Nitrogen Emissions from U.S. Transportation Sources

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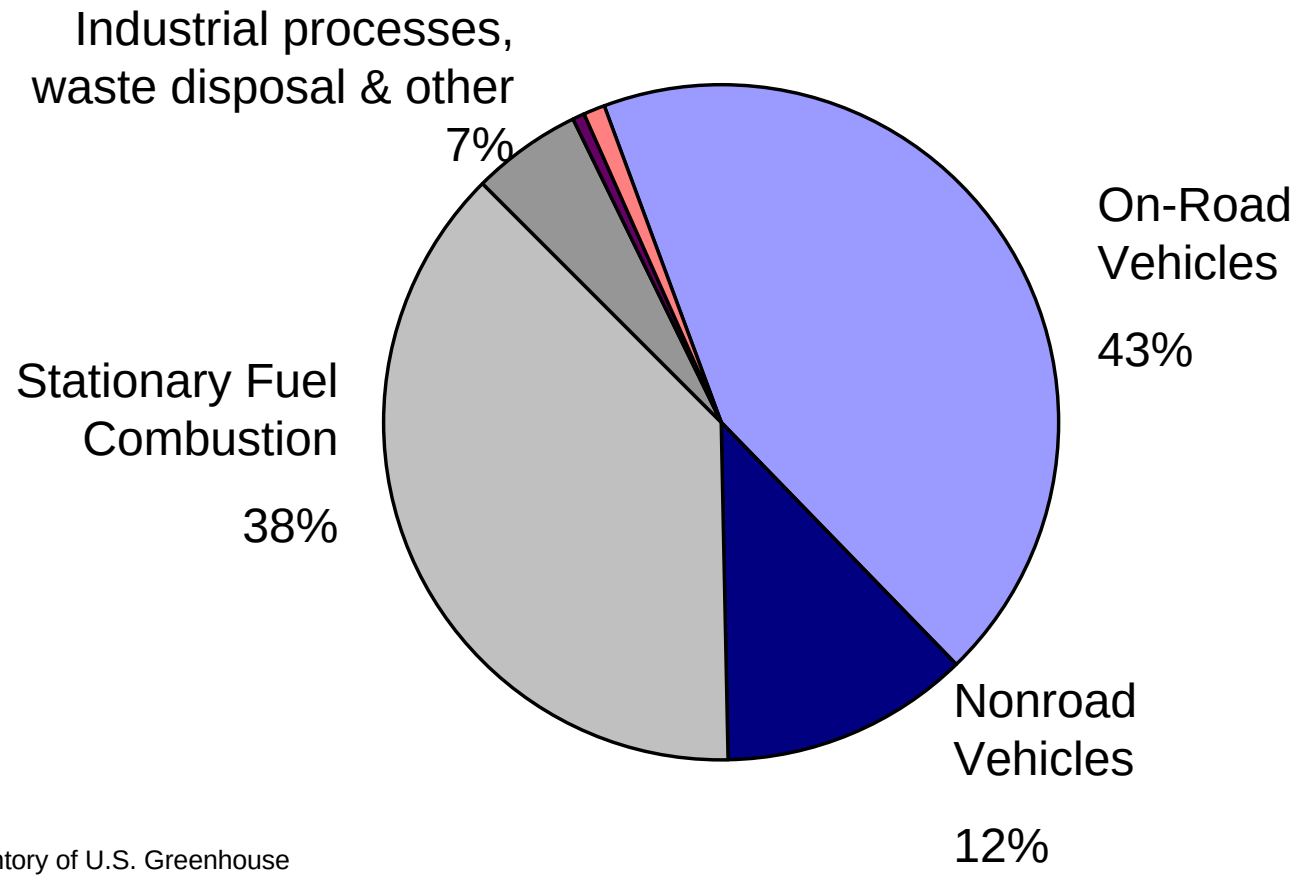
Overview

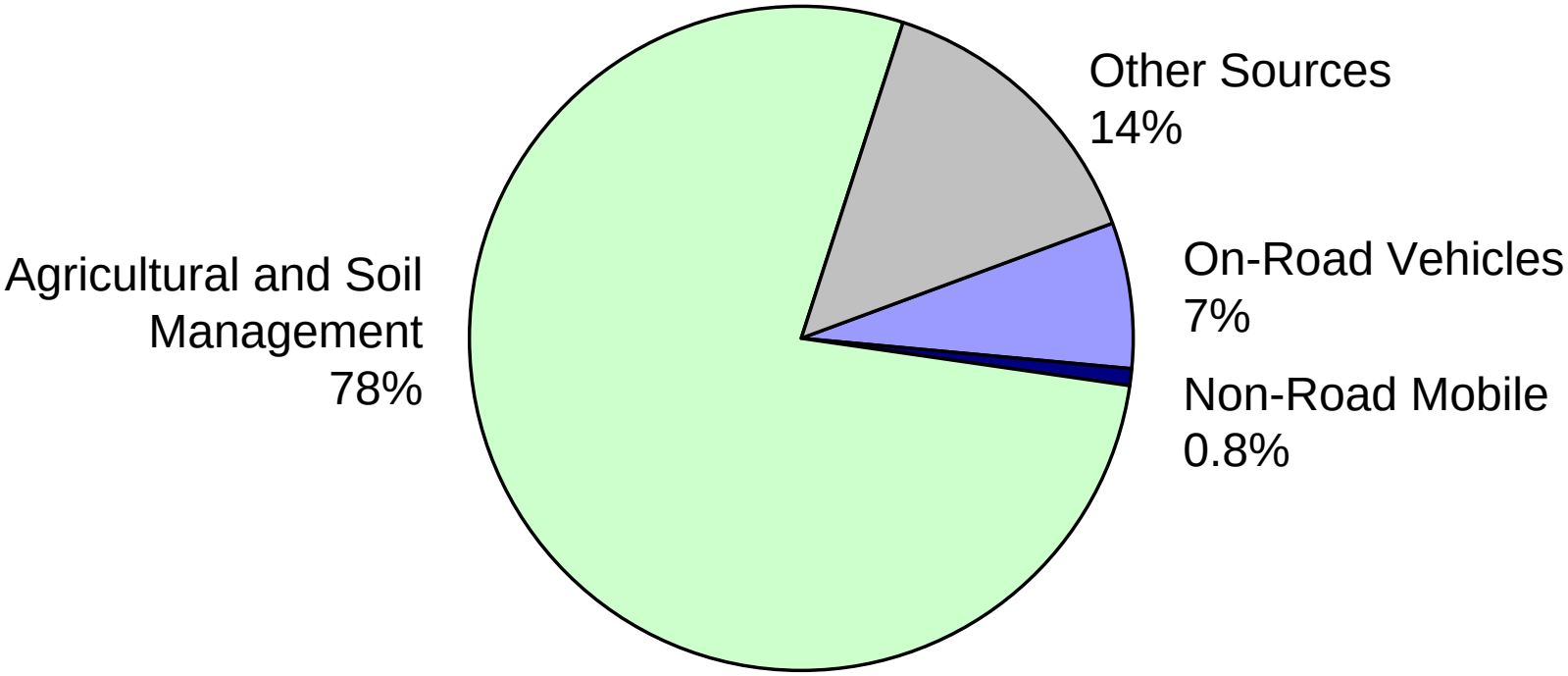
- Transportation Combustion emissions
  - NO_x
  - N_2O
  - Relative significance of activity trends and emissions controls
- Factors affecting transportation fuel consumption and GHG emissions
- Relationship of NOx / N2O emissions controls to fuel consumption

U.S. NO_X Emissions in 2005



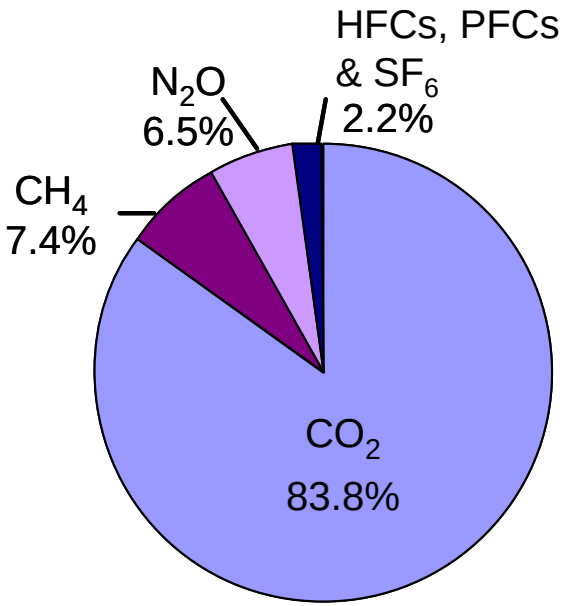
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

U.S. N_2O Emissions in 2005

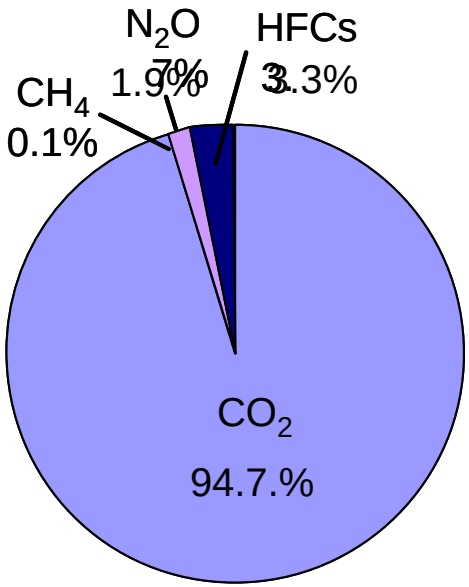


Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Greenhouse Gas Emissions by Gas, 2005



