Given/Assume

Combustion

	Enter Value	
C1 =	167	Coal burn, tons/hr
HV =	11,313	Btu/lb
S1 =	0.63	Coal sulfur weighted average, %

K2 =	0.875	0.95	for bituminous coals
		0.875	for subbituminous coals
			= 0.55 to 0.85 for lignite, based on the Na content
		1.0	for oil

F1 = 0.0019 Fuel Impact Factor from F1 table

F2 (AH) =	1.00	Technology Impact Factor from F2 tables	If not applicable, enter "1".
F2 (PM) =	1	Technology Impact Factor from F2 tables	If not applicable, enter "1".
F2 (FGD) =	0.01	Technology Impact Factor from F2 tables	If not applicable, enter "1".

For SCR

S2 =	0.03	SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops =	0.9647	portion of time that SCR is in use

F2 (AH) =	1.00	Technology Impact Factor from F2 tables	If not applicable, enter "1".
F2 (PM) =	1	Technology Impact Factor from F2 tables	If not applicable, enter "1".
F2 (FGD) =	0.01	Technology Impact Factor from F2 tables	If not applicable, enter "1".

F3SCR =	1	**Technology Impact Factors for SCR**		
		Coal Type	**F3SCR**	
		PRB	0.17	
		Other Coals	1	(no data available)

fsreagent =	0.95	fraction of operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet

Equation 4-1 EMComb = K • F1 • E2

K =	3063	lb H2SO4/ton SO2
F1 =	0.0019	Fuel Impact Factor from F1 table

Equation 4-3 ? = K1 • K2 • C1 • S1

C1 =	167	Coal burn, tons/hr
S1 =	0.63	Coal sulfur weighted average, %
K1 =	Molecular weight and units conversion constant	
	0.02	SO2/%S
K2 =	Sulfur conversion to SO_2	
	0.875	

0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1.0 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	167	*	0.63
E2 =	2	SO2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	2
EMComb =	10.74	total H2SO4 *manufactured* from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)

Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	11	*	1	*	1	*	0.01
ERComb =	0.11	total H2SO4 *released* from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)

EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour

K =	3063	lb H2SO4/ton SO2							
S2 =	0.03	SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)							
fsops =	0.9647	for continuous operation							
E2 =	2	SO2 produced, tons per hour							
F3SCR =	1	Technology Impact Factor, for SCR			Table 4-2				
EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0.9647	*	2	*	1
EMSCR =	163.66	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SNCR	+	EMFGC
TSAM =	11	+	164		
TSAM =	174.40	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR
Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x
ERSCR = Total H2SO4 released from SCR, lbs per hour
EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11,313	Btu/lb
B =	3.79E-03	Coal burn in TBtu/hr
fsreagent =	0.95	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =		[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =		(	164	– (	3799	*	3.79E-03	*	0.95	*	0.75	))*	1	*	1	*	0.01
ERSCR =		(	164	– (			1.03E+01					))*	0.01				
ERSCR =			153									*	0.01				
ERSCR =	1.53	Total H2SO4 released from SCR, lbs per hour															

Equation 4-11b: Release
TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SNCR	+	ERFGC
TSAR =	0.11	+	1.53	+	
TSAR =	1.64	Total H2SO4 released, lbs per hour			

Table 4-1
Summary of Fuel Impact Factors (F1) for Steam Generating Units

Fuel	**Equipment**	**F1**	**Comment**
Eastern Bituminous (all)	Dry Bottom Boiler	0.0000011163*SO2+0.0064877	32 data points; SO2 = S1*KF1/HV
			SO2 = Boiler SO2 concentration (ppmvd, 3% O2, dry) derived from fuel sulfur content (%)
			S1 = Coal sulfur weighted average, % dry = 0.63
			KF1 = 10,003,602
			HV = Coal heating value, Btu/lb, dry = 11,313
			SO2 = 0.63 * 10,003,602 / 11313 = 557 ppmvd
		0.007109571	
Med-High S Eastern Bituminous (>2.5%)	Cyclone	0.016	One data point.
W. Bituminous	Dry Bottom Boiler	0.00111	One data point.
W. Bituminous	Cyclone	0.0022	One data point.
Subbituminous/PRB	All Boilers	0.0019	Average of 8 units
Lignite	Dry Bottom Boiler	0.0044	Two data points.
Lignite	Cyclone	0.00112	One data point.
Petroleum coke	Boiler	0.04	One data point.
Natural gas	Boiler	0.01	
#2 Fuel oil	Boiler	0.01	
#6 Fuel oil	Boiler	0.025	
Used oil	Boiler	0.0175	
Natural gas	CT	See Table 6-1	
#2 Fuel oil	CT	See Table 6-1	
Natural gas	CC	0.0555	
#2 Fuel oil	CC	0.0555	New category in 2007.
Other Alternative Fuels	Any	0.04	
Other Alternative Fuels, co-fired w/coal, >75% heat throughput	NA		Use Coal F1, in absence of any applicable data.

