Fundamentals

of

Air Pollution

and

Motor Vehicle Emissions

EPA

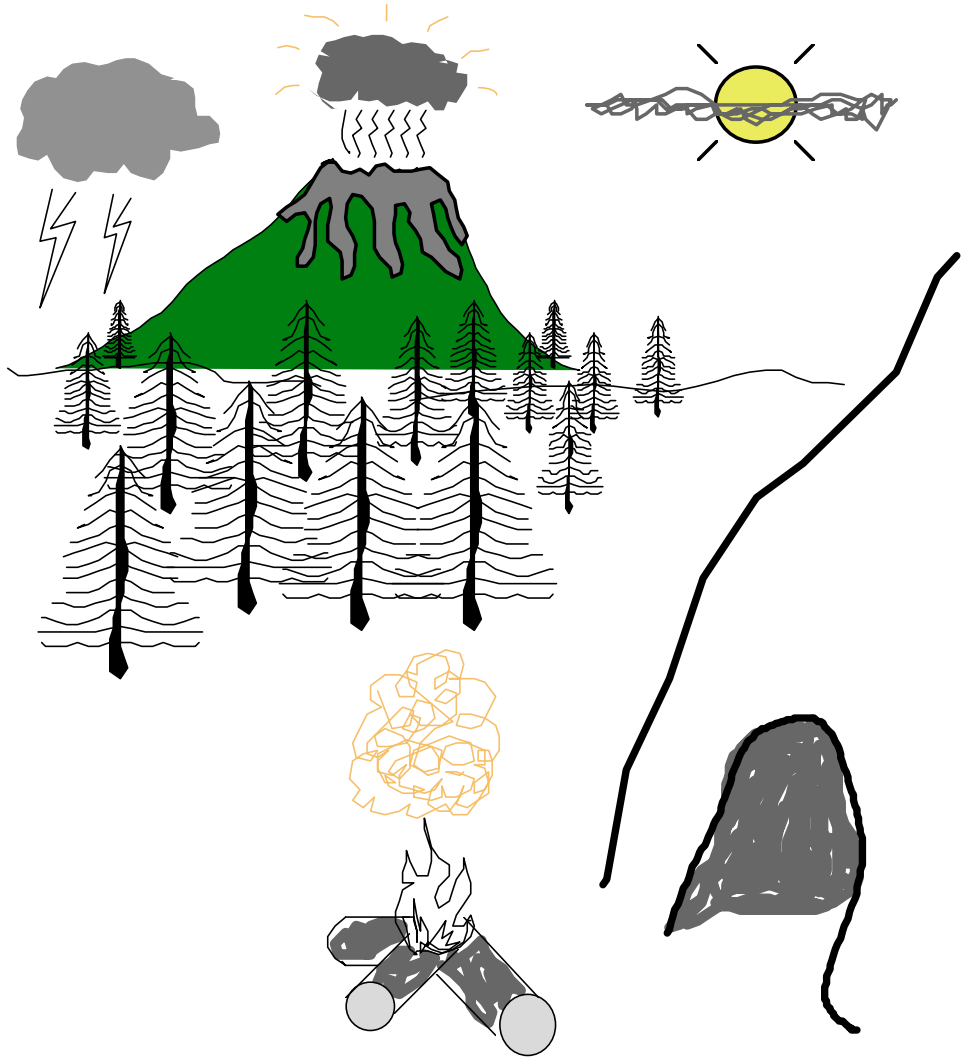
Outline

- **The History of Air Pollution**
- **Air Pollution Today**
- **Why Control is Difficult**
- **The Impact of Motor Vehicles**
- **The Clean Air Act and EPA**
- **How Vehicles are Tested**
- **What We have Learned**
- **Conclusions**
- **EPA's Next Steps**
- **What You Can Do to Help**

EPA

The Early Days of Air Pollution

The More Recent Days of Air Pollution



EPA

Outline

- The History of Air Pollution
- **Air Pollution Today**
- Why Control is Difficult
- The Impact of Motor Vehicles
- The Clean Air Act and EPA
- How Vehicles are Tested
- What We have Learned
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

What Causes Air Pollution Today?

Stationary Sources

- Combustion of fuels for power and heat
- Other burning such as incineration or forest fires
- Industrial/commercial processes
- Solvents and aerosols

Mobile Sources

- Highway vehicles: cars, trucks, buses and motorcycles
- Off-highway vehicles such as aircraft, boats, locomotives, farm equipment, RVs, construction machinery and lawn mowers

EPA

Primary Types of Air Pollutants

- **Carbon Monoxide (CO)**
- **Volatile Organic Compounds (VOCs)**
- **Oxides of Nitrogen (NOx)**
- **Sulfur Dioxide (SO_2)**
- **Particulate Matter (PM_{10})**
- **Lead (Pb)**

EPA

Carbon Monoxide (CO)

- **Odorless, colorless gas**
- **Caused by incomplete combustion of fuel and air**
- **Most of it comes from motor vehicles**
- **Reduces the transport of oxygen through the bloodstream**
- **Affects mental functions and visual acuity, even at low levels**
- **Improvements are being made but there are still problems in some urban areas**

EPA

Volatile Organic Compounds (VOCs)

- **General term for a wide range of hydrocarbon compounds**
- **VOCs result from combustion processes and evaporation of gasoline vapors, solvents, etc.**
- **They contribute to Global Warming**
- **In sunlight, they combine with NOx to form ozone (smog)**
- **Ozone irritates eyes, aggravates respiratory ills, damages crops**
- **The ozone problem is the one affecting the most people today**

EPA

Oxides of Nitrogen (NOx)

- **Nitrogen dioxide is the prominent one (it's the yellow-brown color in smog)**
- **NOx results from high temperature combustion processes, e.g. cars and utilities**
- **They affect the respiratory system**
- **They play a major role in atmospheric reactions**
- **Overall levels unchanged but transportation sources are cleaner**

EPA

Lead (Pb)

- **Long known as one of the worst toxics in common use**
- **Emitted from gasoline additives, battery factories and non-ferrous smelters**
- **Affects various organs and can cause sterility and neurological impairment, e.g. retardation and behavioral disorders**
- **Infants and children especially susceptible**
- **Control of mobile sources has been exceptionally successful**

EPA

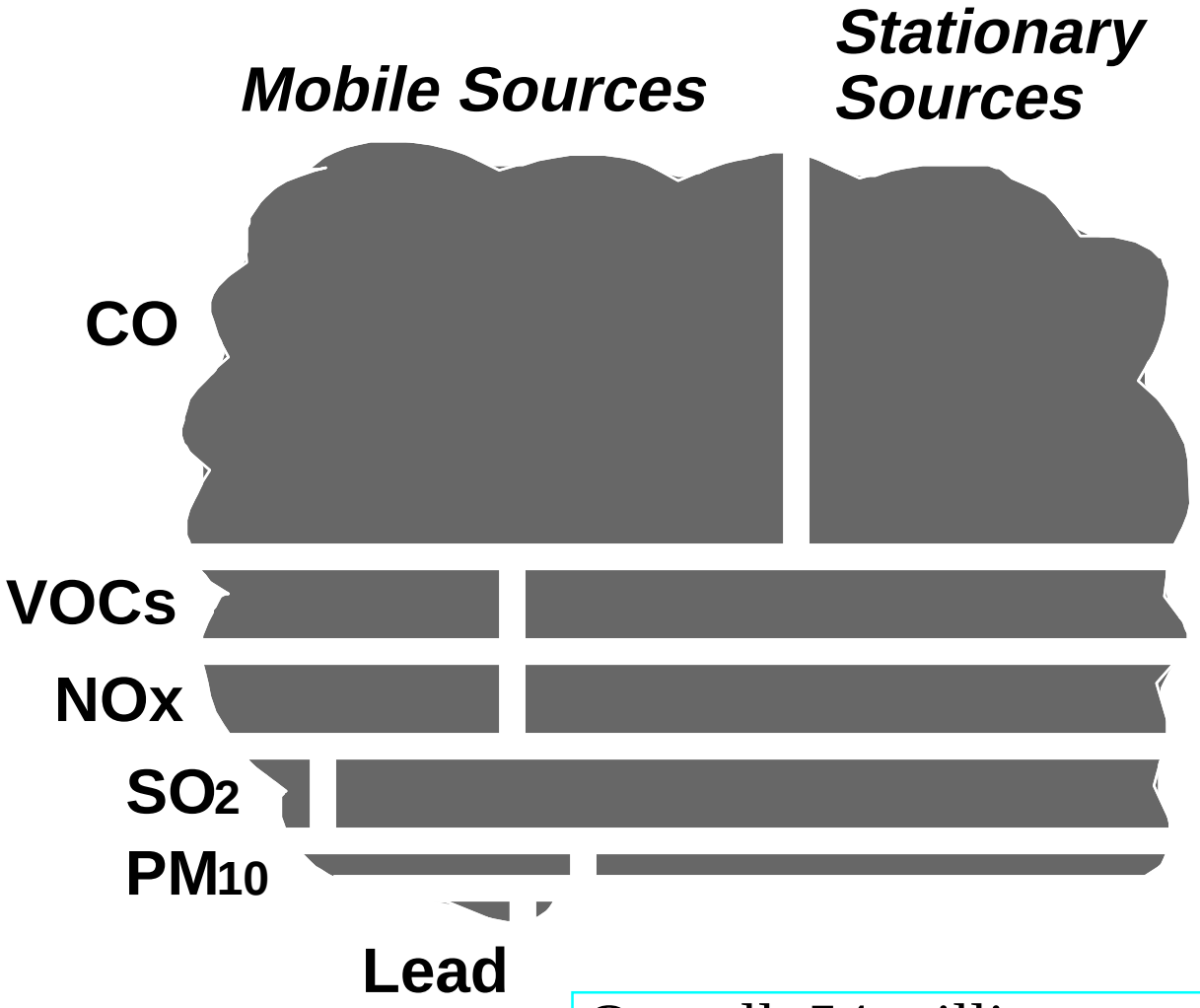
Particulate Matter (PM_{10})

