

DOE's Gasoline/Diesel PM Split Study

Eric M. Fujita, David E. Campbell, William P. Arnott,
Barbara Zielinska and Judith C. Chow

Division of Atmospheric Sciences
Desert Research Institute
Reno, NV

Douglas R. Lawson

National Renewable Energy Laboratory
Golden, CO

9th Diesel Engine Emission Reduction (DEER) Workshop
Newport, RI
August 24-28, 2003

Acknowledgments

Sponsor

DOE's Office of FreedomCAR and Vehicle Technologies

Dr. James Eberhardt

Additional Support

U.S. Environmental Protection Agency

California Bureau of Automotive Repair

South Coast Air Quality Management District

Participants

- Desert Research Institute and University of Wisconsin Madison
 - Source and ambient measurements and source apportionment
- U.S. Environmental Protection Agency and Clean Air Vehicle Technology Center
 - LD vehicle dynamometer measurements
- West Virginia University
 - MDD and HDD truck dynamometer measurements
- Bureau of Automotive Repair and South Coast Air Quality Management District
 - Light-duty vehicle recruitment
 - Smog check
- California Trucking Associations
 - Heavy-duty vehicle recruitment
- Ralphs Grocery Distribution Center
 - Test site and logistics

Gasoline/Diesel PM Split Study

Objective: To quantify the relative contribution of PM emissions from gasoline- and diesel-powered engines in the South Coast Air Basin

Approach:

- Source testing of SI and CI vehicles using EPA's and WVU's transportable dynamometers (May-September 2001)
 - 51 LDGV (9 groups of model years and mileage), 6 LDGV smokers and 2 LDDV
 - 32 HDDV (3 weight class and 4 model-years groups) and 2 transit buses

Gasoline/Diesel PM Split Study

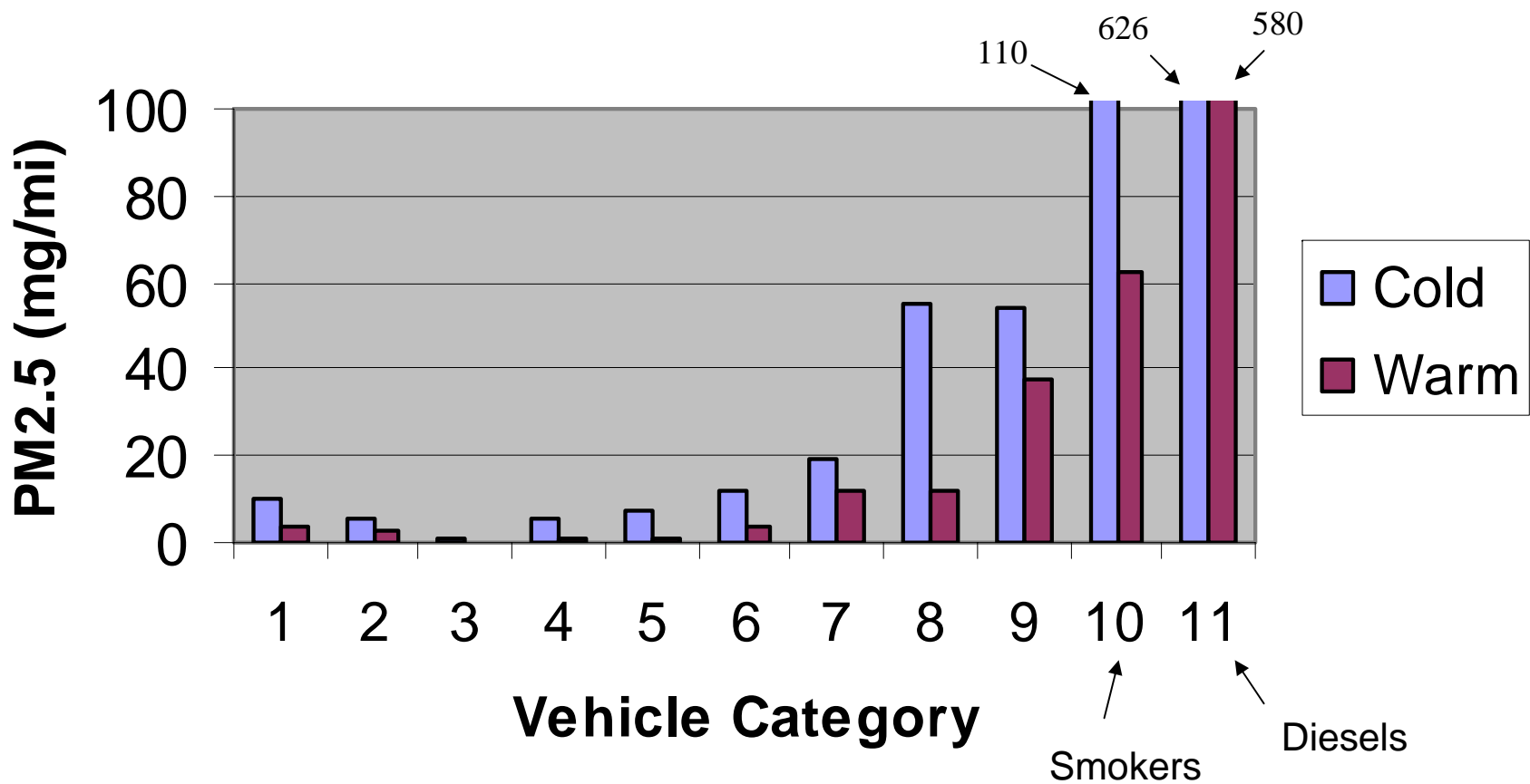
Approach (Continued):

