PM$_{2.5}$ and Ozone Permitting and Modeling in the Age of MERPs

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Midwest A&WMA's 27th Annual Technical Conference
Lenexa, KS

October 1, 2019
Agenda

- About PM2.5 and Ozone
- MERPs guidance overview
- Other PM$_{2.5}$ and Ozone guidance
- Case Study: Using MERPs in a permit application
- Summary and Outlook
PM$_{2.5}$ and Ozone Formation

- PM$_{2.5}$ = Particulates with diameters ≤ 2.5 µm
  - Emitted directly (primary) or formed in the atmosphere (secondary)
  - Sulfate, nitrate, ammonium, organic carbon, elemental carbon, crustal elements, sea spray constituents, and oxidized metals
- Ozone = O$_3$, good in the stratosphere, not in the troposphere!
- Secondary PM$_{2.5}$ and Ozone are formed in the atmosphere via complex photochemical reactions
  - Warm, sunny days => More formation
  - “Ozone Season”
- Precursors are emitted by sources:
  - Ozone: VOC and NO$_X$
  - PM$_{2.5}$: SO$_2$ and NO$_X$
PM$_{2.5}$ and Ozone Formation

• How to quantify secondary PM$_{2.5}$ and Ozone?
  • Atmospheric conditions (temperature, solar radiation, wind speeds, humidity)
  • Ambient concentrations
    • Ozone: NO$_x$, VOC
    • PM$_{2.5}$: SO$_2$, NOX, Ammonia (NH3)
• Photochemical Grid models: CAMx, CMAQ
  • Highly complex, typically used for regional-scale modeling and SIP evaluations
  • Generally impractical for single-source permitting
• But secondary formation has to be evaluated for permits…
Enter MERPs
What is a MERP?

- **Modeled Emission Rates for Precursors**
  - Represent the emission rate of a precursor that *(by itself)* will not exceed the relevant Significant Impact Level (SIL)
- Developed by EPA as a “Tier 1” demonstration tool to evaluate secondary impacts of PM$_{2.5}$ and Ozone
- Based on photochemical grid modeling completed by EPA
- Basic MERP equation:
  - \( MERP[tpy] = SIL \left[ ppb \text{ or } \frac{\mu g}{m^3} \right] \times \frac{\text{Precursor Emission Rate}[tpy]}{\text{Air Quality Impact}[ppb \text{ or } \frac{\mu g}{m^3}]} \)
- MERPs for each precursor and each standard
## Precursors and Standards with MERPs

<table>
<thead>
<tr>
<th></th>
<th>PM$_{2.5}$ 24-hr</th>
<th>PM$_{2.5}$ Annual</th>
<th>Ozone 8-hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO$_2$</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NO$_2$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>VOC</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
MERPs Guidance

- EPA released final April 30, 2019
- Guidance includes
  - Information about PM$_{2.5}$ and Ozone formation
  - Results and descriptions of EPA’s modeling
  - Information for developing additional MERPs
  - Example permitting evaluations using MERPs
  - Excel file of modeled sources and results

- Available on the SRAM Permit Modeling Guidance page:
  - https://www.epa.gov/scram/clean-air-act-permit-modeling-guidance
Hypothetical Sources

• Generic point sources used for EPA’s photochemical modeling

• Point source parameters:
  • Diameter: 5 m (16.4 ft)
  • Temperature: 311 K (100 °F)
  • Velocity: 27 m/s (89 ft/s)

• Two Release Heights:
  • Low: 10 m (33 ft)
  • High: 90 m (295 ft)

• Three Precursor emission rates: 500, 1000, or 3000 tpy

• Modeled impacts for each precursor, pollutant, and standard at each release height and emission rate
Hypothetical Sources

Dec 2016 Draft

Apr 2019 Final
Climate Zones

• Hypothetical sources subdivided by NOAA Climate Zone

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>10</td>
</tr>
<tr>
<td>Southeast</td>
<td>9</td>
</tr>
<tr>
<td>Ohio Valley</td>
<td>19</td>
</tr>
<tr>
<td>Upper Midwest</td>
<td>12</td>
</tr>
<tr>
<td>Rockies/Plains</td>
<td>14</td>
</tr>
<tr>
<td>South</td>
<td>17</td>
</tr>
<tr>
<td>Southwest</td>
<td>15</td>
</tr>
<tr>
<td>West</td>
<td>6</td>
</tr>
<tr>
<td>Northwest</td>
<td>3</td>
</tr>
</tbody>
</table>
MERPs Guidance

- Final guidance expanded info about hypothetical sources
  - Maximum terrain height within 50 km
  - Fractional Urban coverage within 50 km
  - Lat/Long coordinates

- Example scenarios for use of MERPs
  - PSD Significant Impact
  - Cumulative Analysis
  - Class I Analysis
Regional MERPs – PM2.5 24-hr