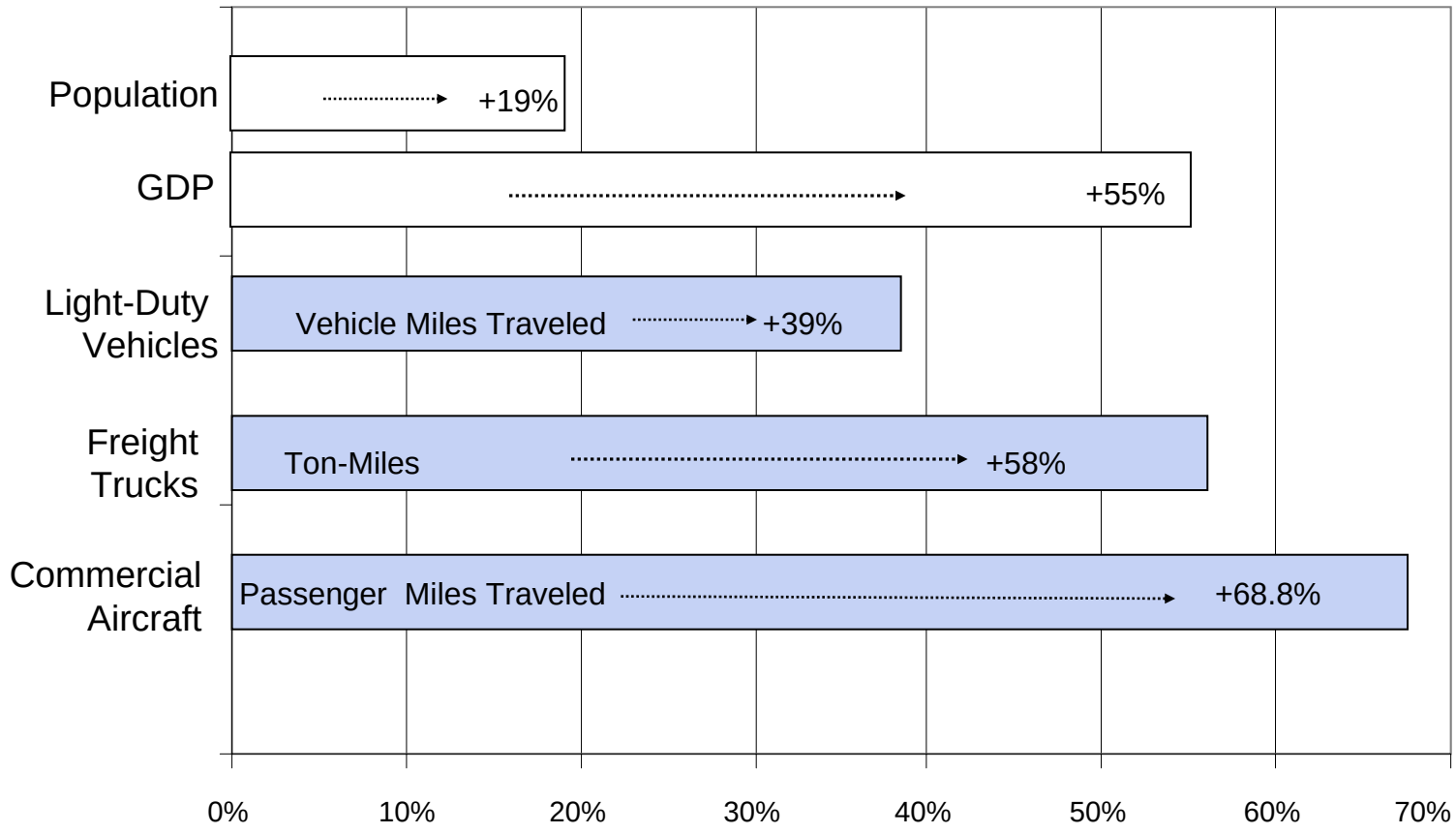
All U.S. Sources



Transportation Only

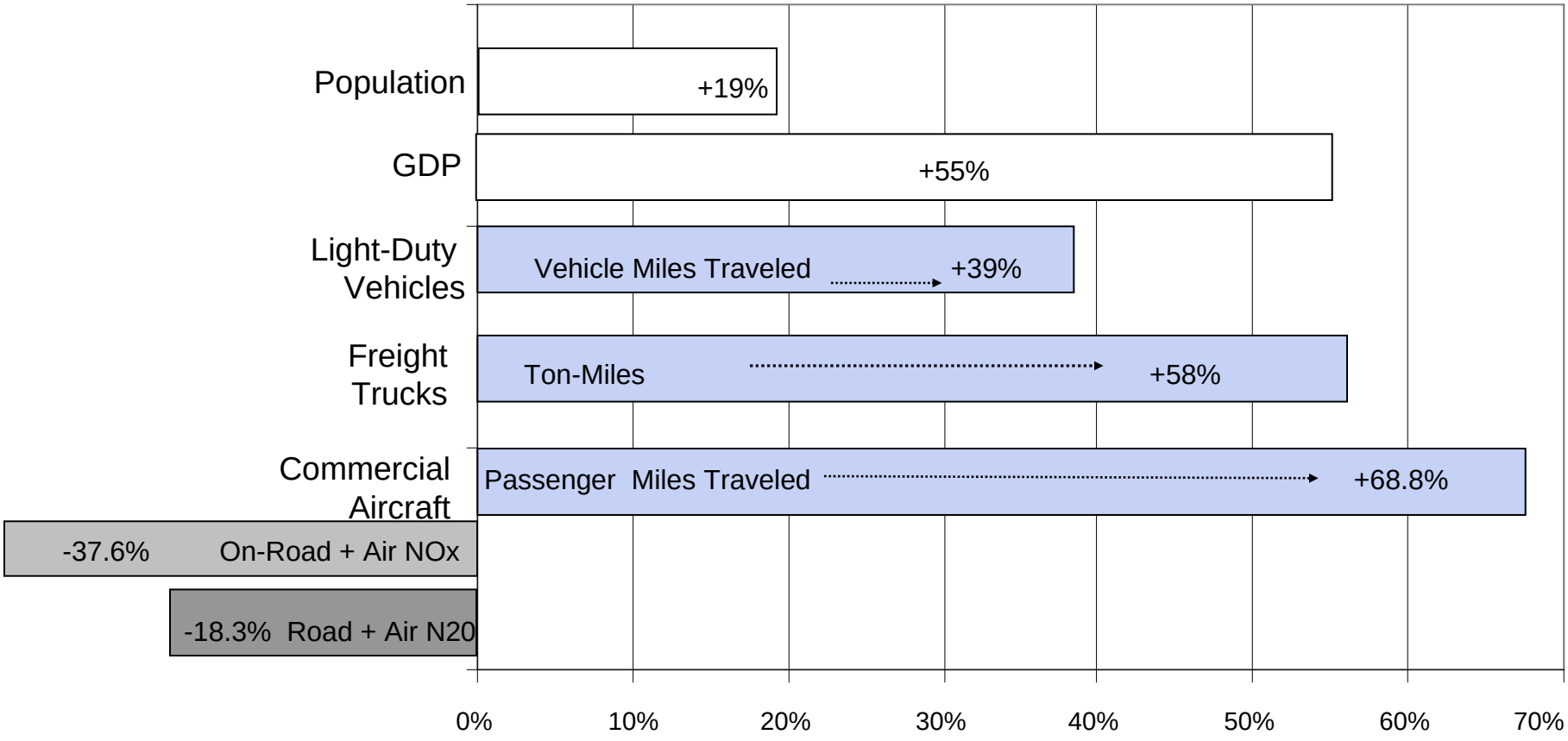
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Change in U.S. Vehicle Movement, 1990-2005



Sources: Highway Statistics 2006 Table VM-1,
National Transportation Statistics 2005 Table 4-21

Change in U.S. Vehicle Movement, 1990-2005

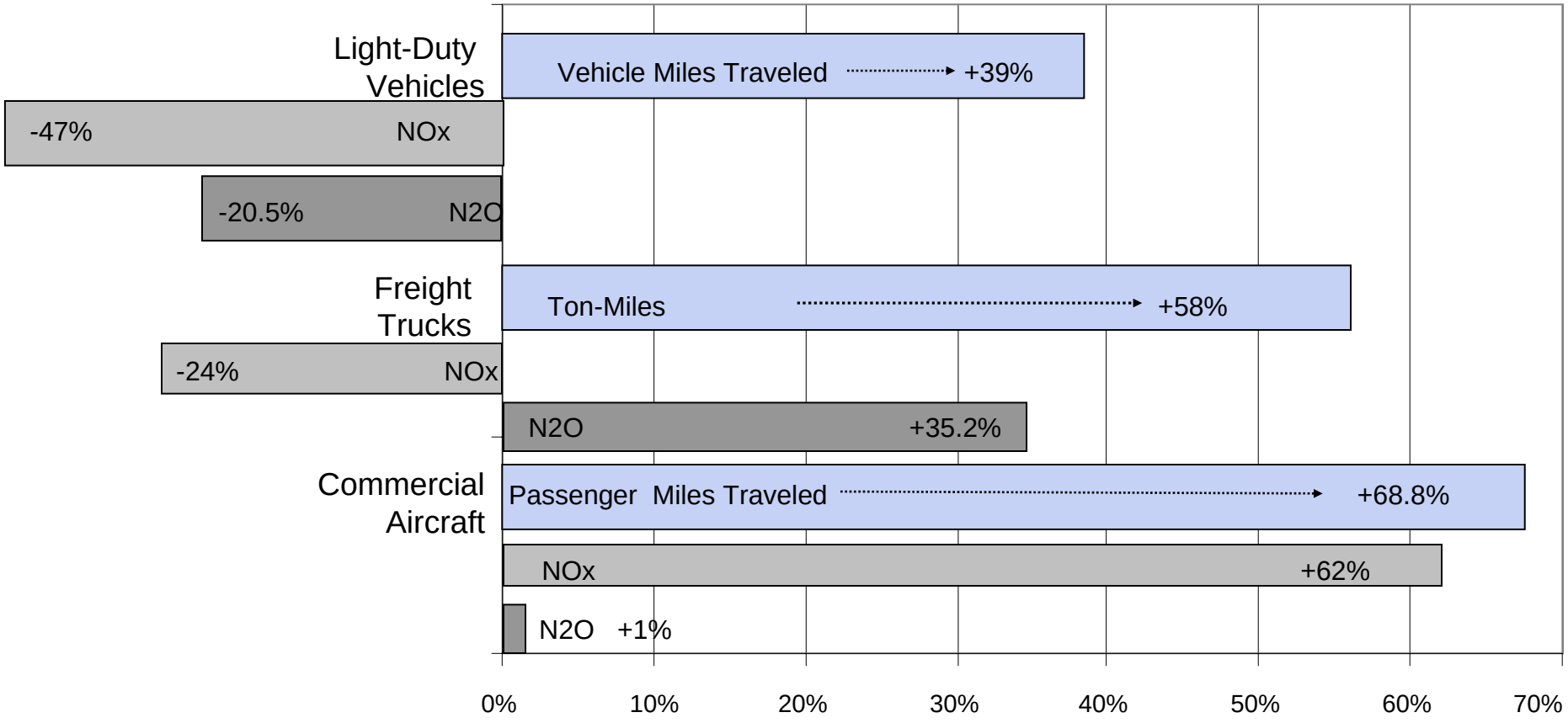


Sources: Highway Statistics 2006 Table VM-1,
National Transportation Statistics 2005 Table 4-21
Inventory of U.S. GHG Emissions and Sinks