Table 4-3
Summary of F2 Factors for Air Heater Removal of Sulfuric Acid

Boiler Type	Fuel	F2	Comment
All Boilers	Low S Eastern Bit	0.50	Average of measurements at 7 units.
All Boilers	Med-High S Eastern Bit (S >2.5%)	0.85	Based on two data points.
All Boilers	PRB	0.36	Based on two data points.

Table 3-2
Summary of F2 Factors for Particulate Control Devices (ESP, Baghouse)

Equipment Type	Coal Type	F2 Factor	Comment or Observation
Cold-side ESP	Low S Eastern Bit	0.63	Average of measurements at 4 units.
Cold-side ESP	High S Eastern Bit (>2.5%)	0.77	Average of measurements at 3 units.
Cold-side ESP	Subbituminous (PRB)	0.72	Based on one measurement at one unit.
Hot-side ESP	All	0.63	Based on one measurement at one unit.
Wet ESP	All	0.12	Average of measurements at 2 units.
Baghouse	Subbituminous coal	0.10	Two data points.

Table 3-3
Summary of F2 Factors for Wet, Dry FGD Equipment and Additives

FGD Type	Coal Type	F2 Factor	Comment or Observation
Wet: Spray Tower	E. Bituminous	0.47	Seven data points.
Wet: Spray Tower	PRB or Lignite	0.40	Two data points.
Wet: Venturi Tower	All coals	0.73	Four data points.
Dry FGD and baghouse	All coals	0.01	Two data points.
Mg-Ox mixed w/fuel oil	All fuel	0.50	One data point.
Mg-Ox into furnace	All fuel	0.25	One data point.

Table 4-2
$F3_{SCR}$ Technology Impact Factors for SCR

Coal Type	**$F3_{SCR}$**
PRB	0.17
Other Coals	1 (no data available)

Equation 4-1 EMComb = K • F1 • E2
where,
EMComb= total H_2SO_4 *manufactured* from combustion, lbs/yr
K = Molecular weight and units conversion constant, equal to 3,063.
This value is derived as follows: 98.07/64.04 • 2000 = 3,063.
Here, 98.07 is the molecular weight of H_2SO_4; 64.04 is the molecular weight of SO_2; conversion from tons per year to pounds per year requires multiplying by 2000.
F1 = Fuel Impact Factor
E2 = Sulfur dioxide (SO_2) emissions, either: (1) recorded by a continuous emissions monitor, tons/yr, or (2) calculated from coal burn data, tons/yr.

When any source uses FGD equipment or another technology to control SO_2 emissions, either the fuel basis **must** be used for the manufacturing and release calculations, or CEMS data can be used but only when the CEMS precedes the FGD or SO_2 control equipment

As an alternative to using CEMS data, the following relationship based on coal burn data can be used to estimate the rate of SO_2 emissions:
Equation 4-2b E2 = K1 • K2 • C1 • S1
where,
E2 = SO_2 mass rate, tons/yr
C1 = Coal burn, tons/yr
S1 = Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant, equal to 0.02. This value is derived from (64.04)/(100 • 32.06) = 0.02. Here, 64.04 is the molecular weight of SO_2; 32.06 is the molecular weight of S; and conversion of % S to a fraction requires multi
K2 = Sulfur conversion to SO_2, implicit from EPA AP-42 (EPA, 1995b)
= 0.95 for bituminous coals
= 0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
= 1.0 for oil

Sulfuric Acid Released from Combustion (ERComb)
For units that do not employ SCR or SNCR NOx control or FGC, the sulfuric acid released is the product of the amount manufactured and the Technology Impact Factors (F2) for all downstream equipment (the air heater, the particulate control device, the FGD,
Equation 4-3 ERComb = EMComb • F2 (all that apply)

Sulfuric Acid Manufacture by SCR (EMSCR)

The following relationship estimates the total H_2SO_4 manufactured from an SCR equipped utility boiler or steam generator:

Equation 4-4 EMSCR = K • S2 • fsops • E2• F3SCR

$$EMSCR = K \cdot S2 \cdot fsops \cdot E2 \cdot F3SCR$$

where,

EMSCR = Total H_2SO_4 manufactured from SCR, lbs per year

K = Conversion factor = 3063

S2 = SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001-0.03)

fsops = Operating factor of SCR system, or the fraction of coal burn when the flue gas is directed through the SCR, whether NH_3 reagent is injected to derive NO_x reduction or not. This value should reflect the hours the SCR reactor processed flue gas, whi