- **PM10 is a general term for tiny airborne particles (under ten microns), e.g., dust, soot, smoke**
- **Primary sources are fuel-burning plants and other industrial/ commercial processes**
- **Some are formed in the air**
- **They irritate the respiratory system and may also carry metals, sulfates, nitrates, etc.**
- **Some overall decreases seen but trends may be masked by meteorological changes**

Sulfur Dioxide (SO_2)

- **This term is used for a number of compounds containing sulfur**
- **Primarily caused by burning of coal, oil and various industrial processes**
- **They can affect the respiratory system**
- **They react in the atmosphere to form acids, sulfates and sulfites**
- **Substantial reductions due to controls at the sources and through use of low sulfur fuels**

The Extent of Air Pollution Today



Overall, 54 million metric tons from mobile sources in 1990 (43% of total)

EPA

Other Air Pollutants

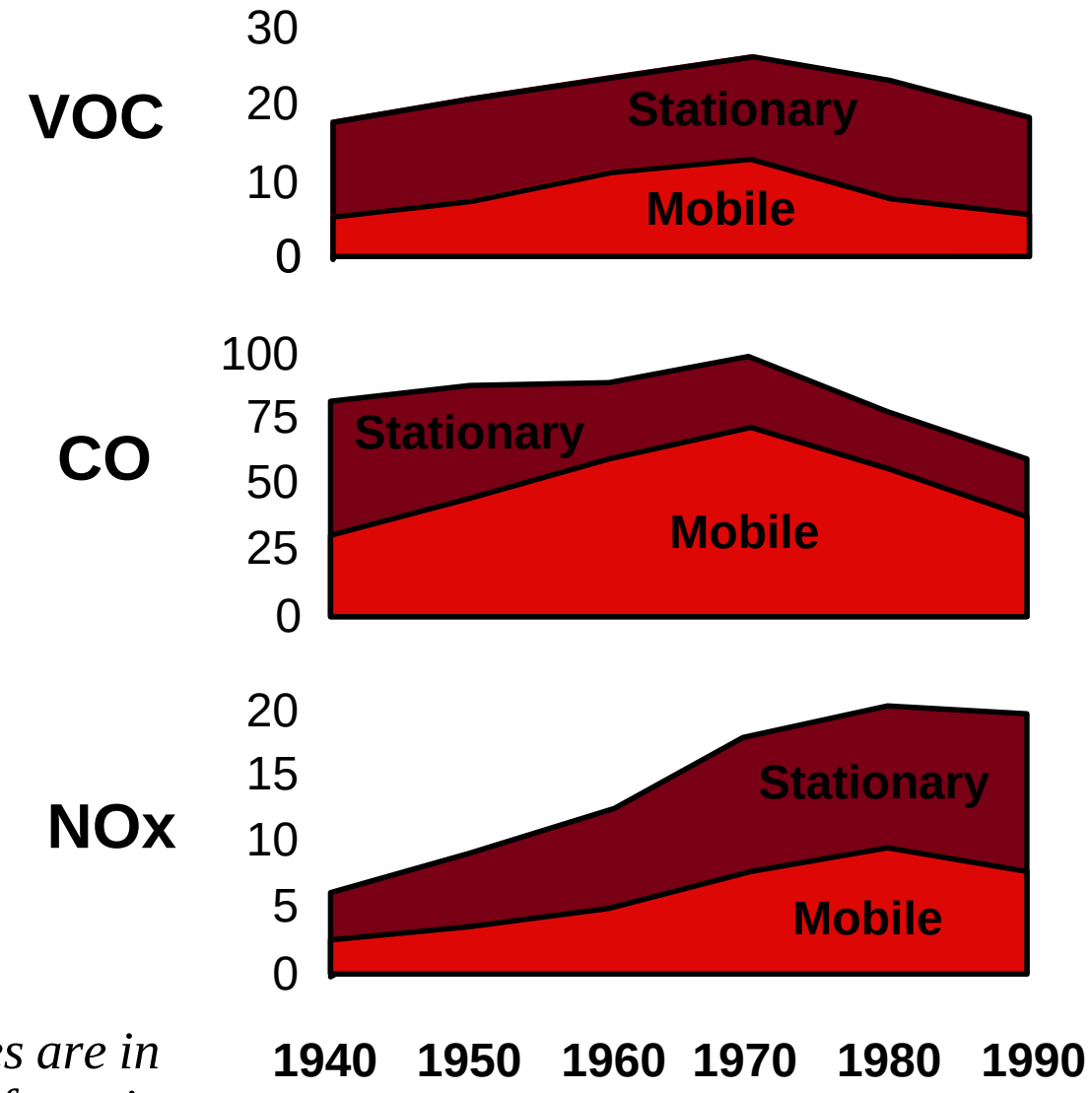
- **Carbon dioxide**
- **Chlorofluorocarbons**
- **Formaldehyde**
- **Benzene**
- **Asbestos**
- **Manganese**
- **Dioxins**
- **Cadmium**
- **Still others which are yet to be fully characterized**

EPA

Global Warming

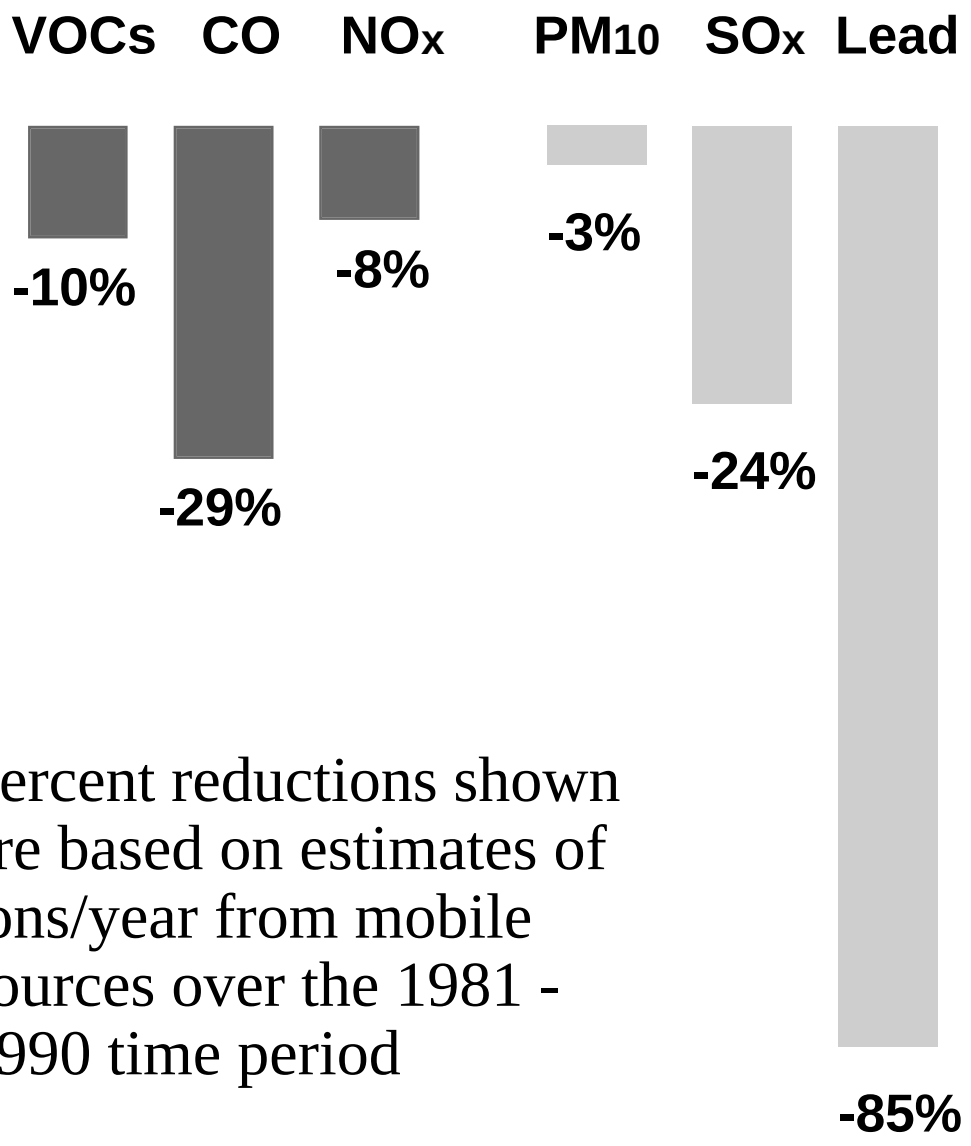
- **Certain gases in the troposphere absorb some of the infrared radiation reflected from the earth**
- **Carbon Dioxide is the major one (50%).**
- **Others include methane (18%) and CFCs (14%). CFCs also are responsible for destroying the stratospheric ozone layer**
- **The United States produces over 20% of the world's "greenhouse" gases**