- Ambient samples (June -July 2001)
 - Downtown Los Angeles and Azusa - daily 24 hr, four weeks, composite by day-of-week
 - Variety of locations with variable amount of gasoline and diesel traffic
- Chemically analyze source and ambient samples
 - Organic and elemental carbon, ions, elements, semi-volatile and particulate PAH, hopanes, steranes, polar organics and alkanes.
- Construct source profiles
- Perform Chemical Mass Balance (CMB) receptor modeling
- Publish results in peer-reviewed literature

LDV and HDV Exhaust Sampling Systems



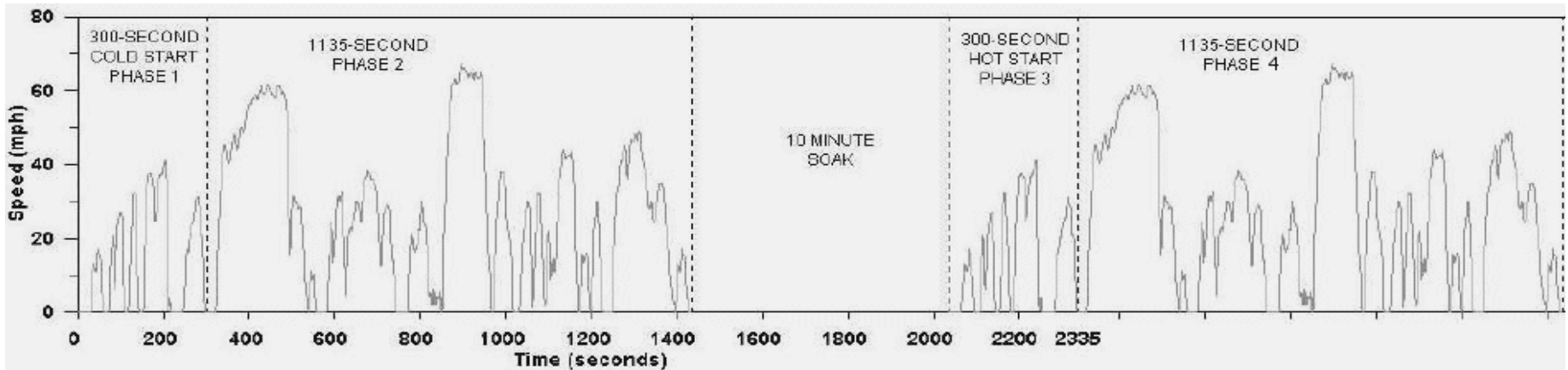
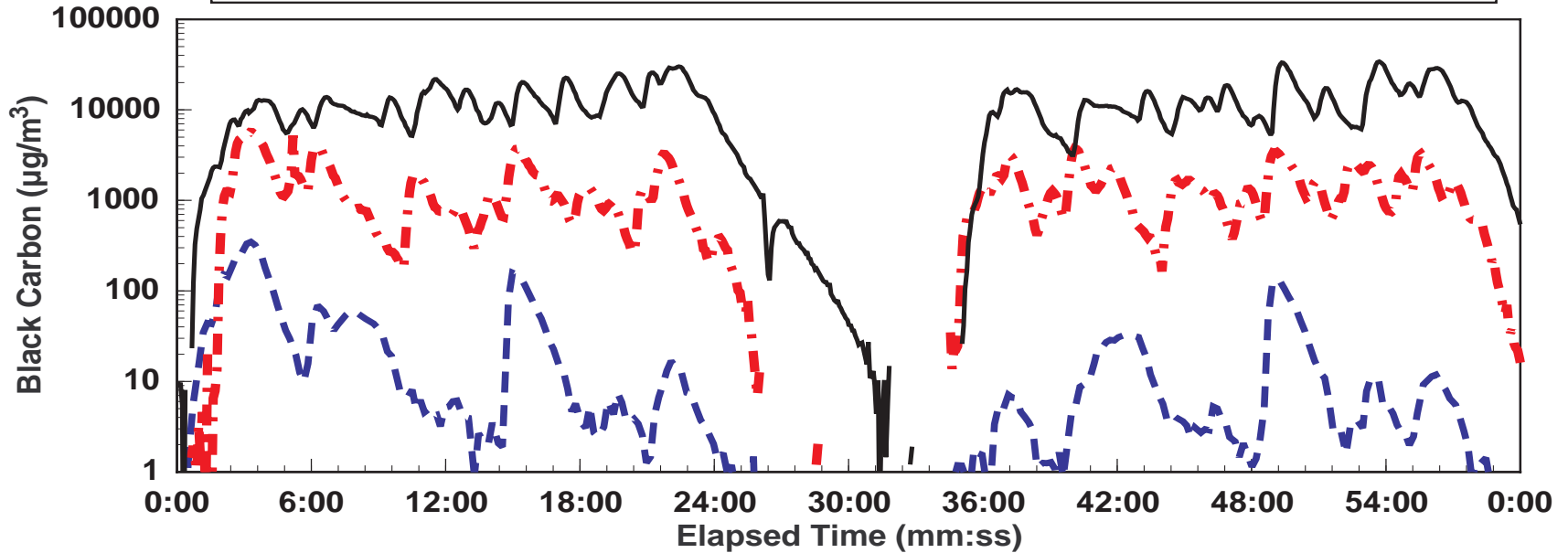
Gasoline/Diesel PM Split Study – Average PM_{2.5} Emission Rates for 11 Categories Tested



