

# From Science to Regulation-- California's Air Quality Program

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# Outline

- Four regulatory issues with evolving science
  - Vehicle exhaust, atmospheric chemistry, and smog (a retrospective)
  - Particles and health
  - Oxides of nitrogen
  - Global warming
- Some successes and challenges



# Regulatory Issue #1

## VEHICLE EXHAUST, ATMOSPHERIC CHEMISTRY, AND SMOG

*(A retrospective)*



# 1940s: Los Angeles



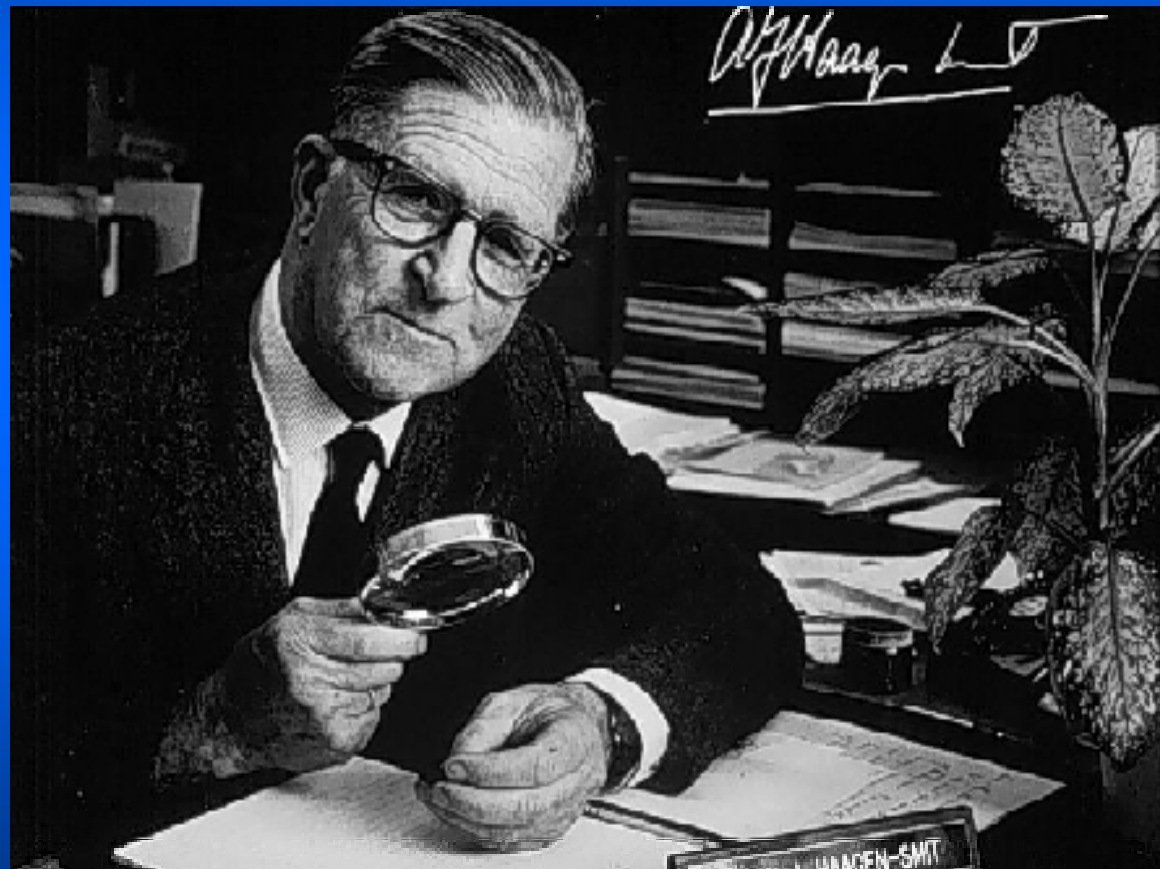
County air pollution control districts established



2.8 million vehicles



# 1950s: Photochemical smog described by Prof. Arie Haagen-Smit



4.5 million vehicles



# 1960s: automotive emissions controls

- Motor Vehicle Pollution Control Board
- California positive crankcase ventilation (PCV) control
- California authority to set own motor vehicle emission standards
- Tailpipe standards for CO, HC
- California Air Resources Board (CARB)
- Prof. Haagen-Smit first chair (1967)

8 million vehicles



# 1970s: U. S. Clean Air Act

- U.S. EPA, 1970
- Los Angeles ozone 580 ppb
- CARB automotive NO<sub>x</sub> standards, 1971
- National ambient air quality standards, 1971
- 2-way, 3-way automotive catalysts

12 million vehicles



# 1980s: expanding regulation

- In-use compliance testing
- Low emission vehicle (LEV) standards
- On-board diagnostics (OBD) rule
- Toxic air contaminant bill

17 million vehicles



# 1990s: tightening standards

- Cleaner burning gasoline program
- Zero emission vehicle (ZEV) program
- California diesel fuel introduction
- Smog check II
- LEV II standards (98+% reduction)
- MTBE ban

23 million vehicles



# 2000s: climate change

- No Stage 1 smog alerts (200 ppb O<sub>3</sub>) in South Coast Air Basin
- Diesel risk reduction program
- AB1493 (Pavley) motor vehicle greenhouse gas emissions reduction
- Climate change action plan for California
- AB32 California Global Warming Solutions Act of 2006
- U.S. Supreme Court: CO<sub>2</sub> is an air pollutant