E2 = SO_2 produced, tons per year

F3SCR = Technology Impact Factor, for SCR

An F3SCR factor for PRB coals is shown in Table 4-2. This factor is derived from measurements at two PRB-fired units. SO_3 emitted from these units was lower than specified in the catalyst guarantee, which was based on laboratory test data. At present, the

Table 4-2
F3SCR Technology Impact Factors for SCR

Coal Type	F3SCR
PRB	0.17
Other Coals	1 (no data available)

Sulfuric Acid Released from SCR and SNCR

The sulfuric acid released from SCR or SNCR is determined by subtracting from the sulfuric acid manufactured the amount removed by the residual ammonia, or ammonia slip. For SCR, the sulfuric acid released (ERSCR) is estimated with the following relations

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

where,

ERSCR = Total H2SO4 released from SCR, lbs per year

EMSCR = Total H2SO4 manufactured from SCR, lbs per year

Ks = Conversion factor = 3799

B = Coal burn in TBtu/yr

fsreagent = fraction of SCR operation with reagent injection, when residual NH3 is produced that will remove SO3. The value of fsreagent will be similar to, but slightly less than, the value of fsops, defined for Equation 4-4.

SNH3 = NH3 slip from SCR/SNCR, ppmv at 6% O2, wet:

• SCR averages 0.75 ppmv over catalyst guarantee period

• SNCR averages 5 ppmv

• Note: actual NH3 slip data should be used if available

F2x = Technology Impact Factors, all that apply

The conversion factor Ks, equal to 3799, considers all relevant constants to yield the result in pounds per year of sulfuric acid. The derivation of this constant, for the case where residual NH3 is reported in terms of 6% oxygen and "wet" flue gas at 8.1

The coal burn rate in TBtu/yr is obtained from coal use records, such as those reported to EIA in Form 767. The operating factor of the SCR describes the portion of the coal burn that reflects the period of SCR operation, based on whether the unit operate

Accordingly, total sulfuric acid manufacture (TSAM) and release (TSAR) is estimated for agenerating unit equipped with SCR and flue gas conditioning by the following equations:

Equation 4-11a: Manufacture

TSAM = EMComb + EMSCR/SNCR + EMFGC

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H_2SO_4/ton SO_2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **186.853** Coal burn, tons/hr
S1 = **0.45** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO_2/%S
K2 = Sulfur conversion to SO_2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1	
E2 =	0.02	*	0.875	*	186.853	*	0.45	
E2 =	1.471467	SO_2 mass rate, tons/hr						
EMComb =	K	*	F1	*	E2			
EMComb =	3063	*	0.0019	*	1.471467			
EMComb =	8.563499	total H_2SO_4 manufactured from combustion, lbs/hr						

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)	
ERComb =	8.563499	*	1	*	0.72	*	0.73	
ERComb =	4.500975	total H_2SO_4 released from combustion, lbs/hr						

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour
K = 3063 lb H_2SO_4/ton SO_2
S2 = 0.03 SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0** no SCR in baseline case
E2 = 1.47 SO_2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR	
EMSCR =	3063	*	0.03	*	0	*	1.47	*		1
EMSCR =	0	= Total H_2SO_4 manufactured from SCR, lbs per hour								

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	8.563499	+	0		
TSAM =	8.563499	= Total H_2SO_4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR
Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x
ERSCR = Total H2SO4 released from SCR, lbs per hour
EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor																
HV =	11458	Btu/lb																
B =	0.004282	Coal burn in TBtu/hr																
fsreagent =	0	fraction of SCR operation with reagent injection																
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet																
		• SCR averages 0.75 ppmv over catalyst guarantee period																
		• SNCR averages 5 ppmv																
		• Note: actual NH3 slip data should be used if available																
F2x =		Technology Impact Factors, all that apply																
ERSCR =		[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)	
ERSCR =		(	0	– (	3799	*	0.004282	*	0	*	0.75	))*	1	*	1	*	0.01	
ERSCR =		(	0	– (			0					))*	0.01					
ERSCR =			0									*	0.01					
ERSCR =	0	Total H2SO4 released from SCR, lbs per hour																

