Meeting PM2.5 Standards in the San Joaquin Valley

Public Workshop
Fresno, California
December 1, 2016
Today’s Agenda

• Workshop Overview
• Nature and Sources of PM2.5
• Preliminary Air Quality Modeling
• Attainment Strategy
• Opportunities for Emission Reductions
What is PM2.5?

- Inhalable particles with a diameter 2.5 micrometers and smaller
- Can penetrate deep into the lungs and blood stream
- Mixture of many different chemical components
- Can be directly emitted as well as formed through reactions between gases
Health and Economic Impacts of Exposure to PM2.5

- Exposure to PM2.5 increases hospitalizations for respiratory and cardiac illness and exacerbates incidences of asthma attacks
- Results in approximately 1200 cases of premature mortality in the Valley each year
- Significant economic impacts from lost work days and health care costs
Board Direction on PM2.5 SIP

- Conduct additional public outreach on development of PM2.5 SIP for 12 ug/m3 annual standard
- Assess opportunities for further reductions from stationary and mobile sources
- Prioritize near-term reductions as part of overall attainment strategy
- Report back to Board in February with recommended actions
Focus of Today’s Workshop

- Present science-based assessment of nature and sources of PM2.5 and how that informs strategy
- Present preliminary attainment strategy to address multiple PM2.5 standards
- Discuss opportunities for emission reductions and mechanisms to overcome barriers
- Subsequent workshops will focus on specific measure recommendations
Path to PM2.5 Attainment

• Integrated strategy for multiple standards
  • 35 ug/m³ 24-hour
  • 15 ug/m³ annual
  • 12 ug/m³ annual

• Build on current progress under Clean Air Act

• Attainment achievable through combination of new ARB and District actions

• Include both regulatory and incentive-based approaches
District PM2.5 SIP Development Process

- District scoping meeting to discuss 2017 PM2.5 Plan on December 7, 2016
- Initiate Public Advisory Working Group
- Governing Board consideration in summer 2017
Nature and Sources of PM2.5
How Measurements and Inventory Inform the Attainment Strategy

- Magnitude and extent of current concentrations
- Seasonal variation in PM2.5 levels
- Chemical makeup of PM2.5 and contributing sources
- Regional and local contributions
- Progress due to implemented controls
The Valley’s PM2.5 Challenge

- Topography and weather conducive to formation and accumulation of PM2.5
- Weather conditions associated with drought have exacerbated challenge
- Highest levels measured in central and southern Valley
Need to Address PM2.5 Year-Round

- Highest levels during winter months
- Summer and fall also above annual standard
- Sources vary by season
- Requires year-round control strategy
Winter Composition

Bakersfield Monthly Average PM$_{2.5}$ Concentrations

Bakersfield Average Winter PM$_{2.5}$ Composition

- Ammonium Nitrate: 51%
- Carbon: 29%
- Ammonium Sulfate: 9%
- Dust: 9%
- Elements: 2%
Summer/Fall Composition

Bakersfield Monthly Average PM$_{2.5}$ Concentration

<table>
<thead>
<tr>
<th>Month</th>
<th>Concentration (µg/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>40</td>
</tr>
<tr>
<td>Feb</td>
<td>30</td>
</tr>
<tr>
<td>Mar</td>
<td>25</td>
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<td>Apr</td>
<td>20</td>
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<tr>
<td>May</td>
<td>15</td>
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<td>Jun</td>
<td>10</td>
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<td>Jul</td>
<td>5</td>
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<tr>
<td>Aug</td>
<td>0</td>
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<td>Sep</td>
<td>0</td>
</tr>
<tr>
<td>Oct</td>
<td>3</td>
</tr>
<tr>
<td>Nov</td>
<td>5</td>
</tr>
<tr>
<td>Dec</td>
<td>8</td>
</tr>
</tbody>
</table>

Bakersfield Summer/Fall Composition

- Carbon: 37%
- Dust: 21%
- Ammonium Sulfate: 21%
- Ammonium Nitrate: 18%
- Elements: 3%
What are the Key Sources Contributing to PM2.5?
Both Mobile and Stationary Sources are Significant Contributors

**Contribution to Annual Average**
- **Mobile Sources**
- **Stationary/Area Sources**

**Contribution to 24-Hour Average**
- **Mobile Sources**
- **Stationary/Area Sources**

**Mobile Sources**: Includes cars, trucks, trains, planes, ships, tractors, construction equipment, forklifts, and other off-road equipment

