Cleveland Cliffs Indiana Harbor East

NO_x and SO_2 Control Cost Analysis for Walking Beam Furnace and Sinter Plant Windbox

Cost Detail Description	NO_x Controls		Sinter Plant Windbox	
	Ultra Low NO_x Burners		SO_2 Controls	
	WBF #5	WBF #6	Spray Dryer Absorber	Dry Sorbent Injection
Equipment	1,111,000	1,111,000		
Installation	2,287,000	2,287,000		
Total Direct Capital Cost (DCC)	3,398,000	3,398,000		
Total Indirect Capital Cost (IOC)	550,200	550,200		
Total Capital Investment (TCI)	5,133,000	5,133,000	56,004,757	56,004,757
Total Direct Operating Costs	82,500	82,500	2,203,032	2,203,032
Total Indirect Operating Costs	684,300	684,300	7,448,000	7,448,000
Total Annual Costs	766,800	766,800	9,651,032	9,651,032

The detailed cost estimates for the reasonable set of emission control measures can be found in ArcelorMittal's submittal "Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control for Indiana Harbor East attached in Appendix B.

Operating Company: Cleveland Cliffs Steel
Facility: Indiana Harbor East
State: Indiana

NO_x and SO_2 Controls

Control Cost Summary	80" Hot Strip Mill Walking Beam Furnaces Low-NOx Burners NO_x Controls		Sinter Plant Windbox SO_2 Controls	
	WBF #5	WBF #6	Spray Dryer Absorber	Dry Sorbent Injection
Total Capital Cost	$5,133,000	$5,133,000	37,871,432	30,433,986
Total Annual Cost (Capital & Operating)	$766,800	$766,800	$9,651,032	$9,651,032
Current Emissions (ton/yr)	214	236.6	371	371
Control Efficiency	39%	46%	90%	70%
New Emission Rate (tons/yr)	131	127	37	111
Emission Reductions (tons/yr)	83	110	334	260
Cost-Effectiveness ($/ton)	9,300	7,000	28,900	38,200

Note: Cost-Effectiveness ($/ton) = Total Annual Cost/New Emission Rate (the cost effectiveness number shown in the table reflects the numbers provided in ArcelorMittal's submittal "Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control" for Indiana Harbor East attached in Appendix B.

Cleveland Cliffs Burns Harbor

SO_2 Control Cost Analysis for Spray Dryer Absorber on Battery Nos. 1 and 2; Spray Dryer Absorber and Dry Sorbent Injection on Power Station Boilers; and Coke Oven Gas Desulfirization on Clean Coke Oven Gas Export Line

Control Cost Summary	Battery No. 1	Battery No. 2	Gas Export Line and Flare	Power Station Boilers											
				No. 7		No. 8		No. 9		No. 10		No. 11		No. 12	
	Spray Dryer Absorber	Spray Dryer Absorber	Coke Oven Gas Desulfurization	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection
Equipment	28,530,312	25,769,315		39,881,082	9,080,638	39,881,082	7,757,623	39,881,082	7,547,825	39,881,082	7,546,432	39,881,082	7,453,627	39,881,082	8,476,187
Installation	21,112,431	19,069,293		29,512,001	6,719,672	29,512,001	5,740,641	29,512,001	5,585,391	29,512,001	5,584,359	29,512,001	5,515,684	29,512,001	6,272,379
Total Direct Capital Cost (DCC)	49,642,743	44,838,608		69,393,083	15,800,310	69,393,083	13,498,264	69,393,083	13,133,216	69,393,083	13,130,791	69,393,083	12,969,311	69,393,083	14,748,566
Total Indirect Capital Cost (IOC)	14,835,762	13,400,044		20,738,163	4,721,932	20,738,163	13,400,044	20,138,763	3,924,869	20,738,163	3,924,144	20,738,163	3,875,886	20,738,163	4,407,617
Total Capital Investment (TCI)	64,282,882	58,061,815		89,645,479	20,522,242	89,754,364	17,155,347	90,131,245	16,690,046	89,745,523	16,669,213	89,774,258	16,488,210	89,690,262	18,715,200
Total Direct Operating Costs	1,313,341	1,345,217		1,566,988	2,706,554	1,269,063	2,081,855	1,204,881	1,832,253	1,166,516	1,502,284	1,195,479	1,872,475	1,408,712	2,271,859
Total Indirect Operating Costs	8,213,753	7,437,372		11,458,125	2,848,930	11,431,233	2,452,235	11,429,049	2,391,409	11,433,416	2,395,387	11,426,319	2,362,350	11,447,064	2,668,916
Total Annual Costs	9,527,094	8,782,589	27,854,000	13,025,113	5,555,484	12,700,296	4,534,089	12,633,930	4,223,662	12,599,932	3,897,671	12,621,798	4,234,824	12,855,776	4,940,775