Equation 4-11b: Release
TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	4.500975	+	0	+	
TSAR =	**4.500975**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H_2SO_4/ton SO_2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **167.456** Coal burn, tons/hr
S1 = **0.63** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO_2/%S
K2 = Sulfur conversion to SO_2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	167.456	*	0.63
E2 =	1.846202	SO_2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	1.846202
EMComb =	10.74434	total H_2SO_4 manufactured from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	10.74434	*	1	*	1	*	0.01
ERComb =	**0.107443**	**total H_2SO_4 released from combustion, lbs/hr**					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour
K = 3063 lb H_2SO_4/ton SO_2
S2 = 0.03 SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0.9647** for continuous operation
E2 = 1.846202 SO_2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0.9647	*	1.846202	*	1
EMSCR =	163.659	= Total H_2SO_4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	10.74434	+	163.659		
TSAM =	174.4033	= Total H_2SO_4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11313	Btu/lb
B =	0.003789	Coal burn in TBtu/hr
fsreagent =	0.95	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =		[	EMSCR	– (	Ks •	B •	fsreagent •	SNH3	)] •	F2 (AH) •	F2 (PM) •	F2 (FGD)
ERSCR =		(	163.659	– (	3799 *	0.003789 *	0.95 *	0.75	))*	1 *	1 *	0.01
ERSCR =		(	163.659	– (		10.25564			))*	0.01		
ERSCR =			153.4033						*	0.01		
ERSCR =	1.534033	Total H2SO4 released from SCR, lbs per hour										

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	0.107443	+	1.534033	+	
TSAR =	**1.641477**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H2SO4/ton SO2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **186.747** Coal burn, tons/hr
S1 = **0.45** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO2/%S
K2 = Sulfur conversion to SO2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	186.747	*	0.45
E2 =	1.470633	SO2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	1.470633
EMComb =	8.558641	total H2SO4 manufactured from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	8.558641	*	1	*	0.72	*	0.73
ERComb =	4.498422	total H2SO4 released from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour
K = 3063 lb H2SO4/ton SO2
S2 = 0.03 SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0** no SCR in baseline case
E2 = 1.470633 SO2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	1.470633	*	1
EMSCR =	0	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	8.558641	+	0		
TSAM =	8.558641	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR
Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x
ERSCR = Total H2SO4 released from SCR, lbs per hour
EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11410	Btu/lb
B =	0.004262	Coal burn in TBtu/hr
fsreagent =	0	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =	(	0	– (	3799	*	0.004262	*	0	*	0.75	))*	1	*	1	*	0.01
ERSCR =	(	0	– (			0					))*	0.01				
ERSCR =		0									*	0.01				
ERSCR = 0	Total H2SO4 released from SCR, lbs per hour															

Equation 4-11b: Release
TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	4.498422	+	0	+	
TSAR =	**4.498422**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H2SO4/ton SO2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **163.736** Coal burn, tons/hr
S1 = **0.59** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO2/%S
K2 = Sulfur conversion to SO2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1	
E2 =	0.02	*	0.875	*	163.736	*	0.59	
E2 =	1.690574	SO2 mass rate, tons/hr						

EMComb =	K	*	F1	*	E2	
EMComb =	3063	*	0.0019	*	1.690574	
EMComb =	9.838635	total H2SO4 manufactured from combustion, lbs/hr				

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	9.838635	*	1	*	1	*	0.01
ERComb =	**0.098386**	**total H2SO4 released from combustion, lbs/hr**					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour
K = 3063 lb H2SO4/ton SO2
S2 = 0.03 SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0.988** for continuous operation
E2 = 1.690574 SO2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0.988	*	1.690574	*	1
EMSCR =	153.4827	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	9.838635	+	153.4827		
TSAM =	163.3213	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11523	Btu/lb
B =	0.003773	Coal burn in TBtu/hr
fsreagent =	0.97	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =	(	153.4827	– (	3799	*	0.003773	*	0.97	*	0.75	))*	1	*	1	*	0.01
ERSCR =	(	153.4827	– (			10.42898					))*	0.01				
ERSCR =		143.0537									*	0.01				
ERSCR =	1.430537	Total H2SO4 released from SCR, lbs per hour														

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SI	+	ERFGC
TSAR =	0.098386	+	1.430537	+	
TSAR =	**1.528924**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H_2SO_4/ton SO_2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = 199.105 Coal burn, tons/hr
S1 = 0.45 Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO_2/%S
K2 = Sulfur conversion to SO_2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	199.105	*	0.45
E2 =	1.567952	SO_2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	1.567952
EMComb =	9.12501	total H_2SO_4 manufactured from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	9.12501	*	1	*	0.1	*	0.4
ERComb =	0.365	total H_2SO_4 released from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour
K = 3063 lb H_2SO_4/ton SO_2
S2 = 0.03 SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = 0 no SCR installed at Hunter 3
E2 = 1.567952 SO_2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	1.567952	*	1
EMSCR =	0	= Total H_2SO_4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	9.12501	+	0		
TSAM =	9.12501	= Total H_2SO_4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR
Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x
ERSCR = Total H2SO4 released from SCR, lbs per hour
EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11453	Btu/lb
B =	0.004561	Coal burn in TBtu/hr
fsreagent =	0	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	• F2 (FGD)
ERSCR =	(	0	– (	3799	*	0.004561	*	0	*	0.75	))*	1	*	1	* 0.01
ERSCR =	(	0	– (			0					))*	0.01			
ERSCR =		0									*	0.01			
ERSCR =	0	Total H2SO4 released from SCR, lbs per hour													