Factors Affecting Mobile N_2O and NO_X tailpipe emissions

- Vehicle activity
- Fuel consumption
- Fuel characteristics
- Air-Fuel mixes
- Combustion temperatures
- **Emissions control equipment**

Change in U.S. Vehicle Movement, 1990-2005



Sources: Highway Statistics 2006 Table VM-1,
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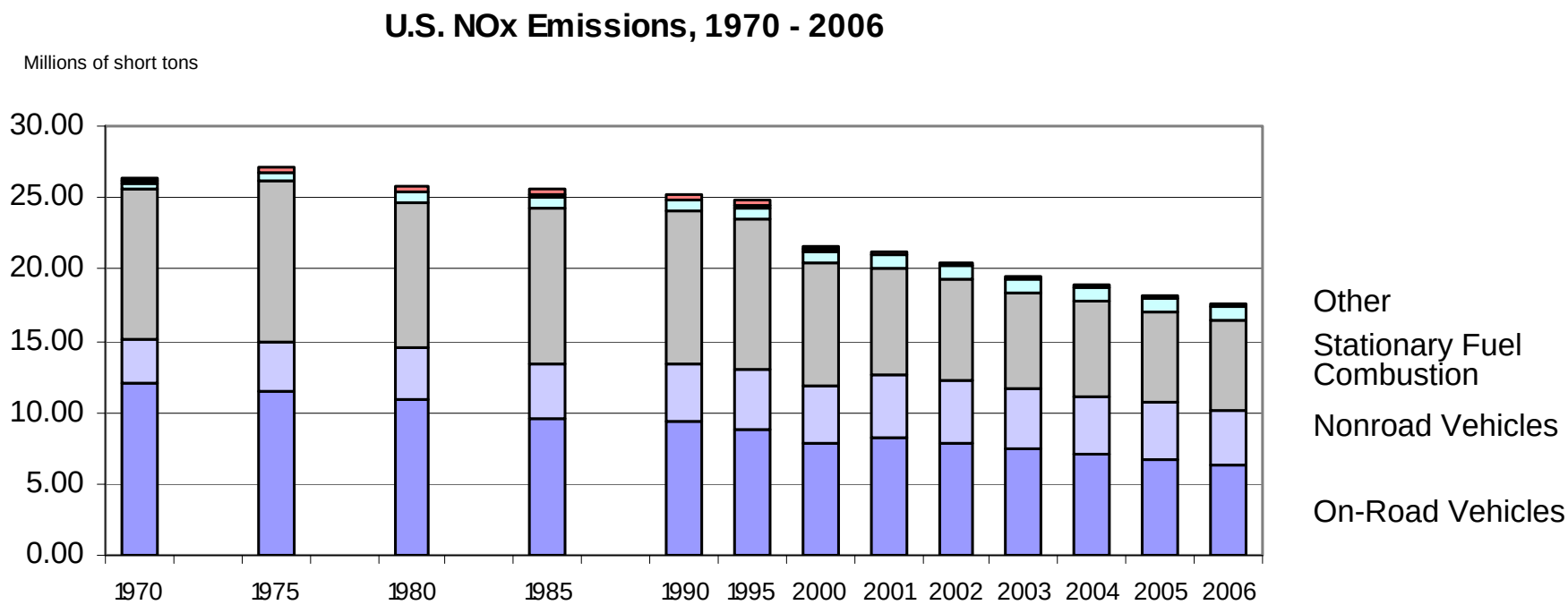
NO_x Trends



Oxidation Catalyst 1975 to 1980 (cars) and 1980 to 1985 (trucks)

egan e y
1980s; common until 1984

Implemented in cars and LD trucks

3-way catalyst; on-board diagnostic computer and oxygen sensor

Reduced NOX to nitrogen and oxygen; 1.0 g / mil for cars

Added advanced emissions controls, including elec. Controlled fuel injection & ignition timing, EGR and air injection

NOx reduced 60 percent from Tier 0

Diesel truck and bus standards

Locomotive and Marine Rule

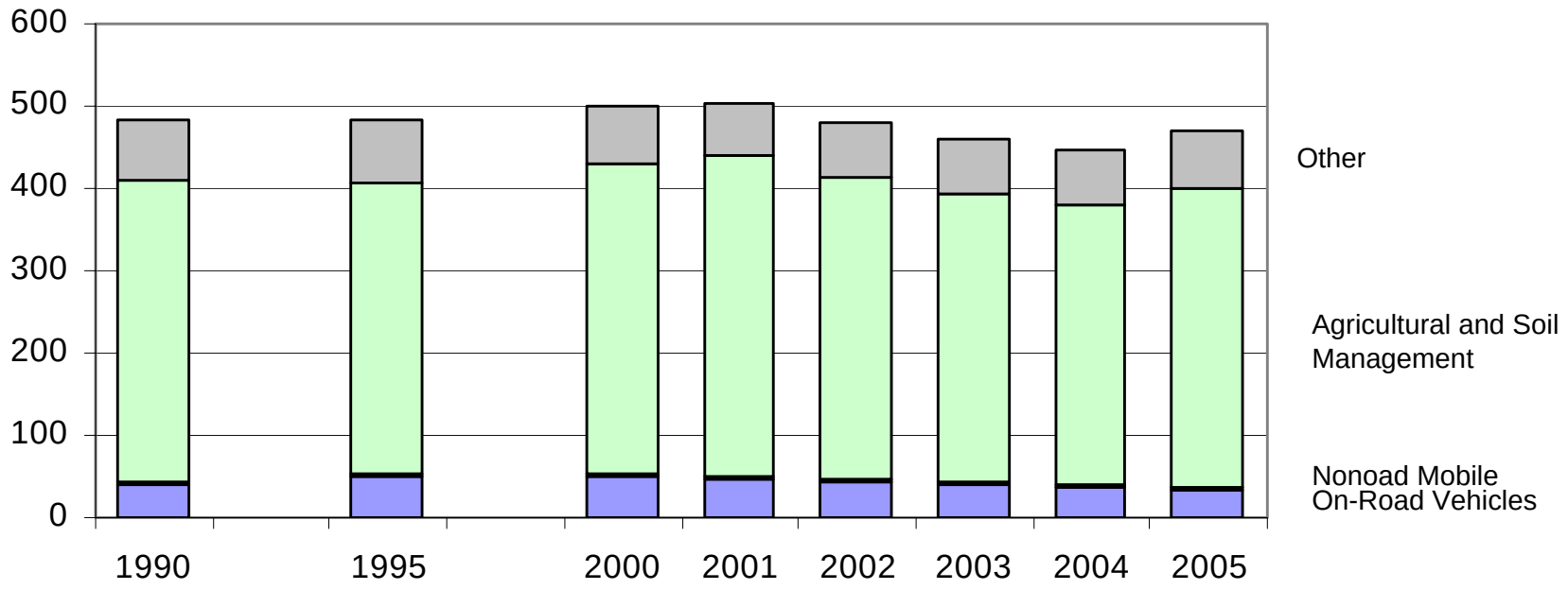
EPA Tier 2 - 2004

Added more advanced emissions controls, including improved combustion,

NOx reduced 90 percent from Tier 0

Nonroad Diesel Rule

N_2O Trends

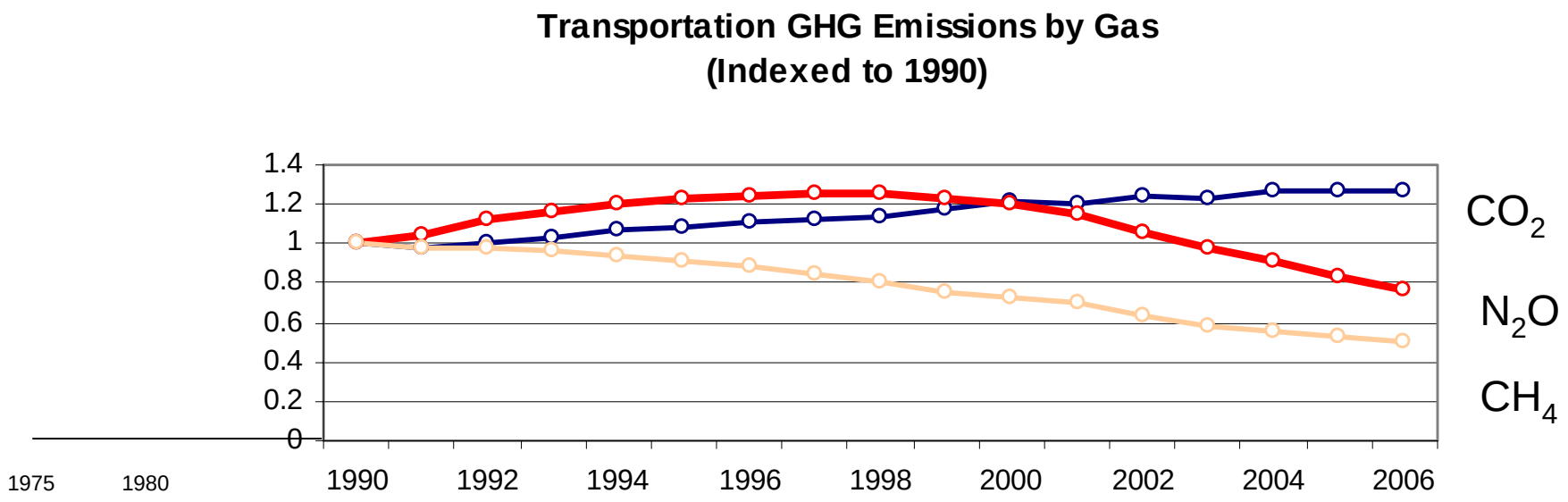


Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Factors Affecting Mobile N2O and NOX tailpipe emissions

- Fuel characteristics
- Air-Fuel mixes
- Combustion temperatures
- Use of pollution control equipment
- **N2O in particular can be formed by catalytic processes used to control NOx, CO, and hydrocarbon emissions**