The detailed cost estimates for the reasonable set of emission control measures can be found in ArcelorMittal's submittal "Regional Haze Four-Factor Analysis with Visibility" Benefits Evaluation for NO_x and SO_2 Emissions Control" for Burns Harbor in Appedix D.

Operating Company: Cleveland Cliffs Steel
Facility: Burns Harbor
State: Indiana

SO_2 Controls

Control Cost Summary	Battery No. 1	Battery No. 2	Export Line and Flare	Power Station Boilers											
				No. 7		No. 8		No. 9		No. 10		No. 11		No. 12	
	Spray Dryer Absorber	Spray Dryer Absorber	Coke Oven Gas Desulfurization	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection	Spray Dryer Absorber	Dry Sorbent Injection
Total Capital Cost	$64,282,882	$58,061,815	CBI	$89,645,479	$20,036,476	$89,754,364	$17,155,347	$89,763,206	$16,690,046	$89,745,523	$16,669,213	$89,774,258	$16,488,210	$89,690,262	$18,715,200
Total Annual Cost (Capital & Operating)	$9,527,094	$8,782,589	$27,854,000	$13,025,113	$5,555,484	$12,700,296	$4,534,089	$12,633,930	$4,223,662	$12,599,932	$3,897,671	$12,621,798	$4,234,824	$12,855,776	$4,940,775
Current Emissions (ton/yr)	1,675	1,854	8,096	901	901	651	651	524	524	334	334	554	554	703	703
Control Efficiency	90%	90%	86%	90%	70%	90%	70%	90%	70%	90%	70%	90%	70%	90%	70%
New Emission Rate (tons/yr)	167	185	1,099	90	270	65	195	52	157	33	100	55	166	70	211
Emission Reductions (tons/yr)	1,507	1,668	6,997	811	631	586	456	472	367	300	233	499	388	633	492
Cost-Effectiveness ($/ton)	6,300	5,300	4,000	16,100	8,800	21,700	9,900	26,800	11,500	42,000	16,700	25,300	10,900	20,300	10,000

Note: Cost-Effectiveness ($/ton) = Total Annual Cost/New Emission Rate (the cost effectiveness numbers shown in the tables below reflect the numbers provided in ArcelorMittal's submittal
"Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control" for Burns Harbor attached in Appendix D.

US Steel Gary Works

NO_x Control Cost Analysis for Low-NO_x Burners on 84" Hot Strip Mill Reheat Furnaces 1 - 4 and Waste Heat Boiler No. 1 and 2

Cost Detail Description	Low-NO_x Burners		
	84" Hot Strip Mill Reheat Furnaces 1 - 4	Waste Heat Boiler No. 1	Waste Heat Boiler No. 2
Equipment	6,100,000	492,800	492,800
Installation	10,000,000	660,000	660,000
Total Direct Capital Cost (DCC)	16,100,000	1,152,800	1,152,800
Total Indirect Capital Cost (IOC)	6,910,000	653,940	653,940
Total Capital Investment (TCI) = DC + IC	23,010,000	1,806,740	1,806,740
Total Direct Operating Costs	82,450	82,450	82,450
Total Indirect Operating Costs	2,895,331	272,926	272,926
Total Annual Costs	2,977,781	355,376	355,376

The detailed cost estimates for the reasonable set of emission control measures can be found in US Steel's submittal "Regional Haze Four-Factor Analysis with Visibility" Benefits Evaluation for NO_x and SO_2 Emissions Control" for Gary Works in Appedix E.