Equation 4-11b: Release
TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	0.365	+	0	+	
TSAR =	**0.365**	**Total H2SO4 released, lbs per hour**			

Equation 4	EMComb = K • F1 • E2							
K =	3063	lb H_2SO_4/ton SO_2						
F1 =	0.0019	Fuel Impact Factor from F1 table						

Equation 4	E2 = K1 • K2 • C1 • S1							
C1 =	199	Coal burn, tons/hr						
S1 =	0.56	Coal sulfur weighted average, %						
K1 =	Molecular weight and units conversion constant							
	0.02	SO_2/%S						
K2 =	Sulfur conversion to SO_2							
	0.875		0.95	for bituminous coals				
			0.875	for subbituminous coals				
				= 0.55 to 0.85 for lignite, based on the Na content				
			1	for oil				
E2 =	K1	•	K2	•	C1	•	S1	
E2 =	0.02	*	0.875	*	199	*	0.56	
E2 =	1.9502	SO_2 mass rate, tons/hr						

EMComb =	K	*	F1	*	E2	
EMComb =	3063	*	0.0019	*	1.9502	
EMComb =	11.34958	total H_2SO_4 manufactured from combustion, lbs/hr				

Sulfuric Acid Released from Combustion (ERComb)

Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	11.34958	*	1	*	0.72	*	0.73
ERComb =	5.965339	total H_2SO_4 released from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)

EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour

K =	3063	lb H_2SO_4/ton SO_2							
S2 =	0.03	SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)							
fsops =	0	no SCR in baseline case							
E2 =	1.9502	SO_2 produced, tons per hour							
F3SCR =	1	Technology Impact Factor, for SCR				Table 4-2			
EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	1.9502	*	1
EMSCR =	0	= Total H_2SO_4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture

TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	11.34958	+	0		
TSAM =	11.34958	= Total H_2SO_4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H_2SO_4 released from SCR, lbs per hour

EMSCR = Total H_2SO_4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11564	Btu/lb
B =	0.004602	Coal burn in TBtu/hr
fsreagent =	0	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH_3 slip from SCR/SNCR, ppmv at 6% O_2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH_3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR – (	Ks •	B •	fsreagent •	SNH3)] •	F2 (AH) •	F2 (PM) •	F2 (FGD)
ERSCR =	(	0 – (	3799 *	0.004602 *	0 *	0.75))*	1 *	1 *	0.01
ERSCR =	(	0 – (		0		))*	0.01		
ERSCR =		0				*	0.01		
ERSCR =	0	Total H_2SO_4 released from SCR, lbs per hour							

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb +	ERSCR/SN +	ERFGC
TSAR =	5.965339 +	0 +	
TSAR =	**5.965339**	**Total H_2SO_4 released, lbs per hour**	

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H2SO4/ton SO2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = 164.883 Coal burn, tons/hr
S1 = 0.6 Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO2/%S
K2 = Sulfur conversion to SO2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	164.883	*	0.6
E2 =	1.731272	SO2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	1.731272
EMComb =	10.07548	total H2SO4 manufactured from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	10.07548	*	1	*	1	*	0.01
ERComb =	**0.100755**	**total H2SO4 released from combustion, lbs/hr**					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour
K = 3063 lb H2SO4/ton SO2
S2 = 0.03 SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = 0.977 for continuous operation
E2 = 1.731272 SO2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0.977	*	1.731272	*	1
EMSCR =	155.4275	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	10.07548	+	155.4275		
TSAM =	165.503	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	12011	Btu/lb
B =	0.003961	Coal burn in TBtu/hr
fsreagent =	0.96	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =	(	155.4275	– (	3799	*	0.003961	*	0.96	*	0.75	))*	1	*	1	*	0.01
ERSCR =	(	155.4275	– (			10.83395					))*	0.01				
ERSCR =		144.5936									*	0.01				
ERSCR =	1.445936	Total H2SO4 released from SCR, lbs per hour														

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	0.100755	+	1.445936	+	
TSAR =	**1.546691**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H_2SO_4/ton SO_2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **198.598** Coal burn, tons/hr
S1 = **0.56** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO_2/%S
K2 = Sulfur conversion to SO_2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	198.598	*	0.56
E2 =	1.94626	SO_2 mass rate, tons/hr					

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	1.94626
EMComb =	11.32665	total H_2SO_4 manufactured from combustion, lbs/hr			