Impact of Emissions Control Devices on Transportation N2O Emissions



Oxidation Catalyst 1975 to 1980 (cars) and 1980 to 1985 (trucks)

Increased N2O emissions rate almost 3X

Rate = 0.050 g / mile

EPA Tier O –

Increased per-mile N2O through NOx controls

Rate = 0.064 g / mi

EPA Tier 1

Reduced N2O emissions rates, but still higher than non-catalyst systems

Rate = 0.0429 g / mi

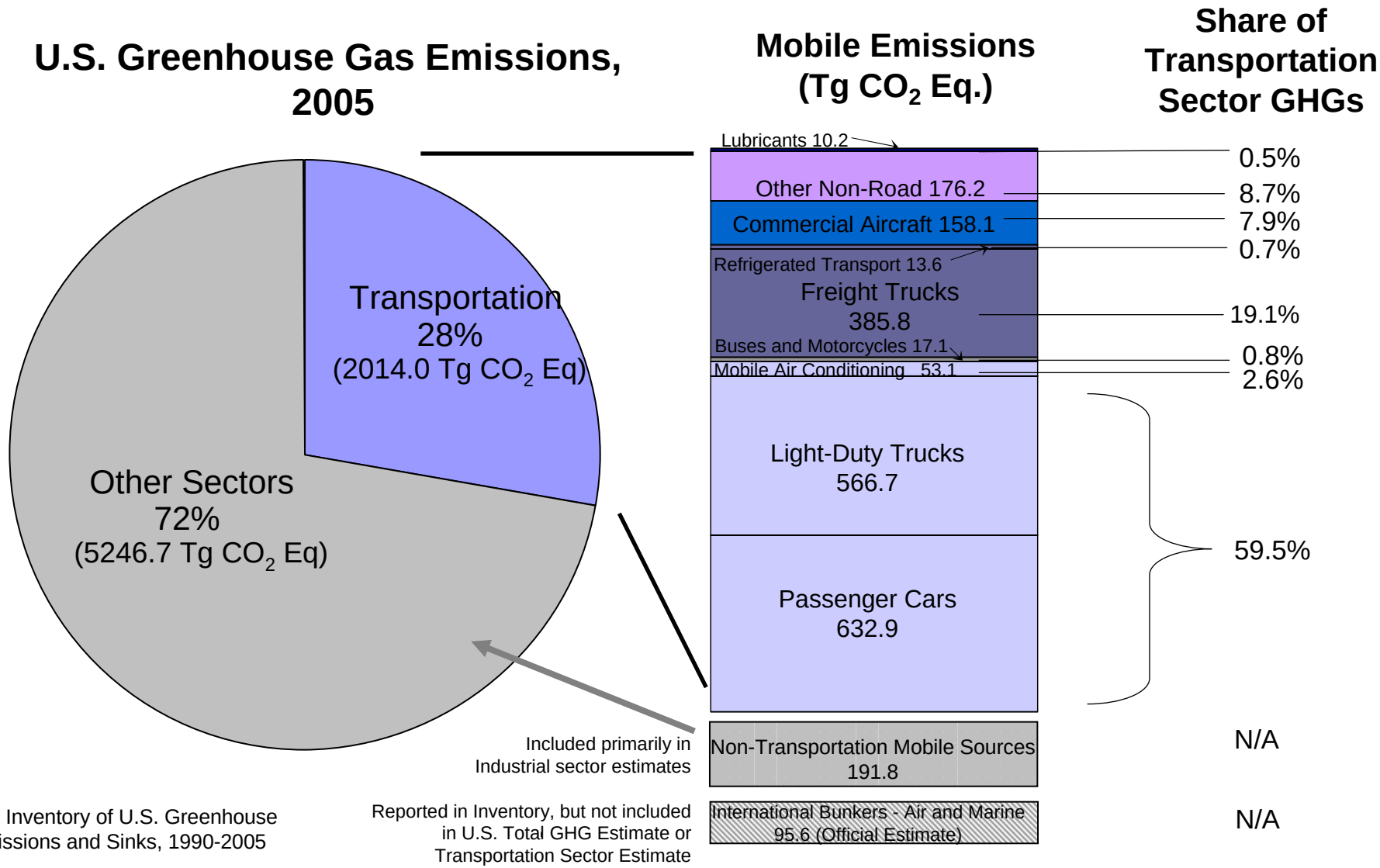
EPA Tier 2 – 2004

Reduced N2O emissions by 90 percent relative to Tier 1

Rate = 0.0036 g / mi

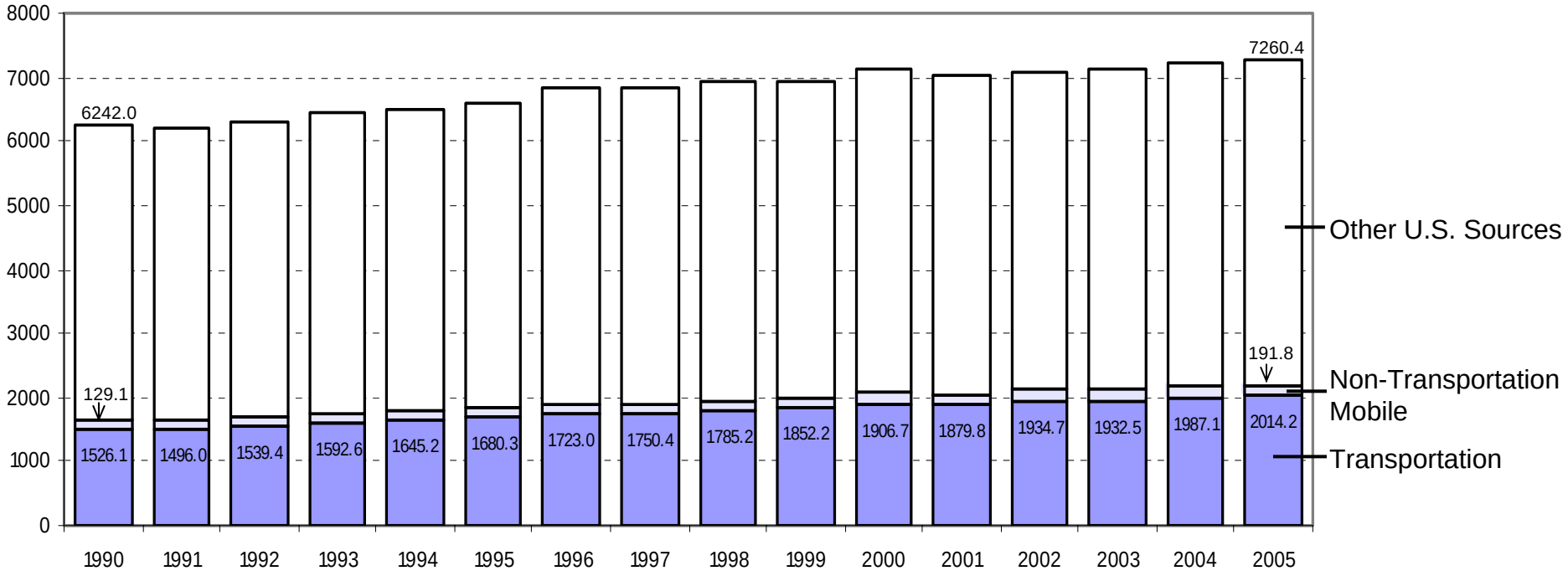
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Transportation Source GHGs Relative to Total U.S. Emissions



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

U.S. Greenhouse Gas Emissions, 1990-2005, Transportation and other U.S. Sources

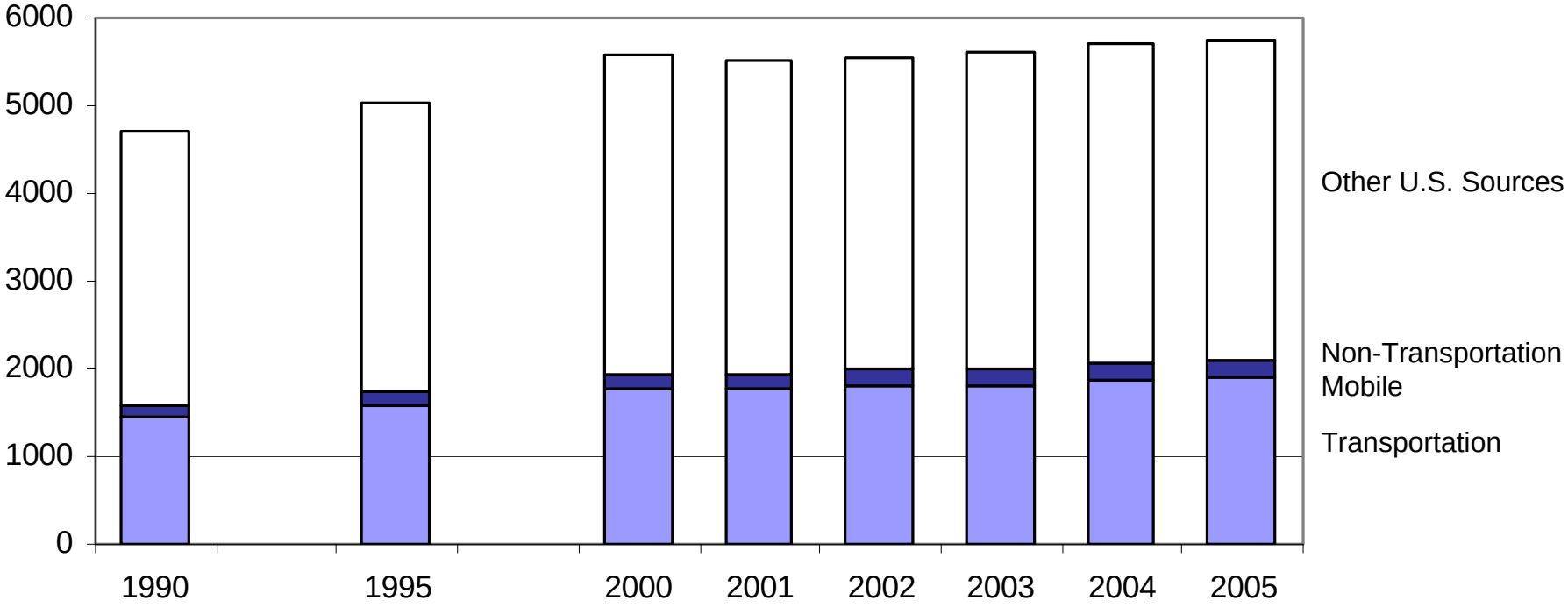


Absolute increase, 1990-2005		Percent Change, 1990-2005	
Transportation	+ 487.9 Tg CO_2 Eq.	Transportation	+32.0%
Non-Trans Mobile	+62.7 Tg Co2 Eq.	Non-Trans Mobile	+48.6%
All other sources	+ 467.8 Tg CO_2 Eq.	All other sources	+ 10.2%
Total	+1018.4 Tg CO_2 Eq.	Total (including transport)	+16.3%

