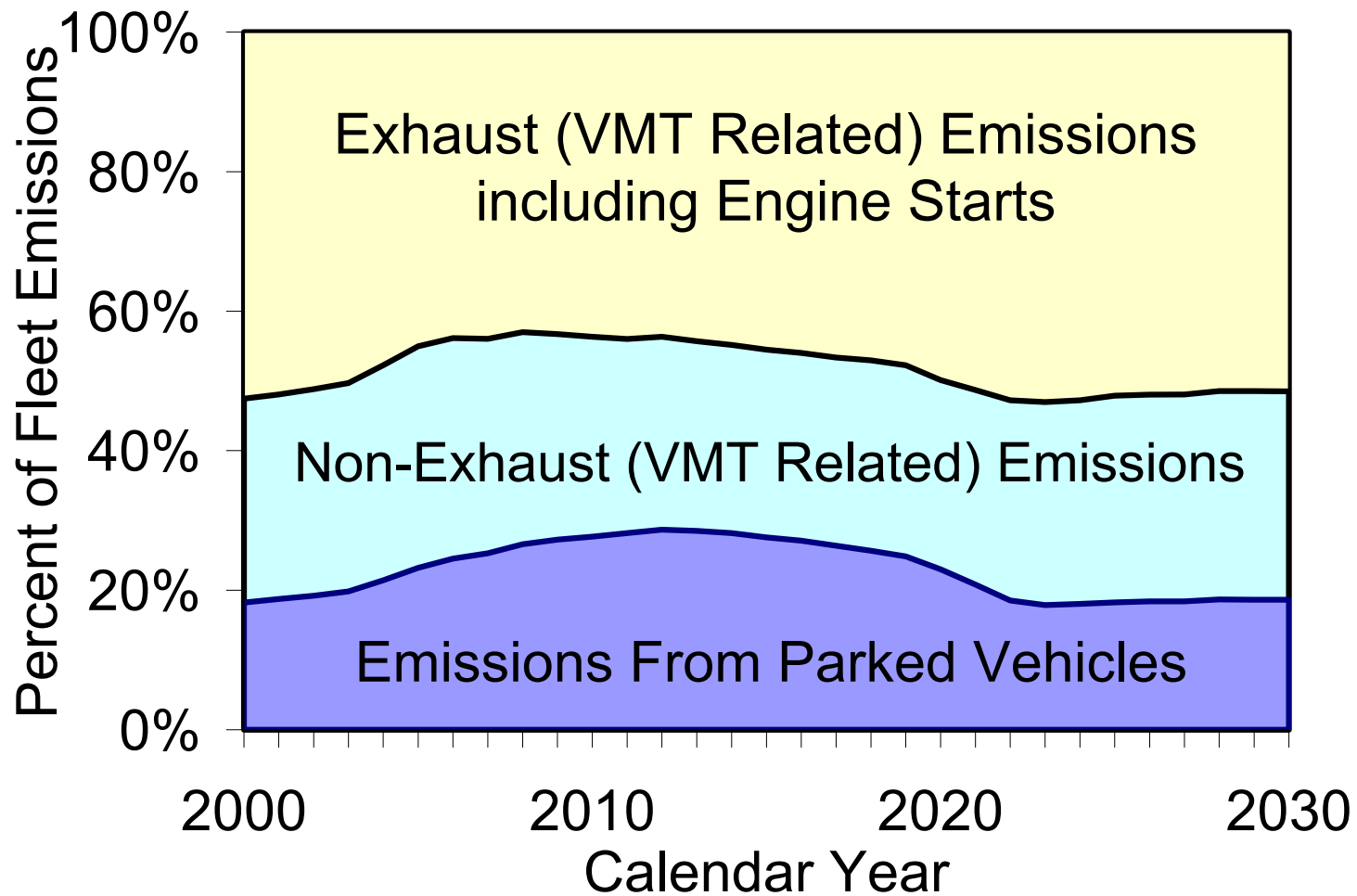
MOVES Activity Bases

<i>Total Activity Basis</i>	<i>Corresponding Emission Factor Units</i>	<i>Total Emissions Calculated</i>
Source Hours Operating (SHO)	grams/hour	Operating emissions
Source Hours Parked (SHP)	grams/hour	Parked (engine off) emissions
Source Hours (SH)	grams/hour	Continuous emissions independent of on/off status (e.g. outgassing)
Source Hours Extended Idling (SHEI)	grams/hour	Extended idling emissions
Starts (Starts)	grams/start	Start emissions
Gallons Refuelled (GR)	grams/gallon	Refuelling emissions