26 million vehicles



# Regulatory Issue #2

## PARTICLES AND HEALTH

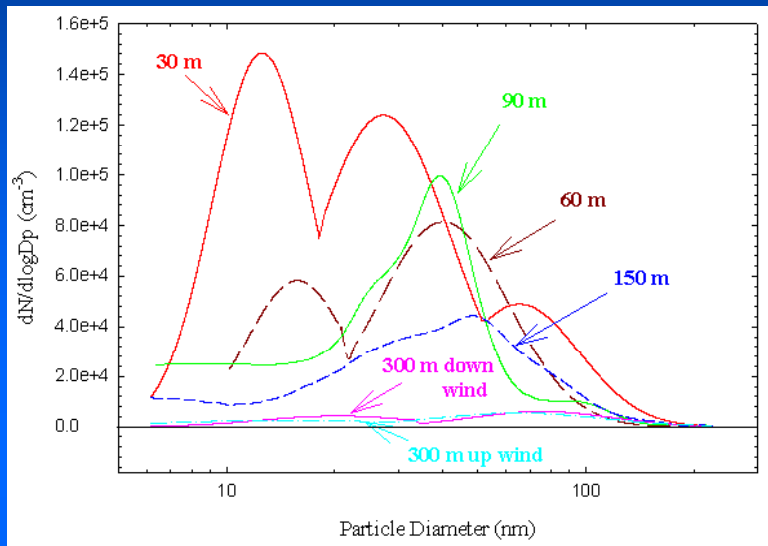


# Particle health effects issues

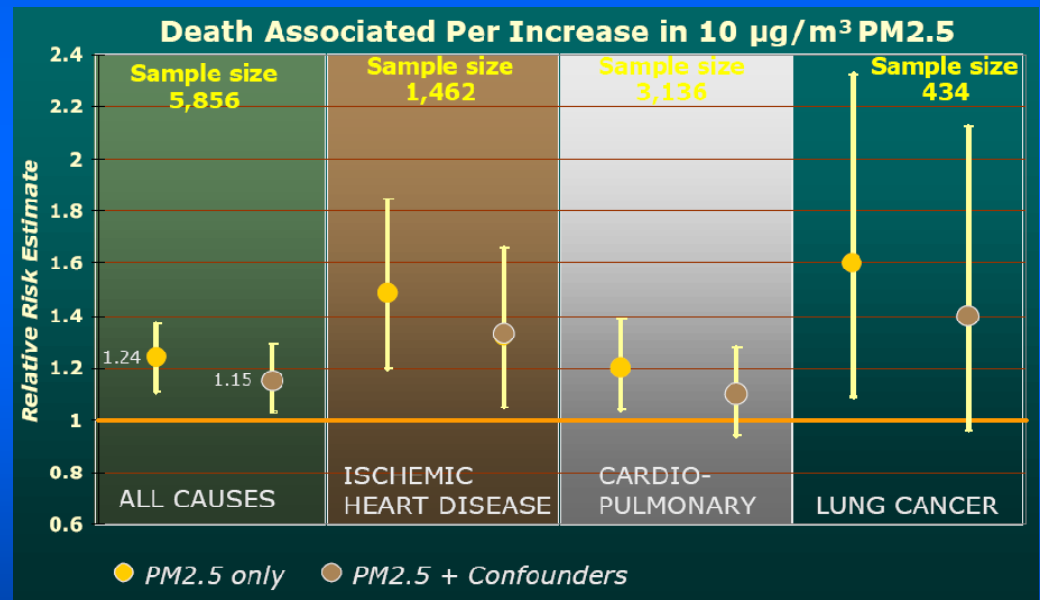
- Understanding of effects has changed dramatically: cardiovascular vs pulmonary
- Science base: toxicology to epidemiology
- Short term and long term exposures
- Importance of size and composition?
- $PM_{10}$ ,  $PM_{2.5}$ ,  $PM_{0.25}$  and/or number standard?



# Getting exposure right



C. Sioutas, near freeway studies



M. Jerrett, zip code linked exposures (2005)



# Regulatory Issue #3

## OXIDES OF NITROGEN



# Nitrogen oxygen chemistry

- NO (combustion)
  - $\text{N}_2 + \text{O} \rightarrow \text{NO} + \text{N}$
  - $\text{O}_2 + \text{N} \rightarrow \text{NO} + \text{O}$
- NO<sub>2</sub> (combustion, troposphere, catalysis)
  - $\text{NO} + \text{OH} \rightarrow \text{NO}_2 + \text{H}$
  - $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$
  - $\text{NO} + \text{O}(\text{surface}) \rightarrow \text{NO}_2$
- N<sub>2</sub>O (soil, stratosphere, catalysis)
- HONO (combustion, troposphere)
- HONO<sub>2</sub> (troposphere)