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	11.32665	*	1	*	0.72	*	1
ERComb =	8.155189	total H_2SO_4 released from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour
K = 3063 lb H_2SO_4/ton SO_2
S2 = 0.03 SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0** no SO_2 control at Huntington 2 baseline case
E2 = 1.94626 SO_2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	1.94626	*	1
EMSCR =	0	= Total H_2SO_4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	11.32665	+	0		
TSAM =	11.32665	= Total H_2SO_4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	**11560**	Btu/lb
B =	0.004592	Coal burn in TBtu/hr
fsreagent =	**0**	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =		[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =		(	0	– (	3799	*	0.004592	*	0	*	0.75	))*	1	*	1	*	0.01
ERSCR =		(	0	– (			0					))*	0.01				
ERSCR =			0									*	0.01				
ERSCR =	0	Total H2SO4 released from SCR, lbs per hour															

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	8.155189	+	0	+	
TSAR =	**8.155189**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2

K =	3063	lb H2SO4/ton SO2							
F1 =	0.0019	Fuel Impact Factor from F1 table							

Equation 4 E2 = K1 • K2 • C1 • S1

C1 =	**173.942**	Coal burn, tons/hr						
S1 =	**0.6**	Coal sulfur weighted average, %						
K1 =	Molecular weight and units conversion constant							
	0.02	SO2/%S						
K2 =	Sulfur conversion to SO2							
	0.875		0.95	for bituminous coals				
			0.875	for subbituminous coals				
				= 0.55 to 0.85 for lignite, based on the Na content				
			1	for oil				
E2 =	K1	•	K2	•	C1	•	S1	
E2 =	0.02	*	0.875	*	173.942	*	0.6	
E2 =	1.826391	SO2 mass rate, tons/hr						

EMComb =	K	*	F1	*	E2	
EMComb =	3063	*	0.0019	*	1.826391	
EMComb =	10.62905	total H2SO4 manufactured from combustion, lbs/hr				

Sulfuric Acid Released from Combustion (ERComb)

Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	10.62905	*	1	*	1	*	0.01
ERComb =	**0.10629**	**total H2SO4 released from combustion, lbs/hr**					

Sulfuric Acid Manufacture by SCR (EMSCR)

EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour

K =	3063	lb H2SO4/ton SO2							
S2 =	0.03	SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)							
fsops =	**0.964**	for continuous operation							
E2 =	1.826391	SO2 produced, tons per hour							
F3SCR =	1	Technology Impact Factor, for SCR				Table 4-2			
EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0.964	*	1.826391	*	1
EMSCR =	161.7853	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture

TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	10.62905	+	161.7853		
TSAM =	172.4143	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	11995	Btu/lb
B =	0.004173	Coal burn in TBtu/hr
fsreagent =	0.95	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =	(	161.7853	– (	3799	*	0.004173	*	0.95	*	0.75	))*	1	*	1	*	0.01
ERSCR =	(	161.7853	– (			11.29507					))*	0.01				
ERSCR =		150.4902									*	0.01				
ERSCR =	1.504902	Total H2SO4 released from SCR, lbs per hour														

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	0.10629	+	1.504902	+	
TSAR =	**1.611193**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H2SO4/ton SO2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = 27.606 Coal burn, tons/hr
S1 = 0.76 Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO2/%S
K2 = Sulfur conversion to SO2
0.875 0.95 for bituminous coals
0.875 for subbituminous coals
= 0.55 to 0.85 for lignite, based on the Na content
1 for oil

E2 =	K1	•	K2	•	C1	•	S1	
E2 =	0.02	*	0.875	*	27.606	*	0.76	
E2 =	0.36716	SO2 mass rate, tons/hr						

EMComb =	K	*	F1	*	E2	
EMComb =	3063	*	0.0019	*	0.36716	
EMComb =	2.13676	total H2SO4 manufactured from combustion, lbs/hr				

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	2.13676	*	1	*	0.72	*	1
ERComb =	1.538467	total H2SO4 released from combustion, lbs/hr					

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H2SO4 manufactured from SCR, lbs per hour
K = 3063 lb H2SO4/ton SO2
S2 = 0.03 SCR catalyst SO2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = 0 no SO2 control installed at Carbon 1
E2 = 0.36716 SO2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	0.36716	*	1
EMSCR =	0	= Total H2SO4 manufactured from SCR, lbs per hour							

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	2.13676	+	0		
TSAM =	2.13676	= Total H2SO4 manufactured, lbs per hour			

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	12125	Btu/lb
B =	0.000669	Coal burn in TBtu/hr
fsreagent =	0	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =		[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =		(	0	– (	3799	*	0.000669	*	0	*	0.75	))*	1	*	1	*	1
ERSCR =		(	0	– (			0					))*	1				
ERSCR =			0									*	1				
ERSCR =	0	Total H2SO4 released from SCR, lbs per hour															

