Trends in Emissions of Air Toxics from Highway Mobile Sources, 1990 to 2002

Richard Cook

U.S. EPA, Office of Transportation and Air Quality

Laurel Driver

U. S. EPA, Office of Air Quality Planning and Standards

Maureen Mullen

E. H. Pechan and Associates, Inc.

Introduction

- MOBILE6.2 integrates calculation of HAP emission factors into MOBILE6 modeling framework
- Used to develop county-level nationwide emission inventories of motor vehicle air toxics for 1990, 1996, 1999, and 2002

Methods

- Pollutants estimated using MOBILE6.2

1,3-Butadiene	Benzo(a)pyrene	Fluoranthene	Nickel
2,2,4-Trimethylpentane	Benzo(b)fluoranthene	Fluorene	Phenanthrene
Acenaphthene	Benzo(g,h,i)perylene	Formaldehyde	Propionaldehyde
Acenaphthalene	Benzo(k)fluoranthene	Hexane	Pyrene
Acetaldehyde	Chromium (VI and III)	Indeno(1,2,3,c,d)pyrene	Styrene
Acrolein	Chrysene	Manganese	Toluene
Anthracene	Debenzo(a,h)-anthracene	MTBE	Xylene
Benzene	Ethylbenzene	Naphthalene	Benz(a)athracene

Methods

- MOBILE6.2 explicitly estimates emissions for the following pollutants when the AIR TOXICS command is selected:
  - benzene
  - 1,3-butadiene
  - formaldehyde
  - acetaldehyde
  - MTBE
  - acrolein

Methods

- A number of fuel parameters are required, including benzene, aromatics, olefins, and oxygenate content
  - obtained from winter and summer surveys
  - For 1990, 1996 and 1999, seasonal inputs developed
    - summer parameters used in Fall and winter parameters used in spring
  - For 2002, monthly parameters developed by interpolating from summer and winter survey data

Methods

- For other pollutants, ADDITIONAL HAPS command used
  - user enters emission factors or air toxic ratios for additional air toxic pollutants
    - gaseous HAPs fraction of VOC
    - gas and particle-phase PAHs fraction of PM
    - metals mg/mi EFs
  - input files developed for several fuel types (e.g. baseline gasoline, reformulated gasoline with MTBE, reformulated gasoline with ethanol)