Fifty Years of Air Pollution



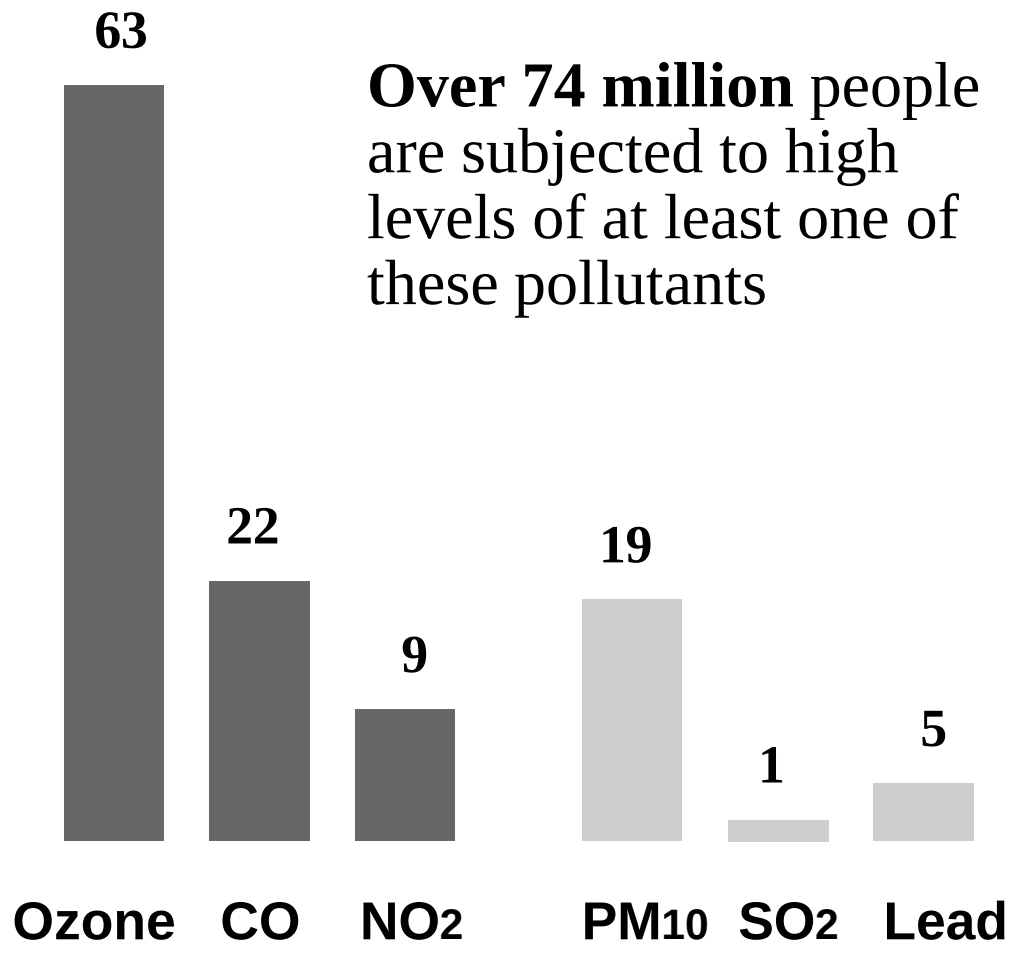
Figures are in millions of metric tons per year

Mobile Sources: The Last Ten Years



Percent reductions shown are based on estimates of tons/year from mobile sources over the 1981 - 1990 time period

Who is Affected by Air Pollution?



Over 74 million people are subjected to high levels of at least one of these pollutants

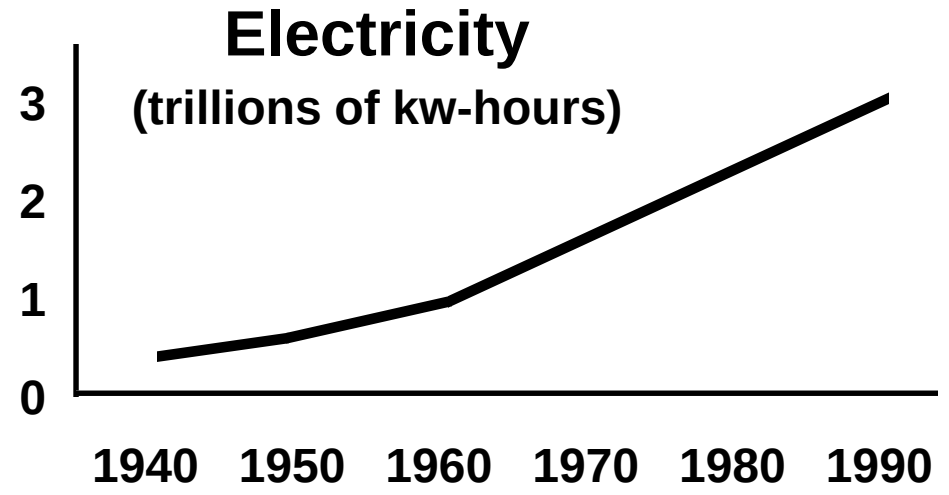
Millions of people living in counties with air quality that exceeds each NAAQS (1990 data)

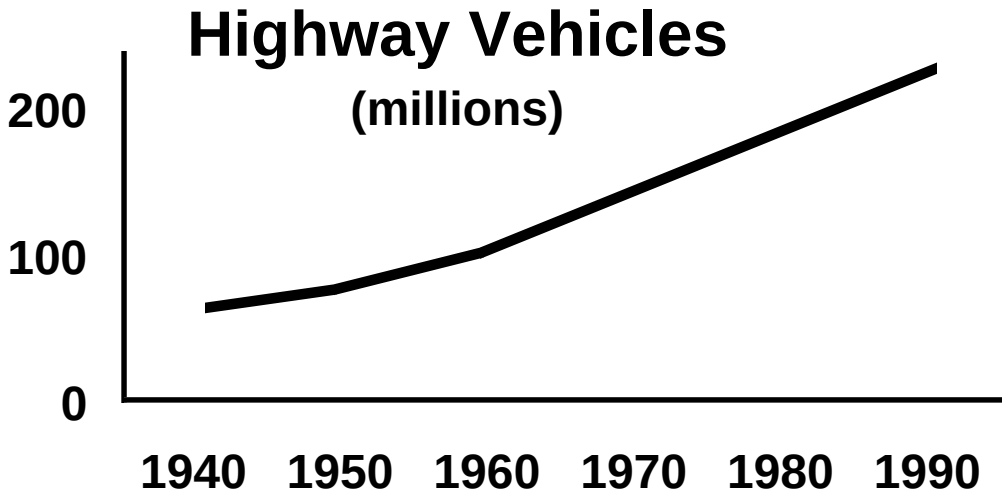
EPA

Outline

- The History of Air Pollution
- Air Pollution Today
- **Why Control is Difficult**
- The Impact of Motor Vehicles
- The Clean Air Act and EPA
- How Vehicles are Tested
- What We have Learned
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

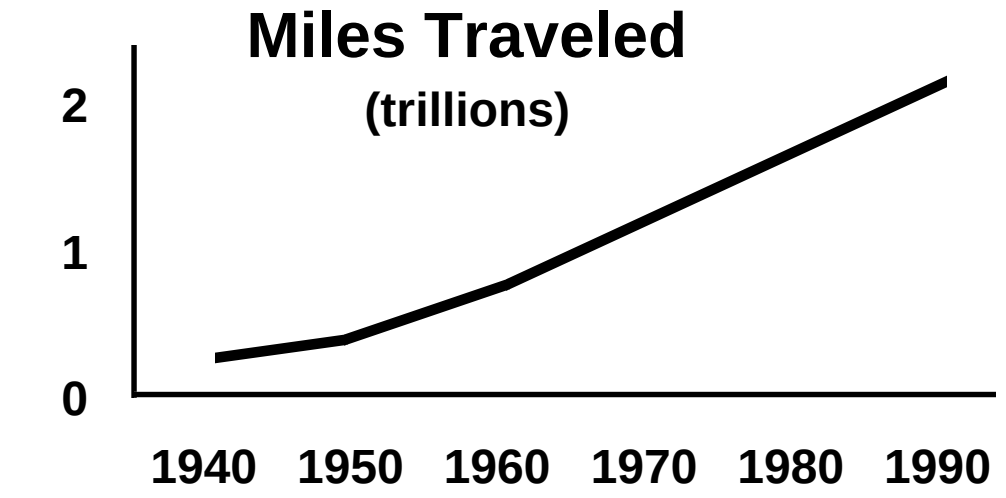
We Want More Energy and More Vehicles

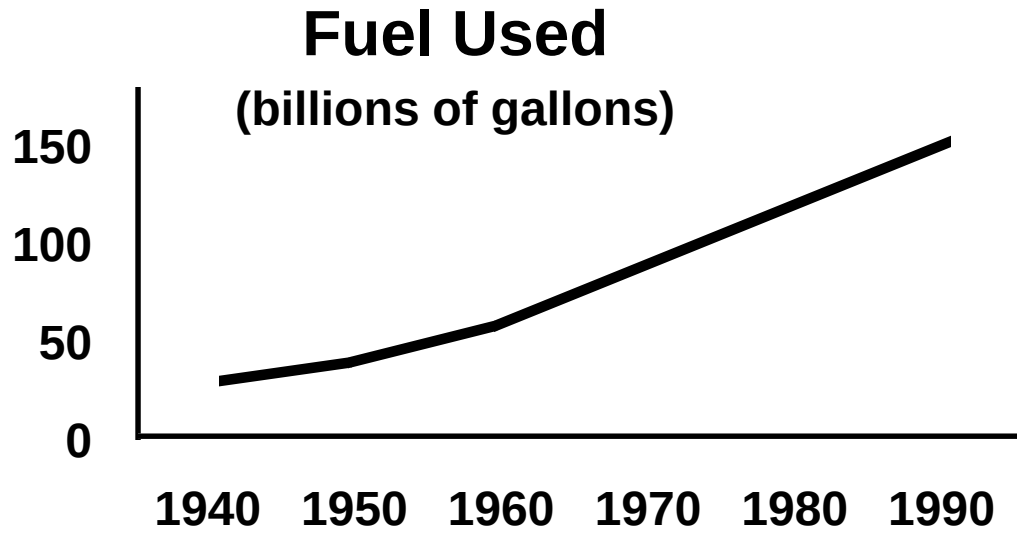




EPA

We
Drive More
and
Use
More Fuel





EPA

Outline

- The History of Air Pollution
- Air Pollution Today
- Why Control is Difficult
- **The Impact of Motor Vehicles**
- The Clean Air Act and EPA
- How Vehicles are Tested
- What We have Learned
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

