Benefits and Costs of Tier 3 Low Sulfur Gasoline Program

CT DEEP SIPRAC Meeting
Hartford, CT
January 12, 2012
Presentation Overview

• EPA’s expected Tier 3 motor vehicle standards and low sulfur gasoline proposal
• Need for additional NOx reductions
• Projected emission benefits
• Cost and cost-effectiveness
• Monetized health benefits
• Impacts on oil industry
• Conclusions
Tier 3 Rulemaking

- EPA expected to propose Tier 3 rule for cars and light-duty trucks in early 2012 and finalize in late 2012

- Includes tailpipe standards for NOx, VOCs, and PM and evaporative emission standards, which they intend to harmonize with CA LEV III

- Expected to include a requirement to lower gasoline sulfur to an average of 10 ppm
Lower Sulfur Gasoline

- Lowering the sulfur content of gasoline allows pollution control equipment (3-way catalysts) on cars and trucks to operate more effectively.
- Will reduce NOx from existing gasoline vehicle fleet by about 25%.
- Emission reductions from the in-use fleet would be achieved concurrent with the introduction of the cleaner fuel, without the need for fleet turnover.
Sulfur Content in Gasoline Worldwide Comparison

<table>
<thead>
<tr>
<th></th>
<th>PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>China III</td>
<td>150</td>
</tr>
<tr>
<td>SAC IV</td>
<td>50</td>
</tr>
<tr>
<td>SAC V (P)</td>
<td>10</td>
</tr>
<tr>
<td>MEP Haz IV</td>
<td>50</td>
</tr>
<tr>
<td>MEP Haz V</td>
<td>10</td>
</tr>
<tr>
<td>Beijing</td>
<td>50</td>
</tr>
<tr>
<td>Shanghai</td>
<td>50</td>
</tr>
<tr>
<td>Euro III</td>
<td>150</td>
</tr>
<tr>
<td>Euro IV</td>
<td>50</td>
</tr>
<tr>
<td>Euro V</td>
<td>10</td>
</tr>
<tr>
<td>US EPA</td>
<td>30</td>
</tr>
<tr>
<td>CARB</td>
<td>15</td>
</tr>
<tr>
<td>WW Fuel Charter</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>10</td>
</tr>
</tbody>
</table>
NOx Contributes to Wide Range of Health & Environmental Problems

- Fertilization: altered biodiversity, plant damage
- Leaching of nutrients and aluminum
- Acidification of water + Eutrophication

Sunlight
Cloud Chemistry
Wet Deposition/Acid Rain

NOx
SO2
NOx

N emissions
Dry deposition
N emissions
PM

Fertilization altered biodiversity plant damage
Leaching of nutrients and aluminum

Acidification of water + Eutrophication
Need for Additional NOx Reductions

• Ozone and PM2.5
  – Reduces lung function, aggravates asthma and other chronic lung diseases
  – Can cause permanent lung damage from repeated exposures
  – Contributes to premature death

• Acid Deposition
  – Damages forests
  – Damages aquatic ecosystems
  – Erodes manmade structures

• Coastal Marine Eutrophication
  – Depletes oxygen in the water, which suffocates fish and other aquatic life in bays and estuaries (e.g., Long Island Sound)

• Visibility Impairment
  – Contributes to regional haze that mars vistas and views in urban and wilderness areas
Source of NOx Emissions in the Northeast/Mid-Atlantic

Preliminary Top NOx Source Categories in 2007
MANE-VU Region Without VA

- External Combustion Boilers / Industrial
- Industrial Processes / Mineral Products
- NONROAD Mobile / Railroad Equipment
- NONROAD Mobile / Commercial Marine Vessels
- Stationary Source Fuel Combustion / Residential
- NONROAD Mobile / Diesel Vehicles
- External Combustion Boilers / EGU
- ONROAD Mobile / Diesel Vehicles
- ONROAD Mobile / Gasoline Vehicles

* MARAMA 2007 V2 Inventory

NOx (TPY)
Projected 2015 Average Contribution by State/Sector to Exceedance-level O3

*Local states: NY, NJ, and CT; Nearby states: DE, MA, and PA.
Overall Tier 3
Emission Reduction Benefits

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>16%</td>
<td>59%</td>
</tr>
<tr>
<td>VOC</td>
<td>4%</td>
<td>32%</td>
</tr>
<tr>
<td>CO</td>
<td>8%</td>
<td>38%</td>
</tr>
</tbody>
</table>
## State Emissions and Estimated Reductions from 10 ppm Sulfur