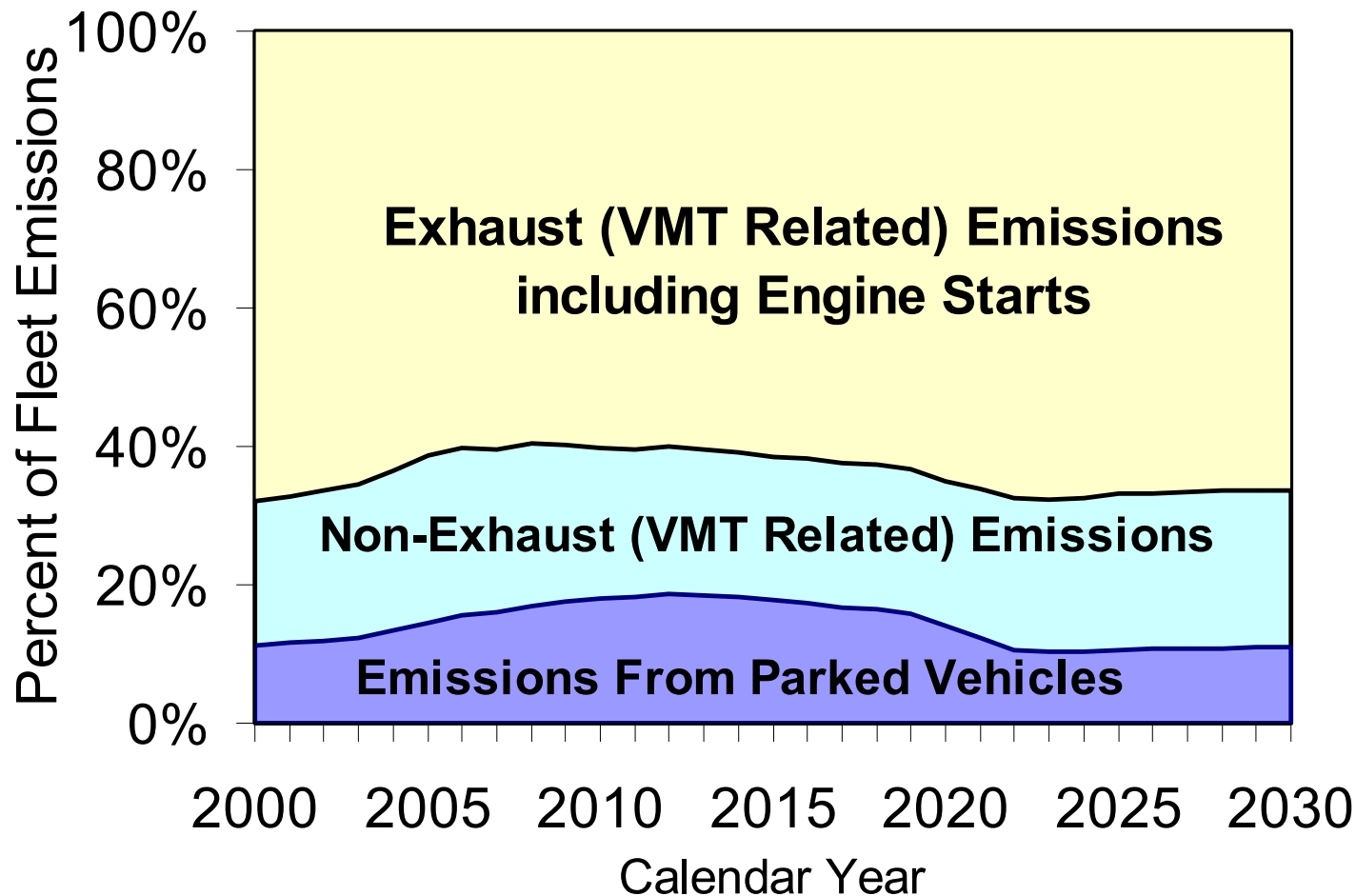
The Importance of Emissions from Parked Vehicles

- Parked cars emit hydrocarbons from three processes: hot soaks, diurnal losses, and resting losses.
- In warm climates (e.g., Miami, FL), these represent 20%-30% of total annual HC emissions from the entire on-road fleet.
- In cooler climates (e.g., Chicago), 10%-20% annually, higher in the summer.

