The Next 20 Years in Air Quality and Climate Change

Bart E. Croes, P.E., Chief
Research Division

California Air Resources Board
1. Air Resources Board
2. Policy Drivers
3. Air Pollution Policies
4. Global Warming Policies
Governing Board

Appointed by Governor, traditionally bipartisan

Rule-making body for motor vehicles, air toxics, consumer products, greenhouse gases

Clean Air Act exemptions for motor vehicles if “extraordinary and compelling” conditions

Stationary and area source oversight

Public workshops and stakeholder meetings

Public and legislative support
Scientific/Technical Input to Policy

Legislative requirements
- Automotive Engineer and M.D. on Governing Board
- Health-based ambient air quality standards
- Extramural research program with external oversight committee
- University of California peer review of scientific basis for regulations

70% engineers and scientists

In-house research and technical work

Air quality field and modeling studies in major airsheds
Air Pollution Management Instruments

**Performance-based emission standards**
- Aftertreatment effective but vehicle turnover can be slow
- Retrofits and repowering also beneficial
- Fuel improvements provide immediate benefits

**Incentive funding**
- $150M per year for diesel engines
- $1B for port trucks and equipment

**Market-based programs**
- Carbon emission trading for large sources under design
- Mitigation fees, feebeates and others being explored

**Enforcement and monitoring programs**
1 Air Resources Board
2 Policy Drivers
3 Air Pollution Policies
4 Global Warming Policies
California’s Air Pollution Problem

- 24 million gasoline-powered vehicles
- 1.3 million diesel-fueled vehicles and engines
- 38 million people
- Unique geography and meteorology confine air pollutants
- Over 90% of Californians breathe unhealthy air
Unique, Adverse Meteorology
Lowest Per Capita Emission Targets

Onshore circulation pattern, high temperatures, stagnant air masses, and mountain ranges that trap pollutants lead to ...

<table>
<thead>
<tr>
<th>Location</th>
<th>Population (million)</th>
<th>Carrying Capacity (VOC+NO$_x$) tpd</th>
<th>Carrying Capacity (VOC+NO$_x$) lb/person/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>16.9</td>
<td>840</td>
<td>36</td>
</tr>
<tr>
<td>San Joaquin Valley</td>
<td>4.1</td>
<td>630</td>
<td>69</td>
</tr>
<tr>
<td>Houston</td>
<td>5.5</td>
<td>1360</td>
<td>181</td>
</tr>
</tbody>
</table>
California’s Disproportionate Air Pollution Exposure

8-Hour Ozone (NAAQS = 80 ppb)
- Rest of Nation: 59%
- California: 41%

Annual PM2.5 (NAAQS = 15 µg/m³)
- Rest of Nation: 37%
- California: 63%

Population-weighted and minus national ambient air quality standard (NAAQS), based on 2000-2002 data
# Air Pollution and Premature Death

**California Estimates for 2005**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5</td>
<td>5,000 to 30,000*</td>
</tr>
<tr>
<td>Ozone</td>
<td>300 to 1000</td>
</tr>
<tr>
<td>Toxic Air Contaminants</td>
<td>&lt;400</td>
</tr>
</tbody>
</table>

* Under review
Children’s Health Study Findings
(5,400 children followed 1993-2004)

PM, EC, NO$_2$, acid vapors associated with:
1% / year lower lung function growth
5-fold likelihood of permanent 20% deficit

Relocation to cleaner PM10 areas improves lung function growth
63% school absence increase per 20 ppb ozone (10 am – 6 pm)

New cases of asthma onset related to high ozone & exercise, traffic

www.arb.ca.gov/research/chs/chs.htm
Significance of Indoor Exposures

Majority of time spent indoors

Building shell traps pollutants from indoor sources

Activities put people in close proximity to sources

Indoor pollutants 1000 times more likely to be inhaled

Little authority

Californians’ Time

INDOORS 87%

ENCLOSED

TRANSIT 7%

OUTDOORS 6%
California Climate Impacts
over the past 100 years

- 1.3ºF (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
- 4-fold increase in wildfire frequency (over 34 years)

Cal/EPA-OEHHA, “Environmental Protection Indicators for California” (2002),
www.oehha.ca.gov/multimedia/epic/Epicreport.html
Lyell Glacier
Yosemite National Park

1903

2003
Projected Climate Impacts on California, 2070-2099
(as compared with 1961-1990)

<table>
<thead>
<tr>
<th>°F</th>
<th>Sierra Snowpack</th>
<th>Sea Level</th>
<th>Energy Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Warming Range (3 – 5.5 °F)</td>
<td>30-60% loss</td>
<td>6-14”</td>
<td>3-6%</td>
</tr>
<tr>
<td>Medium Warming Range (5.5 – 8 °F)</td>
<td>70-80% loss</td>
<td>14-22”</td>
<td>10%</td>
</tr>
<tr>
<td>Higher Warming Range (8 – 10.5 °F)</td>
<td>90% loss</td>
<td>22-30”</td>
<td>20%</td>
</tr>
</tbody>
</table>

Climate Change Hotspots in U.S.