**Stationary/Area Sources**: Includes industrial sources, wood burning, dust, commercial cooking, ag and forest burning, and residential and commercial fuel use
Ammonium Nitrate Sources

- Winter weather conditions conducive to formation
- NOx controls most effective in reducing ammonium nitrate levels

San Joaquin Valley NOx Emissions (tpd)
Ammonium Sulfate Sources

- Summer weather conditions most conducive to formation
- Large number of small sources
Fugitive Dust Sources

- Largest contribution in summer and fall
- Fallow fields and drier soils in recent years have increased dust fraction
- Contributions are more local in nature
Combustion Carbon Sources

- Primarily directly emitted combustion particles
- Contributions are more local in nature
- Chemical markers also help identify sources

San Joaquin Valley Combustion PM2.5 Emissions (tpd)

- Stationary
- Managed Burning
- Cooking
- Residential Burning
- Mobile

2013
Chemical Markers Identify Wood Smoke Contribution

- Levoglucosan formed during high-temperature combustion of biomass
- Useful in apportioning fraction of organic carbon from wood smoke
- Demonstrates wood smoke comprises 30 to 60 percent of measured carbon during the winter

Estimated Wood Burning Contribution to Measured Organic Carbon using Levoglucosan as Marker
Nov-Feb Average for Modesto and Visalia 2010-2012
Sources Can Have Different Localized Impacts

2013 Annual PM$_{2.5}$ Cooking Emissions

Fresno

Bakersfield
What are the Benefits of Emission Reductions to Date?
Ongoing Progress in Reducing Emissions

Percent Reduction in Emissions: 2002 to 2012

- NOx
- SOx
- Combustion PM2.5
- Dust PM2.5

Percent Reduction: 2002-2012
Reductions in NOx and Combustion PM2.5 Emissions Have Been Effective
Key Findings

• Multiple constituents contribute to measured PM2.5 levels throughout the year

• Both stationary and mobile sources are significant contributors

• Both regional and local scale emissions impact PM2.5 levels

• Reductions in NOx and directly emitted PM2.5 emissions have been effective
Preliminary Air Quality Modeling
How Air Quality Modeling Informs the Attainment Strategy

• Links changes in emissions to changes in future air quality

• Informs control strategy approach:
  • Relative effectiveness of reductions in individual precursors
  • Relative contribution of sources
  • Sensitivity to reductions from specific sources

• Establishes attainment targets
Modeling Approach

- Utilizes the latest peer-reviewed science
- Consistent with U.S. EPA Guidance
- Model base (2013) and future (2025) years
  - Reflects weather conditions associated with drought
  - Includes DISCOVER-AQ (NASA) field campaign from Jan 10 – Feb 10, 2013
- Modeling results used in a relative sense (Relative Response Factor)
What Further Emission Reductions are Included in the Modeling?
Current Control Programs Provide Significant New Reductions

- Will reduce NOx an additional 50 percent and PM2.5 an additional 5 percent by 2025
- Continued implementation of truck and bus regulation through 2023
- New passenger vehicle standards
- Curtailment programs and replacement of fireplaces and wood stoves
- Cleaner agricultural IC engines
- Over $400 million public/private investment in tractor replacements
### Annual NOx Emissions: Benefits of Current Control Program

<table>
<thead>
<tr>
<th>Category</th>
<th>2013 (tpd)</th>
<th>2021 (tpd)</th>
<th>2025 (tpd)</th>
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</thead>
<tbody>
<tr>
<td>Medium &amp; heavy-duty trucks</td>
<td>156.4</td>
<td>76.5</td>
<td>45.7</td>
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<tr>
<td>Farm equipment</td>
<td>48.4</td>
<td>34.0</td>
<td>26.6</td>
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<tr>
<td>Light-duty vehicles</td>
<td>20.7</td>
<td>8.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Trains</td>
<td>13.4</td>
<td>12.9</td>
<td>11.6</td>
</tr>
<tr>
<td>Construction, mining &amp; logging equipment</td>
<td>10.8</td>
<td>9.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Irrigation pumps</td>
<td>10.2</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Off-road equipment</td>
<td>8.4</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Glass and related products</td>
<td>6.2</td>
<td>4.5</td>
<td>4.7</td>
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<tr>
<td>Buses</td>
<td>6.0</td>
<td>3.0</td>
<td>2.0</td>
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<tr>
<td>Residential gas and oil combustion</td>
<td>5.9</td>
<td>6.0</td>
<td>5.9</td>
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<tr>
<td>Remaining emission categories</td>
<td>31.7</td>
<td>32.1</td>
<td>33.7</td>
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<td><strong>Total</strong></td>
<td><strong>318.1</strong></td>
<td><strong>196.2</strong></td>
<td><strong>149.7</strong></td>
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### Annual PM2.5 Emissions: Benefits of Current Control Program

