Application of the EPA's Modeled Emission Rates for Precursors (MERPs) for Secondary Pollutant Formation in Kentucky

KENTUCKY ENERGY & ENVIRONMENT CABINET

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Introduction

The US Environmental Protection Agency (EPA) released a draft guidance on the development of modeled emission rates for precursors (MERPs) as a Tier 1 demonstration tool for ozone and $PM_{2.5}$ under the PSD permitting program (Draft Guidance) on December 2, 2016. The Kentucky Division for Air Quality (Division) has reviewed the draft guidance and has identified three hypothetical sources provided in the Draft Guidance that best represent Kentucky sources. Two sources are located outside of Kentucky (Ashe County, NC and Dubois County, IN), and one source is located in Kentucky (Barren County, KY). This application was completed with assistance from the Georgia Environmental Protection Division's Guidance on MERPs.[1]

Appendix A of the Draft Guidance provides modeled hypothetical sources that permitting agencies can use to develop area representative MERPs. The Division has identified the hypothetical sources listed in Table 1 as being most representative for Kentucky sources.

Table 1. Selected Hypothetical Sources

Area	Source ID	FIPS	Source Location	Emission Rates (tpy)
Central US	2	18037	Dubois County, IN	500, 1000, 3000
Eastern US	18	21009	Barren County, KY	500, 1000, 3000
Eastern US	13	37009	Ashe County, NC	500, 1000, 3000

Development of Default MERPs

The Division calculated MERPs based on the following equation provided by the EPA in the Draft Guidance:

$$MERP\ (tpy) = Significant\ Impact\ Level * \frac{Precursor\ Emissions\ Rate\ (tpy)}{Maximum\ Model\ Impact}$$

Significant impact levels (SILs) are an important part of the equation and are identified by their pollutants and averaging times in Table 2.

[1] Guidance on the Use of EPA's MERPs to Account for Secondary Formation in Georgia. Georgia EPD. 2018.

Table 2. SILs

Pollutant	Averaging Time	SIL
Ozone (O_3)	8-Hr	1.0 ppb
$PM_{2.5}$	Annual	0.2 μg/m^3
$PM_{2.5}$	Daily (24-Hr)	1.2 μg/m^3

Table 3 identifies the most conservative (lowest) MERPs developed by the Division. The values provided in Table 3 will serve as the default MERPs for PSD Tier 1 demonstrations in Kentucky.

Table 3. Default MERP Values for Kentucky PSD Applications

Precursor	8-Hour Ozone	Daily PM2.5	Annual PM2.5
NOx	169	2,449	8,333
SO2	-	1,500	10,000
VOC	3,333	-	-

Alternative MERPs may be considered if an applicant chooses not to use the default values provided in this guidance, however, justification must be provided. Such justification should discuss the hypothetical source and the distance to the project site, terrain, meteorology, stack heights and emission rates. The modeling protocol provided to the Division should contain the justification within the discussion and will be subject to approval of the Division.

Table 4. NOx MERP Values for Ozone

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (ppb)	MERP Value (tpy)
NOx	CUS	500	H	2	18037	Indiana	Dubois	2.11	237
NOx	CUS	500	L	2	18037	Indiana	Dubois	2.14	234
NOx	CUS	1000	H	2	18037	Indiana	Dubois	3.76	266
NOx	CUS	3000	H	2	18037	Indiana	Dubois	8.83	340
NOx	EUS	500	H	18	21009	Kentucky	Barren	2.95	169*
NOx	EUS	500	L	18	21009	Kentucky	Barren	2.91	172
NOx	EUS	1000	H	18	21009	Kentucky	Barren	5.03	199
NOx	EUS	3000	H	18	21009	Kentucky	Barren	10.69	281
NOx	EUS	500	H	13	37009	North Carolina	Ashe	1.87	267
NOx	EUS	500	L	13	37009	North Carolina	Ashe	1.81	276
NOx	EUS	1000	H	13	37009	North Carolina	Ashe	3.14	318
NOx	EUS	3000	H	13	37009	North Carolina	Ashe	6.34	473