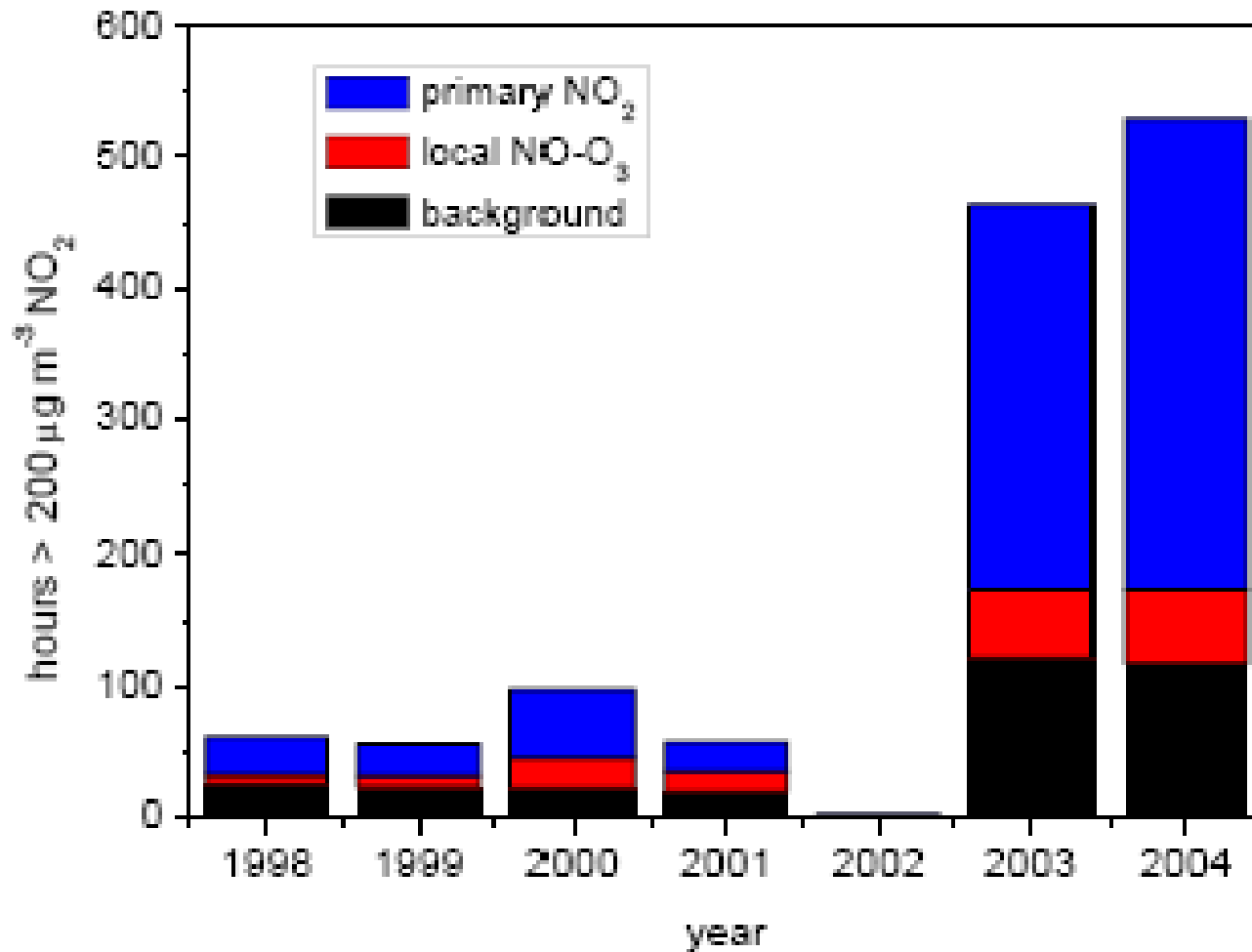
# Nitrogen dioxide issues

- Air quality standard
  - US EPA: 53 ppb (annual mean)
  - California (new): 30 ppb (annual mean)  
180 ppb (1 hour)
  - WHO (new): 20 ppb (annual mean)  
100 ppb (1 hour)
- Formation on diesel catalytic trap



# London experience

## Marylebone Road NO<sub>2</sub>

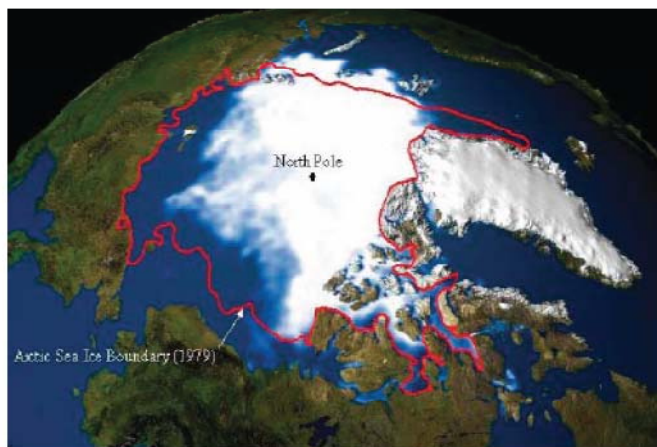
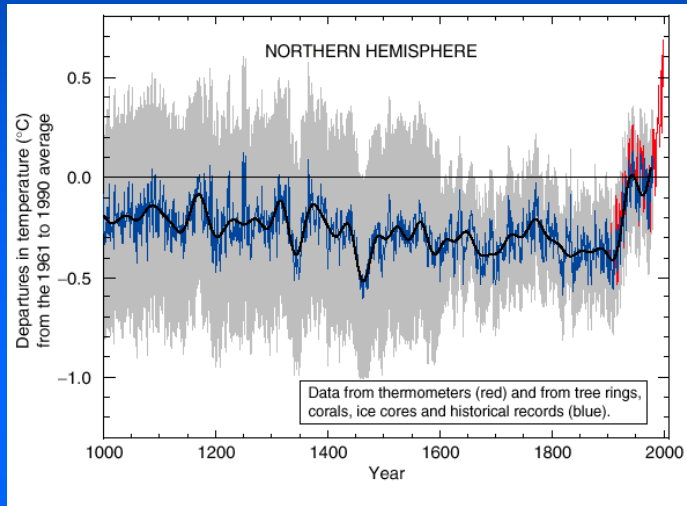