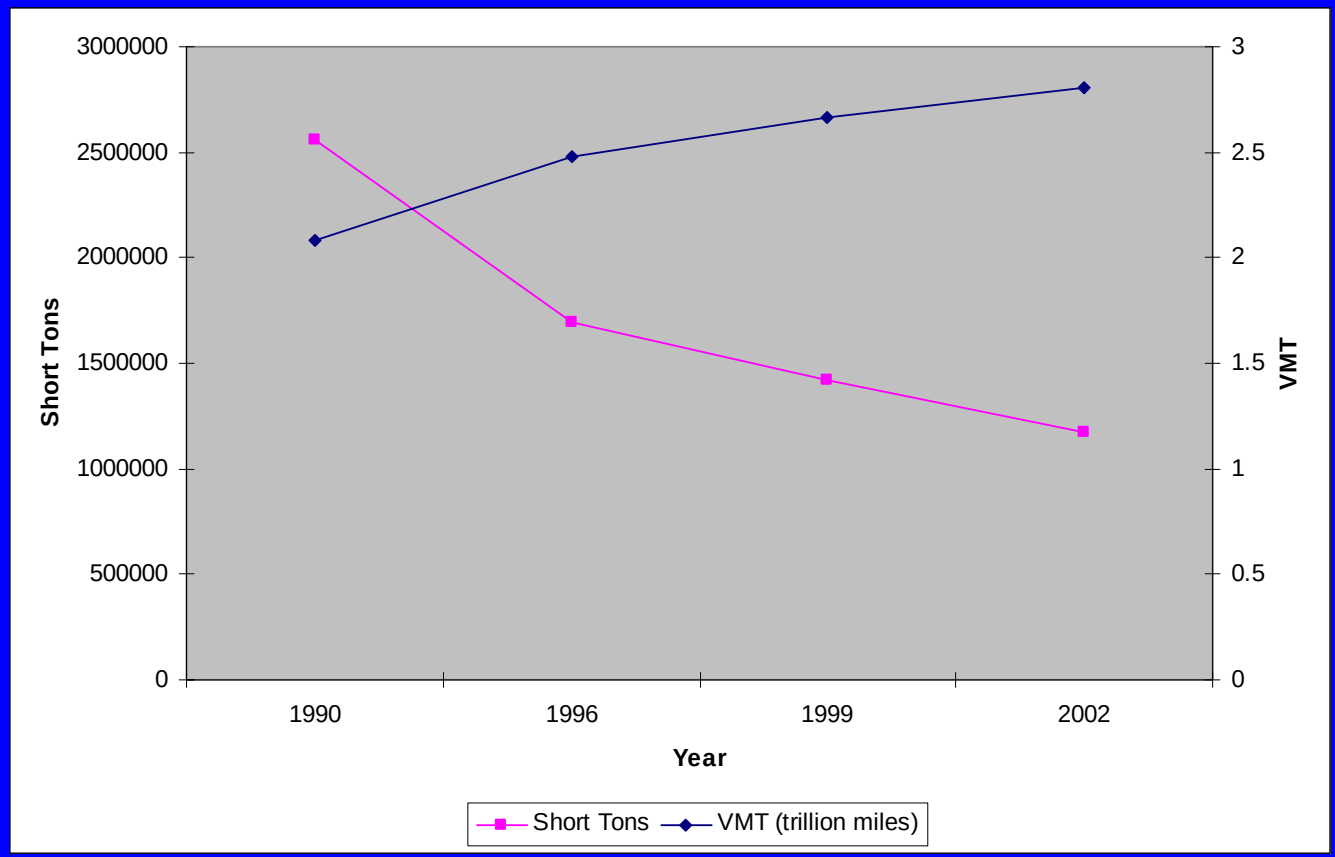
Methods

- Number of MOBILE6.2 input files required to model all counties in a State were determined based on unique combinations of control programs and fuel parameters
- County level emission factors were multiplied by VMT from the Highway Performance Monitoring System (HPMS)
- California provided its own HAP emission factors for 1999