Annual Parked Emissions from Total On-Road Fleet, Miami, FL



Annual Parked Emissions from Total On-Road Fleet, Chicago, IL

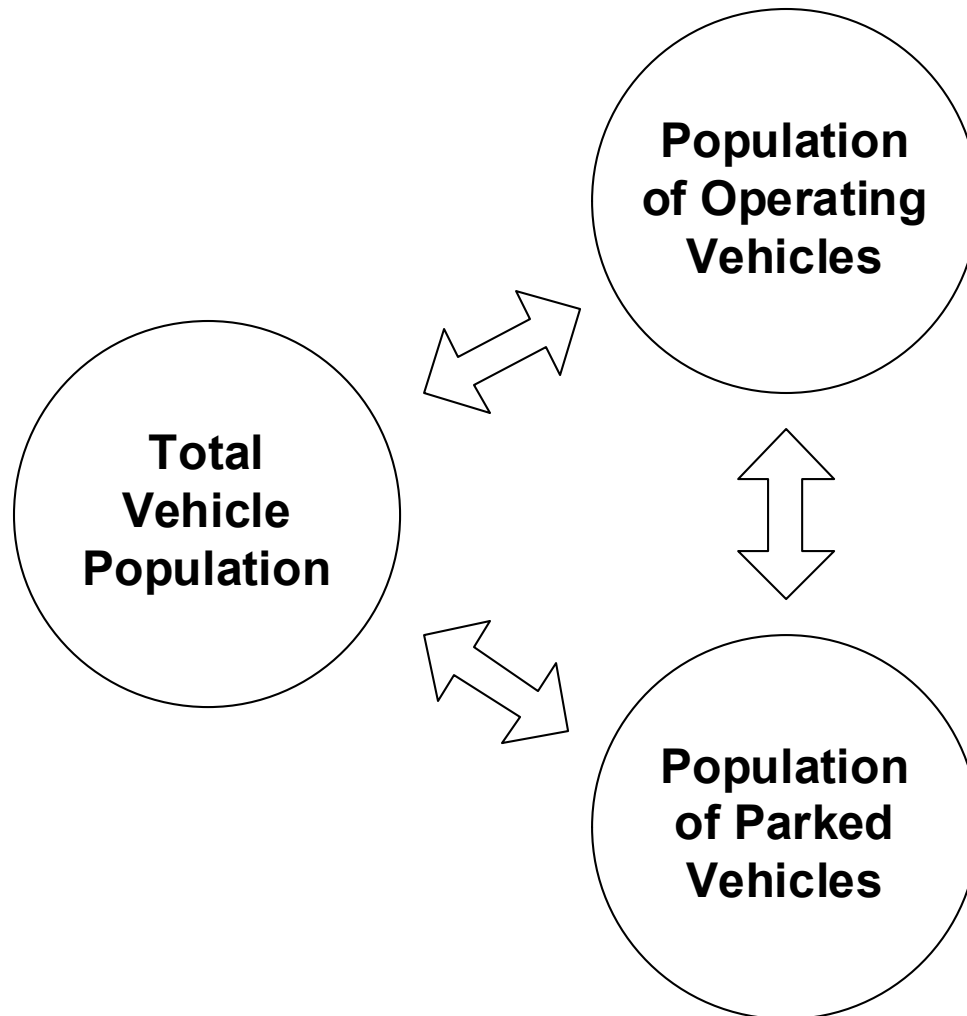


Activity Parameters

- Activity parameters are inter-related; a change in one implies changes in others. A partial list:
- Populations in an area--registered, total, operating, parked
- Total activity bases--VMT, SHO, SHP, SHEI, GR, SH, Starts, GR.
- Individual vehicle activity parameters--OnsPerDay, OffsPerDay, TripsPerDay, ExtendedIdlesPerDay, MAR
- Trip parameters--DistancePerTrip, TimePerTrip, TimePerOff, Average Speed