<table>
<thead>
<tr>
<th>Region</th>
<th>MERP (tpy)</th>
<th>NOx</th>
<th>SO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>2,218</td>
<td>623</td>
<td>1,943</td>
</tr>
<tr>
<td>Southeast</td>
<td>1,943</td>
<td>367</td>
<td>2,570</td>
</tr>
<tr>
<td>Ohio Valley</td>
<td>2,570</td>
<td>348</td>
<td>2,963</td>
</tr>
<tr>
<td>Upper Midwest</td>
<td>2,963</td>
<td>454</td>
<td>1,740</td>
</tr>
<tr>
<td>Rockies/Plains</td>
<td>1,740</td>
<td>251</td>
<td>1,881</td>
</tr>
<tr>
<td>South</td>
<td>1,881</td>
<td>274</td>
<td>1,508</td>
</tr>
<tr>
<td>Southwest</td>
<td>6,514</td>
<td>1,508</td>
<td>1,073</td>
</tr>
<tr>
<td>West</td>
<td>1,073</td>
<td>188</td>
<td>1,203</td>
</tr>
<tr>
<td>Northwest</td>
<td>3,003</td>
<td></td>
<td>1,203</td>
</tr>
</tbody>
</table>
Regional MERPs – PM$_{2.5}$ Annual

Northeast: 10,142
Southeast: 5,679
Ohio Valley: 7,625
Upper Midwest: 10,011
Rockies/Plains: 9,220
South: 7,453
Southwest: 11,960
West: 3,182
Northwest: 11,276

Bars represent MERP (tpy) for the following regions:
- NOx
- SO2
Regional MERPs – Ozone 8-hr

The bar chart shows the MERPs (tpy) for different regions:
- Northeast: 2,068 tpy
- Southeast: 1,936 tpy
- Ohio Valley: 1,159 tpy
- Upper Midwest: 1,560 tpy
- Rockies/Plains: 1,067 tpy
- South: 2,307 tpy
- Southwest: 1,079 tpy
- West: 1,094 tpy
- Northwest: 1,049 tpy

The chart also indicates NOx and VOC emissions for each region.
State/Agency Guidance

- Individual state/agency guidance
  - Check with agency before submitting protocol/application
  - Iowa – Follow EPA guidance, use MERPs from Upper Midwest zone
  - Nebraska – State guidance in development
  - Kansas
  - Missouri – Follow EPA guidance
Other Relevant Guidance

- **PM$_{2.5}$ and Ozone SILs Guidance – April 2018**
  - Revised SILs for PM$_{2.5}$
  - First time Ozone has had a SIL

- **June 2018 Regional, State, and Local Modeling Workshop**
  - 2014 PM$_{2.5}$ Modeling Guidance to be revised (soon?)
  - No more qualitative analyses - use MERPs
  - Do PM$_{2.5}$ Modeling + MERPs when:
    - PM$_{2.5}$ Primary, NO$_2$, or SO$_2$ ≥ SER
    - Analysis includes all three, regardless of emission rates
  - Some exceptions for remote areas (AK)

- **June 2019 Webinar**
  - Additional example senarios
MERPs in Action

\[ V = \frac{1}{3} \pi r^2 h \]
Case Study Project

- Company XYZ proposes a chemical process plant near Lake Charles, LA
- Natural Gas Combustion (boilers, process heaters)
- Hydrocarbon Storage, loading, fugitives
Case Study Project

• Step 1: Calculate PTE
  • Major for PM$_{10}$, PM$_{2.5}$, NO$_X$, CO, and VOC (Listed source)
  • SO$_2$ below SER
  • PM$_{10}$, PM$_{2.5}$, NO$_X$, CO, and SO$_2$ from combustion
  • VOC and HAP from storage tanks, loading, fugitives

• Step 2: Conduct SIL Modeling
  • PM$_{10}$, PM$_{2.5}$, NO$_2$, and CO
Case Study Project

• Step 3: Determine Appropriate MERPs
  • Option 1: Conservative regional MERPs (Table 4-1)

<table>
<thead>
<tr>
<th>Standard</th>
<th>SO$_2$</th>
<th>NO$_X$</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$ 24-hr</td>
<td>274</td>
<td>1,881</td>
<td>--</td>
</tr>
<tr>
<td>PM$_{2.5}$ Annual</td>
<td>1,781</td>
<td>7,453</td>
<td>--</td>
</tr>
<tr>
<td>Ozone</td>
<td>--</td>
<td>190</td>
<td>2,307</td>
</tr>
</tbody>
</table>
Case Study Project

• Option 2: Review MERPs Guidance Spreadsheet
  • Identify most representative hypothetical source(s)
  • Consider:
    • Proximity to project
    • Latitude
    • Terrain features/elevation
    • Landuse (urban/rural)
    • Waterbodies
    • Climate Region
Hypothetical Sources in Louisiana

Nearby Terrain Ht.