Results

50 State motor vehicle HAP emissions versus VMT, 1990 to 2002.

Over 50 % reduction in HAP emissions



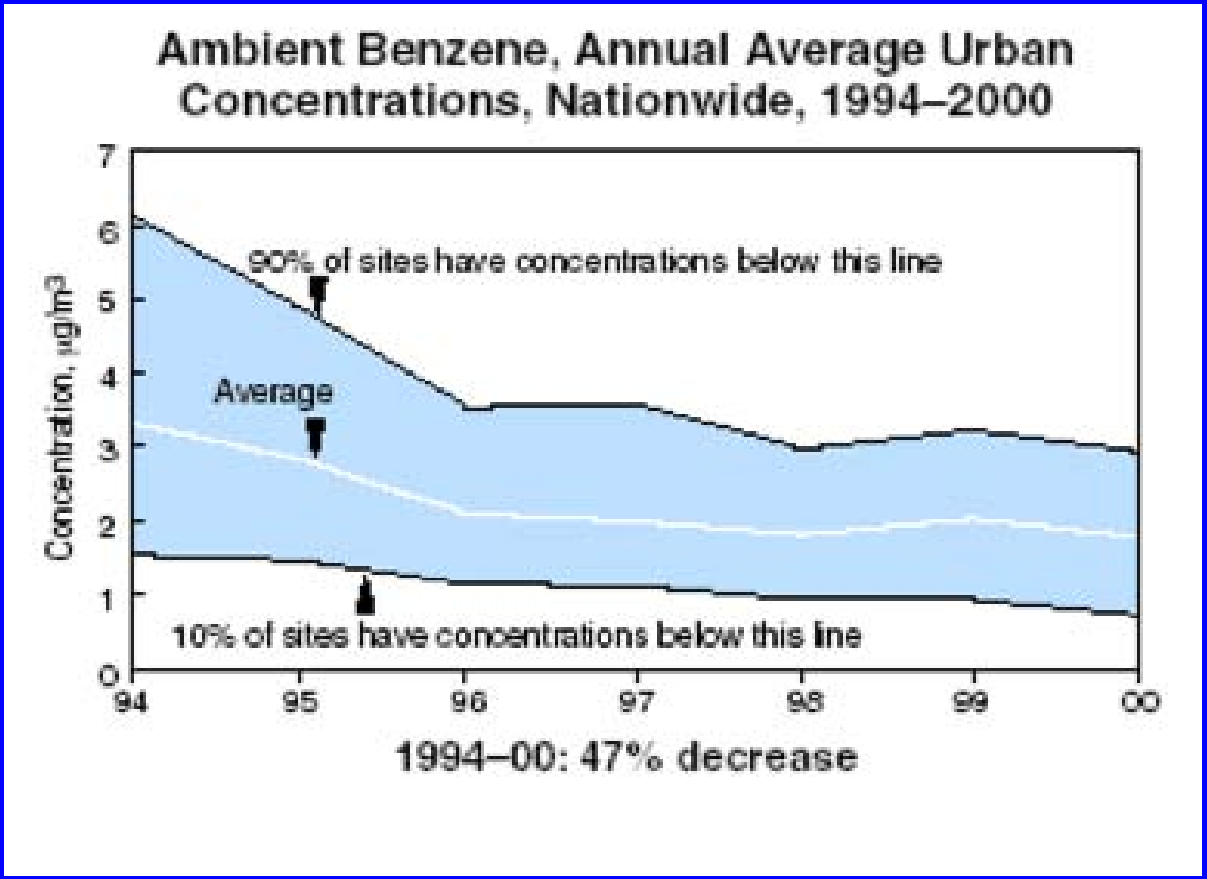
Results

Tons of gaseous HAPs

Pollutant	1990	1996	1999	2002
Benzene	311987	198072	171644	149180
MTBE (Methyl Tert-Butyl Ether)	26157	50205	82777	50332
1,3-Butadiene	49051	30780	23785	18666
Formaldehyde	162365	100341	81081	62760
Acetaldehyde	51309	34730	30068	23524
Acrolein	7743	4911	4013	2986
Ethyl Benzene	128261	83640	70075	57170
n-Hexane	98346	67911	65898	50209
Styrene	27199	17219	13266	11214
Toluene	878170	566100	460240	380949
Xylenes (mixture of o, m, and p isomers)	494714	320020	242172	215985
2,2,4-Trimethylpentane	304069	205667	167576	143730
Propionaldehyde	7816	5164	4231	3410
Total	**2547186**	**1684760**	**1416826**	**1170114**
%Reduction from 1990		**34**	**44**	**54**

Results

- Trends in Monitored ambient benzene



Results

PAH Emissions

	1990	1996	1999	2002
Tons	7556	5287	4471	3925
% Reduction from 1990		30	41	48

Results

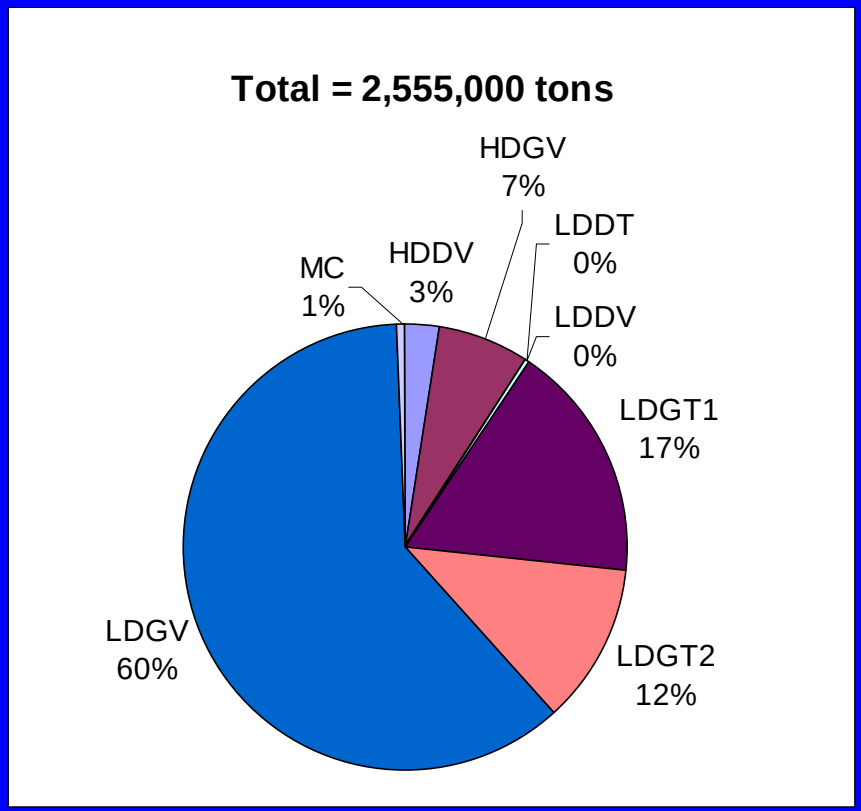
Metal Emissions

Pollutant	1990	1996	1999	2002
Chromium (CR6+)	4.2	5.0	4.9	5.8
Chromium (CR3+)	6.3	7.6	7.3	8.7
Manganese & Compounds	3.6	4.3	4.1	4.9
Nickel & Compounds	8.0	9.5	9.3	10.9
TOTAL	**22.1**	**26.4**	**25.6**	**30.3**
% Increase from 1990		**19**	**16**	**37**