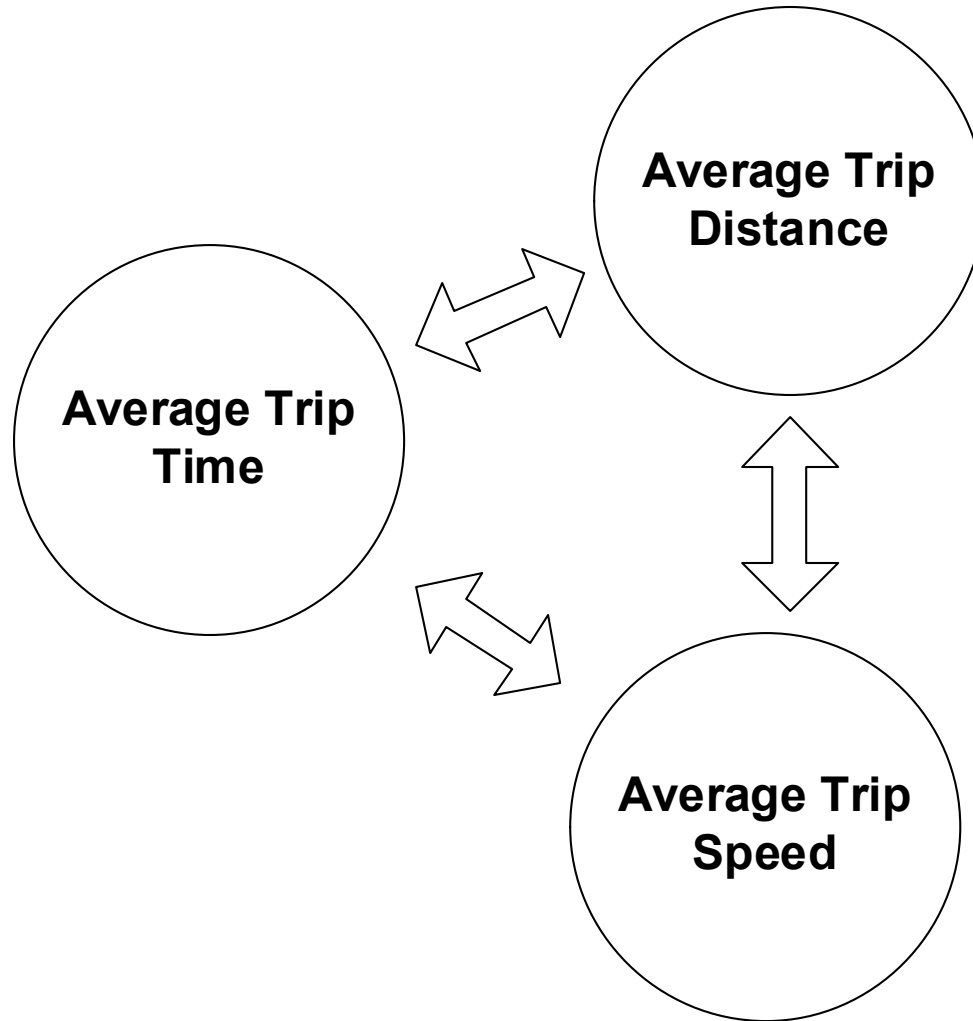
Consistency Between Vehicle Populations

(Total = Parked + Operating)



Consistency Between Trip Parameters

(Time = Distance / Speed)



- $Popn = O + P + EI$
- $SH = SHO + SHP + SHEI$
- Assuming $SHEI=0$ for passenger cars,

$$VMT = AverageSpeed * (SH-SHP)$$

Consistent Relationships: Individual Vehicle Parameters

- $\text{OnsPerDay} = \text{OffsPerDay} = \text{StartsPerDay}$
- $\text{AverageOnsPerDay} = \text{AverageOffsPerDay}$
 $= \text{AverageStartsPerDay}$
- $\text{AVMT} \approx \text{MAR} * \text{Popn}$