<table>
<thead>
<tr>
<th>State</th>
<th>2017 Gasoline On-road Base NOx (tpy)</th>
<th>Estimated NOx Reductions from 10 ppm Sulfur Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(tpy)</td>
</tr>
<tr>
<td>Connecticut</td>
<td>20,700</td>
<td>-3,100</td>
</tr>
<tr>
<td>Delaware</td>
<td>5,400</td>
<td>-800</td>
</tr>
<tr>
<td>District of Columbia</td>
<td>2,000</td>
<td>-300</td>
</tr>
<tr>
<td>Maine</td>
<td>10,000</td>
<td>-1,500</td>
</tr>
<tr>
<td>Maryland</td>
<td>32,600</td>
<td>-5,000</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>35,100</td>
<td>-5,300</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>8,400</td>
<td>-1,300</td>
</tr>
<tr>
<td>New Jersey</td>
<td>44,300</td>
<td>-6,700</td>
</tr>
<tr>
<td>New York</td>
<td>88,600</td>
<td>-13,500</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>70,500</td>
<td>-10,700</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>5,600</td>
<td>-900</td>
</tr>
<tr>
<td>Vermont</td>
<td>5,000</td>
<td>-800</td>
</tr>
<tr>
<td>Virginia (Northern counties)</td>
<td>11,300</td>
<td>-1,700</td>
</tr>
<tr>
<td><strong>Northeast/Mid-Atlantic</strong></td>
<td><strong>339,500</strong></td>
<td><strong>-51,600</strong></td>
</tr>
</tbody>
</table>
## Regional Gasoline Vehicle Emissions and Estimated Reductions from 10 ppm Sulfur

<table>
<thead>
<tr>
<th>Region</th>
<th>2017 Gasoline On-road Baseline NOx (tpy)</th>
<th>Estimated NOx Reductions from 10 ppm Sulfur Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(tpy)</td>
</tr>
<tr>
<td>Northeast/Mid-Atlantic States</td>
<td>339,500</td>
<td>-51,600</td>
</tr>
<tr>
<td>Midwest States (IL, IN, IA, MI, MN, MO, OH, WI)</td>
<td>402,300</td>
<td>-61,000</td>
</tr>
<tr>
<td>Southeast States (AL, FL, GA, KY, MS, NC, SC, TN, VA, WV)</td>
<td>427,800</td>
<td>-64,900</td>
</tr>
<tr>
<td><strong>3 Region Total</strong></td>
<td><strong>1,169,600</strong></td>
<td><strong>-177,500</strong></td>
</tr>
</tbody>
</table>
### Annual NOx Reductions from 10 ppm Sulfur Gasoline & CSAPR

<table>
<thead>
<tr>
<th>Region</th>
<th>2017 NOx Reductions from 10 ppm Sulfur Gasoline (tpy)</th>
<th>2014 NOx Reductions from CSAPR* (tpy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast/Mid-Atlantic States</td>
<td>-51,600</td>
<td>-17,068</td>
</tr>
</tbody>
</table>
Predicted Cost-Effectiveness of Tier 3/Low Sulfur Gasoline

<table>
<thead>
<tr>
<th>Cost (cents per gallon)</th>
<th>Cost Effectiveness ($/ton NOx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 cents (MSAT)</td>
<td>$2,500</td>
</tr>
<tr>
<td>0.8 cents (ICCT/MathPro) sensitivity case</td>
<td>$4,000</td>
</tr>
<tr>
<td>1.4 cents (ICCT/MathPro) study case</td>
<td>$7,000</td>
</tr>
</tbody>
</table>
## Relative Cost-Effectiveness of Lower Sulfur Gasoline

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost Effectiveness ($/ton NOx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICI Boilers (area &amp; point sources)</td>
<td>$750 - $7,500 (Low NOx Burners)</td>
</tr>
<tr>
<td></td>
<td>$1,300 - $3,700 (SNCR)</td>
</tr>
<tr>
<td></td>
<td>$2,000 - $14,000 (SCR)</td>
</tr>
<tr>
<td>Combustion Turbines – SCR</td>
<td>$2,010 - $19,120</td>
</tr>
<tr>
<td>Highway – Heavy-duty Diesel Engine Standards &amp; Fuel Sulfur</td>
<td>$10,561</td>
</tr>
<tr>
<td>Tier 2 Light-duty Vehicle Emissions &amp; Gasoline Sulfur</td>
<td>$6,297</td>
</tr>
<tr>
<td>10 ppm Sulfur Gasoline</td>
<td>$2,500 – $7,000</td>
</tr>
</tbody>
</table>
## Annual Monetized Health Benefits in Northeast/Mid-Atlantic (2018)

