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\textsubscript{x} 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 O₃) 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: CO₂ 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?
• $\text{PM}_{10}$, $\text{PM}_{2.5}$, $\text{PM}_{0.25}$ 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$_2$ (combustion, troposphere, catalysis)
  - NO + OH $\rightarrow$ NO$_2$ + H
  - NO + O$_3$ $\rightarrow$ NO$_2$ + O$_2$
  - NO + O(surface) $\rightarrow$ NO$_2$
- N$_2$O (soil, stratosphere, catalysis)
- HONO (combustion, troposphere)
- HONO$_2$ (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$\textsubscript{2}$

![Chart showing the hours per year with NO$\textsubscript{2}$ concentrations exceeding 200 µg m$\textsuperscript{-3}$ from 1998 to 2004. The chart is divided into four categories: primary NO$\textsubscript{2}$, local NO$\textsubscript{2}$-O$_\textsubscript{3}$, and background NO$\textsubscript{2}$ concentrations. The years 2003 and 2004 show a significant increase in primary NO$\textsubscript{2}$ concentrations compared to the previous years.]
Climate change science drives policy decisions
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

Cal/EPA-OEHHA, “Environmental Protection Indicators for California” (2002)
www.oehha.ca.gov/multimedia/epic/Epicreport.html
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$_2$ 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$_2$-equivalents)

- Transportation: 22%
- Agriculture and Forestry: 8%
- Industrial: 21%
- Electrical Power: 41%
- Others: 8%

GHG Emissions by Type

- CO$_2$: 83%
- CH$_4$: 7%
- N$_2$O: 6%
- HFCs: 4%

www.climatechange.ca.gov/policies/greenhouse_gas_inventory/index.html
Motor vehicle climate change emissions control regulation (AB1493 Pavley)

- Light duty passenger cars and trucks
- CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}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

![Graph showing particulate emissions](chart.png)
Challenge: heavy duty diesel NO\textsubscript{x} reduction

- On-road emissions have not matched emission standards
- NO\textsubscript{x} 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.”