Consistent Relationships: Trip Parameters

- $\text{TripDistance} / \text{TripTime} = \text{AverageTripSpeed}$
- $\text{AverageTripDistance} * \text{AverageTripsPerDay} * \text{Popn} = \text{DVMT}$
- $\text{OnsPerDay} * \text{AverageTimePerOn} =$
 $24 - \text{OffsPerDay} * \text{AverageTimePerOff}$
- $\text{TripsPerDay} * \text{AverageTimePerTrip} +$
 $\text{ExtendedIdlesPerDay} * \text{AverageExtendedIdleTime} +$
 $\text{OffsPerDay} * \text{AverageTimePerOff} = 24$
- Combining and rearranging gives:

$$\text{AverageTimePerOff} = \frac{1}{\text{TripsPerDay}} \left(24 - \frac{\text{DVMT}}{\text{Popn} * \text{AverageSpeed}} \right)$$

Example of Inter-Relationships

$$\text{AverageTimePerOff} = \frac{1}{\text{TripsPerDay}} \left(24 - \frac{\text{DVMT}}{\text{Popn} * \text{AverageSpeed}} \right)$$

- If DVMT or TripsPerDay increases, AverageTimePerOff decreases
- If AverageSpeed or Popn increases, AverageTimePerOff increases.
- If two or more of these parameters are changed together, AverageTimePerOff may increase, decrease, or stay the same.
- In addition to these average relationships, changing the distribution of trips during the day will change the distribution of off times.
- The important point is that no parameter can be changed independently.

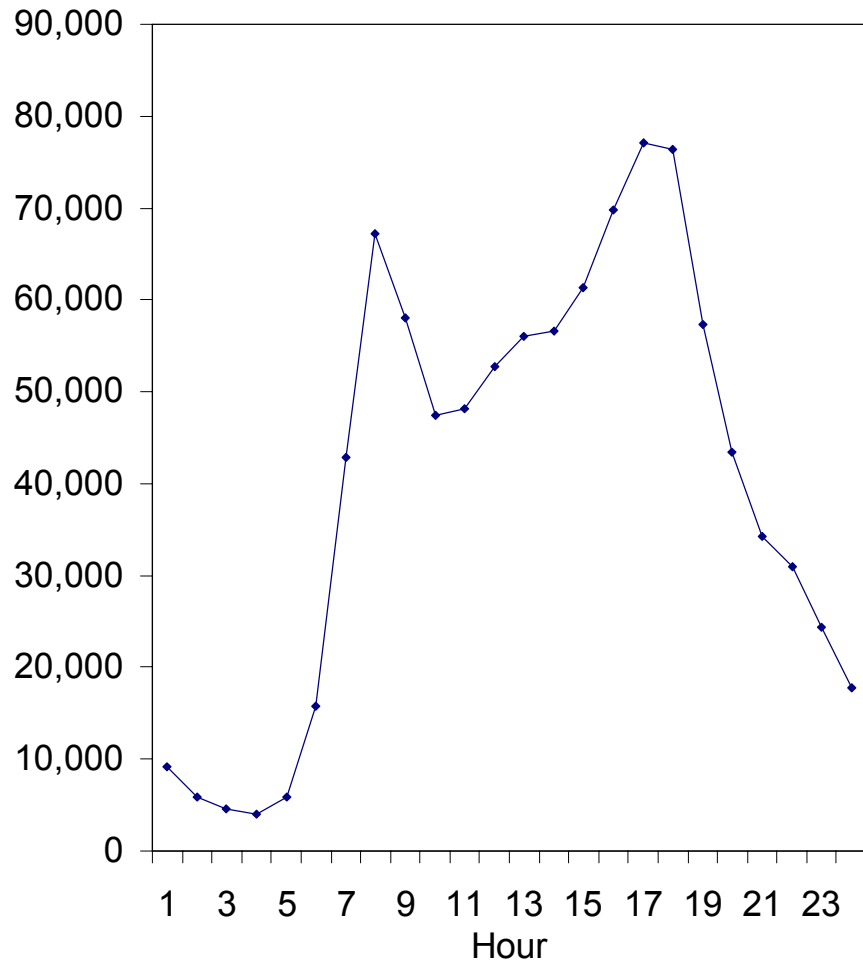
Consistent Estimation of Hourly Parked Passenger Car (PC) Populations in Counties

- $P = \text{Popn} - O$ (Ignoring EI for PCs)
- $O = \text{HVMT} / \text{AverageSpeed}$ (for a given hr)
- To solve for P , we need the actual hourly Popn.
- $\text{Popn} \neq \text{Reg}$ because of asymmetrical inter-county travel.