Operating Company: United States Steel Corporation

Facility: Gary Works

State: Indiana

NO_x Controls

Control Cost Summary	Low-NO_x Burners		
	84" Hot Strip Mill Reheat Furnaces 1 - 4	**Waste Heat Boiler No. 1**	**Waste Heat Boiler No. 2**
Total Capital Cost	$23,010,000	$1,806,740	$1,806,740
Total Annual Cost (Capital & Operating)	$2,977,781	$355,376	$355,376
Current Emissions (ton/yr)	323	89	86
Control Efficiency	65%	65%	65%
New Emission Rate (tons/yr)	113	31	30
Emission Reductions (tons/yr)	211	58	56
Cost-Effectiveness ($/ton)	14,142	6,130	6,344

Note: Cost-Effectiveness ($/ton) = Total Annual Cost/New Emission Rate (the cost effectiveness numbers shown in the table reflect the numbers provided in US Steel's submittal "Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control" for Gary Works attached in Appendix E.

SABIC Mt. Vernon

NO_x Control Cost Analysis for SCR on COGEN

Design Parameters			
Parameter	**Equation**	**Calculated Value**	**Units**
Maximum Annual Heat Input Rate (Q_B) =	HHV x Max. Fuel Rate =	1,812	MMBtu/hour
Maximum Annual fuel consumption (mfuel) =	(QB x 1.0E6 x 8760)/HHV =	15,485,970,732	scf/yr
Actual Annual fuel consumption (Mactual) =		12,643,340,488	scf/yr
Heat Rate Factor (HRF) =	NPHR/10 =	0.82	
Total System Capacity Factor (CFtotal) =	(Mactual/Mfuel) x (t_{scr}/tplant) =	0.816	fraction
Total operating time for the SCR (top) =	CFtotal x 8760 =	7152	hours
NOx Removal Efficiency (EF) =	(NO_{xin} - NO_{xout})/NO_{xin} =	85	percent
NOx removed per hour =	NO_{xin} x EF x Q_B =	28.33	lb/hr
Total NOx removed per year =	(NO_{xin} x EF x Q_B x top)/2000 =	101.30	tons/yr
NOx removal factor (NRF) =	EF/80 =	1.06	
Volumetric flue gas flow rate ($q_{flue\ gas}$) =	Q_{fuel} x Q_B x (460 + T)/(460 + 700)$_{nscr}$ =	818,037.00	acfm
Space velocity (Vspace) =	qflue gas/Volcatalyst =	110.00	
Space velocity (Vspace) =	$q_{flue\ gas}$/$Vol_{catalyst}$ =	110.00	
Residence Time	1/Vspace	0.01	/hour
Coal Factor (CoalF) =	1 for oil and natural gas; 1 for bituminous; 1.05 for subbituminous; 1.07 for lignite (weighted average is used for coal blends)	1.00	hour
SO2 Emission rate =	(%S/100) x (64/32)*1x106)/HHV =	Not applicable; factor applies only to coal-fired boilers.	
Elevation Factor (ELEVF) =	14.7 psia/P =	1.06	
Atmospheric pressure at sea level (P) =	2116 x [(59 -(0.00356 x h) + 459.7)/518.6]5.256 x (1/144)* =	13.90	psia
Retrofit Factor (RF)	Retrofit to existing boiler	1.00	
* Equation is from the National Aeronautics and Space Administration (NASA), Earth Atmosphere Model. Available at https://spaceflightsystems.grc.nasa.gov/education/rocket/atmos.html.			
Catalyst Data			
Parameter	**Equation**	**Calculated Value**	**Units**
Future worth factor (FWF) =	(interest rate)(1/((1 + interest rate)Y -1) , where Y = $H_{catalyts}$/(t_{SCR} x 24 hours) rounded to the nearest integer)	0.3157	fraction
Catalyst volume (Volcatalyst) =	2.81 x Q_B x EF adj x $Slip_{adj}$ x NOx_{adj} x S_{adj} x (T_{adj}/N_{scr})	7,437.61	cubic feet
Cross sectional area of the catalyst (Acatalyst) =	$q_{flue\ gas}$ /(16ft/sec x 60 sec/min)	852	ft^2
Height of each catalyst layer (H_{layer}) =	($Vol_{catalyst}$/(R_{layer} x $A_{catalyst}$)) + 1 (rounded to next highest integer)	4	feet
SCR Reactor Data			
Parameter	**Equation**	**Calculated Value**	**Units**
Cross sectional area of the reactor (A_{SCR}) =	1.15 x $A_{catalyst}$	980	ft^2