Table 5. VOC MERP Values for Ozone

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (ppb)	MERP Value (tpy)
VOC	CUS	500	L	2	18037	Indiana	Dubois	0.1	5,000
VOC	CUS	1000	H	2	18037	Indiana	Dubois	0.2	5,000
VOC	CUS	1000	L	2	18037	Indiana	Dubois	0.2	5,000
VOC	CUS	3000	H	2	18037	Indiana	Dubois	0.89	3,371
VOC	EUS	500	H	18	21009	Kentucky	Barren	0.06	8,333
VOC	EUS	500	L	18	21009	Kentucky	Barren	0.06	8,333
VOC	EUS	1000	H	18	21009	Kentucky	Barren	0.13	7,692
VOC	EUS	3000	H	18	21009	Kentucky	Barren	0.9	3,333*
VOC	EUS	500	H	13	37009	North Carolina	Ashe	0.03	16,667
VOC	EUS	500	L	13	37009	North Carolina	Ashe	0.06	8,333
VOC	EUS	1000	H	13	37009	North Carolina	Ashe	0.08	12,500
VOC	EUS	3000	H	13	37009	North Carolina	Ashe	0.36	8,333

Table 6. NOx MERP Values for Daily $PM_{2.5}$

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (µg/m3)	MERP Value (tpy)
NOx	CUS	500	L	2	18037	Indiana	Dubois	0.18	3,333
NOx	CUS	1000	H	2	18037	Indiana	Dubois	0.13	9,231
NOx	CUS	1000	L	2	18037	Indiana	Dubois	0.49	2,449*
NOx	CUS	3000	H	2	18037	Indiana	Dubois	0.53	6,792
NOx	EUS	500	H	18	21009	Kentucky	Barren	0.05	12,000
NOx	EUS	500	L	18	21009	Kentucky	Barren	0.11	5,455
NOx	EUS	1000	H	18	21009	Kentucky	Barren	0.09	13,333
NOx	EUS	3000	H	18	21009	Kentucky	Barren	0.2	18,000
NOx	EUS	500	H	13	37009	North Carolina	Ashe	0.04	15,000
NOx	EUS	500	L	13	37009	North Carolina	Ashe	0.05	12,000
NOx	EUS	1000	H	13	37009	North Carolina	Ashe	0.08	15,000
NOx	EUS	3000	H	13	37009	North Carolina	Ashe	0.22	16,364

Table 7. SO_2 MERP Values for Daily $PM_{2.5}$

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (µg/m3)	MERP Value (tpy)
SO2	CUS	500	L	2	18037	Indiana	Dubois	0.26	2,308
SO2	CUS	1000	H	2	18037	Indiana	Dubois	0.34	3,529
SO2	CUS	1000	L	2	18037	Indiana	Dubois	0.8	1,500*
SO2	CUS	3000	H	2	18037	Indiana	Dubois	1.33	2,707
SO2	EUS	500	H	18	21009	Kentucky	Barren	0.06	10,000
SO2	EUS	500	L	18	21009	Kentucky	Barren	0.13	4,615
SO2	EUS	1000	H	18	21009	Kentucky	Barren	0.11	10,909
SO2	EUS	3000	H	18	21009	Kentucky	Barren	0.26	13,846
SO2	EUS	500	H	13	37009	North Carolina	Ashe	0.22	2,727
SO2	EUS	500	L	13	37009	North Carolina	Ashe	0.25	2,400
SO2	EUS	1000	H	13	37009	North Carolina	Ashe	0.39	3,077
SO2	EUS	3000	H	13	37009	North Carolina	Ashe	0.81	4,444

Table 8. NOx MERP Values for Annual $PM_{2.5}$

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (µg/m3)	MERP Value (tpy)
NOx	CUS	500	L	2	18037	Indiana	Dubois	0.011	9,091
NOx	CUS	1000	H	2	18037	Indiana	Dubois	0.007	28,571
NOx	CUS	1000	L	2	18037	Indiana	Dubois	0.024	8,333*
NOx	CUS	3000	H	2	18037	Indiana	Dubois	0.026	23,077
NOx	EUS	500	H	18	21009	Kentucky	Barren	0.002	50,000
NOx	EUS	500	L	18	21009	Kentucky	Barren	0.007	14,286
NOx	EUS	1000	H	18	21009	Kentucky	Barren	0.004	50,000
NOx	EUS	3000	H	18	21009	Kentucky	Barren	0.01	60,000
NOx	EUS	500	H	13	37009	North Carolina	Ashe	0.002	50,000
NOx	EUS	500	L	13	37009	North Carolina	Ashe	0.004	25,000
NOx	EUS	1000	H	13	37009	North Carolina	Ashe	0.004	50,000
NOx	EUS	3000	H	13	37009	North Carolina	Ashe	0.01	60,000