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Impact of U.S. Fuel Consumption since 1990

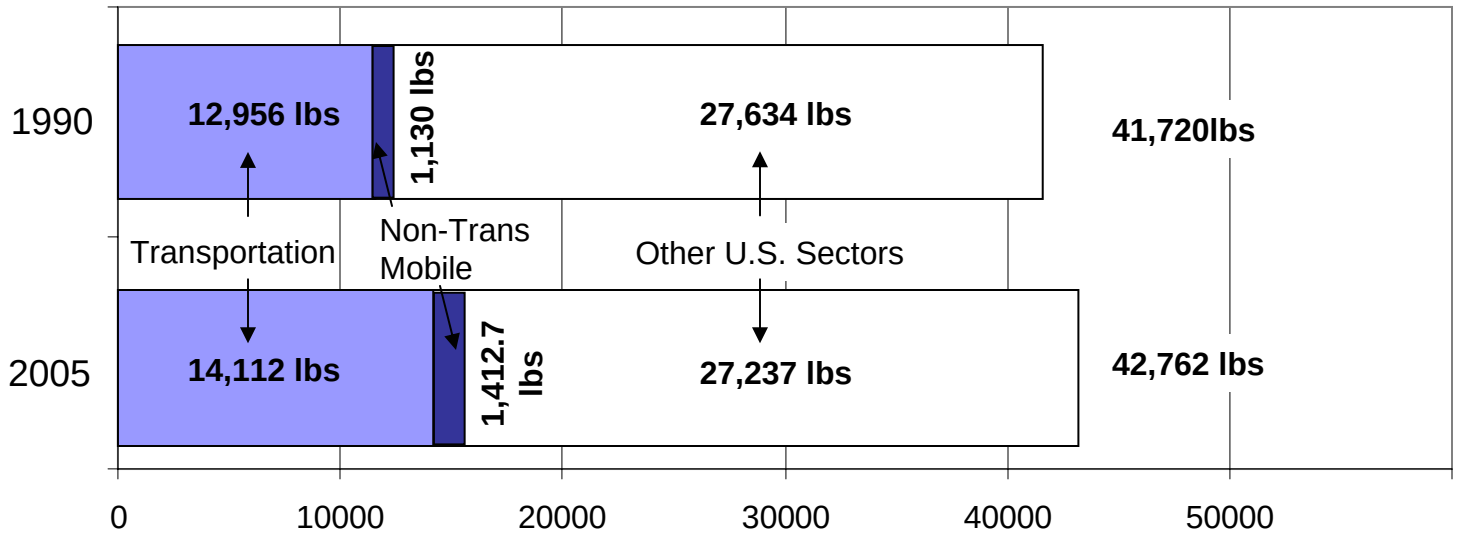
US CO_2 Emissions from Fossil Fuel Combustion



Absolute increase, 1990-2005	
Transportation	+ 431.9 Tg
Non-Trans Mobile	+ 62.1 Tg
All other sources	+ 534.1 Tg
Total	+1027.1 Tg

Percent Change, 1990-2005	
Transportation	+29.4%
Non-Trans Mobile	+48.6%
All other sources	+ 11.2%
Total (including transport)	+21.7%

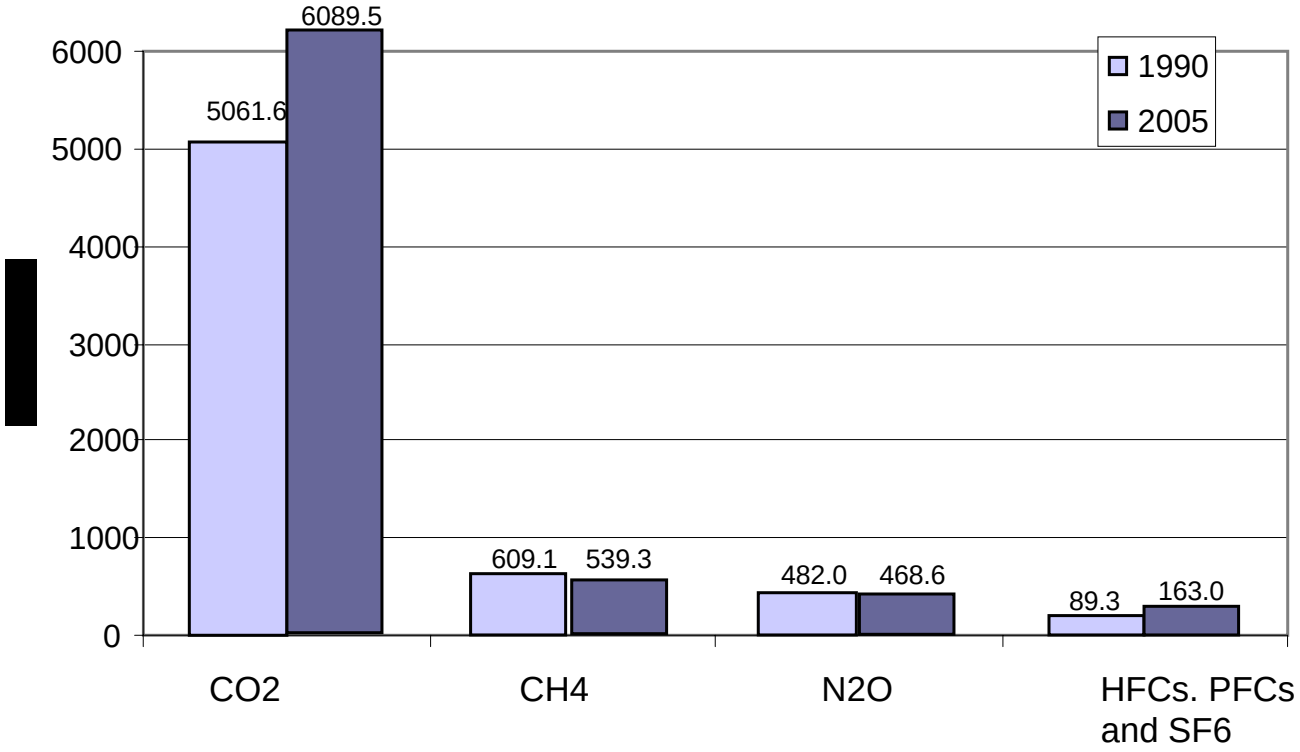
Per Capita CO2 Emissions from Fossil Fuel Combustion, 1990 and 2005



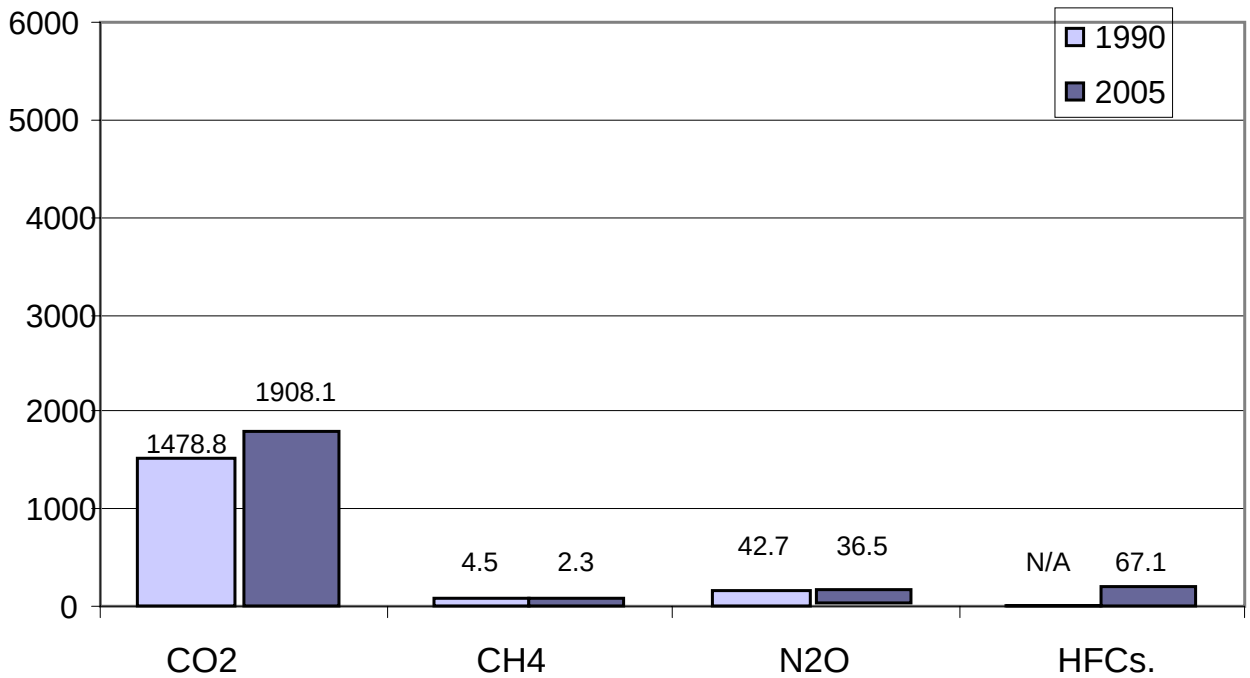
Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