Reactor length and width dimensions for a square reactor =	$(A_{SCR})^{0.5}$	7,437.61	feet
Reactor height =	$(R_{layer} + R_{empty})$ x (7ft + h_{layer}) + 9ft	852	feet
Reagent Data			
		Molecular Weight of Reagent (MW) =	17.03 g/mole
Type of reagent used	Ammonia	Density =	56 lb/ft^3
Parameter	**Equation**	**Calculated Value**	**Units**
Reagent consumption rate ($m_{reagent}$) =	(NO_{xin} x Q_B x EF x SRF x MW_R)/$MWNO_x$ =	11	
Reagent Usage Rate (m_{sol}) =	$m_{reagent}/C_{sol}$ =	38.00	
	(m_{sol} x 7.4805)/Reagent Density	5	gal/hour
Estimated tank volume for reagent storage =	(m_{sol} x 7.4805 x $t_{storage}$ x 24)/Reagent Density =	1,800	gallons (storage needed to store a 14 day reagent supply rounded to the nearest 100 gallons)
Capital Recovery Factor			
Parameter	**Equation**	**Calculated Value**	
Capital Recovery Factor (CRF) =	i $(1+ i)^n$ /$(1+ i)^n$ - 1 =	0.0837	
	Where n = Equipment Life and i= Interest Rate		
Electricity Usage			
Other Parameters	**Equation**	**Calculated Value**	**Units**
Electricity Consumption (P) =	A x 1,000 x 0.0056 x $(\text{CoalF} \times \text{HRF})^{0.43}$ =	931.72	kW
	Where A = (0.1 x Q_B) for industrial boilers.		
Cost Estimate			
Total Capital Investment (TCI) for Oil and Natural Gas Boilers			

For Oil and Natural Gas-Fired Utility Boilers between 25MW and 500 MW:

TCI = 86,380 x (200/BMW)0.35 x BMW x ELEVF x RF

For Oil and Natural Gas-Fired Utility Boilers >500 MW:

TCI = 62,680 x BMW x ELEVF x RF

For Oil-Fired Industrial Boilers between 275 and 5,500 MMBTU/hour :

TCI = 7,850 x $(2,200/Q_B)^{0.35}$ x Q_B x ELEVF x RF

For Natural Gas-Fired Industrial Boilers between 205 and 4,100 MMBTU/hour :

TCI = 10,530 x $(1,640/Q_B)^{0.35}$ x Q_B x ELEVF x RF

For Oil-Fired Industrial Boilers >5,500 MMBtu/hour:

TCI = 5,700 x Q_B x ELEVF x RF

For Natural Gas-Fired Industrial Boilers >4,100 MMBtu/hour:

TCI = 7,640 x Q_B x ELEVF x RF

Total Capital Investment (TCI) = 21,805,180 in 2019 dollars

Annual Costs		
Total Annual Cost (TAC)		
TAC = Direct Annual Costs + Indirect Annual Costs		
Direct Annual Costs (DAC) =	$773,776 in 2019 dollars	
Indirect Annual Costs (IDAC) =	$1,829,030 in 2019 dollars	
Total Annual Costs (TAC) = DAC + IDAC	$2,602,806 in 2019 dollars	
Direct Annual Costs (DAC)		
DAC = (Annual Maintenance Cost) + (Annual Reagent Cost) + (Annual Electricity Cost) + (Annual Catalyst Cost)		
Annual Maintenance Cost =	0.005 x TCI =	$109,026 in 2019 dollars
Annual Reagent Cost =	msol x $Cost_{reag}$ x top =	$10,628 in 2019 dollars
Annual Electricity Cost =	P x $Cost_{elect}$ x top =	$476,453 in 2019 dollars
Annual Catalyst Replacement Cost =	n^{scr} x Vol_{cat} x ($CC_{replace}$/R_{layer}) x FWF	$177,669 in 2019 dollars
Indirect Annual Cost (IDAC)		
IDAC = Administrative Charges + Capital Recovery Costs		
Administrative Charges (AC) =	0.03 x (Operator Cost + 0.4 x Annual Maintenance Cost) =	$3,936 in 2019 dollars
Capital Recovery Costs (CR)=	CRF x TCI =	$1,825,094 in 2019 dollars
Indirect Annual Cost (IDAC) =	AC + CR =	$1,829,030 in 2019 dollars
Cost Effectiveness		
Cost Effectiveness = Total Annual Cost/NO_x Removed/Year		
Total Annual Cost (TAC) =	$2,602,806 in 2019 dollars	
NO_x Removed =	101 tons/yr	
Cost Effectiveness =	$25,691 per ton of NO_x removed in 2019 dollars	

