California Emission Control Case Study

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California Environmental Protection Agency
Air Resources Board

www.arb.ca.gov
Main Points

- California has realized significant non-CO$_2$ GHG reductions
- California has reduced the growth of CO$_2$ emissions
- These reductions were realized for reasons other than climate change
- Further reductions will focus on diesel and other PM sources
California has realized significant non-CO$_2$ GHG reductions ...
Stationary Source Controls

- Low-NO$_x$ Burners
- Selective Catalytic Reduction
- Cleaner Fuels (i.e., compressed natural gas)
- Vapor Recovery
- Low-NMVOC Coatings and Solvents
Evolution of NO\textsubscript{X} Controls from Power Plants in California
(Combined-Cycle/Cogeneration Configurations)

![Graph showing the evolution of NO\textsubscript{X} controls from power plants in California over the years. The graph indicates a significant decrease in NO\textsubscript{X} emissions from low-NO\textsubscript{X} burners and SCR systems, with a notable reduction in emissions from 1982 to 1998.]
Evolution of California Auto Controls
Implementation: 1963 - 1993

- Positive Crankcase Ventilation
- Exhaust Standards
- Oxidation Catalyst
- EGR
- Three Way Catalyst
- On-Board Computer
- Advanced Computer
- Fuel Injection
- O₂ Sensor
- Phase 1 Gasoline
Evolution of California Auto Controls
Implementation: 1994 - 2010

- Low Emission Vehicle I
- Phase 2 Gasoline
- Low Emission Vehicle II
Cost-effectiveness Values for Various Mobile Source and Fuel Regulations

- 0.4 NOx LDV
- 0.25 HC LDV
- OBD 1
- LEV
- 2-Stroke Lawn
- 4-Stroke Lawn
- RFG 2
- Off-road Diesel
- Off-cycle LDT
- Medium Duty Truck
- 2.4 HDDE
- Off-Road CI
- NTE & ESC
- 2007 HDDE

Board Hearing Year:

Dollars per Pound of Ozone Precursors

- 3.0
- 2.5
- 2.0
- 1.5
- 1.0
- 0.5
- 0.0
## California Emission Reductions

(Tg/ yr)

<table>
<thead>
<tr>
<th>Source</th>
<th>1980</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary (NMVOC+NO\textsubscript{X})</td>
<td>0.93</td>
<td>0.40</td>
</tr>
<tr>
<td>- Electricity Prod. (NO\textsubscript{X})</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>Autos (NMVOC+NO\textsubscript{X})</td>
<td>1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Autos (CO)</td>
<td>10.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Trucks (PM ≅ BC)</td>
<td>0.013</td>
<td>0.007</td>
</tr>
</tbody>
</table>
California has reduced the growth of CO$_2$ emissions ...
California GHG Emission Trend

(CO\textsubscript{2} equivalents for Kyoto Protocol Gases)
Carbon Intensities for California and Selected States - 1995

The graph shows the emissions per capita (metric tons CO₂/person) and emissions per Gross State Product (metric tons CO₂/thousand 1999 U.S. dollars) for various states. The states include California, Texas, Ohio, Pennsylvania, Rhode Island, South Dakota, Massachusetts, Connecticut, and D.C. The graph indicates that California has the lowest emissions per capita and emissions per GSP compared to the other states.
Carbon Intensities for California and Selected Countries - 1995
Growth Trends

Normalized to 1980

- Population
- Vehicle Miles Traveled
- Gross State Product

## Changes Since 1990

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO(_x)</td>
<td>-29%</td>
<td>-37%</td>
</tr>
<tr>
<td>NMVOC</td>
<td>-32</td>
<td>-40</td>
</tr>
<tr>
<td>CO</td>
<td>-39</td>
<td>-46</td>
</tr>
<tr>
<td>SO(_x)</td>
<td>-44</td>
<td>-50</td>
</tr>
<tr>
<td>Combustion PM ((\approx) BC)</td>
<td>-16</td>
<td>-25</td>
</tr>
<tr>
<td>GHG (CO(_2) equivalent)</td>
<td>+8</td>
<td>-4</td>
</tr>
<tr>
<td>- CH(_4)</td>
<td>-9</td>
<td>-19</td>
</tr>
<tr>
<td>- N(_2)O</td>
<td>-4</td>
<td>-15</td>
</tr>
</tbody>
</table>
## Net Effect From 1990 to 2000

(Tg/ yr CO$_2$ equivalent)

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyoto GHG</td>
<td>378</td>
<td>399</td>
</tr>
<tr>
<td>Other GHGs and BC</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>394</td>
<td>409</td>
</tr>
</tbody>
</table>

GWPs: CO$_2$=1, N$_2$O=296, CH$_4$=23, NO$_X$=0, NMVOC=2.8, CO=1.2, SO$_X$=0, aerosols not considered
These reductions were realized for reasons other than global climate change ...
Improvement in Ambient Air Quality Over Past 20 Years

- Nitrogen Dioxide
- Sulfur Dioxide
- Carbon Monoxide
- Ozone
- PM10
- Air Toxics (Cancer Risk)

Percent Change

-80%
-60%
-40%
-20%
0%

Approaching Standards
Attained Standards
Air Pollution Health Effects

• Currently, air pollution in California contributes annually to as many as:

  ▸ 17,000 premature deaths
  ▸ 55,000 hospital admissions
  ▸ 1,300,000 asthma attacks
  ▸ 3,300,000 lost work days
Visibility Reduction

10-75% of light extinction in urban areas is from diesel black carbon.
Further reductions will focus on diesel and other PM sources...
Ozone and PM10 Exposure

1-Hour Ozone Exposure 1993-1995
- California: 71%
- Rest of Nation: 29%

Annual Mean PM10 Exposure 1994-1996
- California: 43%
- Rest of Nation: 57%
Toxic Air Contaminants

- Diesel PM: 60%
- Benzene & 1,3-Butadiene: 20%
- All Others: 0%
75% Reduction in Diesel PM by 2010
(On- and Off-road Vehicles, Stationary Engines)

- New vehicle and engine standards
- Retrofits where technically feasible and cost-effective
- International Advisory Committee
- Low-sulfur (15 ppmw) diesel fuel
- Enforcement programs

www.arb.ca.gov/diesel/dieselrrp.htm
California Climate Change Activities

• Assembly Bill 1058
  ‣ Instructs CARB to adopt regulations that achieve the maximum feasible, cost-effective, and technologically achievable reductions of CO₂ emitted by passenger vehicles
  ‣ Passed Senate, amended by Senate

• Senate Bills 1771 and 527
  ‣ Created California GHG Registry
Summary

- Technology exists for significant non-CO$_2$ GHG reductions
- Improvements in power generation have slowed the growth of CO$_2$ emissions
- Emission reductions to address health and welfare concerns have a co-benefit for climate change
- Further reductions will focus on diesel and other PM sources