(On-Road) Mobile Source Emissions and Mitigation Potential

Douglas R. Lawson
National Renewable Energy Laboratory
Golden, CO
doug.lawson@nrel.gov

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Soot is produced by spark-ignition vehicles…and lots of other sources! (from the tailpipe of relatively new (7k mi) Toyota Prius at NREL)

Ref: A. Lloyd, 13th CRC On-Road Vehicle Emissions Workshop, 2003
Evolution of CARB LD Vehicle Standards
(Implementation: 1994 – 2010 and beyond!)

Ref: A. Lloyd, 13th CRC On-Road Vehicle Emissions Workshop, 2003
HD Diesel Emission Standards
US EPA

Source: Shawn Whitacre, Cummins
Sec-by-sec emissions from a 5-yr old SUV
DOE/NREL Gasoline/Diesel PM Split Study

Ref: Lawson et al., 14th On-Road Vehicle Emissions Workshop, 2004
PM Emissions from “Mobile Sources”

PM from light-duty vehicle “normal” emitter’s tailpipe = <1-2 mg/mile
PM from new 2007-compliant heavy-duty diesel trucks = 1-4 mg/mile
PM from Amy Winehouse’s open window at 60 mph = 5 mg/mile
What do we need to do to improve our mobile source emission inventories?
Denver Winter PM$_{2.5}$ Inventory, 1995

Ref: Denver Regional Air Quality Council, “Blueprint for Clean Air,” April 24, 1998
24-hour average $PM_{2.5}$ blame apportionment at Welby during the Winter 1997 NFRAQS episode periods, using receptor modeling with detailed speciation. Sources of ammonium nitrate and ammonium sulfate not identified.

Refs: Watson and Fujita et al. (1998); Lawson et al. (1998)
If HC, CO, NOx and PM emissions from new vehicles are so low, why are we having problems with urban ozone PM (black carbon) and downwind ozone?
Projected Contributions of Mobile Sources to SoCAB Air Quality

• “It is apparent that by 1980, motor vehicles will not be the major source of hydrocarbons and oxides of nitrogen, and greater emphasis will have to be placed on emissions from nonvehicular sources.” – *Air Pollution Control in California, 1971 Annual Report*, page 34.

• “However, contribution to VOC by mobile sources is reduced due to CARB regulations over time. Area sources become major contributors to VOC emissions (from 27 percent in 2002 to 42 percent in 2020).”, Draft 2007 AQMP, Appendix III, page III-2-14.
SoCAB HC Inventories
“Current” vs. Future

South Coast Air Basin-1970
Current and Future HC Inventories

- Motor Vehicles: 69%
- Petroleum Industry: 19%

South Coast Air Basin-1990
Current and Future HC Inventories

- Motor Vehicles: 46%
- Petroleum Industry: 23%

2003 South Coast AQMP
Base Year and Future HC Inventories

- Motor Vehicles: 64%
- Petroleum Industry: 53%

2007 South Coast AQMP (Draft)
Base Year and Future VOC Inventories

- Motor Vehicles: 68%
- Area: 51%
Weekend Ozone Effect

One of the two major reasons ozone attainment is so difficult: When NOx reductions > HC reductions, ambient urban (and downwind?) ozone levels do not decrease and increase in many locations.
Wednesday-to-Sunday Pollutant Changes
Median Values, 23 States, 1998-2003

- 201 NO monitoring sites
- 249 CO monitoring sites
- 540 O₃ monitoring sites
- 69 PM Nitrate monitoring sites

1987-2000 VOC & NOx (and Beyond)

- Mean Wednesday ± 1 sigma
- Mean Sunday ± 1 sigma

Monitoring Stations
A – Azusa
L – Los Angeles, N. Main
P – Pico Rivera
U – Upland

Weekday VOC and NOx emissions in 2010 are projected to be similar to weekend emissions in 2000.

Ref: Fujita et al., 99th AWMA Nat'l. Conf., 2006
Nationwide On-Road Idle HC Emissions

EPA's 1985 National Tampering Survey
6498 vehicles

On average, fleet emissions increase as vehicles age; mean fleet emissions driven by high emitters

Most new cars are clean; a few new vehicles are dirty; most old cars are “clean”

New vehicles irrelevant to air quality

Ref: Lawson et al., 1993, 1996
Speer Blvd. RS HC Emissions by Quintile
10,015 Measurements, Dec. 3, 5, 6, 2002

Ref: http://www.feat.biochem.du.edu
Contribution to Total HC Emissions by Quintile
10,015 RS Measurements, Speer Blvd., Dec. 3, 5, 6, 2002

% of Total HC

Model Year

Ref: http://www.feat.biochem.du.edu
Light-Duty Vehicle OC, EC and PM Emissions
Quantifying influence of fuels (biofuels), lubricant age, temperature, and drive cycle on PM emissions

High EC/TC ratios for Normal Emitter

Low EC/TC ratios for High Emitter White Smoker (Oil Burner)
(On-Road) Mobile Source Emissions and Mitigation Potential – Conclusions

• Ambient data must be reconciled with current inventories for ozone precursors and black carbon; there is little effort in this area [Good inventories $\Rightarrow$ Good policy]
• All new LD and HD on-road vehicles are “clean;” new LD irrelevant to air quality; tightening LD standards does almost nothing to improve air quality
• For urban (and downwind) ozone: when NOx reductions > HC reductions, there is no ozone reduction, and it increases in many locations
• For black carbon, it comes from LD and HD vehicles; I/M programs have been a near-failure in reducing on-road emissions of black carbon and ozone precursors
• High emitters (LD, MD, and HD) have to be quickly identified, diagnosed, and repaired or scrapped: Medicar program?