Operating Company: SABIC

Facility: Mt. Vernon

State: Indiana

NO_x Controls

Control Cost Summary	COGEN
	SCR
Total Capital Cost	$21,805,180
Total Annual Cost (Capital & Operating)	$2,602,806
Current Emissions (ton/yr)	119
Control Efficiency	83%
New Emission Rate (tons/yr)	18
Emission Reductions (tons/yr)	101
Cost-Effectiveness ($/ton)	25,691

Note: Cost-Effectiveness ($/ton) = Total Annual Cost/New Emission Rate (the cost effectiveness numbers shown in the tables below reflect the numbers provided in SABIC's submittal "Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control" for Mt. Vernon attached in Appendix F.

SABIC Mt. Vernon

SO_2 Cost Estimate and Cost Effectiveness for Wet Packed Tower Gas Absorber on COS Vent Scrubber

Capital Cost Summary (See Reference Notes Below)

References	Cost Detail	Notes	Costs	References
1	Preliminary Total Capital Investment (Prelim TCI)	PEC + DC + IC	$38,988,800	Table 1.7
2a	Estimated Direct and Indirect Costs (DC + IC)	Prelim. TCI / 2.17	$17,967,189	Equation 1.100
2b	Retrofit Cost	0.30 * (DC + IC)	$5,390,157	Section 1.2.4.3
1	Quench Chamber Cost		$1,960,556	
	Total Capital Investment (TCI) with Retrofit Cost Consideration and Quench Chamber		$46,339,513	
5	TCI as 2019 $		$51,109,757	
Ref.	*Operation and Maintenance Costs Table*			*Ref*
	Annual Costs			
2a, 6	Ref. Operation and Maintenance Costs Table Ref	0.5 hr/shift * 3 shifts/day * $/hr	$21,920	Table 1.8
2a, 6	Operating Labor	15% of operator labor	$3,288	Table 1.8
2a, 6	Supervisor Labor	0.5 hr/shift * 3 shifts/day * $/hr	$29,044	Table 1.8
2a, 6	Maintenance Labor	100% of maintenance labor	$29,044	Table 1.8
2a	Maintenance Materials			
Ref.	*Cost of Solvent/Reagent (Sodium Hydroxide NaOH)*			
	Total Annual NaOH Usage	tons/yr	975	
	Unit cost	$/ton	$385.49	
	Total	ton/yr * $/ton	$375,960	
Ref.	*Cost of Wastewater Treatment*			
3	Discharge Blowdown	m^3/yr	31,122	
3	Unit cost	$/$m^3$	$2.00	
2a	Total	m^3/yr * $/m	$62,244	
Ref.	*Auxiliary Power Costs*			
3	Power Required	kW	24	
3	Hours Operated	top	6,340	
8	Unit cost	$/kW-hr	$0.07	
2a	Total	kW * $/kWh * top	$11,079	
	Direct Annual Cost (DAC)		**$532,580**	
				Table / Equation
Ref.	*Indirect Annual Cost*			*Ref.*
2a	Overhead	0.60 * Total Labor/Material $	$49,978	Table 1.8