# Regulatory Issue #4

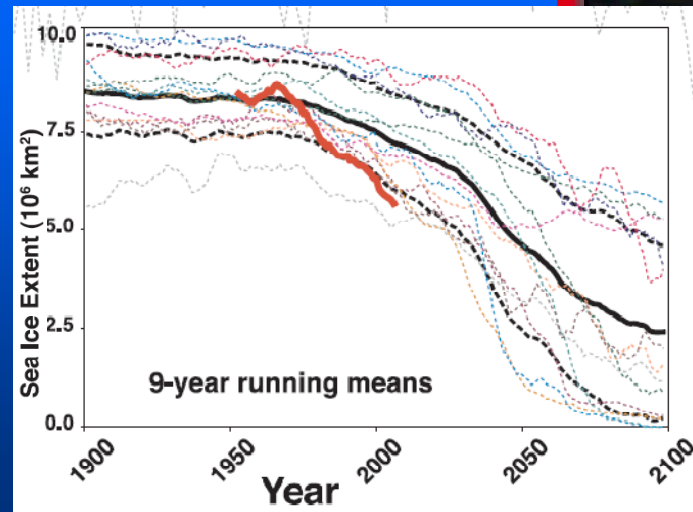
## GLOBAL WARMING



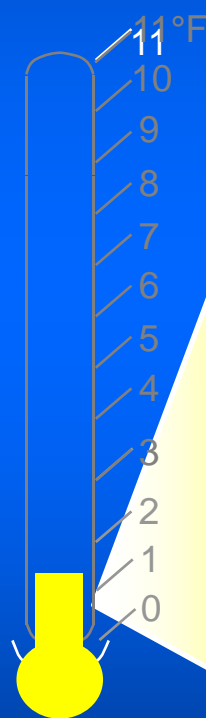
# Climate change science drives policy decisions



Ice loss in the Arctic from 1979 - 2003 is greater than the land area of Texas, California and Maryland combined. Satellite image courtesy of NASA.