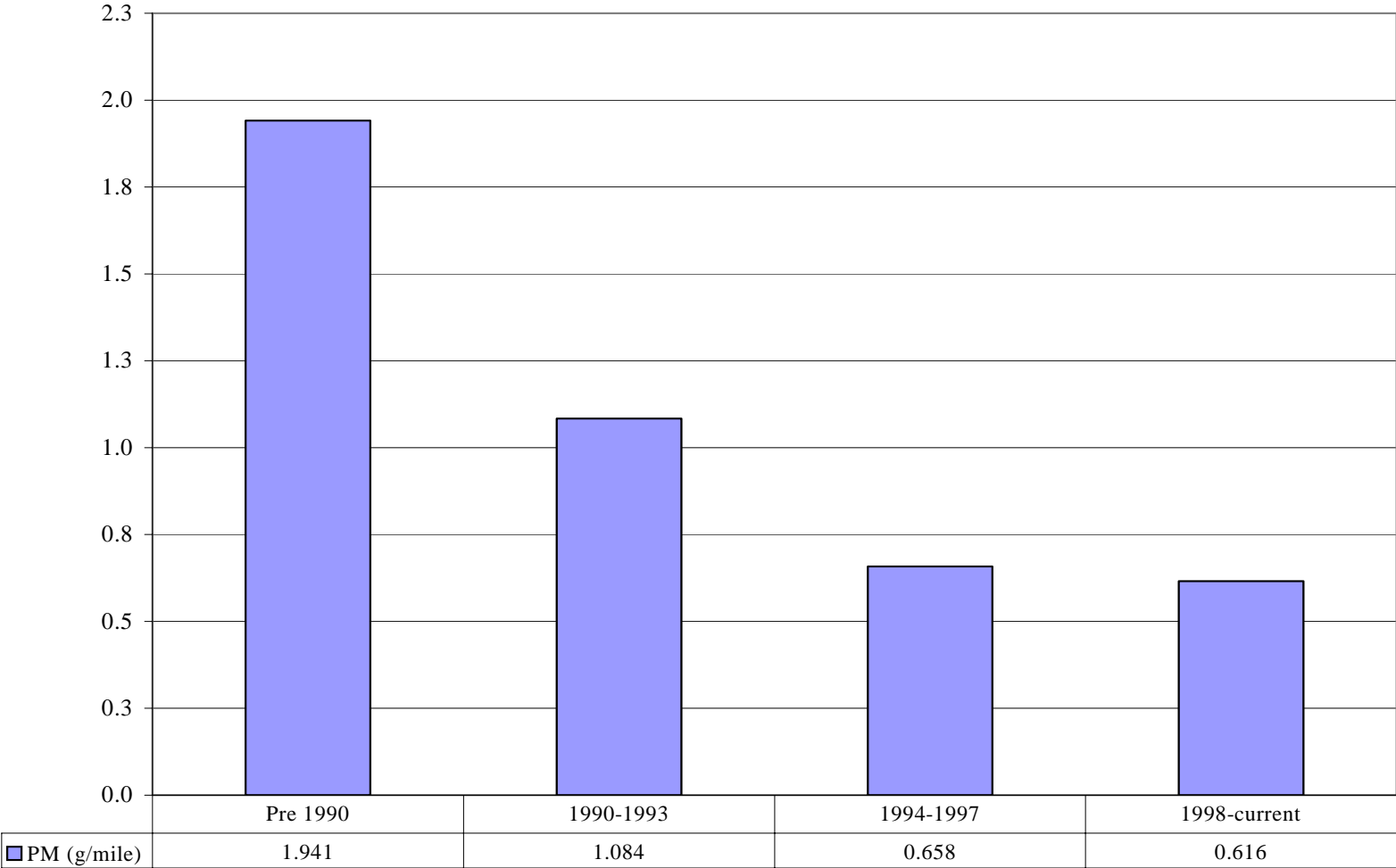
Source: P. Gabele, EPA

Black Carbon During the Modified UC Test Cycle

- - 'Common' Gasoline Vehicle, Run 6-27, Toyota Corolla Wagon
- . - . Smoker, gasoline vehicle, Run 10-53, Mazda B2200
- Diesel Automobile, Run 11-59, Mercedes 300D Turbo