Hotter Days Lead to Higher Emissions and More Smog

California Ozone Standard

Riverside, 2003-2006

Fresno, 2003-2006

Increase in Wildfires

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Air Quality After WWII

Unhealthy levels of lead, NO$_2$, SO$_2$, CO, ozone, particulate matter, and air toxics

   Poor visibility

   Difficulty breathing

   Extreme eye irritation
Technology-based Regulations

Mobile Sources (>99% gasoline, 98% diesel reduction)
   Cleaner engines
   Aftertreatment
   Cleaner gasoline and diesel fuel
   Alternative fuels

Stationary Sources (80-90% reduction)
   Low-NO\textsubscript{X} burners
   Selective catalytic reduction
   Cleaner fuels

Area Sources (~75% reduction)
   Vapor recovery
   Low-volatility solvents, paints, consumer products
Ozone Trends in Los Angeles

- Peak 1 Hr Ozone
- State Standard Exceedances
- Stage 1 Alerts
- Stage 2 Alerts

Days

Concentration (ppm)

- 1965
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

0 50 100 150 200 250 300 350
Ozone Trends In California

Peak Concentration (ppm)


San Diego
San Joaquin Valley
San Francisco Bay Area

California Standard
Pollution Reduced Despite Growth

Percent Change 1968-2008

-100 -50 0 50 100 150 200 250

Carbon Monoxide  Nitrogen Dioxide  Sulfur Dioxide  Population  Number of Vehicles  Vehicle Miles

-100
-50
0
50
100
150
200
250
40 Years of Progress on Diesel PM

Engine diesel PM emission factor
\[\sim 18 \text{ fold}\]

Fuel usage
\[\sim 6 \text{ fold}\]

Ambient diesel PM
\[\sim 3 \text{ fold}\]

As PM2.5 declined, has life expectancy increased?

Overall change in U.S. (1980 to 2000)
2.7 years improvement (health care, lifestyle, diet)

For every decrease of 10 µg/m³ PM2.5
0.61 (± 0.20) years improvement

Reductions in PM2.5 accounted for 15% of life expectancy improvement

COSTS OF CONTROL

~$10 billion per year

BENEFITS OF CONTROL

~$4 in health benefits for each $1 of control

32,000 jobs and $6.2 billion in revenues for air pollution control (2001)
Many Developing Countries Have Adopted New Engine Standards First Demonstrated in California

Percentage of *World Vehicles* With CA/US/EU New Engine Standards

- No Standards: 29%
- Adopted Standards: 71%
Current Air Pollution Targets

**Diesel Engines**
75% below 2000 levels by 2010, 85% below by 2020
Replace or retrofit every diesel engine in California

**Goods Movement**
2001 emission levels by 2010
Diesel PM risk 85% below 2000 by 2020
Air Resources Board
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Governor Schwarzenegger’s Greenhouse Gas Targets

By 2010, reduce to 2000 emission levels*
By 2020, reduce to 1990 emission levels**
By 2050, reduce to 80% below 1990 levels

* Equals ~60 million tons emission reductions, 11% below business as usual (BAU)
** Equals ~174 million tons emission reductions, 29% below BAU
California Global Warming Solutions Act of 2006 (Assembly Bill 32)

Reduce GHG emissions to 80% of 1990 levels

GHG limits and measures operative

Reduce GHG emissions to 1990 levels

Sept 2006
AB 32 signed into legislation

Air Resources Board charged with monitoring and regulating sources of greenhouse gases in order to reduce emissions

2007
Inventory baseline and reporting

2008
Publish list of early actions in June

2009
Adopt enforceable early action regulations

2010

2011
GHG limits and measures adopted

2012

2020

2050

Climate Action Team coordinates State’s overall climate policy with responsibilities for greenhouse gas reductions in some sectors
California Greenhouse Gas Emissions

GHG Emission Sources (~500 MMT CO₂-equivalents)
- Transportation: 22%
- Agriculture and Forestry: 8%
- Industrial: 21%
- Electrical Power: 41%
- Others: 8%

GHG Emissions by Type
- CO₂: 83%
- CH₄: 6%
- N₂O: 7%
- HFCs: 4%

www.arb.ca.gov/cc/inventory/data/data.html
GHG Emissions Per Person
2001-2002

<table>
<thead>
<tr>
<th>Country</th>
<th>Tons of CO₂ Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>24.3</td>
</tr>
<tr>
<td>CA</td>
<td>13.4</td>
</tr>
<tr>
<td>Russia</td>
<td>13.1</td>
</tr>
<tr>
<td>Japan</td>
<td>10.7</td>
</tr>
<tr>
<td>E.U.</td>
<td>10.5</td>
</tr>
<tr>
<td>China</td>
<td>3.9</td>
</tr>
<tr>
<td>India</td>
<td>1.9</td>
</tr>
</tbody>
</table>

World Average: 3.9

Climate Analysis indicators Tool (CAIT US Version 1.0, CAIT version 4.0), World Resources Institute (2007), data includes CO₂, CH₄, N₂O, HFCs, PFCs, and SF₆ with out-of-state electricity generation for California.
How to Reach 2020 Goal?

Mix of Strategies (market mechanisms, regulations, voluntary measures, fees)

Key elements
Transportation (fuels, engine efficiency, VMT)
Renewable Energy Portfolio Standard
Energy Efficiency Programs
Green Building Strategy
Control of High-GWP Gases
Cap and Trade Program (linked to WCI)
State, Regional, and Local Partnerships
Education and Outreach
Yesterday’s Successes
Entire state attainment for lead, CO, SO$_2$, NO$_2$
Peak ozone reduced 75%
PM2.5 and toxics reduced 50%

Today’s Challenges
Public health remains top priority
Ozone and PM2.5 in Los Angeles and the San Joaquin Valley
Diesel and goods movement
Climate change program