# California Climate Impacts over the past 100 years



**1.3°F (0.7°C) higher  
temperatures**

**7 inch sea level rise**

**12% decrease in fraction  
of runoff between April  
and July**

**snowmelt and spring  
blooms advanced  
2 days/decade since 1955**



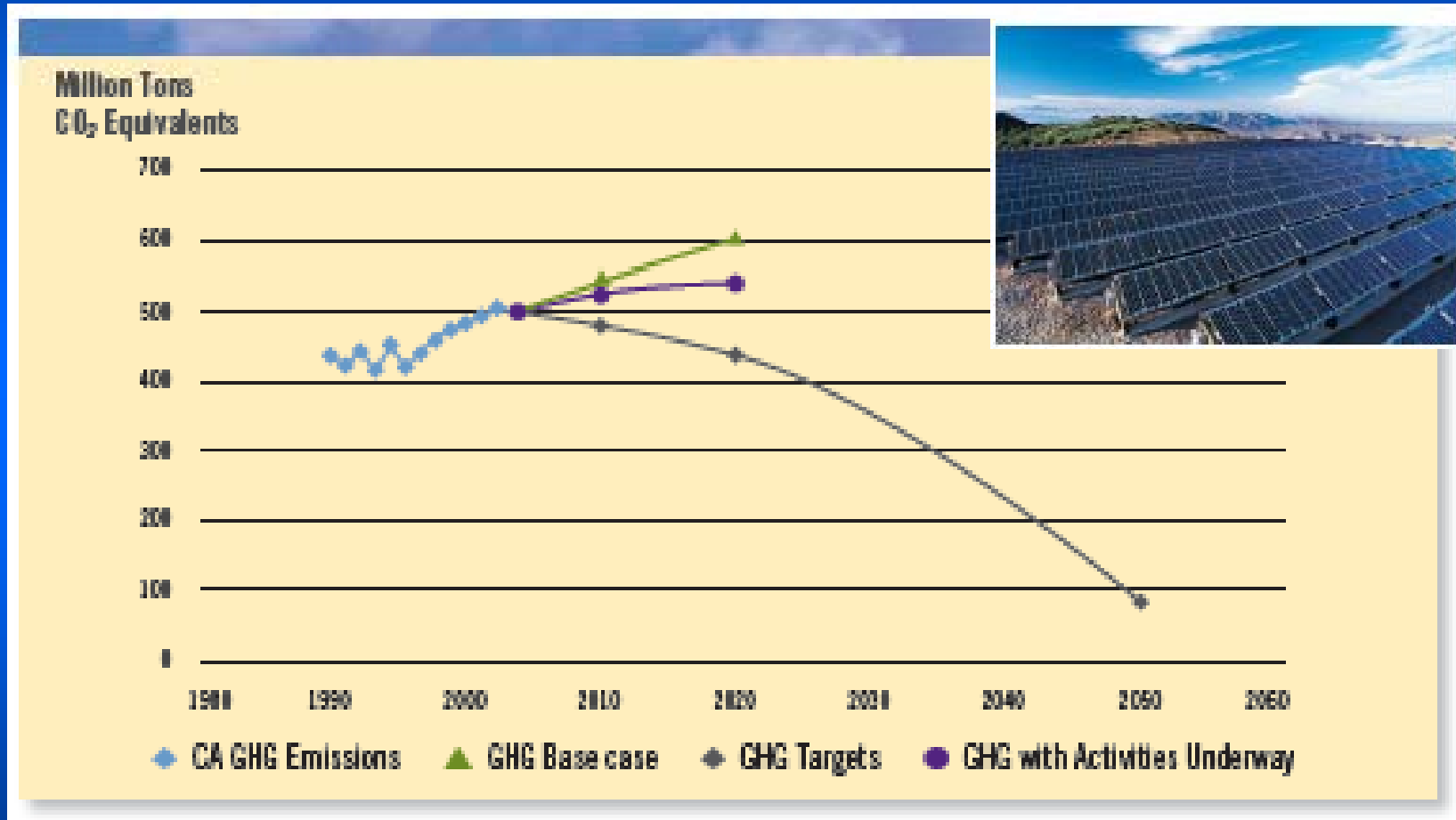
# California initiative



“...the debate is over. We know the science. We see the threat. And we know the time for action is now.”—Gov. Schwarzenegger, 1 June 2005



# California greenhouse gas emission trends (CEC, 2005)



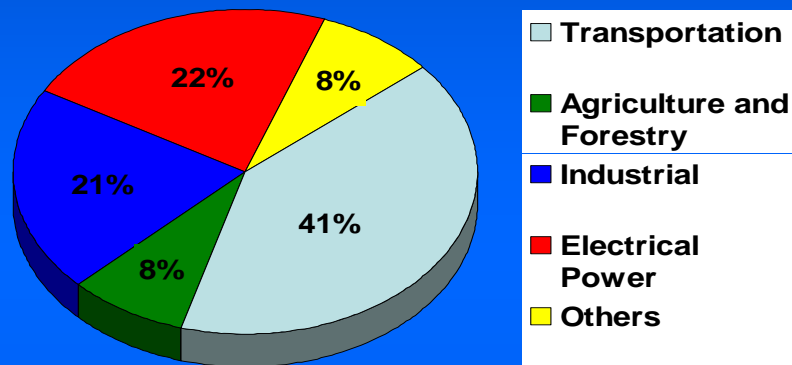
# California Global Warming Solutions Act of 2006 (AB32, Nuñez/Pavley)

- Reduce greenhouse gas emissions to 1990 levels by 2020 (about 174 MT CO<sub>2</sub> eq from BAU)
- Gives authority to Air Resources Board
- Timeline
  - 1/1/07: ARB maintains statewide inventory
  - 6/30/07: List of discrete early actions
  - 1/1/08: Mandatory reporting of emissions  
Adopt 1990 baseline/2020 target
  - 1/1/09: Scoping plan of reduction strategies
  - 1/1/10: Regulations to implement early action items
  - 1/1/11: Regulations to implement scoping plan

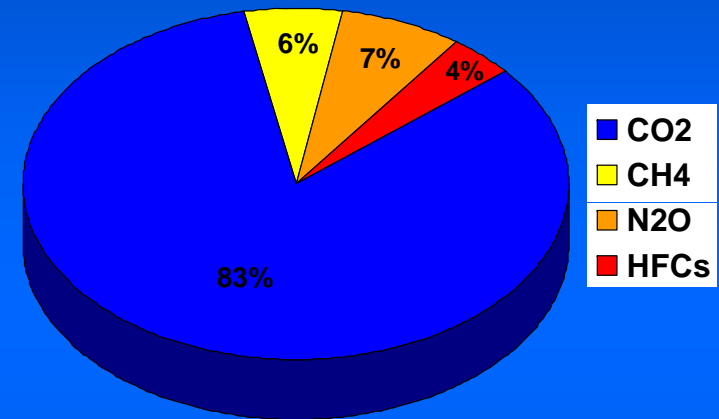


# California Greenhouse Gas Emissions

**GHG Emission Sources**  
(~500 MMT CO<sub>2</sub>-equivalents)



**GHG Emissions by Type**



CO<sub>2</sub>, N<sub>2</sub>O



CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O



CO<sub>2</sub>



CO<sub>2</sub>



HFCs



# Motor vehicle climate change emissions control regulation (AB1493 Pavley)

- Light duty passenger cars and trucks
- CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFC
- 2009-2016 phase-in, fleet averaged
- 30% reduction (new vehicles)
- Cost effective to customer
- Based on existing technology
- Adopted by 12 states, 1/3 U.S. sales
- USEPA waiver hearing
- Legal challenge by automobile industry