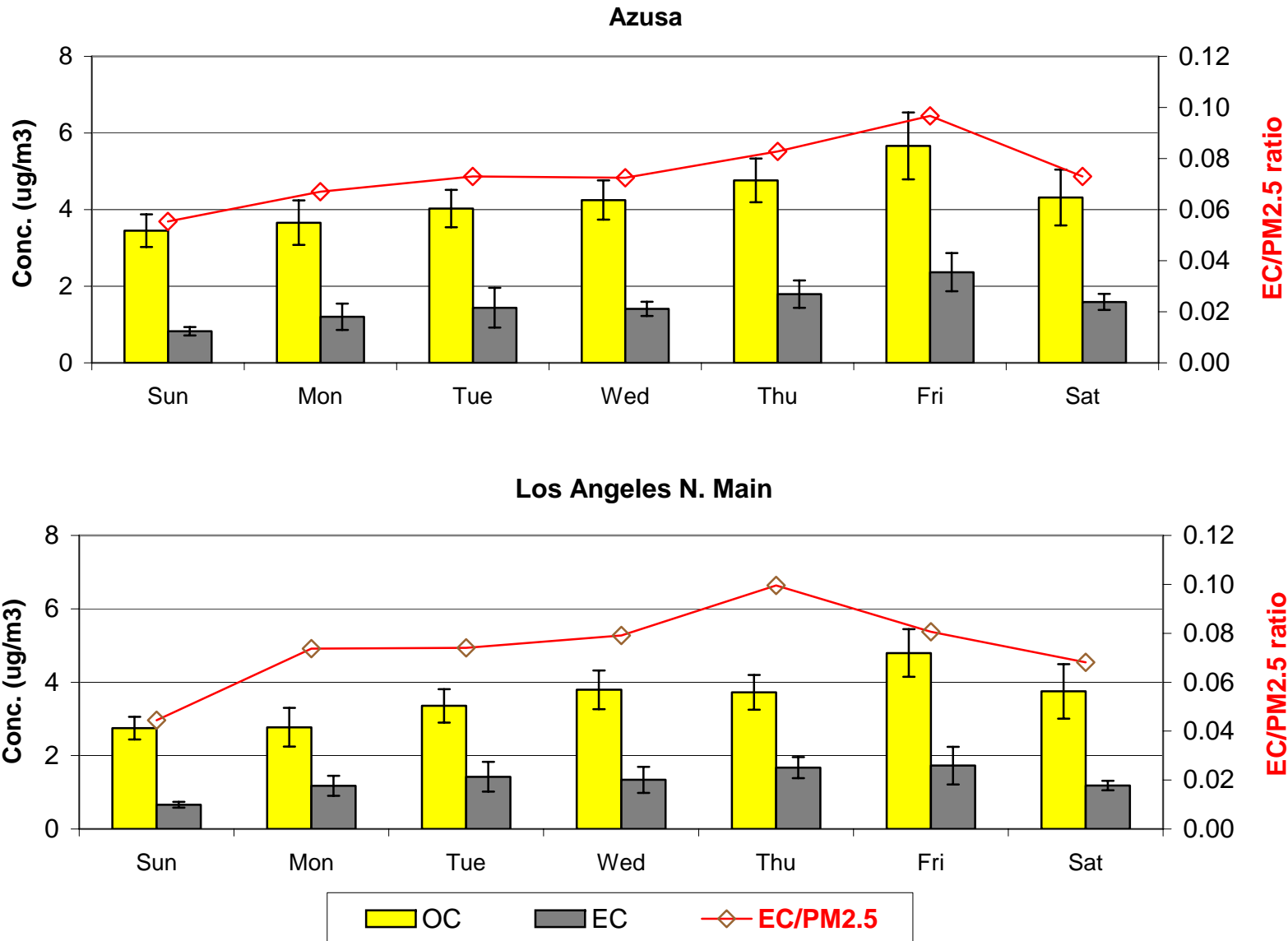


PM emission rates (g/mi) for PM increase in older vehicles in the 30,001-80,000 lbs. portion of the HD vehicle matrix for a CSHVR test