Nearby Urban Frac.
Case Study Project – Selecting MERPs

• Use most conservative MERPs for selected source, or
• Keep refining
  • Release Heights: High or Low?
    • High for NO\textsubscript{X} and SO\textsubscript{2} (combustion stacks)
    • Low for VOC (tanks, loading, fugitives)
  • Emission Rates: 500, 1000, or 3000 tons per year?
    • Emissions of all pollutants < 500 tpy
    • Use 500 tpy source
## PM$_{2.5}$ MERPs for Selected Source

<table>
<thead>
<tr>
<th>Standard</th>
<th>Precursor Emission Rate (tpy)</th>
<th>Src. Height</th>
<th>SO$_2$ MERP (tpy)</th>
<th>NO$_x$ MERP (tpy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5 Daily</td>
<td>500</td>
<td>L</td>
<td>326</td>
<td>3,185</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>1,529</td>
<td>8,275</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>L</td>
<td>274</td>
<td>3,101</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>1,110</td>
<td>7,342</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>H</td>
<td>882</td>
<td>6,751</td>
</tr>
<tr>
<td></td>
<td>Lowest</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 500 L: 326, 3,185
- 500 H: 1,529, 8,275
- 1000 L: 274, 3,101
- 1000 H: 1,110, 7,342
- 3000 H: 882, 6,751
- Lowest: 274, 3,185
### PM$_{2.5}$ MERPs for Selected Source

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<th>Standard</th>
<th>Precursor Emission Rate (tpy)</th>
<th>Src. Height</th>
<th>SO$_2$ MERP (tpy)</th>
<th>NO$_x$ MERP (tpy)</th>
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<tr>
<td>PM2.5 Daily</td>
<td>500</td>
<td>L</td>
<td>326</td>
<td>3,185</td>
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<td></td>
<td></td>
<td>H</td>
<td>1,529</td>
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<tr>
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<td>1,110</td>
<td>7,342</td>
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<td></td>
<td>3000</td>
<td>H</td>
<td>882</td>
<td>6,751</td>
</tr>
<tr>
<td></td>
<td>Lowest</td>
<td></td>
<td>274</td>
<td>3,185</td>
</tr>
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# Case Study Project – Selected MERPs

<table>
<thead>
<tr>
<th>Standard</th>
<th>Src. Emission Rate (TPY)</th>
<th>Precursor</th>
<th>Src. Height</th>
<th>MERP (tpy)</th>
</tr>
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<tbody>
<tr>
<td>PM$_{2.5}$ Daily</td>
<td>500</td>
<td>NO$_x$</td>
<td>H</td>
<td>8,275</td>
</tr>
<tr>
<td>PM$_{2.5}$ Annual</td>
<td>500</td>
<td>SO$_2$</td>
<td>H</td>
<td>1,529</td>
</tr>
<tr>
<td>PM$_{2.5}$ Annual</td>
<td>500</td>
<td>NO$_x$</td>
<td>H</td>
<td>41,426</td>
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<tr>
<td>Ozone</td>
<td>500</td>
<td>NO$_x$</td>
<td>H</td>
<td>199</td>
</tr>
<tr>
<td>Ozone</td>
<td>500</td>
<td>VOC</td>
<td>L</td>
<td>4,378</td>
</tr>
</tbody>
</table>
Case Study Project – Estimating Impacts

• Step 4: Estimate Precursor and Primary Impacts
  • Use the MERPs equation to solve for impacts

  • \[ \text{Air Quality Impact} \ [\text{ppb or } \mu g/m^3] = \text{SIL} \ [\text{ppb or } \mu g/m^3] \times \frac{\text{Precursor PTE [tpy]}}{\text{MERP [tpy]}} \]

• Evaluate for:
  • Each precursor and each NAAQS
  • Each operating scenario, as applicable
Case Study Project – Estimating Impacts

Air Quality Impact [ppb or µg/m³] = SIL [ppb or µg/m³] \times \frac{\text{Precursor PTE [tpy]}}{\text{MERP [tpy]}}

<table>
<thead>
<tr>
<th>Precursor</th>
<th>PTE (tpy)</th>
<th>PM$_{2.5}$ 24-hr (µg/m³)</th>
<th>PM$_{2.5}$ Annual (µg/m³)</th>
<th>Ozone (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_X$</td>
<td>175</td>
<td>0.025</td>
<td>0.0008</td>
<td>0.879</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>15</td>
<td>0.012</td>
<td>0.0004</td>
<td>--</td>
</tr>
<tr>
<td>VOC</td>
<td>200</td>
<td>--</td>
<td>--</td>
<td>0.046</td>
</tr>
<tr>
<td>Total Secondary</td>
<td>--</td>
<td>0.037</td>
<td>0.0012</td>
<td>0.925</td>
</tr>
<tr>
<td>SIL Modeling</td>
<td>--</td>
<td>1.04</td>
<td>0.10</td>
<td>--</td>
</tr>
<tr>
<td><strong>Combined Impact</strong></td>
<td><strong>1.08</strong></td>
<td><strong>0.10</strong></td>
<td><strong>0.93</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SIL</strong></td>
<td><strong>1.2</strong></td>
<td><strong>0.2</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
</tbody>
</table>
Summary and Outlook

• Useful tool to provide regional/local-specific estimates
• Easier than a photochemical model!
• Developing topic with changing guidance/procedures
  • New MERPs may be added – Some states have few or no hypothetical sources or specialized needs
  • State implementation of MERPs
  • Maximum by distance
• EPA 12th Modeling Conference – tomorrow!
  • New PM$_{2.5}$ Modeling guidance soon?
Contact Information

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Questions?

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