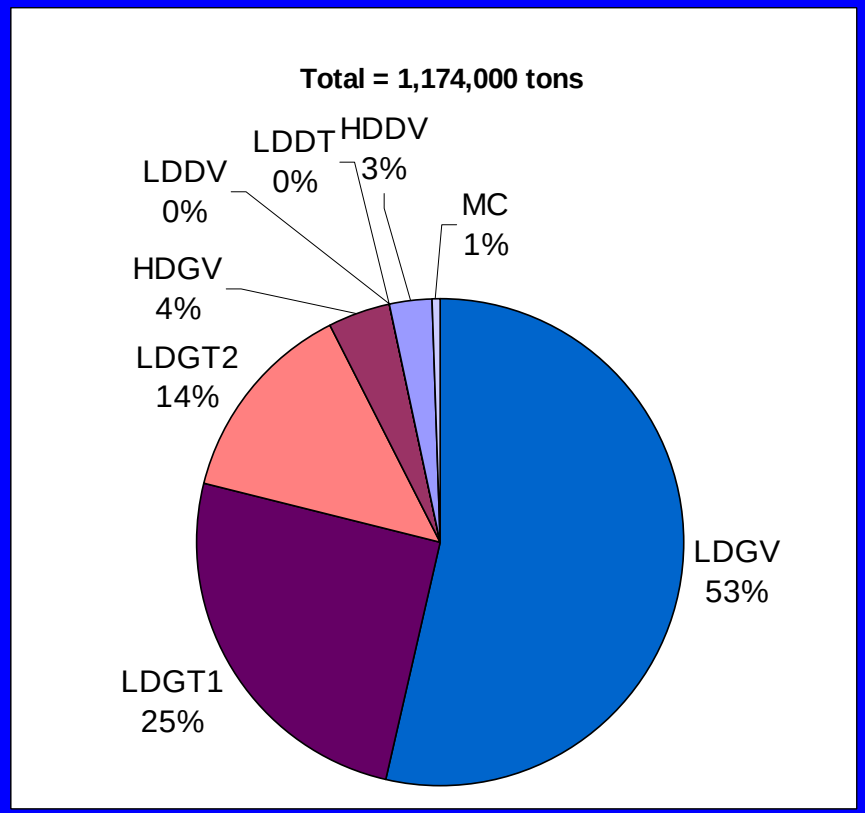
- assumed to be a result of trace level contamination of fuel and engine oil, or a product of engine wear
- estimated by applying emission factors directly to VMT
- Very limited data, methods used not very sensitive

