Black Carbon Mitigation Strategies for the Transportation Sector in California

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Air quality after World War II

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

• Poor visibility

• Difficulty breathing

• Extreme eye irritation

• In Los Angeles
  – Over 100 smog alerts annually
  – Over 300 days with unhealthy air annually

Los Angeles smog in 1948
Air pollution reduced 75-90% over 40 years despite growth

Ozone – Los Angeles peak reduced 70%, hours of exposure by 90%
PM10 – annual-average levels reduced 75%
Air toxics – lead eliminated, cancer risk reduced 80% (since 1989)
Black carbon – reduced 90% (95% by 2020)
Costs of Control
0.5% GDP (US 1990-2020)

Benefits of Control

$10-95 in health benefits for each $1 of control (US 1970-1990)
$30 in health benefits for each $1 of control (US 1990-2020)*
Air pollution control industry – 32,000 jobs and $6.2B (CA 2001)
Clean energy industry – 123,000 jobs and $27B (CA 2009)

* 1990-2020 uncertainty analysis under development

U.S. EPA Reports to Congress on The Benefits and Costs of the Clean Air Act (www.epa.gov/air/sect812/index.html)
Major Drivers for Diesel Emission Reductions

Diesel exhaust is toxic and carcinogenic

- IARC classifies diesel exhaust as probably carcinogenic to humans (Group 2A)
- IARC classifies diesel engine exhaust as carcinogenic to humans (Group 1)
- State of California designates Diesel PM as a Toxic Air Contaminant

Diesel exhaust contributes to regional and local air pollution

- National Ambient Air Quality Standards for PM2.5 and ozone
- Reduce near-source health risk
Cancer Risks from Airborne Toxics

Mobile sources account for more than 75% of cancer risks from TAC exposure.
California Diesel Risk Reduction Plan

**Goal**
Reduce diesel PM 85% from 2000 to 2020

**How**
1. New engine emissions standards
2. Ultra-low-sulfur diesel (15 ppm)
3. In-Use Fleet Rules
   - Transit agency fleet rule (2000)
   - School bus idling (2002)
   - Portable engines (2004)
   - Transport refrigeration units (2004)
   - Commercial vehicle idling (2004)
   - Transit fleet vehicles (2005)
   - Public agency/utility on-road fleets (2005)
   - Port/rail cargo handling equipment (2005)
   - Ship auxiliary engine fuel (2005)
   - Drayage Truck Rule (2007)
   - Off-Road Rule (2007)
   - Truck and Bus Rule (2008)+
California Diesel Risk Reduction Plan

Keys To Success
• Flexibility in regulatory path
• Outreach to affected businesses
• Incentive funding
• Enforcement
• Willingness to adjust
• Research
Progression of PM Emissions

99% PM reduction for diesel and 90% for CNG in 2010

“Old” diesel and CNG number from chassis dynamometer studies, while 2007 and 2010 are average certification values in mg/mi, using 2.9 bhp-hr/mi
Progression of PM Emissions

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Progression of NO$_x$ Emissions

98% PM reduction for diesel and 97% for CNG in 2010
California needs further 90% reduction to meet ozone and PM2.5 standards

“Old” diesel and CNG number from chassis dynamometer studies, while 2007 and 2010 are average certification values in mg/mi, using 2.9 bhp-hr/mi
Financial Incentive Programs

• Grant programs and vouchers
  – Funding primarily for surplus (early) actions
  – $150M per year for diesel engines
  – $1B for port trucks and equipment

• Loan assistance programs

• Funding available for the following:
  – Vehicle replacements
  – Exhaust retrofits
  – Hybrid trucks
  – Engine repowers
Diesel Emission Control Verification

• Verified for PM or NO$_X$ reduction
• Quantifies system performance to determine if emission reductions are real and durable
  – Based on engine model year and engine family
  – Unique for on-road, off-road, stationary, etc.
• Provides a warranty for the device and installation
  – Up to 5 years/150,000 miles for filter
• Remote sensing and other on-road studies
PM2.5 Benefits Already Realized

2,700 tons reduced by 2014

Baseline

With Rule Requirements
Enforcement Activities
2010 Inspections

15,000 Trucks

2,700 Locomotives

300 Ships
45 Years of Progress on Black Carbon

Ramanathan, Kirchstetter, et al. (2013) Black Carbon and the Regional Climate of California, CARB Contract No. 08-323
Black Carbon Reduction Benefits

• Premature death
  – 6% reduction in cardiovascular deaths
    (3% of all-cause deaths)

• Lung cancer risk
  – 6,000 in a million lifetime exposure to 500

• Visibility
  – 10-75% of light extinction in urban areas is from diesel black carbon

• Climate
  – 10% reduction in overall carbon footprint
Conclusions

- Control technologies drastically reduce emissions from diesel and CNG engines
- Significant emissions reductions are possible but holistic approach is needed
  - Flexibility in regulatory path
  - Outreach to affected businesses
  - Incentive funding
  - Enforcement
  - Willingness to adjust
  - Research
- In-use fleet rules accelerate benefits
Next Steps

• In-use heavy-duty rules implemented through 2023
• Continued need for large NO\textsubscript{x} reductions from heavy-duty engines beyond what will be achieved with the 2010 standard
• Reduce fossil fuels usage 50% by 2030
  – U.S. EPA Phase 2 rulemaking on heavy-duty fuel efficiency
  – 10% reduction in life-cycle carbon intensity of fuels by 2020
• Short-lived climate pollutant plan in 2015
• Sustainable (zero emissions) freight by 2050 (plan in 2015)
extra
California’s air pollution problem

Unique geography and meteorology confine air pollutants

38 M people
90 people per km²
24 M gasoline cars
1.3 M diesel vehicles
1.4 B km per day
18 M off-road engines
3 large container ports

Majority of Californians breathe unhealthy air
California Controls on Black Carbon Sources

- Trash burning ban
- Agricultural burning reduced 80-90%
  - Restricted to favorable weather conditions
- Residential burning restrictions
- Smoking gasoline vehicle programs
- Heavy-duty vehicle controls
  - Smoke limits
  - New engine standards
  - Cleaner fuels
  - Retrofits
Black Carbon Emission Reductions from Trucks Operating on I-710 Freeway

Truck and Bus In-Use Regulation

One Million Trucks Affected

- In-State Light, 200,000
- In-State Heavy, 258,000
- Out-of-State, 500,000
Truck and Bus In-Use Regulation

• Basic Requirements
  – Lighter Vehicles
    • Upgrade to 2010+ engine 2015-2023
  – Heavier Vehicles
    • PM filters 2012-2014, then
    • Upgrade to 2010+ engine 2020-2023

• Small fleet options
• Phase-in for large fleets
## Significant Flexibility in Regulation

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Low-Use Agriculture</strong></td>
<td>- Compliance 2017 or 2023</td>
</tr>
<tr>
<td><strong>Log Truck Phase-In</strong></td>
<td>- Upgrade to 2010 engines 2014-2023</td>
</tr>
<tr>
<td><strong>NO\textsubscript{X} Exempt Areas</strong></td>
<td>- Filter only phase-in 2014-2016</td>
</tr>
<tr>
<td><strong>Low-Mileage Construction</strong></td>
<td>- Phase-in 2014 to 2016</td>
</tr>
<tr>
<td><strong>Low-Use Exemption</strong></td>
<td>- 1,000 miles per year&lt;br&gt;- 100 hours per year if stationary work</td>
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BC reduced throughout California