U.S. Census Bureau, Population Division

U.S. GHG Emissions by Gas - All Sources 1990 and 2005

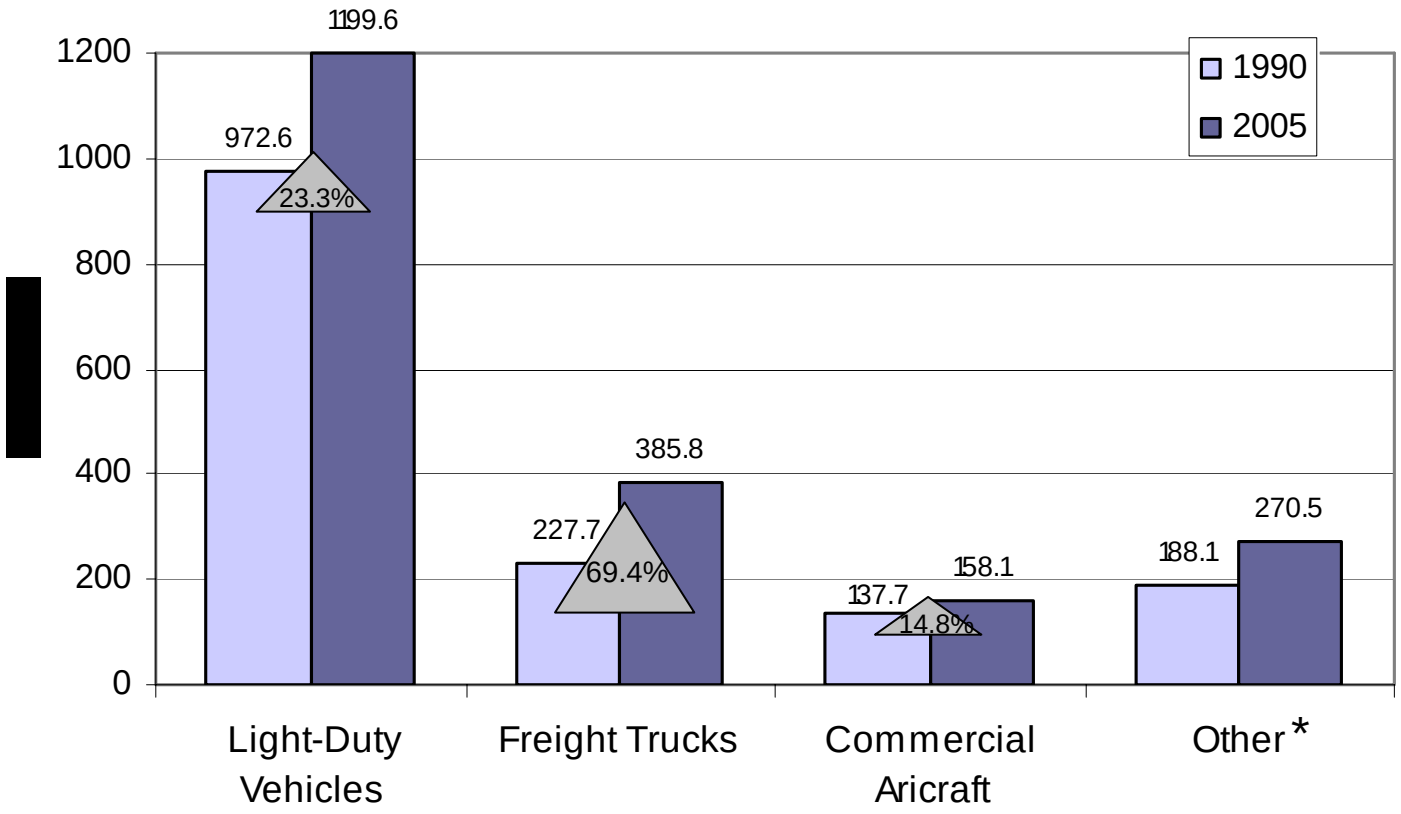


U.S. Transportation GHG Emissions by Gas, 1990 and 2005



(Reflects the phase-in HFCs for ozone-deleting substances)

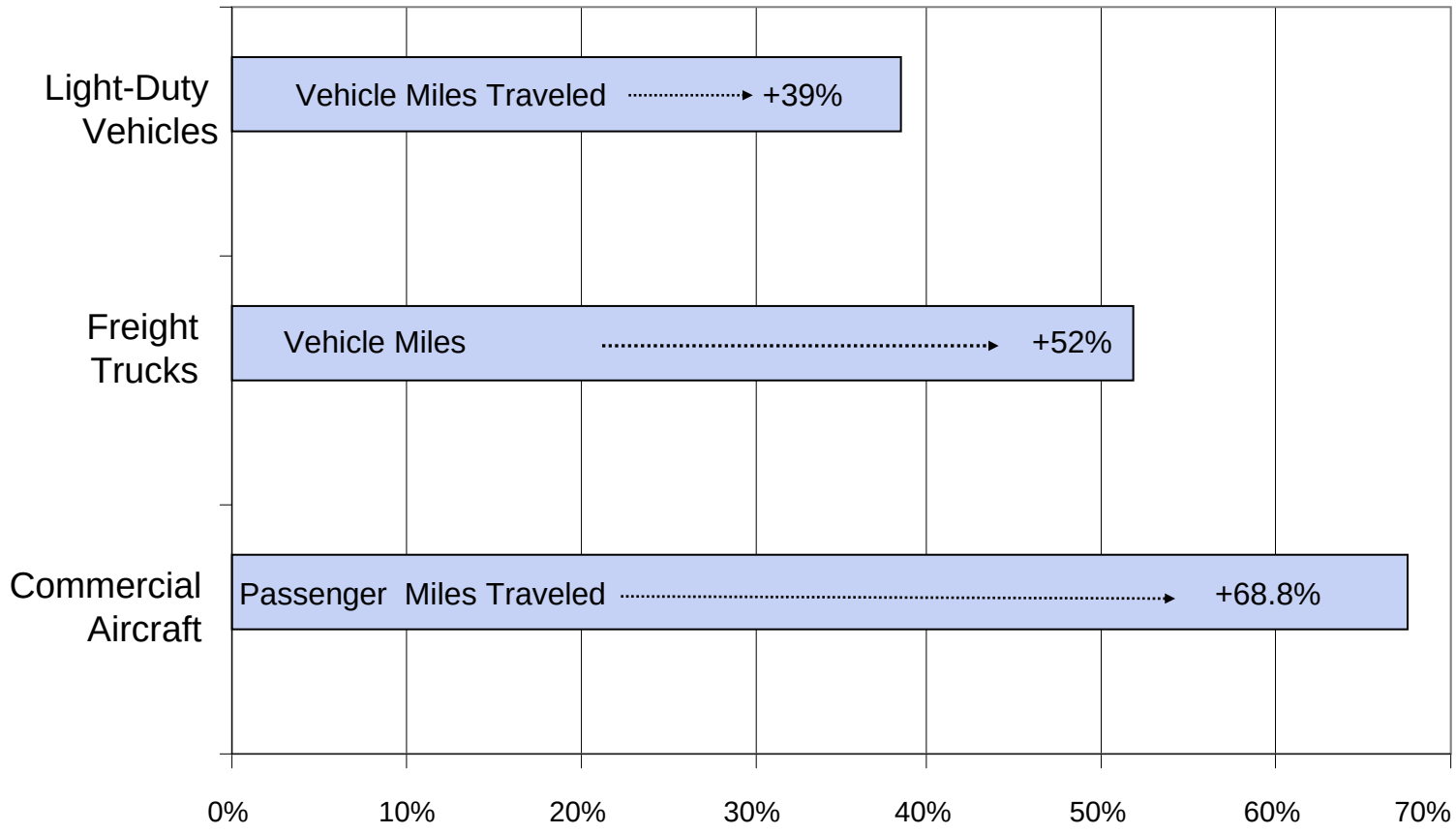
US Transportation GHGs by Major Source, 1990 and 2005



*Other GHGs include emissions from HFCs, which were introduced beginning in the early 1990s to replace ozone depleting substances; increase from 1990 is not meaningful.

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

Change in Vehicle Movement, 1990-2005



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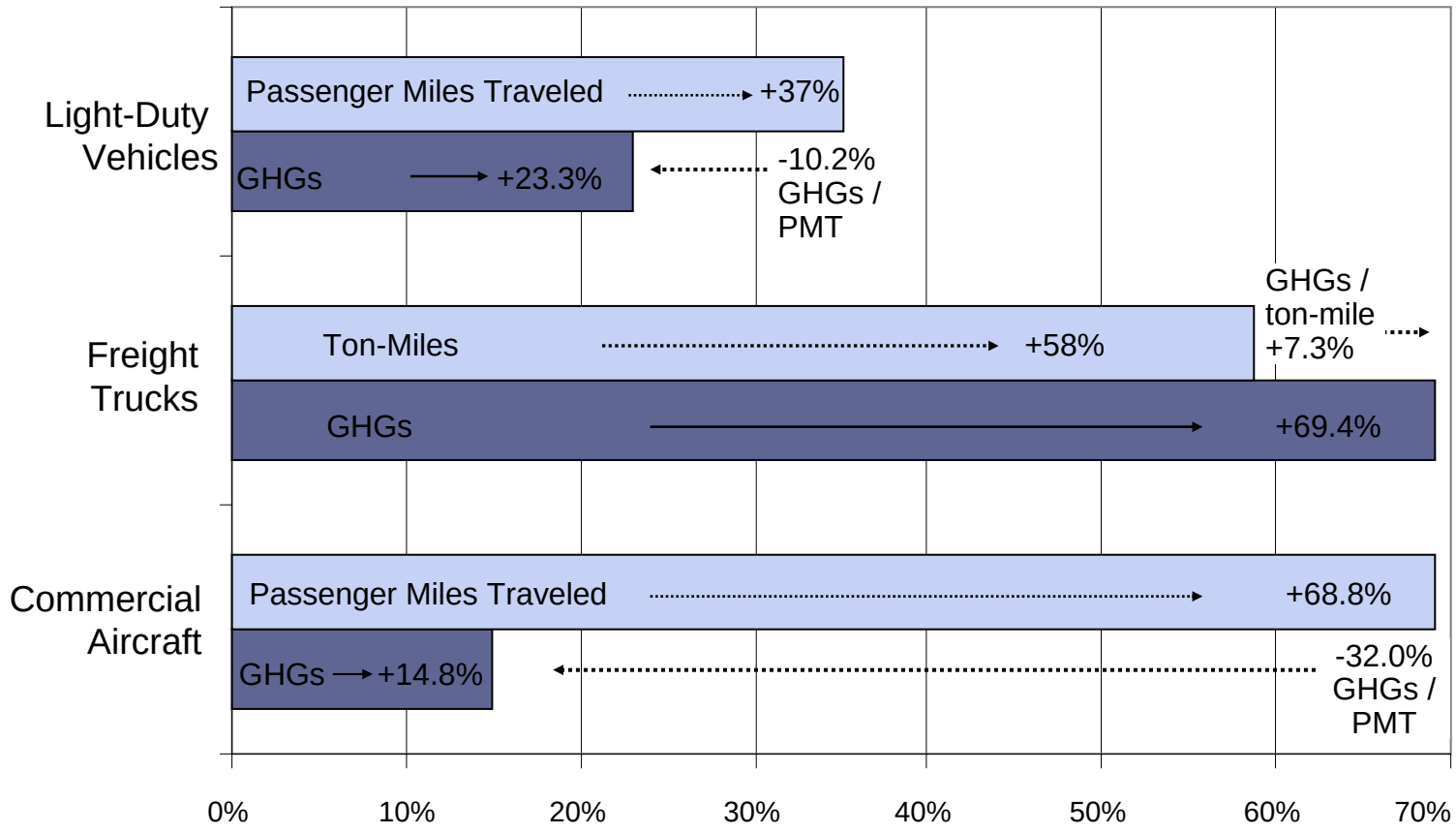
National Transportation Statistics 2005 Table 4-21

