Development of PM2.5 Interpollutant Trading Ratios

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Introduction

• Sources applying for permits in areas designated nonattainment for PM2.5 can offset emissions increases of direct PM2.5 emissions or PM2.5 precursors with reductions of either direct PM2.5 emissions or PM2.5 precursors in accordance with offset ratios contained in the approved SIP for the applicable nonattainment area.
  – An existing source can increases PM2.5 emissions by $X$ tons in exchange for reducing SO2 emissions by $Y$ tons.

• PM2.5 offset ratios can be used to account for secondary formation of PM2.5 in a dispersion model
  – NACAA PM2.5 Secondary Formation Workgroup
EPA developed default PM2.5 offset ratios

- SO2 to Primary PM2.5
  - 40:1 (SO2 tons for PM2.5 tons) nationwide.
- NOx to Primary PM2.5
  - 200:1 (NOx tons for PM2.5 tons) in the eastern United States.
  - 100:1 (NOx tons for PM2.5 tons) in the western United States.
“We will no longer consider the preferred ratios set forth in the preamble to the 2008 final rule for PM2.5 NSR implementation to be presumptively approvable. Instead, any ratio involving PM2.5 precursors adopted by the state for use in the interpollutant offset program for PM2.5 nonattainment areas must be accompanied by a technical demonstration that shows the net air quality benefits of such ratio for the PM2.5 nonattainment area in which it will be applied.”
The general framework for such developmental efforts would include the following steps:

1) **Define the geographic area(s)** in which offsets between emission sources are allowed, i.e., nonattainment area(s).

2) **Conduct a series of sensitivity runs** with appropriate air quality models to develop a database of modeled PM2.5 concentration changes associated with reductions of direct PM2.5 emissions and PM2.5 precursor emissions (e.g., SO2 and NOx) from anthropogenic point sources within the area of interest. For precursor emissions, a photochemical model (e.g., CMAQ, CAMx) at grid resolution of 12 kilometers (km) or less is recommended to predict changes in PM2.5 concentrations. For direct PM2.5 emissions, a dispersion model (e.g., AERMOD) or photochemical model at grid resolution of 4 km or less is recommended to predict changes in PM2.5 concentrations.

3) **Calculate the interpollutant offset ratios** for PM2.5 between direct PM2.5 emissions and precursor emissions in a manner similar to the EPA's 2007 technical assessment, i.e., the ratio of impact metrics from step 3, above.

4) **Conduct quality assurance** of the resulting ratios and evaluate their interpretation and appropriateness given the nature of PM2.5 sources and formation in the area of interest. This evaluation will likely require emissions inventory data and observed ambient data for PM2.5 and its component species.
PM2.5 Offset Ratios

• Normalized Sensitivity or “Effectiveness” of Reductions
  – $\text{Eff}_{\text{SO2}} = (\Delta \text{PM2.5}_{\text{SO2}}/\Delta \text{TPD}_{\text{SO2}})$
  – $\text{Eff}_{\text{NOx}} = (\Delta \text{PM2.5}_{\text{NOx}}/\Delta \text{TPD}_{\text{NOx}})$
  – $\text{Eff}_{\text{PM2.5}} = (\Delta \text{PM2.5}_{\text{PM2.5}}/\Delta \text{TPD}_{\text{PM2.5}})$

• PM2.5 Offset Ratios
  – SO2 to primary PM2.5 = $\text{Eff}_{\text{PM2.5}}/\text{Eff}_{\text{SO2}}$
  – NOx to primary PM2.5 = $\text{Eff}_{\text{PM2.5}}/\text{Eff}_{\text{NOx}}$
State-by-State Modeling

• Started with emission sensitivities to statewide 30% reduction in point source SO2, NOx, and direct PM2.5
  – Air quality impacts were local while the emissions used for normalization were statewide.

• CONCLUSION
  – You can’t use “across the board” emission sensitivities to calculate PM2.5 trading ratios.
  – Preferred approach is to use a single stack to represent other stacks in the region.
    • Fine-grid photochemical modeling
    • Coarse-grid photochemical modeling with plume-in-grid and sub-grid sampling
PM2.5 Offset Ratios

- Do they vary with distance from the source?
- Do they vary with season of the year?
- Do they vary with grid resolution?
- Do they vary by stack height?
- Do they vary by emission rates?
- Do they vary by region within a state?
Case Study: Georgia

• Plant Washington
  – 850 MW Coal Fired Power Plant located in Washington County, GA

• Final permit issued on April 8, 2010

• GA EPD used CAMx modeling to account for secondary PM2.5 impacts and ozone impacts from the proposed facility
  – Sierra Club and GreenLaw did not include this issue in their lawsuit.
Model Setup

- MM5 for Meteorology
  - VISTAS 2002

- SMOKE for Emissions
  - VISTAS 2009 used in Georgia PM2.5 SIP
  - Added power plant emissions
    - 4200 TPY SO2, 1817 TPY NOx, 6 TPY EC

- CAMx with Flexi-nesting
  - 12 km/4 km/1.333 km

- Three sensitivity runs to calculate PM2.5 offset ratios
  - Zero-out stack emissions: SO2, NOx, EC
CAMx Modeling Domains

CAMx 12 km
CAMx 4 km
CAMx 1.3 km
AERMOD
PM2.5 Sensitivity – EC and SO2

PEC Contribution
Annual Average, 1.333 km Domain

SO2 Contribution
Annual Average, 1.333 km Domain
PM2.5 Sensitivity – EC and NOx

PEC Contribution
Annual Average, 1,333 km Domain

NOx Contribution
Annual Average, 1,333 km Domain
Annual $\Delta$PM2.5

dPM25 by SO2, NOx, and PEC
Annual Average, 1.333 km Domain
Annual Effectiveness

PM2.5 Sensitivity to SO2, NOX, and PEC
Annual Average, 1.333 km Domain

- **PEC**
- **SO2**
- **NOX**
Quarterly SO2 Offset Ratios

SO2 Trading Ratio at 1.333 km Domain
Quarterly Average and Annual Average

(dPM2.5/dPEC)/(dPM2.5/dSO2)

Distance from the Stack (km)
Quarterly NOx Offset Ratios

NOx Offset Ratio at 1.333 km Domain
Quarterly Averages and Annual Average

Distance from the Stack (km)
Annual SO2 Offset Ratios

SO2 Offset Ratio
Annual Average, All Domains

Distance from the Stack (m)
Annual NOx Offset Ratios

NOx Offset Ratio
Annual Average, All Domains

Distance from the Stack (km)
Ratios for Washington County

• SO2 to Primary PM2.5
  – 40:1 for annual NAAQS (near source)
  – 10:1 for annual NAAQS (far from source)
  – 25:1 for daily NAAQS (near source)
  – 5:1 for daily NAAQS (far from source)

• NOx to Primary PM2.5
  – 85:1 for annual NAAQS (near source)
  – 40:1 for annual NAAQS (far from source)
  – 60:1 for daily NAAQS (near source)
  – 20:1 for daily NAAQS (far from source)
Summary

• Photochemical grid modeling should be performed for a single stack (not a group)
• PM2.5 offset ratios vary with distance
  – Use maximum value to evaluate near source impacts
• PM2.5 offset ratios vary with season
  – Can use seasonal ratio for daily PM2.5 ratio
  – SO2 ratios are lower in summer than winter
  – NOx ratios are lower in summer than winter
    • NOx ratios can be very large (due to small impact of NOx on PM2.5) or negative (due to NOx disbenefits)
• PM2.5 offset ratios vary with grid resolution
  – May need less than 4-km grid resolution to evaluate near source impacts
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