DOE's Gasoline/Diesel PM Split Study

Fixed-Site Ambient Samples – OC, EC and EC/PM_{2.5} Ratios

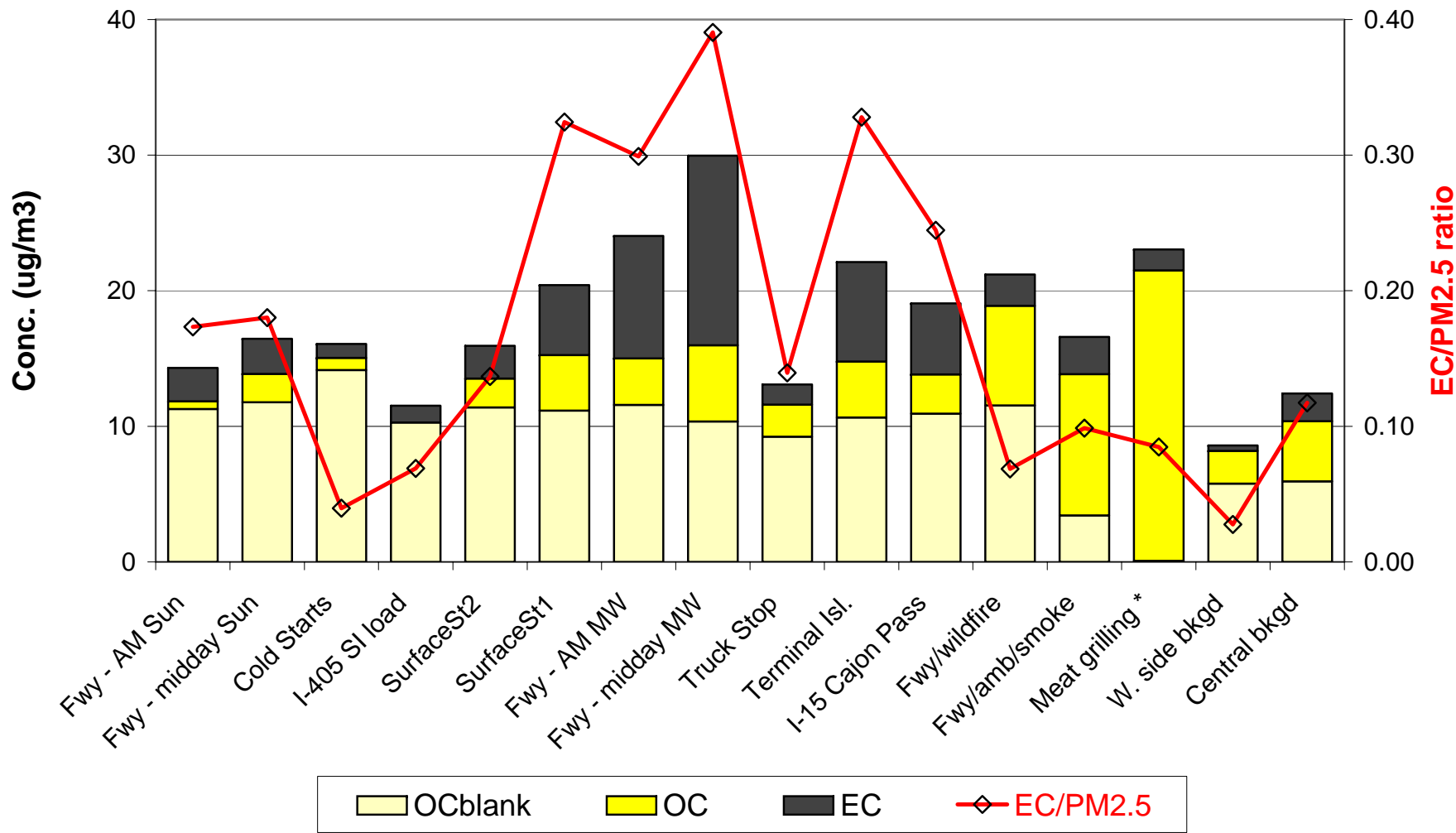


Source-Dominated Ambient Samples



DOE's Gasoline/Diesel PM Split Study

Mobile Ambient Samples – OC, EC and EC/PM_{2.5} Ratios

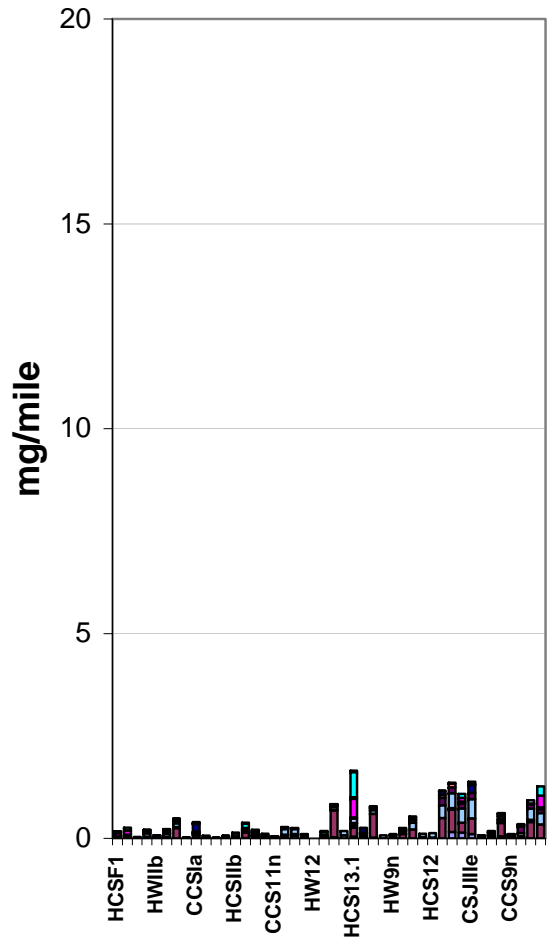


* Concentration divided by 2000.