<table>
<thead>
<tr>
<th>Activity</th>
<th>2013 (tpd)</th>
<th>2021 (tpd)</th>
<th>2025 (tpd)</th>
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<tbody>
<tr>
<td>Tilling, cultivation, harvesting</td>
<td>11.6</td>
<td>11.2</td>
<td>11.0</td>
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<tr>
<td>Fugitive windblown dust</td>
<td>7.5</td>
<td>7.3</td>
<td>7.1</td>
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<tr>
<td>Paved road dust</td>
<td>4.8</td>
<td>5.4</td>
<td>5.8</td>
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<tr>
<td>Medium &amp; Heavy-duty trucks</td>
<td>4.8</td>
<td>1.4</td>
<td>1.2</td>
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<tr>
<td>Residential wood combustion</td>
<td>4.4</td>
<td>3.8</td>
<td>3.8</td>
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<tr>
<td>Unpaved road dust</td>
<td>3.7</td>
<td>3.7</td>
<td>3.7</td>
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<tr>
<td>Commercial cooking</td>
<td>3.6</td>
<td>4.1</td>
<td>4.3</td>
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<tr>
<td>Farm Equipment</td>
<td>2.8</td>
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<td>1.6</td>
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<tr>
<td>Managed farm burning</td>
<td>2.0</td>
<td>1.9</td>
<td>1.9</td>
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<tr>
<td>Fuel use, oil &amp; gas production</td>
<td>1.7</td>
<td>1.4</td>
<td>1.3</td>
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<tr>
<td>Remaining emission categories</td>
<td>16.6</td>
<td>17.4</td>
<td>17.7</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>63.5</strong></td>
<td><strong>59.6</strong></td>
<td><strong>59.4</strong></td>
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# Annual SOx Emissions: Benefits of Current Control Program

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<th>2013 (tpd)</th>
<th>2021 (tpd)</th>
<th>2025 (tpd)</th>
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</thead>
<tbody>
<tr>
<td>Glass &amp; related products</td>
<td>2.0</td>
<td>2.0</td>
<td>2.1</td>
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<tr>
<td>Industrial fuel combustion</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td>Chemical manufacturing and storage</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
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<tr>
<td>Fuel use, oil and gas production</td>
<td>0.7</td>
<td>0.3</td>
<td>0.2</td>
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<tr>
<td>Power generation</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Food production</td>
<td>0.6</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Oil and gas</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>Mineral processes</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>Medium &amp; heavy duty trucks</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
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<tr>
<td>Commercial &amp; service fuel combustion</td>
<td>0.4</td>
<td>0.3</td>
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<tr>
<td>Remaining emission categories</td>
<td>1.3</td>
<td>1.5</td>
<td>1.7</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>8.5</strong></td>
<td><strong>8.2</strong></td>
<td><strong>8.4</strong></td>
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# Annual Ammonia Emissions: Benefits of Current Control Program

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<tr>
<th>Category</th>
<th>2013 (tpd)</th>
<th>2021 (tpd)</th>
<th>2025 (tpd)</th>
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<tbody>
<tr>
<td>Dairy cattle</td>
<td>125.3</td>
<td>125.3</td>
<td>125.3</td>
</tr>
<tr>
<td>Pesticides and fertilizers</td>
<td>117.6</td>
<td>112.5</td>
<td>109.9</td>
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<tr>
<td>Other livestock</td>
<td>61.2</td>
<td>61.2</td>
<td>61.2</td>
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<tr>
<td>Other waste disposal</td>
<td>8.7</td>
<td>9.9</td>
<td>10.6</td>
</tr>
<tr>
<td>Other miscellaneous processes</td>
<td>6.1</td>
<td>6.9</td>
<td>7.3</td>
</tr>
<tr>
<td>Light-duty vehicles</td>
<td>2.5</td>
<td>2.2</td>
<td>2.2</td>
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<tr>
<td>Power generation</td>
<td>1.8</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Medium and heavy-duty trucks</td>
<td>1.6</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Chemical manufacturing and storage</td>
<td>1.1</td>
<td>1.3</td>
<td>1.4</td>
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<tr>
<td>Landfills</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td>Remaining emission categories</td>
<td>2.3</td>
<td>2.5</td>
<td>2.5</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>328.9</strong></td>
<td><strong>325.2</strong></td>
<td><strong>323.9</strong></td>
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</table>
Emissions Inventory
Improvements Underway