Table 9. SO_2 MERP Values for Annual $PM_{2.5}$

Precursor	Area	Emissions (tpy)	Height	Source	FIPS	State	County	Max Impact (µg/m3)	MERP Value (tpy)
SO2	CUS	500	L	2	18037	Indiana	Dubois	0.005	20,000
SO2	CUS	1000	H	2	18037	Indiana	Dubois	0.008	25,000
SO2	CUS	1000	L	2	18037	Indiana	Dubois	0.015	13,333
SO2	CUS	3000	H	2	18037	Indiana	Dubois	0.047	12,766
SO2	EUS	500	H	18	21009	Kentucky	Barren	0.002	50,000
SO2	EUS	500	L	18	21009	Kentucky	Barren	0.004	25,000
SO2	EUS	1000	H	18	21009	Kentucky	Barren	0.004	50,000
SO2	EUS	3000	H	18	21009	Kentucky	Barren	0.014	42,857
SO2	EUS	500	H	13	37009	North Carolina	Ashe	0.007	14,286
SO2	EUS	500	L	13	37009	North Carolina	Ashe	0.01	10,000*
SO2	EUS	1000	H	13	37009	North Carolina	Ashe	0.013	15,385
SO2	EUS	3000	H	13	37009	North Carolina	Ashe	0.033	18,182

*Lowest (most conservative) MERP value.

MERPs in SILs Analyses

MERPs can be instrumental when using the following equations to determine if proposed emission increases from a facility will result in primary and secondary impacts. All relevant pollutants must be included in the analysis. No further analysis is needed if emission increases from all relevant pollutants are below the respective Significant Emission Rates (SER).

The following equation should be used for ozone:

$$\frac{NOx\ Emission\ Rate}{NOx\ MERP} + \frac{VOC\ Emission\ Rate}{VOC\ MERP} < 1$$

In the above equation, all units should be in tons per year (tpy). NOx Emission Rate and VOC Emission Rate are the proposed emission increases for the PSD project. When the sum of the ratios is less than 1, the impacts for secondary ozone are then determined to be below the ozone SIL and there is no need to perform a cumulative analysis for ozone. When the sum of the ratios is greater than or equal to 1, then a cumulative analysis for ozone must be performed by the applicant.

The following equation should be used for $PM_{2.5}$ when primary $PM_{2.5}$ emission increases are above the $PM_{2.5}$ SER of 10 tpy:

$$\frac{Max\ PM2.5\ Modeled\ Concentration}{PM2.5\ SIL} + \frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP} < 1$$

The max $PM_{2.5}$ Modeled Concentration is the highest value (annual or H1H averaged over 5 years) of direct $PM_{2.5}$ emission increases modeled using AERMOD. $PM_{2.5}$ SIL is 1.2 µg/m^3 for daily $PM_{2.5}$ and 0.2 µg/m^3 for annual $PM_{2.5}$. SO2 Emission Rate and NOx Emission Rate represent the proposed tpy emission increases for SO2 and NOx. The respective MERPs are represented in tpy. If the sum of the ratios is less than 1, then the impacts are less than the $PM_{2.5}$ SIL and there is no need for cumulative analysis, however, if the sum is greater than or equal to 1, then a cumulative analysis must be performed for $PM_{2.5}$.

The following equation should be used if the proposed emission increase for primary $PM_{2.5}$ is less than the $PM_{2.5}$ SER of 10 tpy, and either SO_2 or NOx are above respective SERs of 40 tpy:

$$\frac{PM2.5\ Emission\ Increase}{PM2.5\ SER} + \frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP} < 1$$

The $PM_{2.5}$ Emission Increase is the proposed emission increase for primary (direct) $PM_{2.5}$. SO2 Emission Rate and NOx Emission Rate represent the proposed tpy emission increases for SO2 and NOx. The respective MERPs are represented in tpy. The SER for $PM_{2.5}$ is 10 tpy. If the sum of the ratios is greater than or equal to 1, an AERMOD modeling analysis must be performed for primary $PM_{2.5}$ and use the $PM_{2.5}$ SILs equation (previously mentioned) to determine if a cumulative analysis is required.

Cumulative Analysis

A cumulative analysis can performed using MERPs for increases in all precursor pollutant emissions. This is the last step of a Tier 1 demonstration of secondarily formed pollutants.