# Some successes and challenges



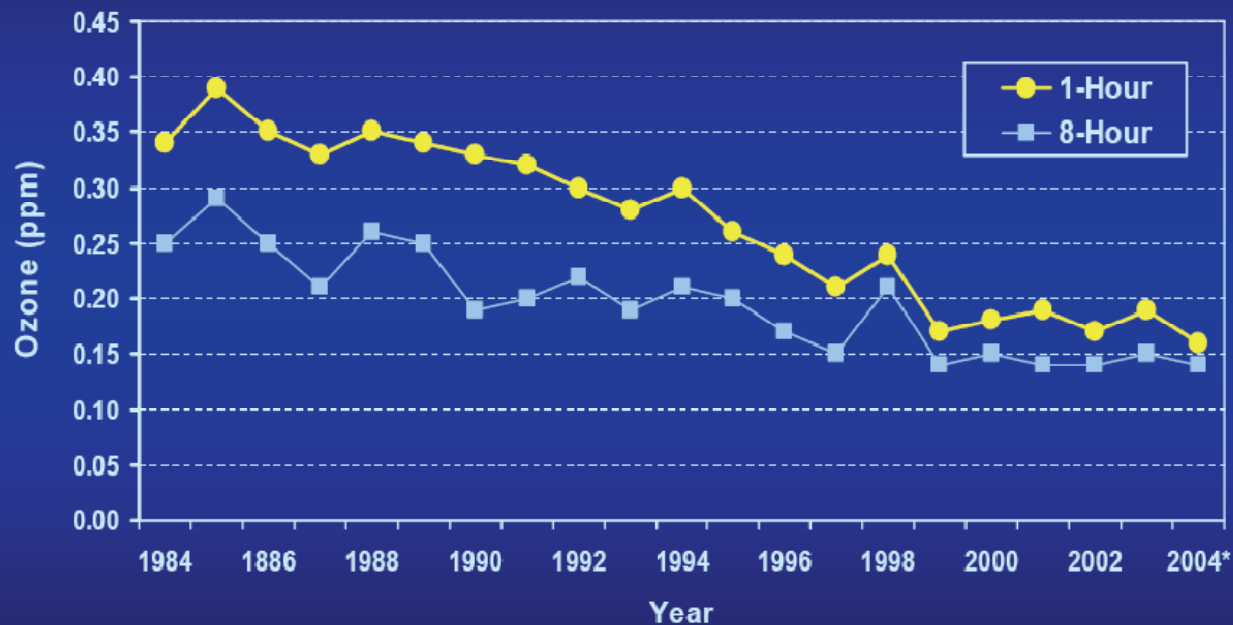
# Success: air quality improving

- ✓ Lead
- ✓ Nitrogen dioxide
- ✓ Sulfur dioxide
- ✓ Carbon monoxide
- Ozone
- Particulate matter



# Success: South Coast ozone falling

## *South Coast Peak Ozone Levels*

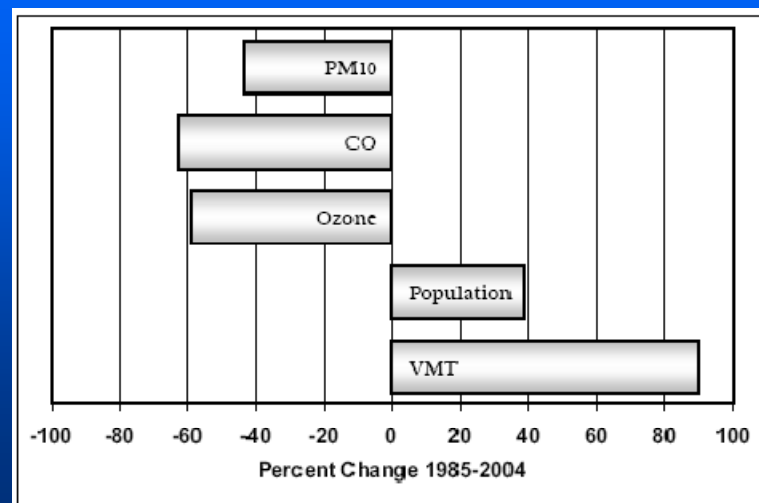


\*2004 data are preliminary and reflect data collected through November 30, 2004.



# Challenge: continuing growth

- Population
- Motor vehicles
- Motor fuel consumption
- Vehicle miles traveled
- Goods movement