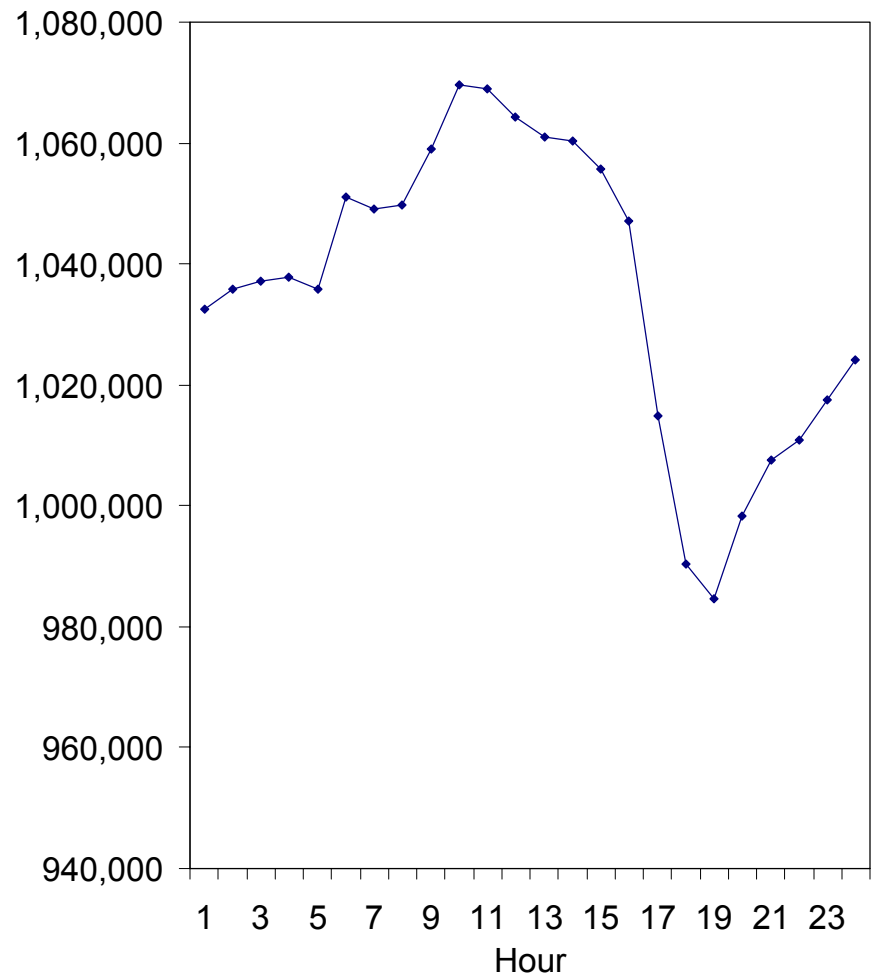
Data Sources for Estimating Hourly Parked Populations in Counties

- VMT from HPMS
- Registrations from States
- Inter-county vehicle flow due to commuter travel from U.S. Census
- Hourly VMT allocations from U.S. DOT
(These data are available for all U.S.
counties.)