<table>
<thead>
<tr>
<th></th>
<th>Value [millions of 2006$]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ozone</td>
</tr>
<tr>
<td><strong>Morbidity</strong></td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td>$20</td>
</tr>
<tr>
<td>PM2.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td></td>
</tr>
<tr>
<td>PM2.5</td>
<td>$196</td>
</tr>
<tr>
<td>Total</td>
<td>$877</td>
</tr>
<tr>
<td><strong>Total Monetized Health Benefits</strong></td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td>$215</td>
</tr>
<tr>
<td>PM2.5</td>
<td>$896</td>
</tr>
</tbody>
</table>
## Cost vs. Health Benefits

<table>
<thead>
<tr>
<th>Annual Cost</th>
<th>Value [millions of dollars]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 cents/gal</td>
<td>$143</td>
</tr>
<tr>
<td>0.8 cents/gal</td>
<td>$229</td>
</tr>
<tr>
<td>1.4 cents/gal</td>
<td>$400</td>
</tr>
<tr>
<td>Total Monetized Annual Health Benefits</td>
<td>$234 – $1,186 (mid-point = $700)</td>
</tr>
</tbody>
</table>
Impact on Oil Industry

• 10 ppm sulfur gasoline proposal would represent the latest in a series of regulatory initiatives to remove sulfur from transportation fuels
  – Tier 2 (30 ppm) - 2000
  – highway diesel (15 ppm) - 2001
  – nonroad diesel (15 ppm) - 2004
• U.S. refiners have already invested in desulfurization capacity
• Oil industry has historically generated conservative estimates of predicted cost of complying with fuel sulfur standards, but has found less costly ways to comply
## Components of US Gas Prices

<table>
<thead>
<tr>
<th>Year</th>
<th>July</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>$1.55</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>$1.42</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>$1.40</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>$1.51</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>$1.91</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>$2.29</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>$2.98</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>$2.97</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>$4.06</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>$2.53</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>$2.72</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>$3.68</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>0.25</td>
<td>0.20</td>
<td>0.18</td>
<td>0.18</td>
<td>0.40</td>
<td>0.40</td>
<td>0.44</td>
<td>0.46</td>
<td>0.34</td>
<td>0.35</td>
<td>0.35</td>
<td>0.42</td>
</tr>
<tr>
<td>Refining</td>
<td>0.43</td>
<td>0.28</td>
<td>0.21</td>
<td>0.21</td>
<td>0.42</td>
<td>0.41</td>
<td>0.78</td>
<td>0.40</td>
<td>0.40</td>
<td>0.26</td>
<td>0.26</td>
<td>0.42</td>
</tr>
<tr>
<td>Distribution &amp; Marketing</td>
<td>0.57</td>
<td>0.14</td>
<td>0.68</td>
<td>0.68</td>
<td>0.88</td>
<td>1.26</td>
<td>1.55</td>
<td>1.68</td>
<td>0.45</td>
<td>0.26</td>
<td>0.26</td>
<td>0.44</td>
</tr>
<tr>
<td>Taxes</td>
<td>0.68</td>
<td>0.59</td>
<td>0.59</td>
<td>0.66</td>
<td>0.66</td>
<td>1.26</td>
<td>1.55</td>
<td>1.68</td>
<td>0.45</td>
<td>0.35</td>
<td>0.35</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Impact on Oil Industry

- Low sulfur gasoline and diesel regulations have had little effect on the numbers or capacities of operable refineries in U.S.
- U.S. gasoline supply increased nearly 10 percent, comparing the year 2000 to the year 2007
- Early compliance was widespread and many refiners generated a surplus of credits
Conclusions

• Lowering the sulfur content of gasoline to an average of 10 ppm would cost-effectively reduce NOx emissions

• Represents one of the most significant strategies available to protect public health by addressing ozone nonattainment in the Northeast/Mid-Atlantic
  – Help areas that need reductions to attain
  – Help other areas stay in attainment
  – Position states to be in attainment with any new NAAQS
Conclusions

• NOx reductions would also help lower fine particle concentrations and mitigate acid rain, water body eutrophication, and regional haze

• As a federal requirement, the low sulfur gasoline rule would result in very significant NOx reductions across the entire domain in the Eastern U.S. that contributes to pollutant burden in Northeast/Mid-Atlantic region

• Emission reductions not achieved through this and other federal measures would have to be accomplished by further controlling local sources in the region