Contributions of Source Categories

1990

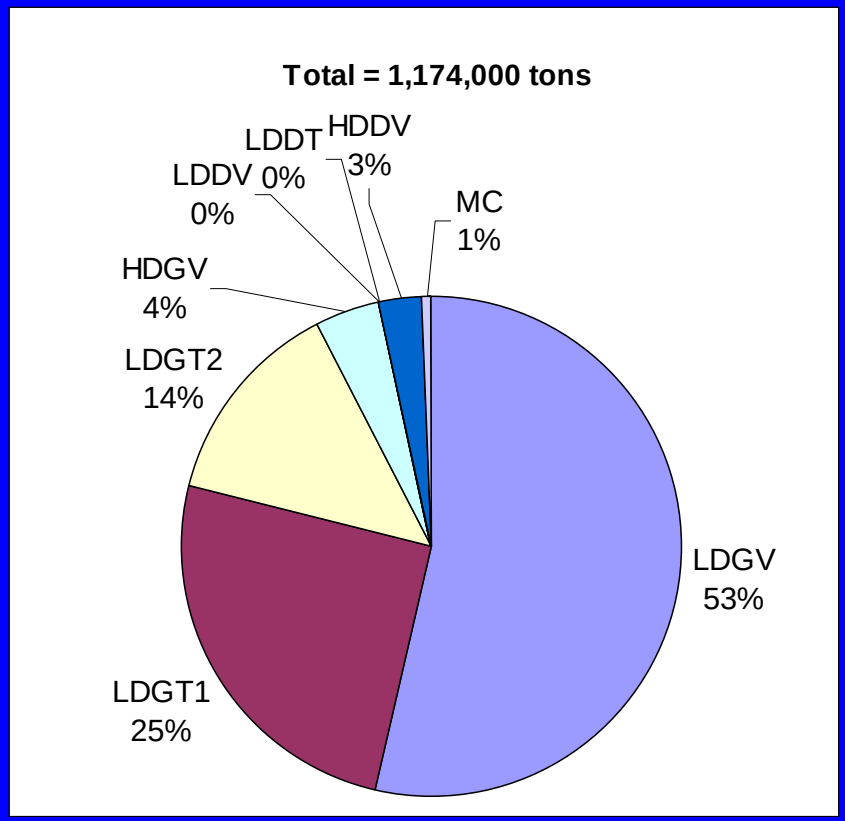


2002

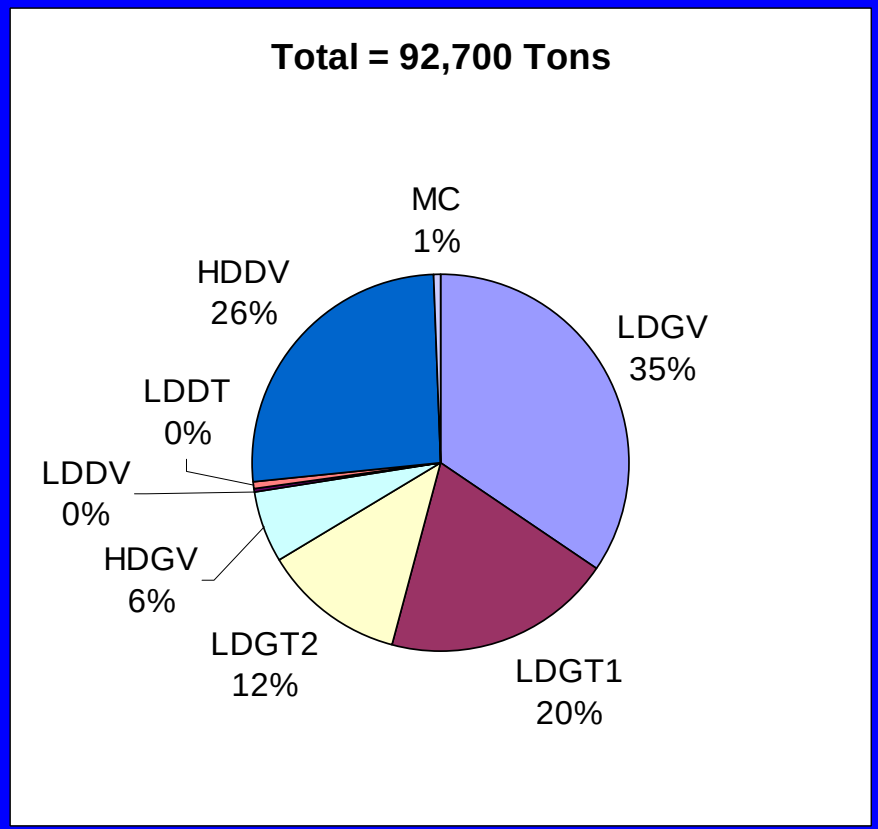


Contributions of Source Categories -- 2002

All HAPs



Carbonyls



Limitations and Uncertainties

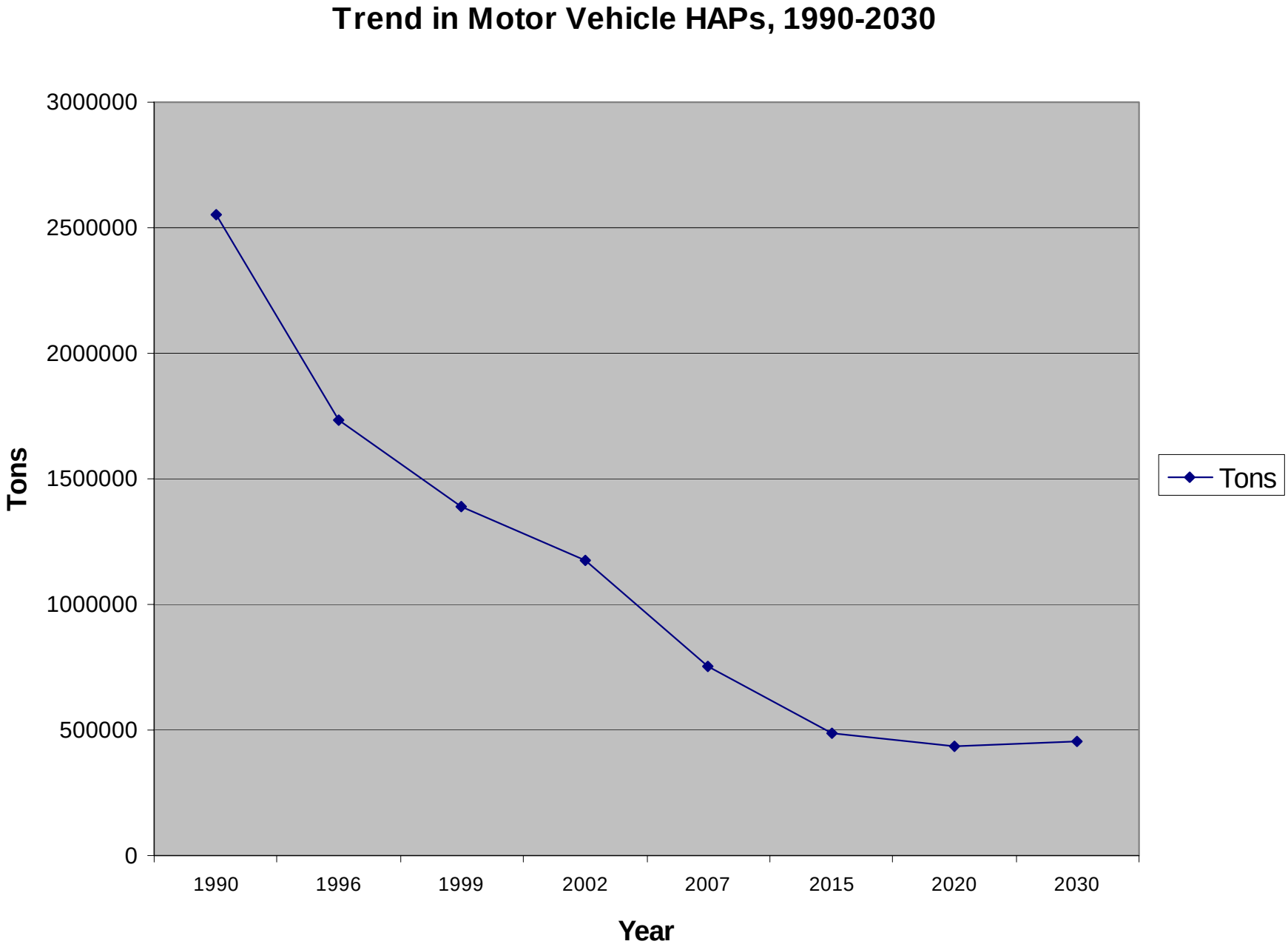
- Toxic to VOC ratios from heavy duty gasoline and diesel vehicles are based on tests from only a few engines.
- MOBILE6.2 does not account for impacts of fuel formulation on toxic to VOC ratios for diesel-powered vehicles.
- The adjustments to toxic to VOC ratios applied to account for off-cycle emissions are based on tests from only twelve vehicles in one study.
- Toxic to VOC ratios are assumed to be the same, regardless of speed, due to a lack of modal emissions data.
- The modeling used default assumptions about the vehicle mix for various roadway types.

Conclusions

- Between 1990 and 2002, motor vehicle HAP emissions are reduced by about 1.4 million tons, or 50 percent, despite large increases in vehicle activity.
- Result of programs which specifically address air toxics, such as RFG, and programs which reduce hydrocarbons and PM
- Reductions will continue into the future

The Future

- Projections of motor vehicle HAP emissions to 2030 just completed.
  - 2007 and later done using National Mobile Inventory Model (NMIM)
  - Reduction in emissions between 1996 and 2020 over 2 million tons, from about 2.5 million to 0.5 millions tons, or 83%
    - continued fleet turnover, Tier 2 tailpipe and low sulfur gasoline standards, 2007 heavy duty standards, etc.
  - Emissions increase slightly between 2020 and 2030


Trend in Motor Vehicle HAPs, 1990-2030
3000000
2500000
2000000
1500000
1000000
500000
0
Tons
1990
1996
1999
2002
2007
2015
2020
2030
Year
Tons