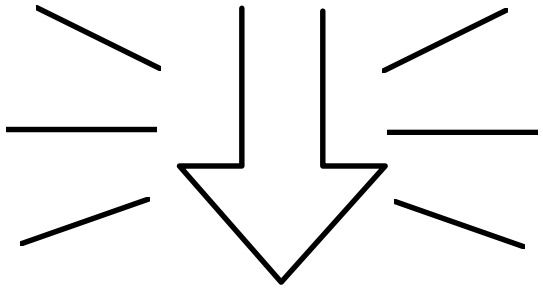
EPA

The Combustion Process

(theoretical)

Gasoline -------- Air ---------

$$C_7H_{13} + 10\,O_2 + 39\,N_2$$



Energy!!

$$7\,CO_2 + 6.5\,H_2O + 39\,N_2$$

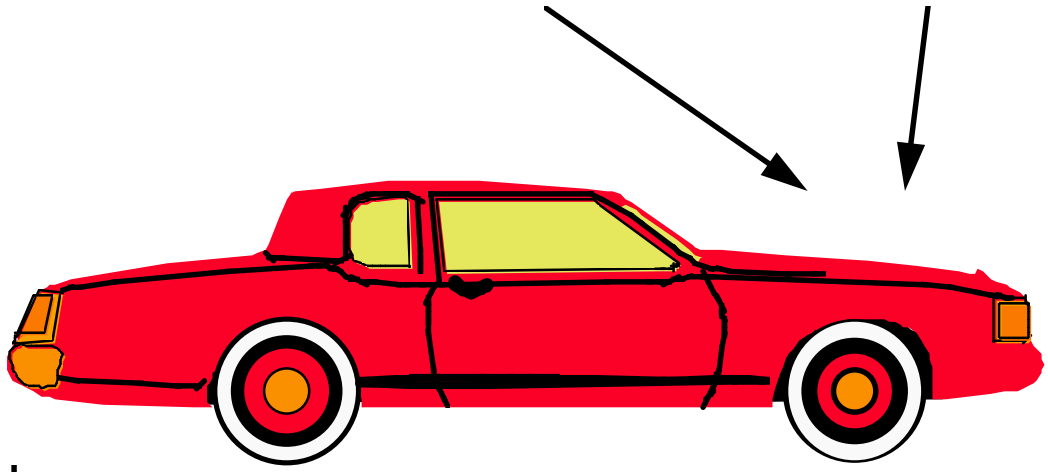
Carbon Dioxide

Water (Steam)

Nitrogen

The Combustion Process

(actual)



Exhaust:

- Nitrogen
- Water (steam)
- Carbon Dioxide
- Pollutants

Pollutants:

Unburned Hydrocarbons

Carbon Monoxide

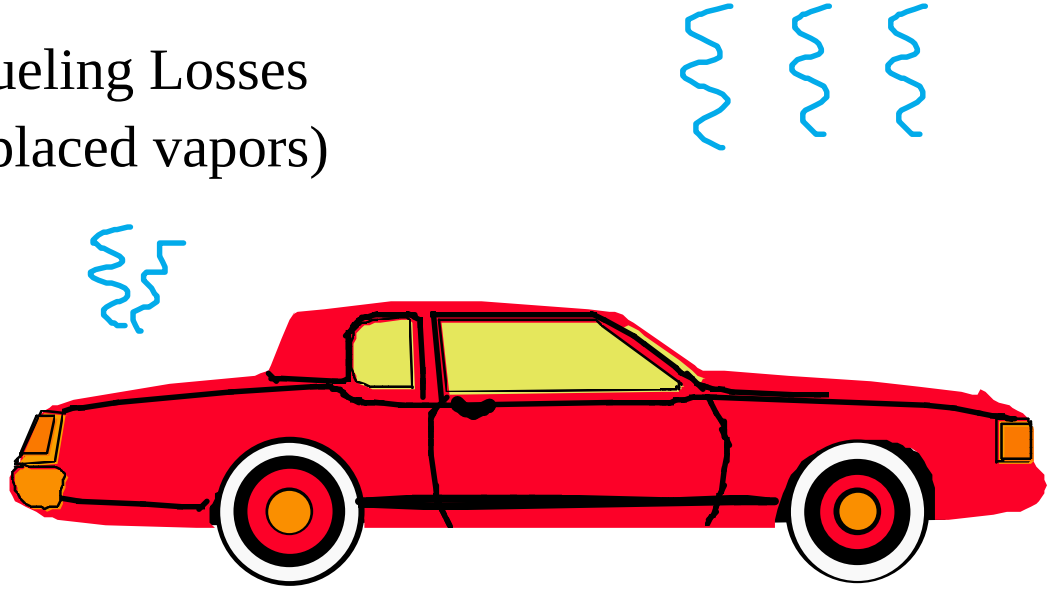
Oxides of Nitrogen

Other elements or compounds

EPA

Other Emissions from Motor Vehicles

- Evaporative Emissions
  (diurnal, running losses, hot soak)
- Refueling Losses
  (displaced vapors)



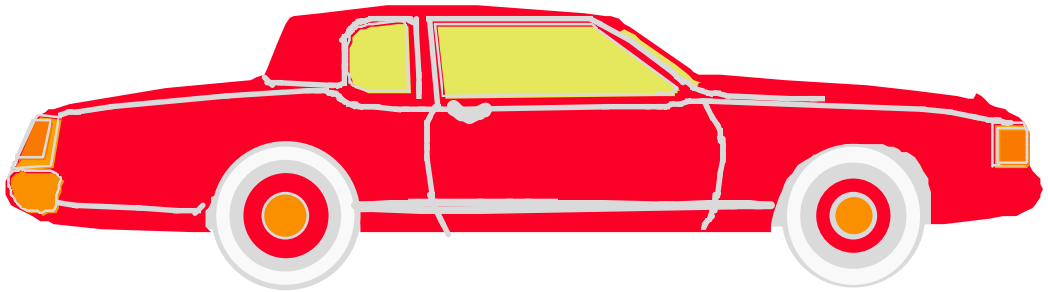
- Miscellaneous Emissions
  (due to other evaporation and wear of brakes, tires, etc.)
- Crankcase Losses
  (due to "blowby")

EPA

The Motor Vehicle as a Source of Air Pollution

Refueling Losses

Evaporative Emissions

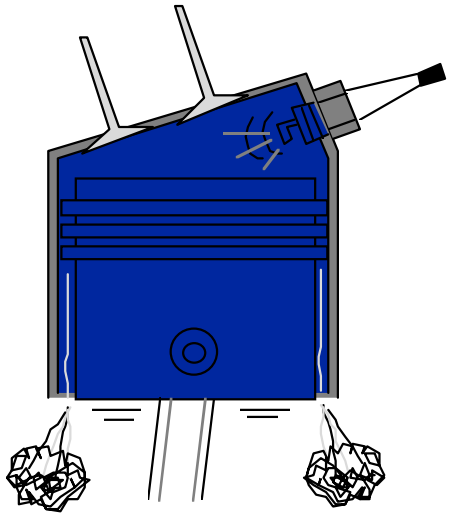


Exhaust Emissions

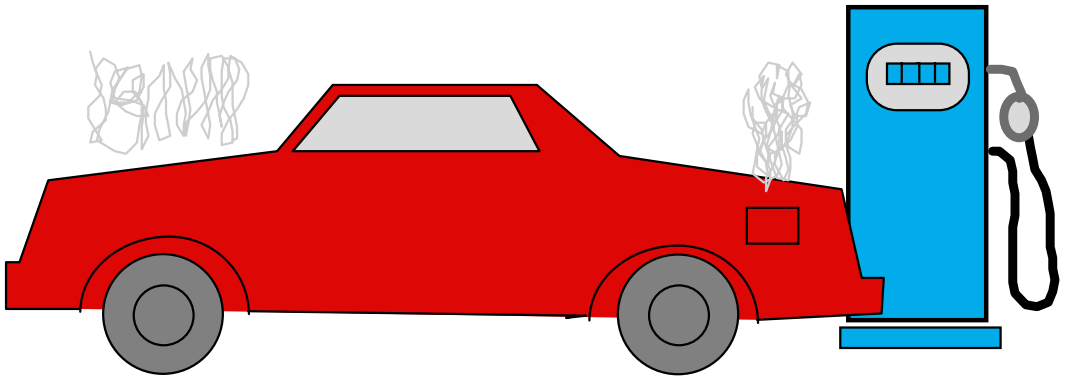
Crankcase Losses, etc.