- Updated Locomotive emissions
  - Revised tier and age distribution

- Updated paved and unpaved road dust emissions
  - Incorporates AP-42 dust fraction

- Updated monthly distribution of crop emissions

- Residential burning
  - Reflects updated Valley activity survey
  - Includes woodstove replacements due to Valley incentive programs
What are the Air Quality Benefits of the Current Control Program?
Current Control Program Provides for Significant Progress

Bakersfield Annual Average PM2.5

- Ammonium Nitrate
- Elemental Carbon
- Ammonium Sulfate
- Combustion Carbon
- Dust

PM2.5 (µg/m³)

<table>
<thead>
<tr>
<th>Year</th>
<th>Ammonium Nitrate</th>
<th>Elemental Carbon</th>
<th>Ammonium Sulfate</th>
<th>Combustion Carbon</th>
<th>Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2025</td>
<td></td>
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</table>
Current Control Program Provides for Significant Progress

Bakersfield 24-Hour Average PM2.5
Which Sources Offer the Greatest Opportunities for Reducing PM2.5?
Actions to Reduce Directly Emitted PM2.5 Are Most Effective

24-Hour Average PM2.5

Annual Average PM2.5
Largest Carbon Contributions in 2025 are from Cooking, Wood Burning, and Dust
U.S. EPA PM2.5 Precursor Demonstration Guidance

- Specifies modeling approach to demonstrate whether precursor emissions contribute significantly to PM2.5 levels
- Recommends modeling 30-70% reductions in anthropogenic precursor emissions in the nonattainment area
- Recommends thresholds below which air quality change is considered “insignificant”:
  - 0.2 µg/m³ for annual PM2.5
  - 1.3 µg/m³ for 24-hour PM2.5
Preliminary Precursor Assessment

24-hour Average PM2.5

Annual Average PM2.5

30% reduction in emissions
Key Findings

- Mobile source NOx and diesel PM reductions provide majority of progress by 2025
- Further reductions in NOx and directly emitted PM2.5 needed to meet both annual and 24-hour standards
- Reductions in sources of directly emitted PM2.5 most effective
- PM2.5 is very responsive to controls on cooking, dust sources, and wood burning
- NOx controls significantly more effective than ammonia in reducing ammonium nitrate
Attainment Strategy
Approach
Strategy Design Principles

• Focus on largest remaining constituents
• Consider most effective precursors
• Address increase in fugitive dust resulting from drought
• Consider strategies that provide multiple benefits:
  • Reducing localized exposure
  • Reducing climate pollutants such as black carbon
  • Accelerating ozone progress
• Pursue opportunities for near-term reductions
Proposed Strategy Reductions
Bakersfield Annual Average PM2.5

15% Further Reduction:
- ~20 tpd of NOx

25% Further Reduction:
- ~7 tpd of combustion PM2.5
- ~7 tpd of dust PM2.5
Strategy Provides for Annual Attainment
Bakersfield Annual Average PM2.5

<table>
<thead>
<tr>
<th>Year</th>
<th>Current Controls</th>
<th>Attainment Strategy</th>
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</thead>
<tbody>
<tr>
<td>2013</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>2025</td>
<td>12</td>
<td>12</td>
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</tbody>
</table>

PM2.5 ug/m³

- Ammonium Nitrate
- Elemental Carbon
- Ammonium Sulfate
- Combustion Carbon
- Dust
Proposed Strategy Reductions
Bakersfield 24-Hour Average PM2.5

PM2.5 (ug/m3)

2013       2025

20% Further Reduction: 
~30 tpd of NOx

25% Further Reduction:
~7 tpd of combustion PM2.5

25% Further Reduction:
~7 tpd of dust PM2.5

PM2.5 (ug/m3)

- Dust
- Combustion Carbon
- Elemental Carbon
- Ammonium Sulfate
- Ammonium Nitrate

Years (2013-2025)
Strategy Provides for 24-Hour Attainment

Bakersfield 24-hour Average PM2.5

<table>
<thead>
<tr>
<th>Year</th>
<th>Current Controls</th>
<th>Attainment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td></td>
<td></td>
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<tr>
<td>PM2.5 (ug/m³)</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
</tr>
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<td></td>
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<td>10</td>
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<tr>
<td></td>
<td>0</td>
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</tr>
</tbody>
</table>