Change in Activity, Intensity and GHGs, 1990-2005 (Passenger Miles and Ton-Miles)

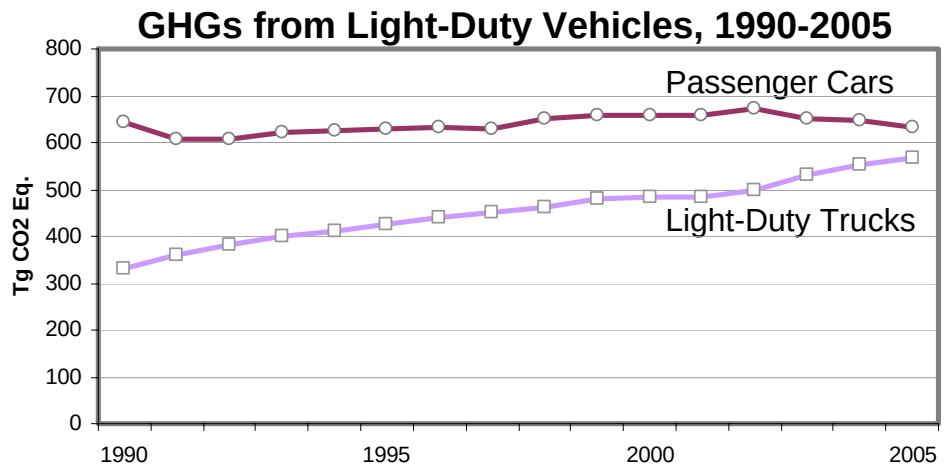


Sources: Highway Statistics 2006 Table VM-1,
National Transportation Statistics 2005 Table 4-21

Light-Duty Vehicles

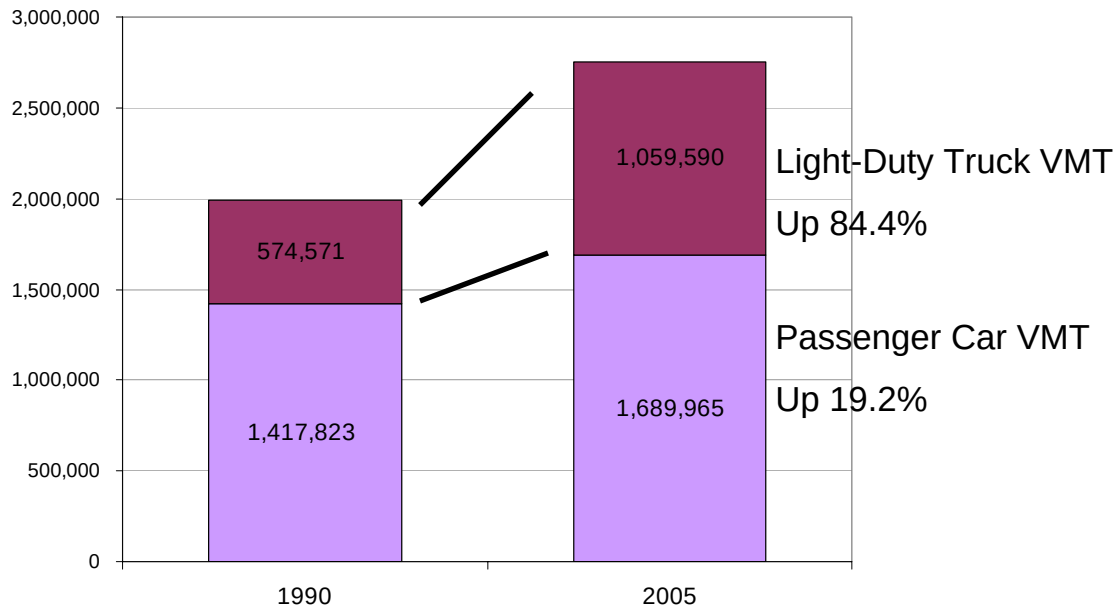
1990-2005

- GHGs up 23.3%; annualized increase of 1.3%
- Passenger Car GHGs decreased by just under 2%
- LD Truck GHGs increased by 72%
- Total VMT up 38 percent (mainly light-duty truck)



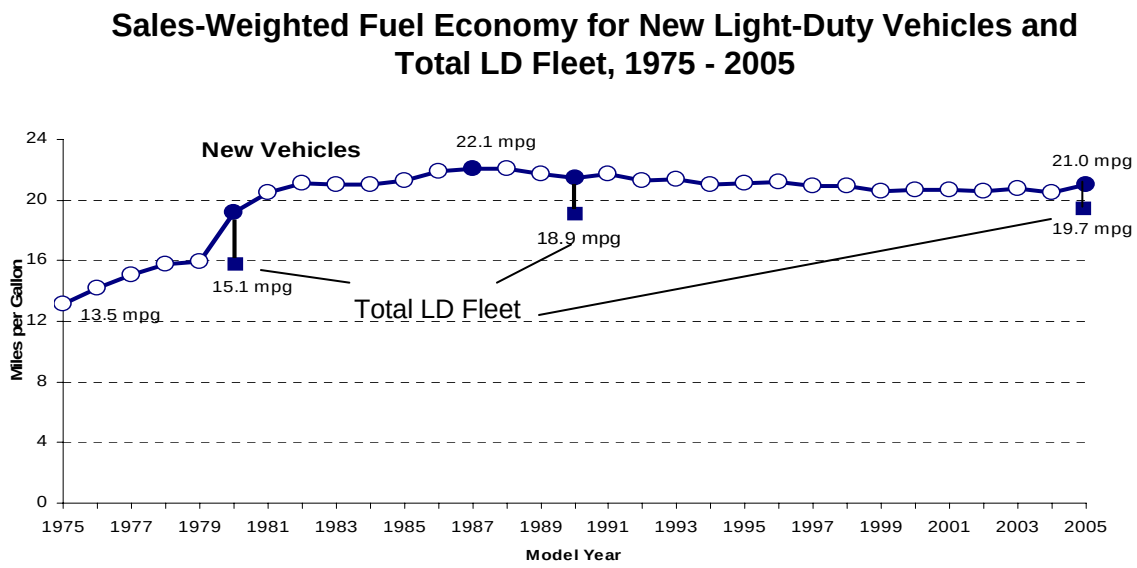
2004-2005

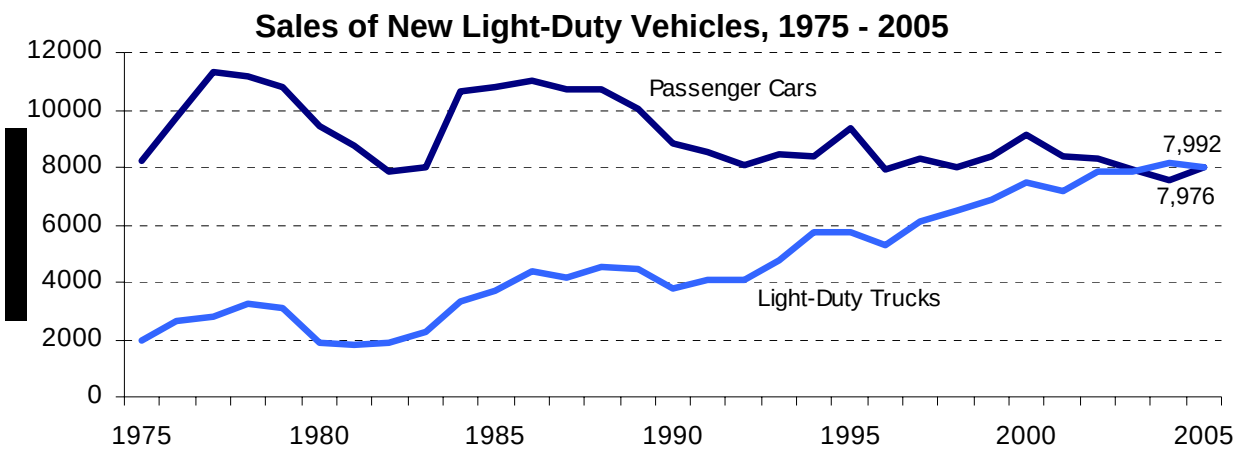
- GHGs declined very slightly (0.04%)
- Likely impact of fuel prices
- Passenger Car GHGs decreased for the third year in a row
- LD Truck GHGs up 2.7 percent, below avg. annual increase of 3.7 percent from 1990 to 2004



Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2005; Highway Statistics 2005