EPA

How Emissions are Formed

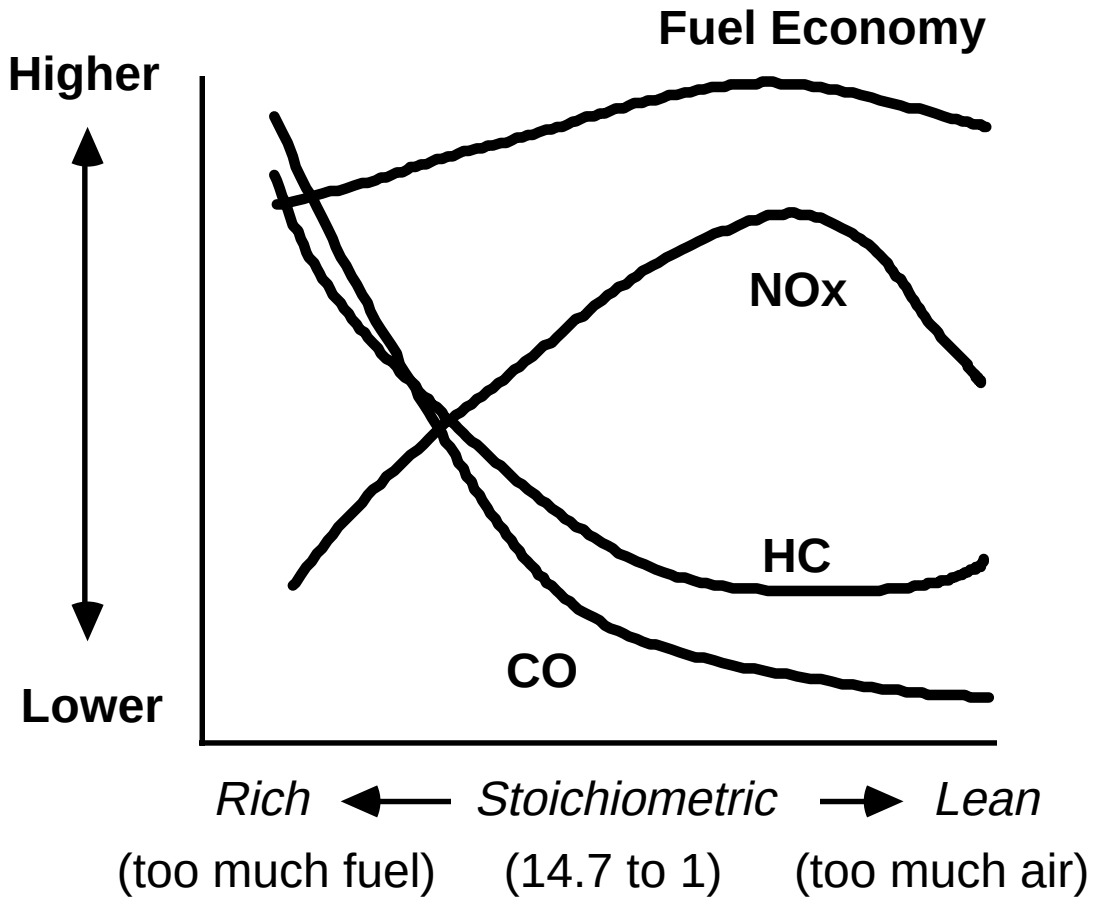


- In the engine
  - -incomplete combustion
  - -"wall quench"
  - -high pressure and temp
  - -"Blowby"
- Due to evaporation of fuel
  - -"breathing"
  - -hot engine and fuel
  - -displacement of vapors