- Red: Ammonium Nitrate
- Black: Elemental Carbon
- Yellow: Ammonium Sulfate
- Blue: Combustion Carbon
- Orange: Dust
Alternative Approaches Don’t Provide for Attainment

Annual Average PM2.5

24-Hour Average PM2.5
Science-Based Attainment Strategy

• Balanced approach focusing on both directly emitted PM2.5 and NOx reductions

• Achieves annual and 24-hour standards

• Directly emitted PM2.5 measures:
  • Most effective in reducing PM2.5 levels
  • Reduce localized exposure
  • Provide opportunities for near-term reductions
  • Reduce black carbon

• NOx measures:
  • Accelerate ozone progress
  • Targeted incentives provide opportunities for near-term reductions
  • Zero emission technologies support climate goals
## Attainment Strategy Reductions
*(between 2013 and 2025)*

<table>
<thead>
<tr>
<th>NO\textsubscript{x} Emissions</th>
<th>Carbon Emissions</th>
<th>Dust Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Truck]</td>
<td>![Fireplace]</td>
<td>![Smoke]</td>
</tr>
<tr>
<td>62%</td>
<td>37%</td>
<td>20%</td>
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Opportunities for Emission Reductions

Potential approaches based on public and agency comments
Mobile Source Strategy

- Future reductions from current mobile source control program: 168 tpd of NOx
- Goal for reductions from new strategies: ~30 tpd
- Proposed State SIP Strategy provides 5 tpd new reductions by 2024/2025
  - Low NOx standard for heavy-duty trucks
  - Last Mile Delivery
  - Advanced Clean Transit
  - Tier 5 engine standard for locomotives
  - Low emission diesel fuel standard
- Continuation of existing incentive programs would provide 10 tpd by 2024/2025
  - Ag tractors: 7.5 tpd
  - Moyer: 2.5 tpd
- Need incentives to accelerate remaining State SIP strategy reductions from 2031 to 2024/2025 to achieve final 15 tpd reductions
  - Low-NOx trucks
  - ZEV/PHEV passenger vehicles
  - Tier 4/5 locomotives
Other Opportunities for NOx Reductions

- Public fleet rules to require cleanest technologies for new vehicle purchase
- Updates to Indirect Source Rule
- More stringent engine standards for agricultural IC engines
- More stringent limits for glass melting furnaces
- Requirements for flaring best practices and use of ultra-low NOx flare technologies
- Agricultural tractor rule
Overcoming Barriers: NOx

- Call for U.S. EPA action on low-NOx standard for heavy-duty trucks and tier 5 standards for locomotives
- Identification of funding to accelerate deployment of new technologies in coordination with the South Coast
- Continued work with U.S. EPA on demonstration of SIP creditability of incentive-based reductions
Opportunities for Combustion Carbon Reductions

• Future reductions from current control program: 5 tpd

• Goal for reductions from new strategies: ~7 tpd
  • Continued Incentives for replacement of fireplaces and woodstoves
  • More stringent limits for wood burning curtailment
  • Further limitations on wood burning devices in new homes
  • Expand charbroiling rule to include underfired broilers
  • Pursue alternatives to agricultural burning
  • Benefits from mobile source NOx measures
Overcoming Barriers: Carbon

- Reducing costs of charbroiling control technologies
- Identification of continued funding for woodstove and fireplace replacements
- Education and outreach on availability of alternatives to residential wood burning
- Development of beneficial uses of ag waste
  - Ag Waste Biomass Summit planned for spring 2017
Opportunities for Dust Reductions

- Future reductions from current control program: 0 tpd
- Goal for reductions from new strategies: ~7 tpd
  - Update Conservation Management Practices
  - Update Regulation VIII to reduce fugitive dust from open areas and roads
  - Updates to Indirect Source Rule
Overcoming Barriers: Dust

- Continued assessment of fugitive dust sources which have greatest impact
- Drought limits availability of water as dust suppression mechanism
- Economics of agricultural operations
Other Opportunities for Reductions

- Potential SOx co-benefits from other strategies
- Potential ammonia strategies
Next Steps

• December 7: District workshop

• January-February: Additional ARB workshops
  • Focused discussion on potential measures and barriers
  • Recommended actions on specific measures

• February: Report back to ARB Board

• January – Summer: District SIP development process

• August: District Board consideration of integrated SIP

• September: ARB Board consideration of integrated SIP
Questions?