Light-Duty Vehicles

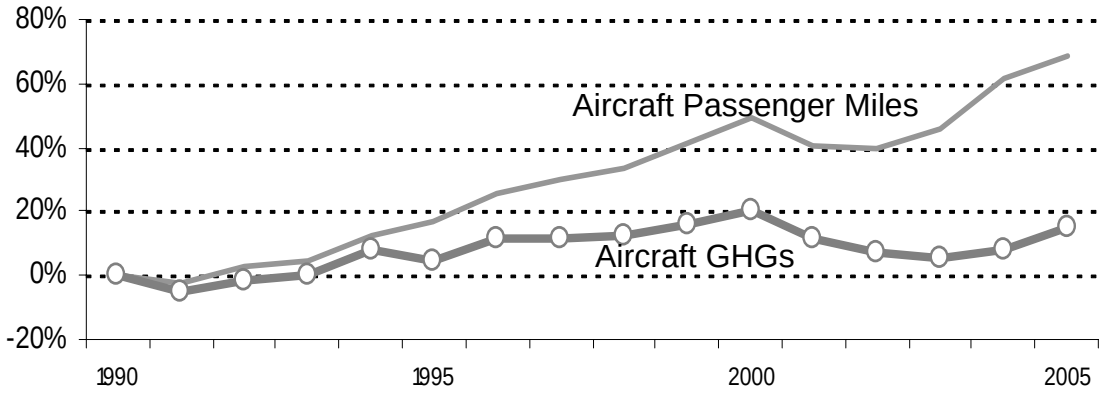




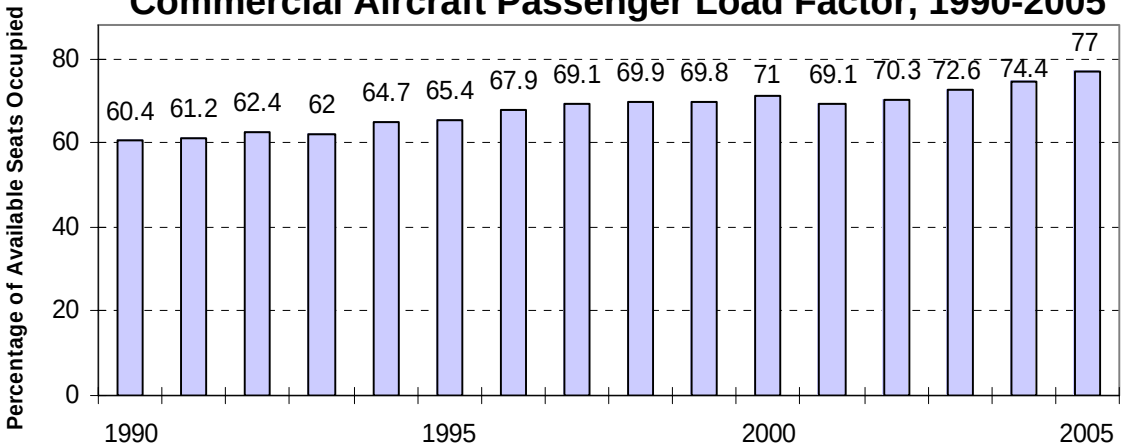
Source:
Light-Duty Automotive and Fuel Economy Trends: 1975 through 2006, U.S. EPA

Commercial Aircraft

Percent Change in Aircraft PMT and GHG Emissions, 1990-2005



Commercial Aircraft Passenger Load Factor, 1990-2005



1990-2005

- GHGs increased 14.8 percent
- Passenger miles increased 68 percent
- GHGs per passenger mile decreased by 32 percent
  - Increased passenger loads
  - Increased fuel efficiency of new aircraft (~2 percent annually)

2004-2005

- GHGs increased 6.4 percent
- Indicate that we're approaching a passenger load ceiling?

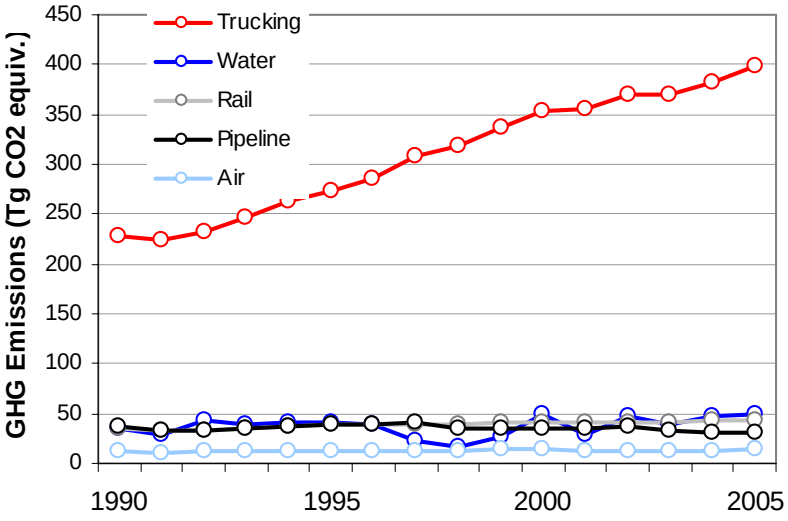
Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2005; National Transportation Statistics 2005

Freight Trucks

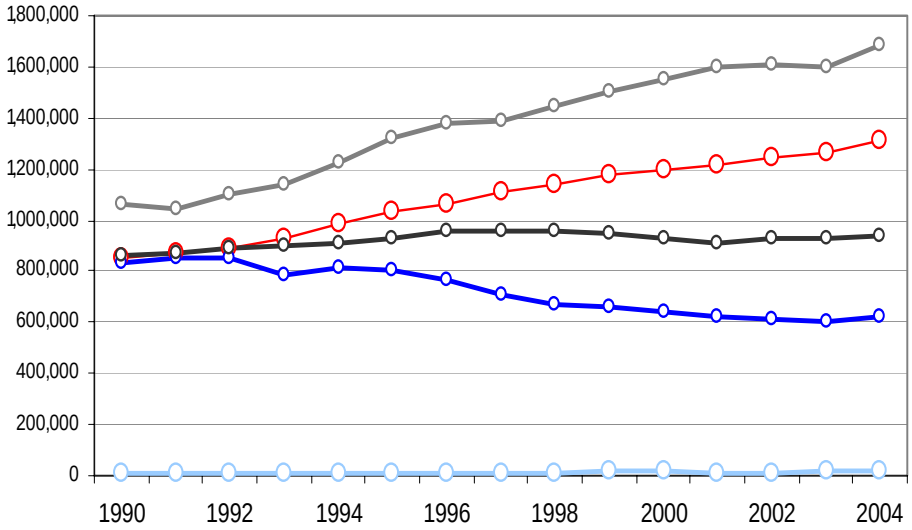
- GHGs increased 69.4 percent (3.6 percent annualized)
- Medium- and havy-duty trucks have become less energy efficient since the mid-1990s (VIUS data)
  - Fuel economy of medium trucks (10,000 to 26,000 lbs) decreased from 8.6 MPG in 1997 to 8.0 mpg in 2002
  - FE of heavy trucks (over 26,000 lbs) decreased from 6.1 MPG in 1997 to 5.8 MPG in 2002
  - Possible explanations for decreased fuel economy
    - Demand for more powerful engines
    - Impact of congestion
    - Elimination of mandatory speed limits

Freight Sources

GHG Emissions, 1990-2005

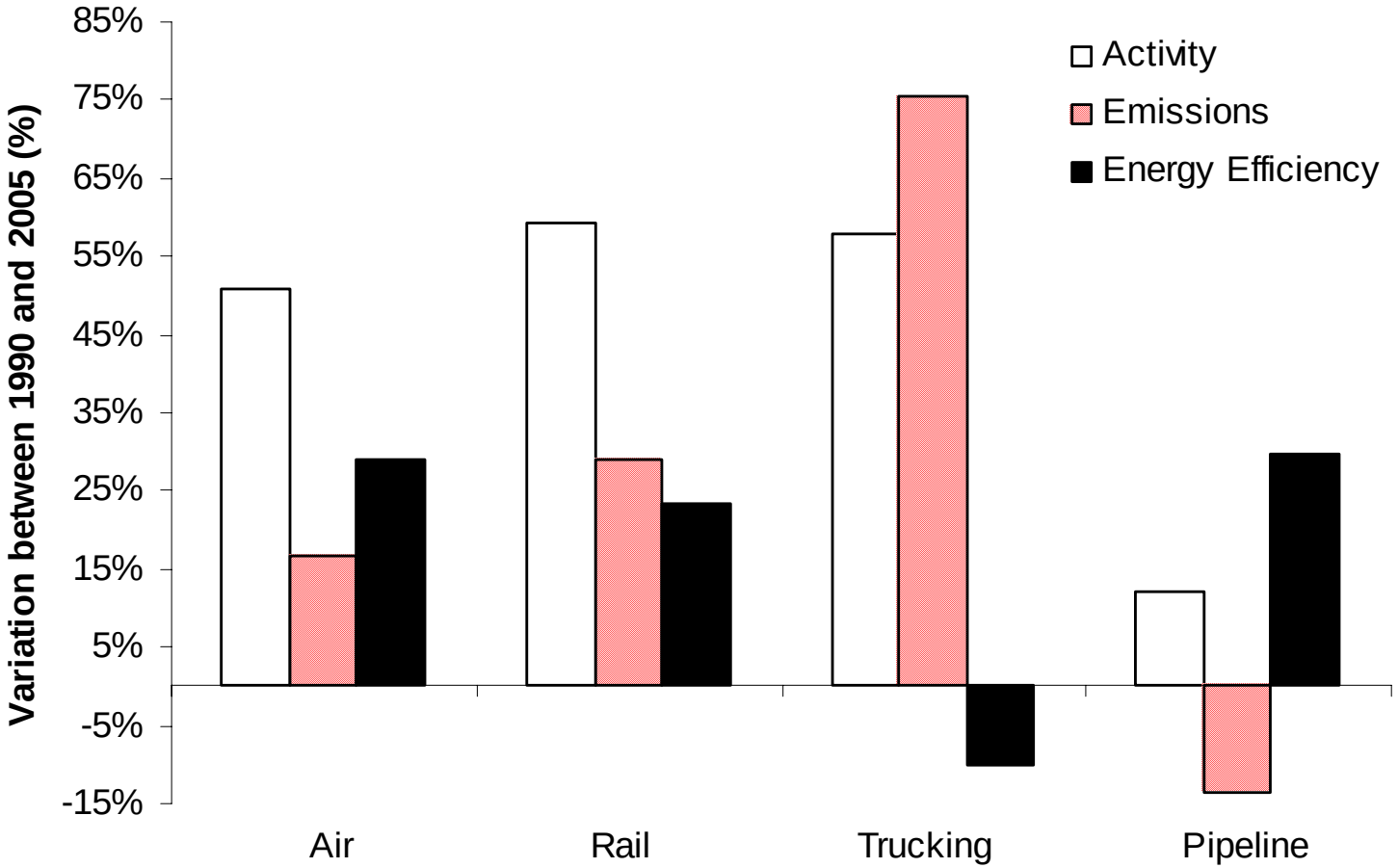


Ton-Miles, 1990-2004



Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2005;
National Transportation Statistics 2005

Change in Freight Activity, Energy Efficiency and GHGs by Mode, 1990 to 2005



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Additional Information

Greenhouse Gas Emissions from Transportation and other Mobile Sources

http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Inventory of U.S. Greenhouse Gas Emissions and Sinks

http://www.epa.gov/climatechange/emissions/usinventoryreport.html