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	1.538467	+	0	+	
TSAR =	**1.538467**	**Total H2SO4 released, lbs per hour**			

Equation 4 EMComb = K • F1 • E2
K = 3063 lb H_2SO_4/ton SO_2
F1 = 0.0019 Fuel Impact Factor from F1 table

Equation 4 E2 = K1 • K2 • C1 • S1
C1 = **42.229** Coal burn, tons/hr
S1 = **0.75** Coal sulfur weighted average, %
K1 = Molecular weight and units conversion constant
0.02 SO_2/%S
K2 = Sulfur conversion to SO_2
0.875

0.95	for bituminous coals
0.875	for subbituminous coals
	= 0.55 to 0.85 for lignite, based on the Na content
1	for oil

E2 =	K1	•	K2	•	C1	•	S1
E2 =	0.02	*	0.875	*	42.229	*	0.75

E2 = 0.554256 SO_2 mass rate, tons/hr

EMComb =	K	*	F1	*	E2
EMComb =	3063	*	0.0019	*	0.554256

EMComb = 3.225601 total H_2SO_4 manufactured from combustion, lbs/hr

Sulfuric Acid Released from Combustion (ERComb)
Equation 4-3 ERComb = EMComb • F2 (all that apply)

ERComb =	EMComb	•	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERComb =	3.225601	*	1	*	0.72	*	1

ERComb = 2.322433 total H_2SO_4 released from combustion, lbs/hr

Sulfuric Acid Manufacture by SCR (EMSCR)
EMSCR = K • S2 • fsops • E2• F3SCR = Total H_2SO_4 manufactured from SCR, lbs per hour
K = 3063 lb H_2SO_4/ton SO_2
S2 = 0.03 SCR catalyst SO_2 oxidation rate (specified as a decimal, typically from 0.001- 0.03)
fsops = **0** no SO_2 controls installed at Carbon 2
E2 = 0.554256 SO_2 produced, tons per hour
F3SCR = 1 Technology Impact Factor, for SCR Table 4-2

EMSCR =	K	•	S2	•	fsops	•	E2	•	F3SCR
EMSCR =	3063	*	0.03	*	0	*	0.554256	*	1

EMSCR = 0 = Total H_2SO_4 manufactured from SCR, lbs per hour

Equation 4-11a: Manufacture
TSAM = EMComb + EMSCR/SNCR +

TSAM =	EMComb	+	EMSCR/SI	+	EMFGC
TSAM =	3.225601	+	0		

TSAM = 3.225601 = Total H_2SO_4 manufactured, lbs per hour

Sulfuric Acid Released from SCR and SNCR

Equation 4-5 ERSCR = [EMSCR – (Ks • B • fsreagent • SNH3)] • F2x

ERSCR = Total H2SO4 released from SCR, lbs per hour

EMSCR = Total H2SO4 manufactured from SCR, lbs per hour

Ks =	3799	Conversion factor
HV =	12128	Btu/lb
B =	0.001024	Coal burn in TBtu/hr
fsreagent =	0	fraction of SCR operation with reagent injection
SNH3 =	0.75	NH3 slip from SCR/SNCR, ppmv at 6% O2, wet
		• SCR averages 0.75 ppmv over catalyst guarantee period
		• SNCR averages 5 ppmv
		• Note: actual NH3 slip data should be used if available
F2x =		Technology Impact Factors, all that apply

ERSCR =	[	EMSCR	– (	Ks	•	B	•	fsreagent	•	SNH3	)] •	F2 (AH)	•	F2 (PM)	•	F2 (FGD)
ERSCR =	(	0	– (	3799	*	0.001024	*	0	*	0.75	))*	1	*	1	*	1
ERSCR =	(	0	– (			0					))*	1				
ERSCR =		0									*	1				
ERSCR =	0	Total H2SO4 released from SCR, lbs per hour														

Equation 4-11b: Release

TSAR = ERComb + ERSCR/SNCR + ERFGC

TSAR =	ERComb	+	ERSCR/SN	+	ERFGC
TSAR =	2.322433	+	0	+	
TSAR =	**2.322433**	**Total H2SO4 released, lbs per hour**			

The following are the special assumptions, knowns and other items of interest involved in the calculations expressed in the previous tabs:

1. The spreadsheet calculations were made according to the version of the spreadsheet sent to UDAQ by EPA. This appears to correspond to a version of the EPRI document from 2012. However, it does not match the document 1023790 downloaded from EPA's website. This can be verified by referencing the equation numbers referred to within the 1023790 document and those listed on the "Explain" tab. The equation reference numbers tend to differ slightly, although the content of the equation itself is identical.