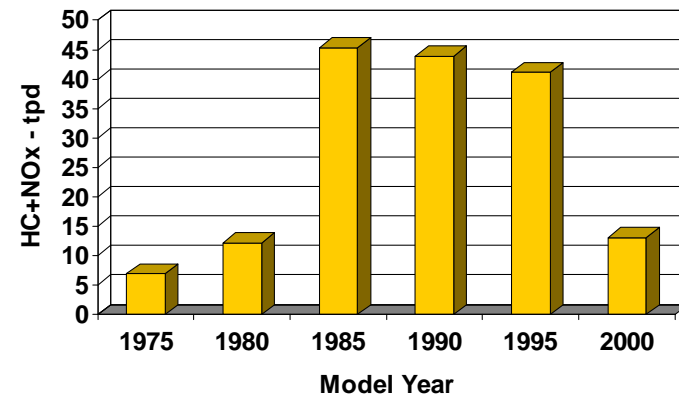
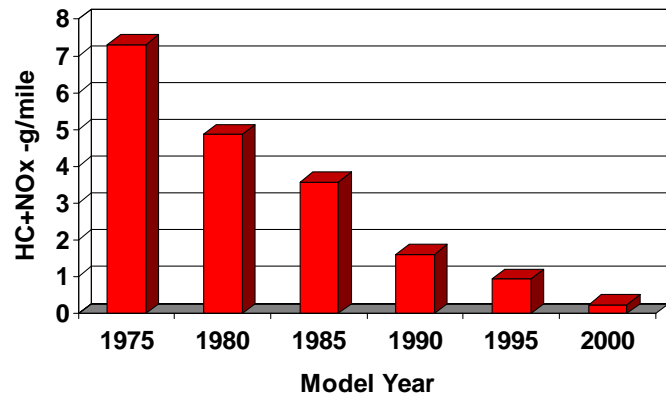


# Success: new light duty fleet clean and durable

- Tailpipe emissions
- Evaporative emissions
- On-board diagnostics



# Challenge: older, in-use light duty vehicles

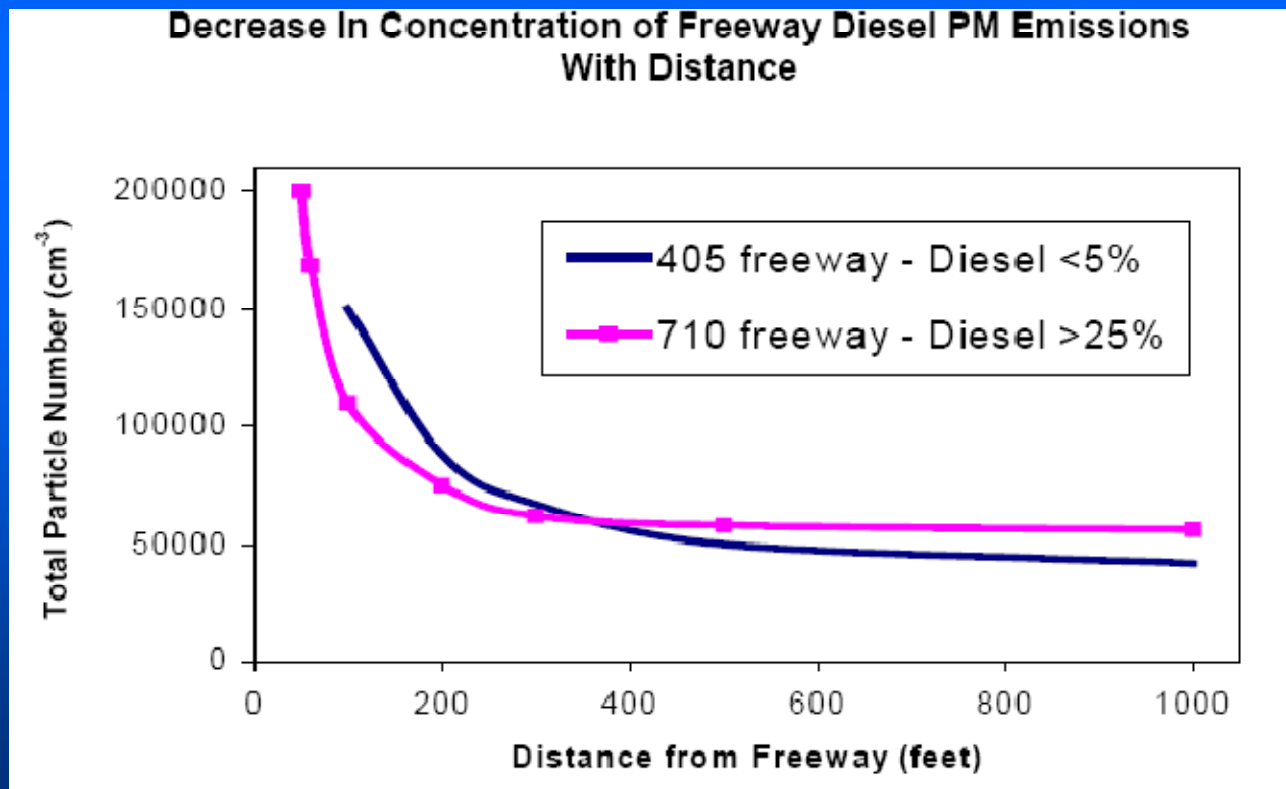


(in 2002)



# Success/challenge: land-use planning

- Air Quality and Land Use Handbook: A Community Health Perspective



# Challenge: ZEV program

- Battery electrics
- Fuel cell vehicles
- 2007 expert panel review



# Success: ZEV program

- PZEVs
- Hybrids
- SULEVs



# Challenge: transportation petroleum use reduction

- Reduce petroleum use 15% by 2020
- Increase alternative fuel use to 20% by 2020
- Focus on renewable, biofuels
- Ethanol: E10 or E85 or both?