EPA

The Effect of Air-Fuel Ratio

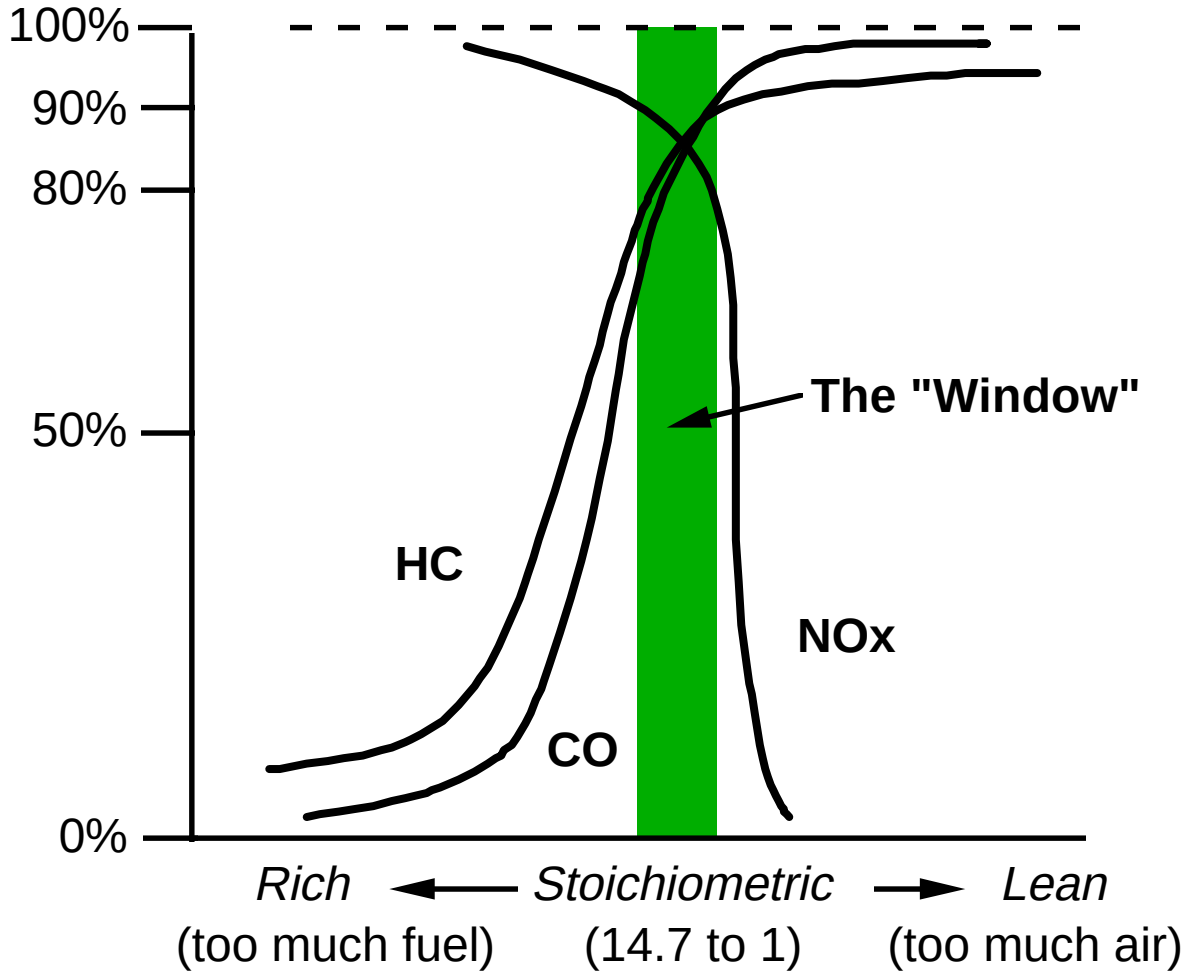


EPA

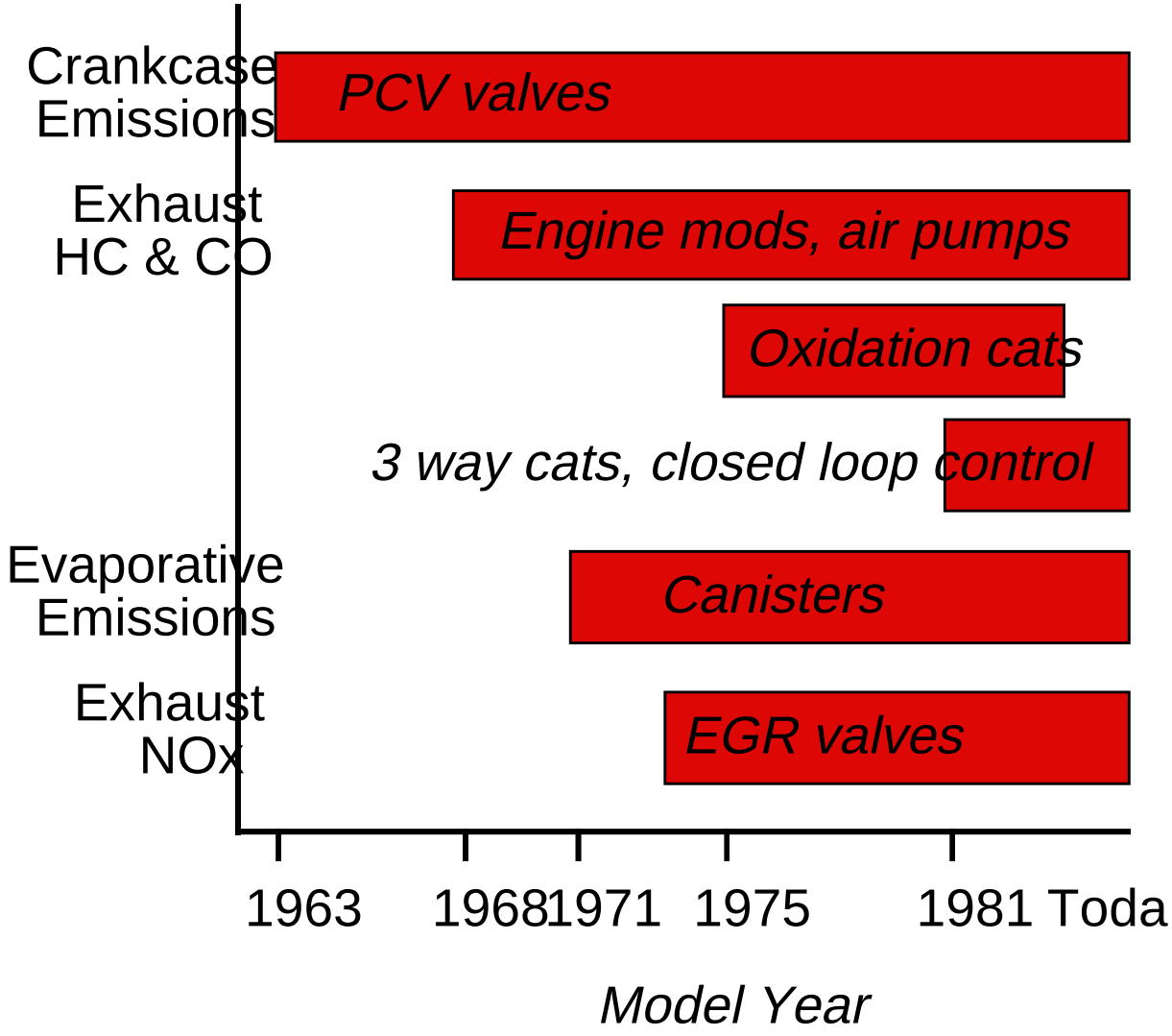
Typical Emission Control Devices

- **Positive Crankcase Ventilation (PCV) Valve**
- **Air Pump**
- **Evaporative Emissions Canister**
- **Exhaust Gas Recirculation (EGR) Valve**
- **Catalytic Converter**

Efficiency of the Three-way Catalyst



The Evolution of Emission Controls



EPA

Outline

- The History of Air Pollution
- Air Pollution Today
- Why Control is Difficult
- The Impact of Motor Vehicles
- **The Clean Air Act and EPA**
- How Vehicles are Tested
- What We have Learned
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

EPA

Milestones in the Control of Automotive Emissions

1952 - Autos linked to air pollution

1963 - Original CAA, PCV valves

1968 - HC & CO exhaust controls

1970 - CAA amendments, EPA formed

1971 - Evaporative controls

1972 - First I/M Program

1973 - NOx exhaust controls

1975 - First catalytic converters

1981 - New cars meet statutory limits

1989 - Volatility limits on gasoline

1990 - New CAA Amendments

The Clean Air Act

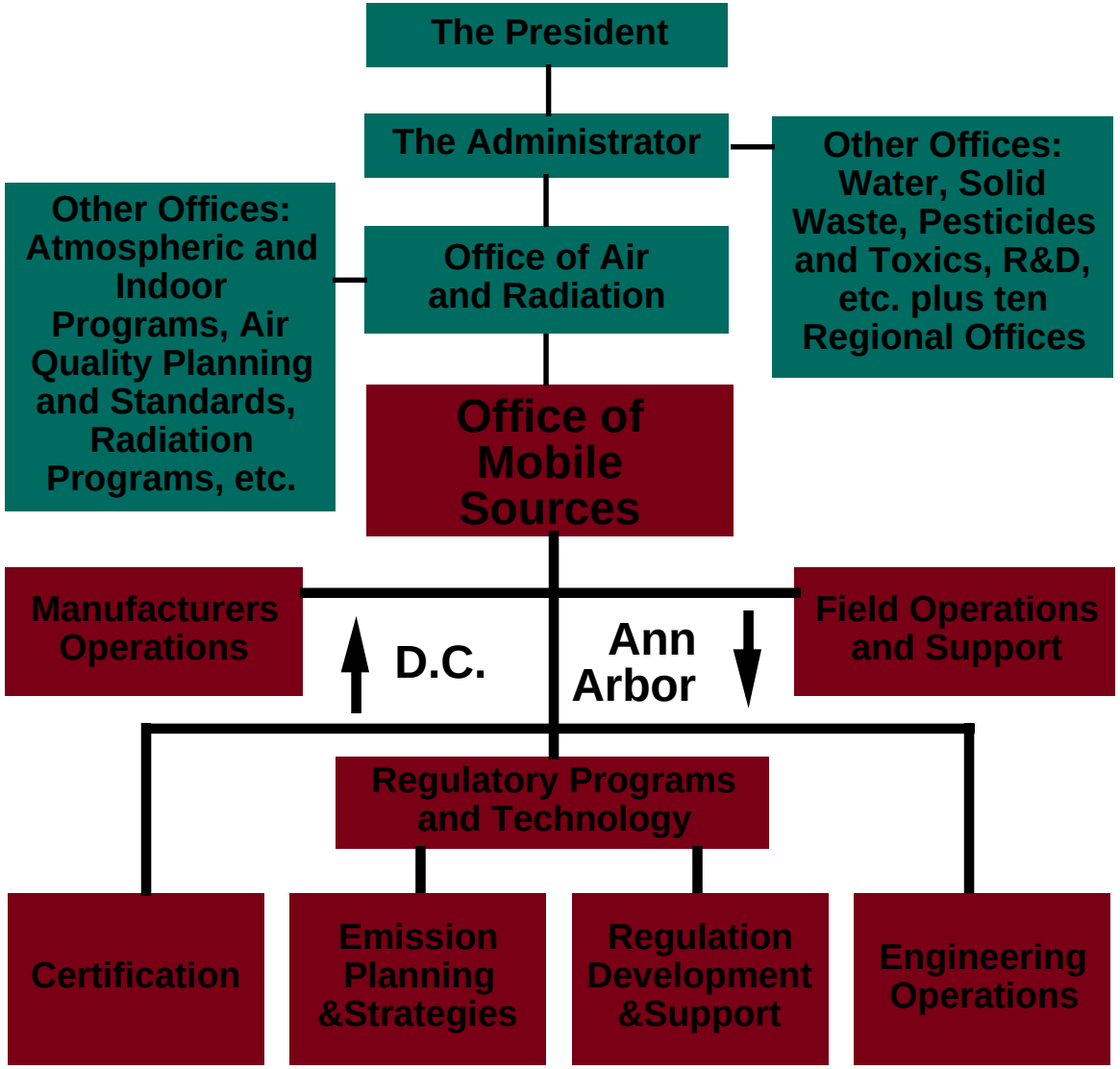
Congress found:

- **Most people now live in urban areas**
- **Growth results in air pollution**
- **Air pollution endangers living things**

It decided:

- **Prevention and control at the source was appropriate**
- **Such efforts are the responsibility of states and local authorities**
- **Federal funds and leadership are essential for the development of effective programs**

EPA's Office of Mobile Sources



EPA

EPA's National Vehicle and Fuel Emissions Laboratory

- **The NVFEL is located in Ann Arbor, Michigan. It is the government's national lab for motor fuels, mobile source emissions and fuel economy**
- **Over 1000 vehicles tested annually**
  - **-from manufacturers for certification**
  - **-from local owners for recall or calculations of air quality**
- **Other work includes:**
  - **-testing of heavy duty engines**
  - **-testing of nonroad mobile sources**
  - **-research on new pollutants**
  - **-development of procedures**
  - **-writing of regulations**
  - **-analysis of fuels & fuel additives**

EPA

A Few Facts about the NVFEL

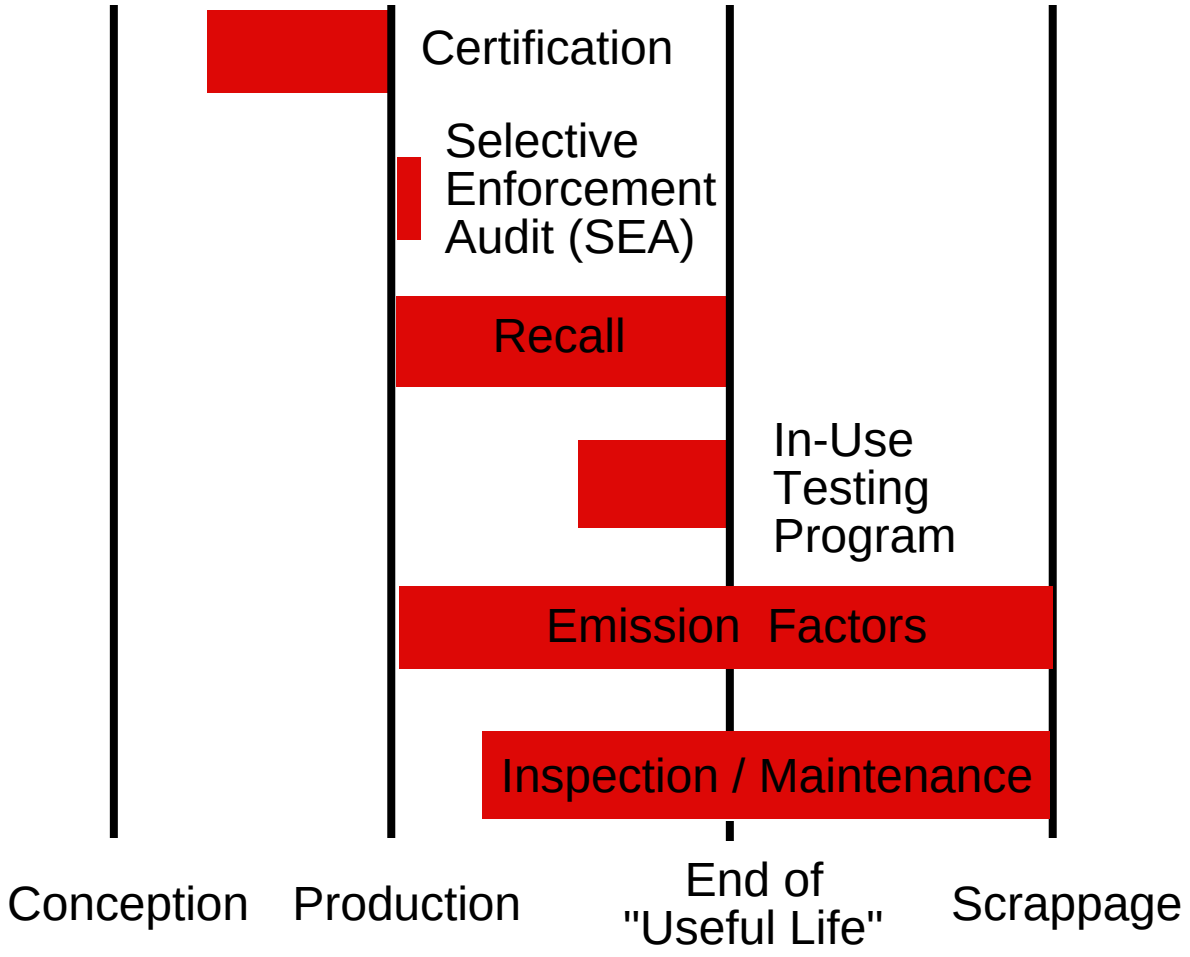
- **Built for EPA as an emissions laboratory in 1971**
- **Sold to EPA in 1991**
- **The building covers 3 acres on grounds of 15 acres**
- **About 500 people are employed**
- **Utility costs are over $1M/year**
- **Major additions in process but more are needed**
- **Additional office space to be leased**

