Exploration of Emissions Factor Adjustments for Using Emissions Factors in Noninventory Applications

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Acknowledgments

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Overview

• Background
• Objective
• Technical Approach
• Results
• Next Steps
Background

- Originally, Emissions Factors (EF) Used for Nationwide Inventories
- EF = Mean Value (Typically)
- Other Noninventory Applications, e.g.,
  - Permit Applicability Determination/Limits
  - Model inputs
  - Plant-wide Applicability Limits (PAL)
Objective

• Explore adjustments to EFs to address uncertainty when using EFs for noninventory applications
General Approach

• Focus on single source:
  – Random sample from population
  – “Boundary statistics” of population distribution; e.g., 95th percentile
  – Variability of the sample provides estimates of uncertainty (between and within facility)

• Develop default adjustments

• Did not focus on uncertainty about the mean value
Approach

• Select EF data sets for analysis
• Statistical procedure
  1. Visualize data
  2. Fit Probability Density Functions to model the data; Use Monte Carlo Techniques to simulate the hypothetical population
  3. Calculate statistics for each population: e.g., median, 90\textsuperscript{th} percentile, 95\textsuperscript{th} percentile
Approach (continued)

4. Select 10,000 random samples from each population for sample size n=1, 3, 5 …25

5. For each of the 10,000 samples, calculate an adjustment to estimate the selected target statistic of the hypothetical population

6. Calculate composite adjustments by pollutant and sample size
1. Data

2. Data Visualization

3. Fit Probability Density Function

4. Simulated Population

5. Obtain 10,000 samples with No. Tests = 3, 5, 10, 15, 25

6. Obtain adjustments for target populations statistics
Emissions Factor Data

• Criteria for selection:
  – data quality (A-rated)
  – data quantity > 15 emissions tests
  – number/type of pollutants
  – accessibility of supporting emissions data
Emissions Factor Data

- 44 A-rated Data Sets
- Wood Residue Combustion
- Refuse Combustion
- Waferboard/Oriented Strandboard
- Hot Mix Asphalt
- Particulate Matter, Sulfur Dioxide, Nitrogen Oxides, Carbon Monoxide, Hazardous Air Pollutants
Distribution of AP-42 Carbon Monoxide EF Data

Min = 0.027
10th Per = 0.12
1st Qu = 0.233
Median = 0.468
Mean = 0.595
3rd Qu = 0.778
90th Per = 1.11
95th Per = 1.52
Max = 2.577
Carbon Monoxide

Empirical and Hypothesized weibull CDFs

Simulated weibull distribution

EF Data

Probability

Emissions, lb/mmbtu x 10-1
Hypothetical Carbon Monoxide Population

Target Statistic = 10th percentile

Median

Mean

Target Statistic = 90th percentile

Target Statistic = 95th percentile

Emissions, lb/mmbtu x 10^-1

Probability
Sample from Hypothetical Carbon Monoxide Population

n=3
10,000 samples

n=5
10,000 samples

n=25
10,000 samples
Distribution of Adjustments for Selected Target Statistics

EF Distribution
n = 3
10,000 samples

10,000 calculations:
EF x ADJ = Target Statistic
ADJ = Target Statistic/EF

Adjustment:
Target statistic = 10th percentile

Adjustment:
Target statistic = 90th percentile

Hypothetical population

90th percentile
Monte Carlo Distribution of Adjustments:
Target Statistic = 90\textsuperscript{th} percentile
EF with \( n = 3 \) Tests

Median = 1.97
Mean = 2.26
95\textsuperscript{th} percentile = 4.35
Example of Adjustments

<table>
<thead>
<tr>
<th>$n$</th>
<th>Percentile</th>
<th>Target Statistic</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5th</td>
<td>10th</td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>0.19</td>
<td>0.30</td>
<td>1.2</td>
</tr>
<tr>
<td>3</td>
<td>0.17</td>
<td>0.27</td>
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<tr>
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<td>0.26</td>
<td>1.0</td>
</tr>
<tr>
<td>25</td>
<td>0.16</td>
<td>0.26</td>
<td>1.0</td>
</tr>
</tbody>
</table>

$n = 3$
Estimate 90th percentile of true population: $\text{EF} \times \text{ADJ} = 0.6 \times 2.0 = 1.2$

$n = 25$
Estimate 90th percentile of true population: $\text{EF} \times \text{ADJ} = 0.6 \times 1.9 = 1.1$
Example of Adjustments

Wood Residue CO emission factor = 0.6 lb/mmbtu
n=128

<table>
<thead>
<tr>
<th>n</th>
<th>Percentile</th>
<th>Mean</th>
<th>Percentile</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>25</td>
<td>0.16</td>
<td>0.26</td>
<td>1.0</td>
</tr>
</tbody>
</table>

n=25
Estimate 90th percentile of true population: \( EF \times ADJ = 0.6 \times 1.9 = 1.1 \)

Estimate 95th percentile of true population: \( EF \times ADJ = 0.6 \times 2.3 = 1.4 \)
## Comparison of Selected Adjustments:
**PM-Filterable, uncontrolled Emissions Factors**

**Target Statistic: 95th Percentile**

<table>
<thead>
<tr>
<th></th>
<th>n =1</th>
<th>n =3</th>
<th>n = 10</th>
<th>n =25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refuse Comb., RDF</td>
<td>1.8</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Wood Comb., Dry Wood</td>
<td>1.9</td>
<td>1.9</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Refuse Comb., Mass burn</td>
<td>2.3</td>
<td>2.1</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Wood Comb., Wet Wood</td>
<td>2.5</td>
<td>2.3</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>OSB, Hot Press</td>
<td>5.1</td>
<td>3.8</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Average (Comp, Default Adjustment)</td>
<td>2.7</td>
<td>2.3</td>
<td>2.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>
Composite Default Adjustments

- For $n<3$, $3<n<10$, $10<n<25$, $n>25$
- HAP, Controlled
- HAP, Uncontrolled
- PM-Condensible
- PM-filterable, controlled
- PM-filterable, uncontrolled
- Gaseous Criteria Pollutants
Other Analyses

• Other analyses were conducted
• Estimates of uncertainty about the mean of the normalized distribution of emissions factors (n=1, n=3, n=5,…n=25)
  – confidence intervals about mean
  – yields smaller adjustment values
• See paper for discussion and results
Summary and Conclusions

• All EF’s examined are Weibull or log-normally distributed
• Adjustments decrease as n increases; begin to stabilize at n>10
• Uncontrolled HAPS have largest variability (and adjustments):
  – For 95th percentile: 19 for n=1; 4.5 for n>25
Additional Information

• Complete report is expected to be available for public review in June 2006
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