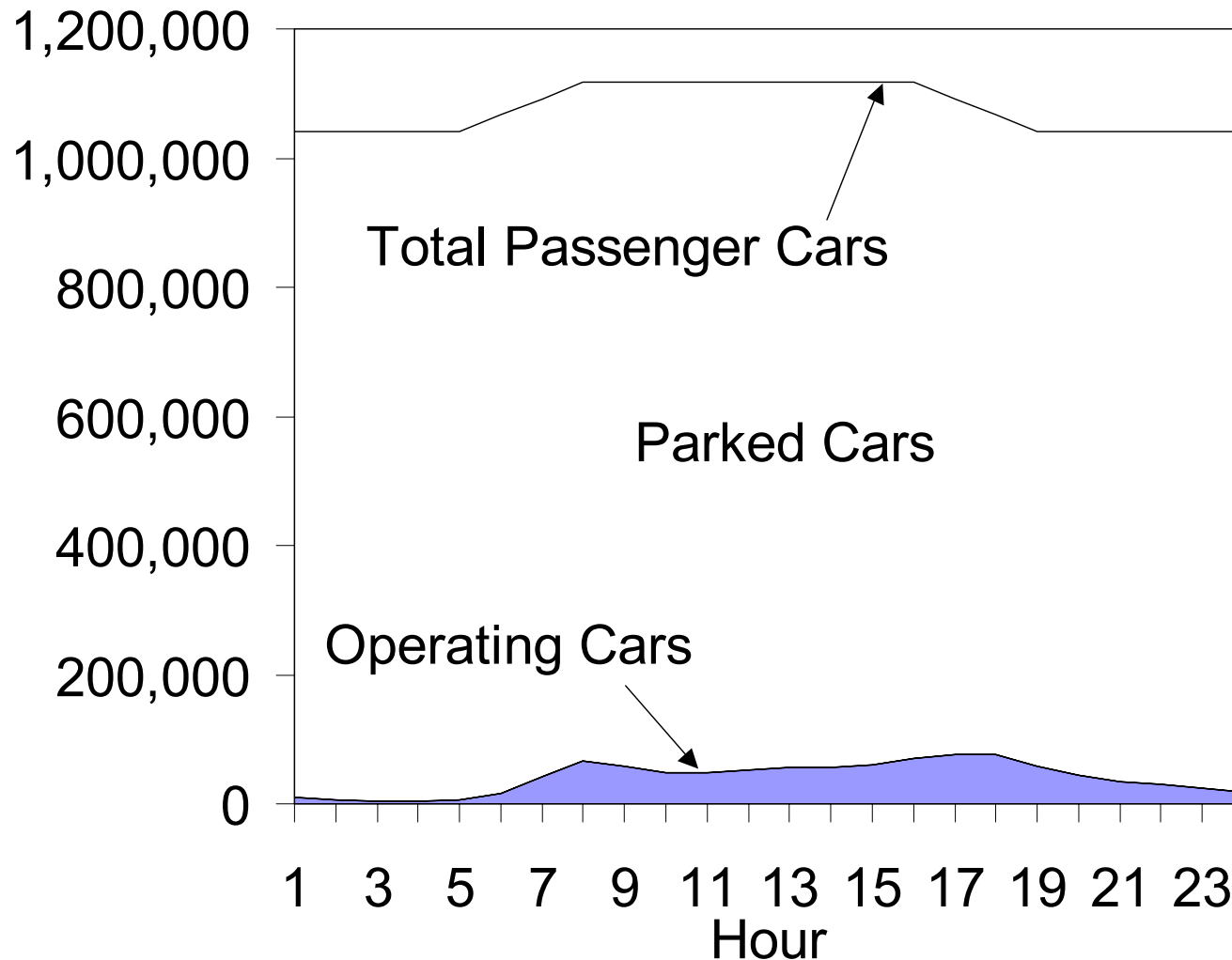
Population of PCs operating in Wayne County on a weekday



Population of PCs parked in Wayne County on a weekday.



Operating, Parked, and Total PCs



Conclusions and Discussion

- County vehicle populations can vary significantly due to asymmetrical commuting.
- About 90% of the PC population is parked at rush hour, more at other times.
- Vehicle populations may also shift during the day for shopping and entertainment, for multi-day periods due to vacation travel, and seasonally due to winter migration.
- Extended idle emissions also potentially important non-traveling emissions
 - Catalysts less effective during extended idle
 - Long-haul trucks may idle 40% of their running time.
 - PCs also engage in extended idling in very cold or hot weather.

Summary

- Historically, parking and other non-traveling activity has been modeled as a function of VMT.
- Time-based activity unifies on-road, non-road and non-traveling emissions. MOVES uses “source-hours” for most emission processes.
- Activity parameters are inter-related; a change in one implies changes in others.
- Parked emissions are a significant fraction of fleet emissions.
- Parked cars can be estimated as $\text{Popn} - \text{Operating}$.
- County Popn can be estimated from registrations, U.S. Census commuting data, and U.S. DOT activity profiles.