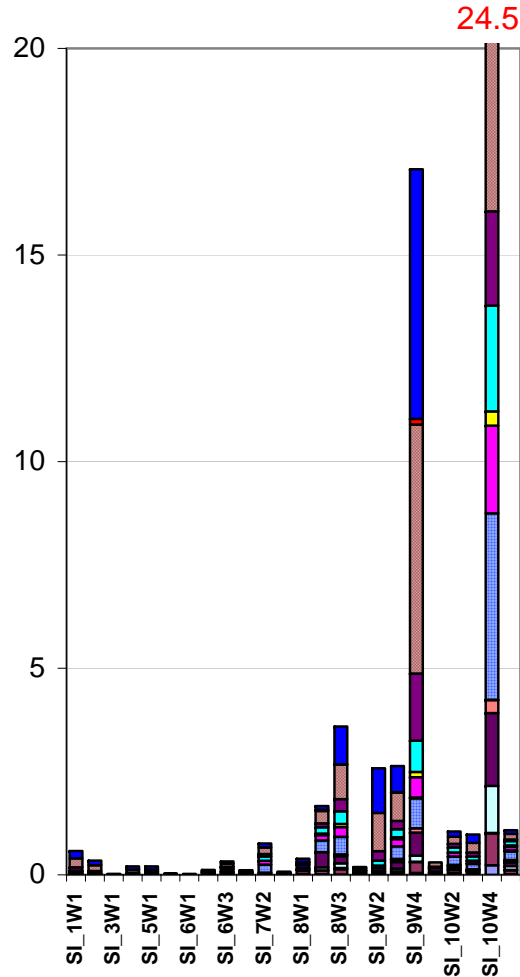
DOE Gasoline/Diesel PM Split Study

Particle-Phase PAH in Exhaust

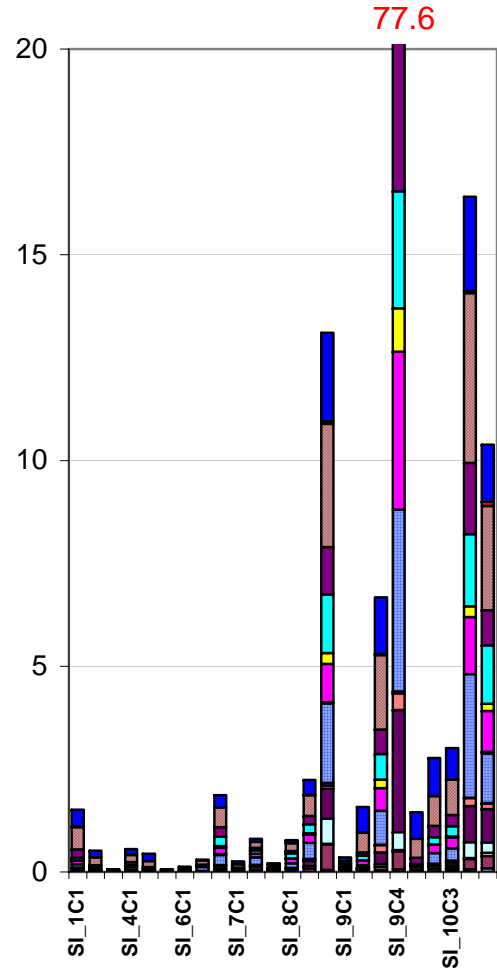
Diesel



SI - Warm Start



SI - Cold Start