EPA

EPA's Vehicle Testing Programs

- **Certification**: demonstrates that prototypes can meet standards
- **Selective Enforcement Audit** (SEA): tests production vehicles at the end of the assembly line
- **Recall**: monitors in-use vehicles to be sure they continue to meet standards during their "useful life"
- **Emission Factors**: tests in-use vehicles for calculations and projections of air quality
- **Inspection/Maintenance**: performed by state or local authorities to minimize effect of gross polluters

How EPA's Testing Programs Fit Together



The Life Cycle of a Vehicle

EPA

Outline

- The History of Air Pollution
- Air Pollution Today
- Why Control is Difficult
- The Impact of Motor Vehicles
- The Clean Air Act and EPA
- **How Vehicles are Tested**
- What We have Learned
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

EPA

Exhaust Emissions

- **Performed in the lab on a "chassis dynamometer" which simulates forces encountered on the road**
- **The basic test for emissions and city fuel economy is a trip to work**
- **Highway fuel economy is based on suburban and rural driving**
- **Exhaust gases are sampled during the tests and analyzed afterwards**
- **Distance travelled is recorded**
- **Results are expressed in grams per mile and miles per gallon**

EPA

Evaporative Emissions

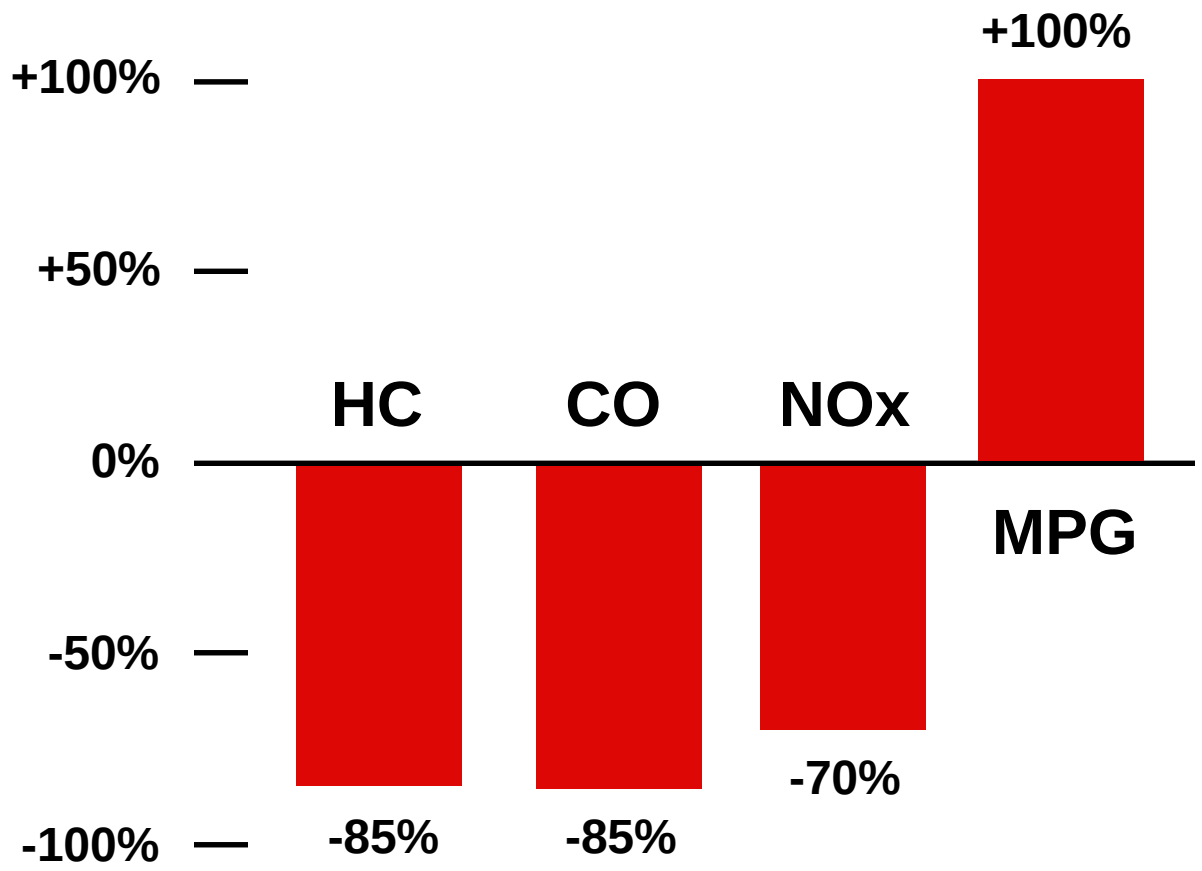
- **Performed in the lab using a SHED (Sealed Housing for Evaporative Determinations)**
- **This two part test approximates conditions encountered by a vehicle on a typical summer day**
- **The Diurnal (daily) part measures vapors which escape from the vehicle as the fuel warms up**
- **The Hot Soak part measures vapors which are given off from a hot engine and fuel system**

EPA

Outline

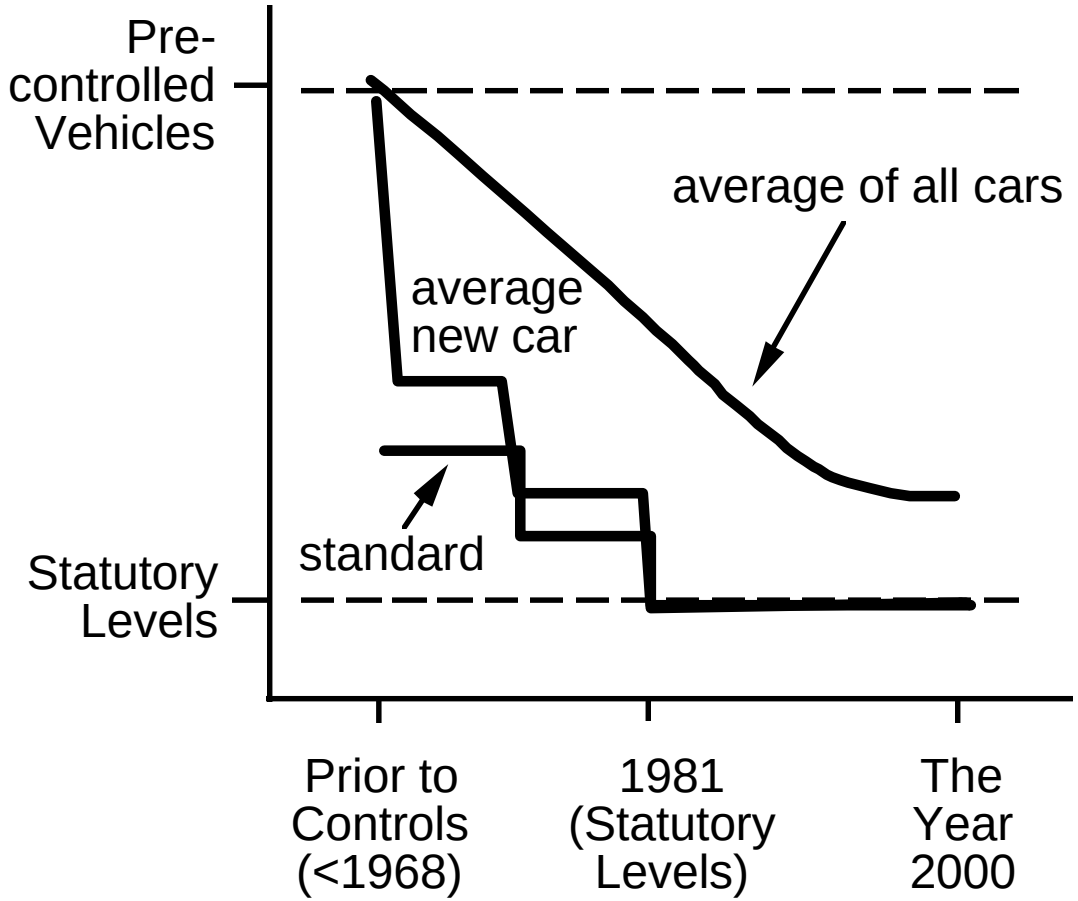
- The History of Air Pollution
- Air Pollution Today
- Why Control is Difficult
- The Impact of Motor Vehicles
- The Clean Air Act and EPA
- How Vehicles are Tested
- **What We have Learned**
- Conclusions
- EPA's Next Steps
- What You Can Do to Help