2. In several places throughout this methodology specific values needed to be supplied which were unavailable at the time of calculation. These values were typically site specific values or estimations of SCR performance (SCR oxidation rate) based on available coal data which could only be obtained through testing. The plants in question - Hunter Units 1, 2, and 3; Huntington 1 and 2; and Carbon Units 1 and 2 - burn a blend of Western sub-bituminous and bituminous (primarily sub-bituminous), low sulfur, low alkaline, coal which is unlike any other fuel type tested or estimated through the EPRI estimation methodology. The closest analogue would be PRB coal, which is higher in both alkalinity and heating value, and was tested primarily in Eastern plants which had switched over from higher sulfur coal to PRB. Although this allowed for some reasonable estimation in the assigning of the various factors - in other cases, some experimentation with the equations was called for.

3. As no power plant burning Utah coal currently operates with an SCR system installed, determining an appropriate SCR oxidation value to use required an analysis of the equation. Eventually, it was determined that using the highest oxidation value of 3% (yielding an S2 factor of 0.03) resulted in the highest possible sulfate value, and the most realistic release totals.

4. The FGD system at Hunter 3 is an upgraded wet scrubber followed by a particulate filter baghouse. Although the total control for this system in terms of SO2 emission is similar to the dry lime injection/baghouse systems currently installed at Hunter Units 1 and 2 and Huntington 1 and 2, the EPRI technology factors (F2) for this system are not precisely defined. Rather than using a single F2 factor of 0.01 as was the case for the Post-Control scenarios for the BART units, a hybrid F2 factor of 0.1 * 0.4 was generated by using the F2(PM) and F2(FGD) factors as found on the "F2" tab. This yielded a resulting F2 factor of 0.04 which is quite similar, and agrees well with observed SO2 emissions from Unit 3.

5. The BART units (Hunter 1 and 2 and Huntington 1 and 2) were previously equipped with cold side ESPs for particulate control, and (with the exception of Huntington 2) first generation wet scrubbers for control of SO2 emissions. Huntington Unit 2 was uncontrolled for SO2 in the baseline case. Therefore, the technology factors chosen were F2(PM) = 0.72 and F2(FGD) = 0.73, Huntington 2's F2(FGD) was set at 1.

6. Following the installation of Modeling Scenario 1 controls (LNB/OFA + FGD/Baghouse) these technology factors were updated. As the installation of the Dry FGD system includes the effect of the baghouse, no particulate control mechanism needs to be included. Although not specifically discussed in the EPRI document under particulate control. UDAQ believes that the effect of "double counting" the impact of particulate control upon H2SO4 release would be excessive. Although the purpose of FGD systems is to remove acid gas emissions; no system is perfectly efficient, and the technology factor assigned to FGD/baghouse systems is already quite good. Therefore for all BART Post scenarios, F2(PM) was set at 1, while F2(FGD) was set at 0.01 as per Table 4-5.

7. Baseline emissions were based on 2003 emission inventory values. This year contained the most up-to-date record of coal burn data, hours of operation coal sulfur weight percentage, and emission inventory data available from the baseline period (2001-2003). Post-control emissions were based on the 2012 and 2013 emission year inventories. Coal sulfur contents rose slightly between 2003 and 2013, although sulfate emissions generally dropped.

8. Carbon Units 1 and 2 are based solely on emissions from 2012/2013. As the effect of shutting down the Carbon Plant is based on removing actual emissions. Those emissions must be calculated using the definition of actual emissions - most commonly this is defined as the emissions from the two-year period immediately preceding the change. Without inventory data currently available from the 2014 reporting year, the two-year period immediately preceding this action would be the 2012-2013 inventory periods.

9. Although each tab shows a section where the "effect" of SCR/SNCR is apparently included, a quick review of the baseline tabs will reveal that this is reduced to zero (0) by setting Fsops = 0. Similarly, the effect of ammonia slip is also reduced to zero (0) in the baseline tabs as Fsreagent has also been set to 0.

10. The GivenAssume tab was used as an input tab, and is not to be used as a representation of the values for all individual calculation tabs. Rather each individual calculation tab (such as "Hunter 1 Baseline") should be viewed independently of the others. These tabs were generated by plugging the appropriate values into the "GivenAssume" tab and then copying/pasting the values directly from the "Calculate" tab once generated. This way the work could be replicated by inserting the same input values. The appropriate values have been highlighted on each tab. Red highlights serve as inputs, these items can be found on both the "Baseline" and "Post" tabs. Purple highlights on the "Post" tabs designate the ERcomb values which is also the release value for each plant under Modeling Scenario 1 (LNB/OFA +FGD/Baghouse) but prior to the installation of SCR. Finally Green highlights designate the final release values for each plant for that particular tab. For the Baseline tabs, this is the total amount. For the Post tabs, this value represents the effect of SCR - in addition to the Scenario 1 controls already present.