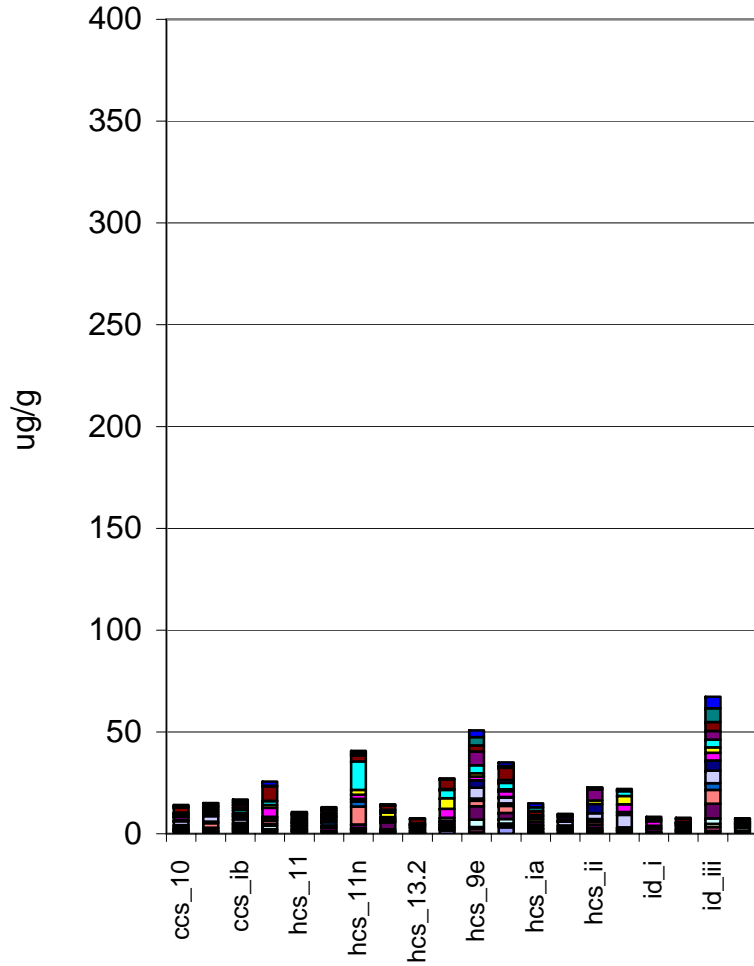


- corone
- dbanth
- bghipe
- incdpy
- bapyrn
- peryle
- bepyrn
- m_7bpy
- bbjkfl
- chry56m
- baa7_12
- bzantone
- chrysn
- m_7baa
- baanth
- bzcphen