# Challenge: diesel risk reduction

- Goals set in 2000
  - 75% reduction by 2010
  - 85% reduction by 2020
- Approaches
  - New engine standards
  - In-use compliance (heavy duty I/M)
  - Clean diesel fuel, alternative fuels
  - Retrofit program
- Growth problem



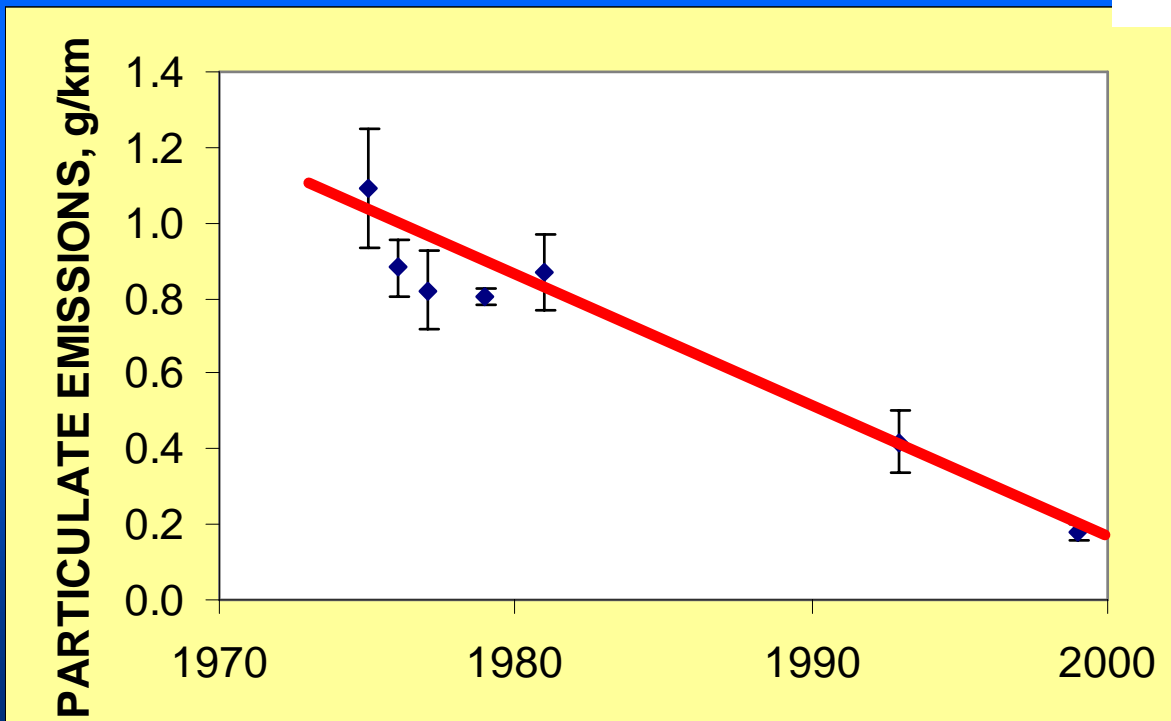
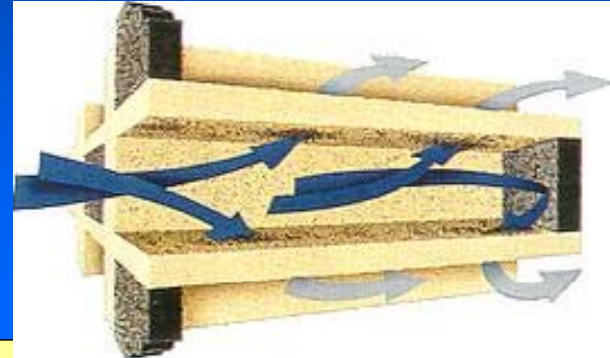
# Success: clean light duty diesels

- Will meet California LEV II standards
- Multiple manufacturers are planning to introduce to California
- Fuel economy, performance
- Larger vehicles



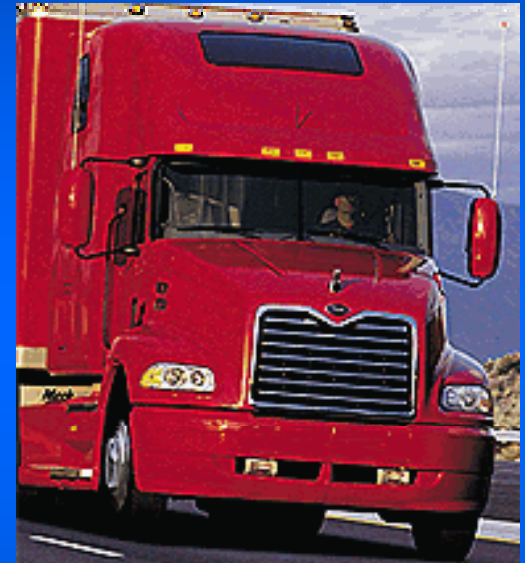
# Success: heavy duty diesel PM reduction

- On-road evidence
- 2007 trap technology,  
98% reduction



# Challenge: heavy duty diesel NO<sub>x</sub> reduction

- On-road emissions have not matched emission standards
- NO<sub>x</sub> versus fuel economy trade-off
- 2010 standards, 98% reduction
  - Urea based selective catalytic reduction



# Challenge: market design

- How to ensure real reductions



## In conclusion:

“Good science is essential to (but does not ensure) good regulation.”