The following equation is for an ozone cumulative analysis:

$$O3\ Background + \left(\frac{NOx\ Emission\ Rate}{NOx\ MERP} + \frac{VOC\ Emission\ Rate}{VOC\ MERP}\right) * O3\ SIL\ \le O3\ NAAQS$$

In order to complete the ozone calculation, three-year design values from a representative ozone monitor must be inserted into the equation. The proposed NOx and VOC tpy emissions increases are the NOx Emission Rate and VOC Emission Rate. The respective MERPs should be represented in tpy. The O3 SIL is 1 ppb. If the sum of the equation is less than or equal to 70 ppb (O3 NAAQS), then the proposed emission increases will not contribute to a violation of the ozone NAAQS. If the sum is greater than the ozone NAAQS, then a Tier 2 demonstration will need to be considered, or the applicant may consider a less conservative MERP along with sufficient justification.

The following equation should be used for $PM_{2.5}$:

$$PM2.5\ Background + PM2.5\ DV + \left(\frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP}\right) * PM2.5\ SIL\ \le PM2.5\ NAAQS$$

The $PM_{2.5}$ Background is the three-year design values from a representative $PM_{2.5}$ background monitor. The $PM_{2.5}$ DV is the AERMOD modeled design value resulting from the proposed direct $PM_{2.5}$ emission increases as well as the direct $PM_{2.5}$ emission from nearby sources. The proposed SO_2 and NOx tpy emissions increases are the SO_2 Emission Rate and NOx Emission Rate. The respective MERPs should be represented in tpy. The $PM_{2.5}$ SILs are 0.2 $\mu g/m^3$ for annual and 1.2 $\mu g/m^3$ for daily. If the sum of the equation is less than or equal to 12.0 $\mu g/m^3$ (PM2.5 NAAQS), then the proposed emission increases will not contribute to a violation of the $PM_{2.5}$ NAAQS. If the sum is greater than the $PM_{2.5}$ NAAQS, then a Tier 2 demonstration will need to be considered, or the applicant may consider a less conservative MERP along with sufficient justification.

Examples

This section provides examples of calculations used in a PSD application. The tables provide emissions (Table A-1), maximum modeled impacts (Table A-2), background monitor concentrations (Table A-3), and default MERPs (Table A-4).

Table A-1. Example emissions

Precursor	Emissions (tpy)
NOx	500
SO_2	500
$PM_{2.5}$	500
VOC	500

Table A-2. Example maximum modeled impacts

Precursor	Highest Modeled Concentration (HMC)	HMC + Nearby Source Impacts
Annual $PM_{2.5}$	0.15 $\mu g/m^3$	0.3 $\mu g/m^3$
Daily $PM_{2.5}$	0.6 $\mu g/m^3$	3.0 $\mu g/m^3$

Table A-3. Example background monitor concentrations

Precursor	Background Concentrations
Ozone	67 ppb
Annual $PM_{2.5}$	10.5 $\mu g/m^3$
Daily $PM_{2.5}$	29 $\mu g/m^3$

Table A-4. Default MERP values (tpy) for Kentucky PSD applications

Precursor	8-Hour Ozone	Daily PM2.5	Annual PM2.5
NOx	169	2,449	8,333
SO2	-	1,500	10,000
VOC	3,333	-	-

Example SILs Analysis

Ozone:
(500/169) + (500/3,333) = 3.11, which is greater than 1. Therefore, a cumulative analysis is required for ozone.

Annual $PM_{2.5}$:
(0.15/0.2) + (500/10,000) + (500/8,333) = 0.86, which is less than 1. Therefore, a cumulative analysis is not required for annual $PM_{2.5}$.

Daily $PM_{2.5}$:
(0.6/1.2) + (500/1,500) + (500/2,449) = 1.04, which is greater than 1. Therefore, a cumulative analysis is required for daily $PM_{2.5}$.

Example Cumulative Analysis

Ozone:
67 ppb + [(500/169) + (500/3,333)] x 1 ppb = 70.1 ppb, which, when truncated to 70 ppb, does not exceed the ozone NAAQS (70 ppb). Therefore, no further analysis is required.

Daily $PM_{2.5}$:
29 $\mu g/m^3$ + 3.0 $\mu g/m^3$ + [(500/1,500) + (500/2,449)] x 1.2 $\mu g/m^3$ = 39.0 $\mu g/m^3$, which is above the daily $PM_{2.5}$ NAAQS (35 $\mu g/m^3$). Therefore, a Tier 2 demonstration is required.