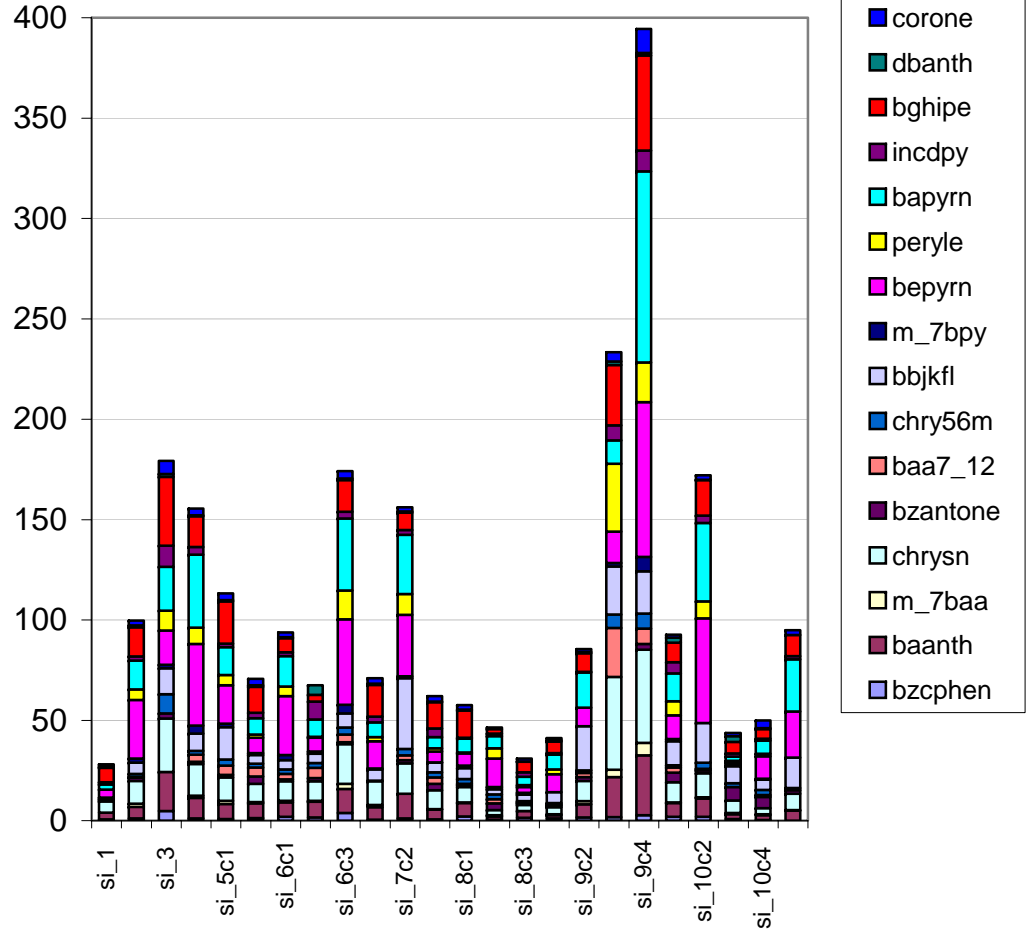
DOE Gasoline/Diesel PM Split Study

Particle-Phase PAH in Lubrication Oil

Lube Oil - Diesel



Lube Oil - Spark Ignition



- corone
- dbanth
- bghipe
- incdpy
- bapyrn
- peryle
- bepyrn
- m_7bpy
- bbjkfl
- chry56m
- baa7_12
- bzantone
- chrysn
- m_7baa
- baanth
- bzcphen

Initial Finding and Observations

- The ten highest PM, HC, CO, and NO_x emitters contributed 66, 66, 58, and 39%, respectively, of the total PM, HC, CO, and NO_x emissions from the 57 gasoline cars tested.
- Gasoline powered 'smokers' can rival diesel cars in PM emission rates, but usually have less PM fraction in soot
- Diesel fuel is enriched in volatile- and semi-volatile PAH in comparison with gasoline fuel.
- Used gasoline oil is enriched in PAH, including heavy, particle phase PAH, as compared with used diesel oil.
- Lube oils in gasoline vehicles absorb and concentrate particulate PAHs that are formed during combustion. This is not the case for diesel vehicles.
- Gasoline vehicle exhaust is enriched in particulate PAH as compared with diesel exhaust.

Current Work

- Construct Source Profile from Gasoline/Diesel PM Split
 - 57 light-duty gasoline vehicles and 2 light-duty diesel vehicles.
 - 34 HD vehicles grouped by model year; tested over a variety of cycles, including cold starts and idle
 - Road dust
- Construct Other Profiles
 - Off-road vehicles (CRPAQS)
 - Brake and tire wear (CRPAQS)
 - Wood combustion (CRPAQS)
 - Meat cooking (CRPAQS)
- Perform Chemical Mass Balance receptor modeling
- Publish results in peer-reviewed literature