New Cars are Cleaner and More Efficient

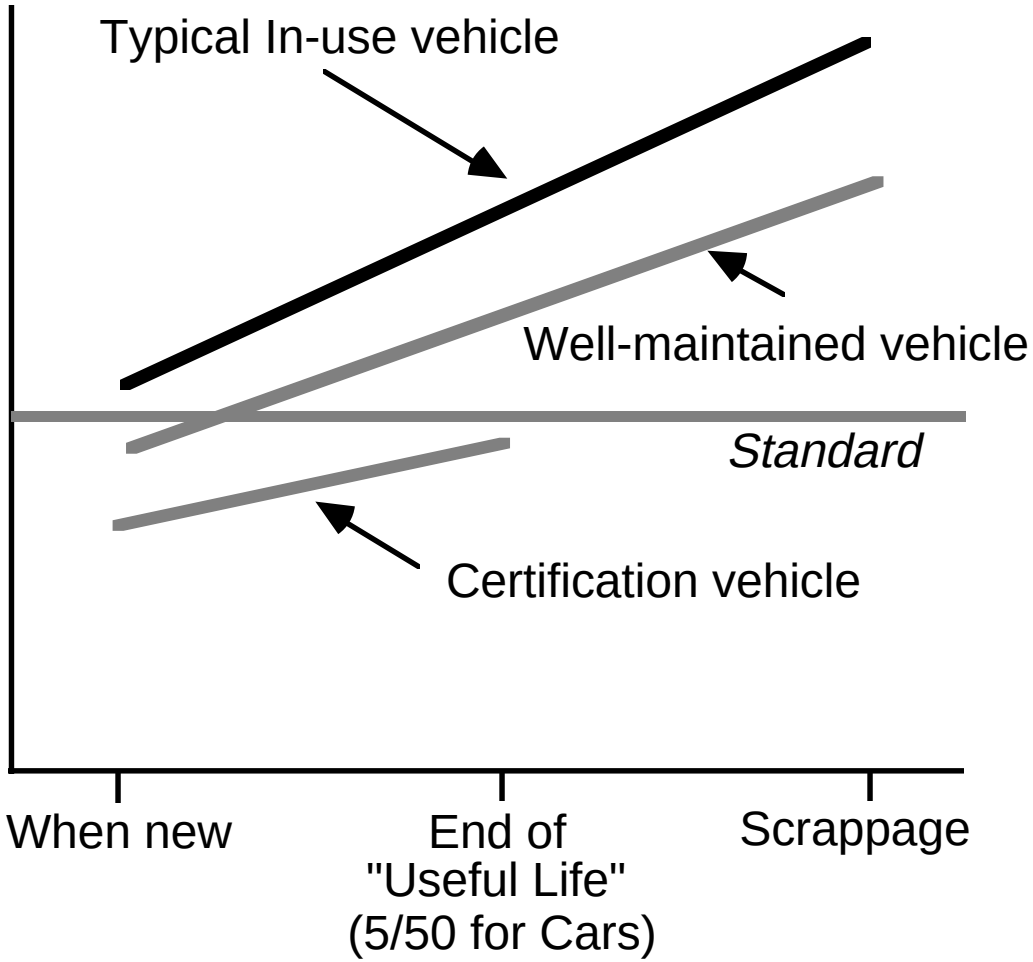


Percent change compared to new cars of the 1970 Model Year

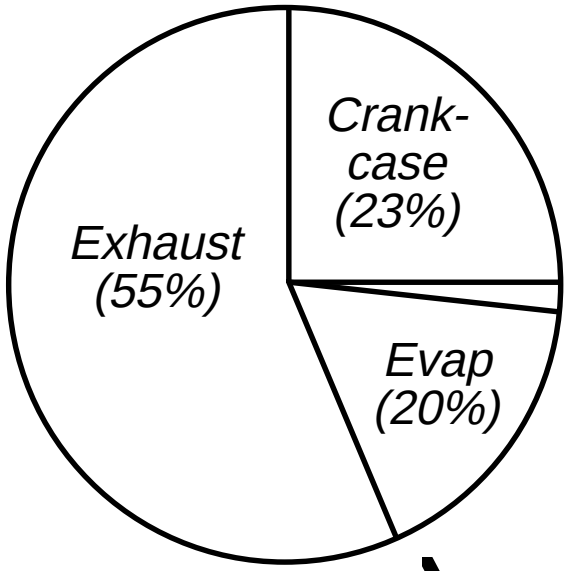
Vehicle Emissions over the Years



Vehicle Emissions versus Age



HC Emissions: Then and Now

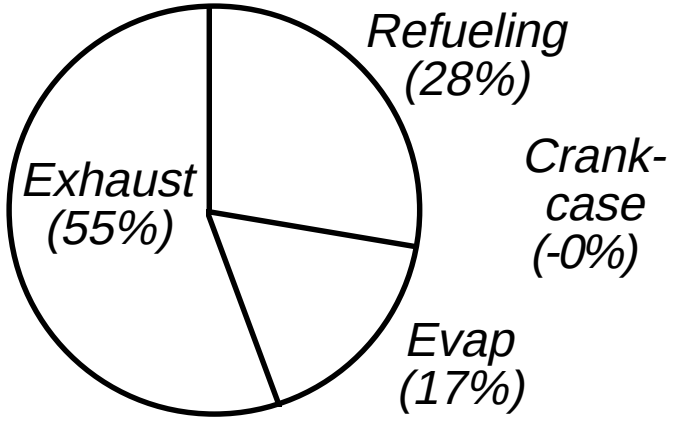


Then

Refueling (2%)

- More vehicles
- More miles
- More volatile fuel
- Other factors

+Public Awareness
+Nationwide Programs



Now

EPA

Outline

- The History of Air Pollution
- Air Pollution Today
- Why Control is Difficult
- The Impact of Motor Vehicles
- The Clean Air Act and EPA
- How Vehicles are Tested
- What We have Learned
- **Conclusions**
- **EPA's Next Steps**
- **What You Can Do to Help**

EPA

Conclusions

- **Controlling air pollution is difficult and complex**
- **We are making headway despite opposing factors**
- **Motor vehicles are doing reasonably well**
- **There is some spirit of cooperation between EPA, the public, the regulated industry and the affected areas**
- **Despite successes, there is still much to be done**

EPA

EPA's Next Steps: The CAAA of 1990

- **Achieve Compliance with NAAQS** to protect public health for over 74 million citizens
- **Reduce Acid Rain** to protect lakes, monuments, visibility and public health
- **Reduce Air Toxics** which cause cancer and major problems for ecosystems
- **Protect the Ozone Layer** to minimize increases in UV radiation

EPA

Principles of Imple-mentation

- **E3** (**E**nvironment, **E**conomic Growth and **E**nergy Policy)
- **Market-based** approaches will seek innovative strategies to allow the greatest benefit for all
- **Consensus-building** requires coordination with all interested parties and will result in joint ventures with state and local governments and consultation and negotiations with industry and environmental groups

EPA

Oppor-tunities

- **Better Control of In-Use Emissions**
  - 10% of cars cause half of all the hydrocarbon emissions from the fleet
  - tuned cars are clean and efficient
- **Cleaner Fuels**
  - advances possible, even with gasoline
- **Marketing**
  - less uncertainty about regulations
  - "green" products are attractive

EPA

Basic Provisions for Motor Vehicles

- **Strengthen Key Components of Earlier Laws**
  - Tighter tailpipe standards
  - Expansion of I/M programs
  - Tampering illegal for individuals
  - Extended durability
  - Constraints on lead and additives

- **Implement New Concepts**
  - On-board diagnostics
  - Clean fuels
  - Non-road engines
  - Alternative transportation programs

EPA

The Car of the Future

- **Almost no emissions** since new controls and clean fuels will virtually eliminate tailpipe pollution while new fuels and various trapping techniques, solvent-free adhesives, water-based paint and replacement of CFCs will minimize evaporative emissions
- **High Fuel Economy** due to powertrain mods, aerodynamics and lightweight materials
- **Reduced Air Toxics** through new fuels and elimination of parts with asbestos, mercury, cadmium, etc.
- **Recyclable or Degradable Parts**
- **Enhanced Safety Features**

EPA

What <u>You</u> Can Do to Help

- **Be aware** of issues and developments in this area
- **Be supportive** where appropriate
- **Maintain your car**
- **Be careful** when refueling
- **Drive smoothly**
- **Help reduce VMT (Vehicle Miles Traveled)**
  - plan your errands
  - promote car pooling
  - use public transportation
  - walk or bike

Fundamentals

of

Air Pollution

and

Motor Vehicle Emissions

EPA

Speaker Info

- **John T. White**
- Assistant to the Director, Engineering Operations Division
- U.S. Environmental Protection Agency
- National Vehicle and Fuel Emissions Laboratory
- 2565 Plymouth Road
- Ann Arbor, Michigan 48105
- (313) 668-4353
- FAX: (313) 668-4440