2a	Administration Charges (AC)	0.02 * TCI	$1,022,195	Table 1.8
2a	Property Tax	0.02 * TCI	$511,098	Table 1.8
2a	Insurance	0.02 * TCI	$511,098	Table 1.8
2a, 4	Economic Life of Control Device	years	30	Table 1.8
2a, 4	Annual Interest Rate	%	7%	Table 1.8
2b	Capital Recovery Factor	CRF	0.0806	Equation 1.30
2a	Capital Recovery (CR)	CRF * TCI	$4,118,751	Table 1.8
	Indirect Annual Cost (IDAC)		**$6,213,119**	
				Table / Equation
Ref.	*Parameter*			*Ref.*
3	Baseline SO_2 Emissions	tons/yr	570	
3	Control Efficiency		95%	
3	Total SO_2 Removed	Baseline SO_2 * (1-Control Efficiency)	542	
2b	Total Annual Cost (2019 $)	TAC = IDAC + DAC	$6,745,699	Equation 1.31
2a	Cost Effectiveness	$/ton removed	$12,449	Equation 1.31

References:

1 TCI is derived using the cost for a similar wet packed tower gas absorber (i.e., scrubber) completed at Mt. Vernon in 2010. Mt. Vernon has assumed the 2010 project include the scrubber body, packing, auxiliary equipment, instrumentation, sales taxes, and freight as well as direct installation costs (foundations, erection, piping, etc.) and indirect installation costs (engineering, start-up, etc.).
Additionally, Mt. Vernon provided an estimate for the TCI for a quench tower, which would be required prior to the scrubber to ensure proper operating conditions.
The gas inlet flow rate from the 2010 project was ratioed with the anticipated COS Vent Oxidizer Scrubber gas inlet flow rate. SABIC used stack test data from the COS Vent Oxidizer (gas outlet flow rate from COS Vent Oxidizer is assumed to equal the inlet to a COS Vent Oxidizer Scrubber) to estimate the inlet gas flow rate for a COS Vent Oxidizer Scrubber.

2 EPA OAQPS, EPA Air Pollution Control Cost Manual , Draft July 2020, Section 5, Chapter 1

2a Wet Packed Tower Gas Absorbers sub-section 1.3 of Section 5, Chapter 1
Table 1.7: Capital Cost Factors for Wet Packed Tower Absorbers
Table 1.8: Suggested Annual Cost Factors for Wet Packed Tower Absorbers
Section 1.3.3: Estimating Total Capital Investment: Equation 1.100

2b Wet Flue Gas Desulfurization sub-section of 1.2 of Section 5, Chapter 1
Section 1.2.4.3: Estimating Total Capital Investment
Section 1.2.4.4: Estimating Total Annual Cost for a Wet FGD System: Equations 1.30, 1.31, and 1.32

3 Data specific to SABIC's facility in Mt. Vernon, Indiana, such as estimations from engineering department and historic annual emission summary data

4 Based on SABIC-specific estimated equipment lifetime and estimated bank interest rate.

5 Used Chemical Engineering Plant Cost Index, https://www.chemengonline.com/pci-home, accessed on February 10, 2020.

6 Hourly labor rates: Operating Labor $40/hr and Maintenance Labor $53/hr. These rates are representative of SABIC's current pay rates.

7 Reagent, sodium hydroxide NaOH, cost is an estimate from Echemi.com.

8 Electrical cost is an estimate from https://www.electricitylocal.com/states/indiana/mount-vernon/.

Operating Company: SABIC

Facility: Mt. Vernon

State: Indiana

NO_x Controls

Control Cost Summary	COS Vent Scrubber
	Gas Absorber
Total Capital Cost	$46,339,513
Total Annual Cost (Capital & Operating)	$6,745,699
Current Emissions (ton/yr)	570
Control Efficiency	95%
New Emission Rate (tons/yr)	29
Emission Reductions (tons/yr)	542
Cost-Effectiveness ($/ton)	12,449

Note: Cost-Effectiveness ($/ton) = Total Annual Cost/New Emission Rate (the cost effectiveness number shown in the table reflect the numbers provided in SABIC's submittal "Regional Haze Four-Factor Analysis with Visibility Benefits Evaluation for NO_x and SO_2 Emissions Control" for Mt Vernon attached in Appendix F.

Operating Company: Alcoa

Facility: Warrick

State: Indiana

SO_2 Controls

Control Cost Summary	Potlines 2-6	Anode Baking Ring Furnace & A-446 Dry Alumina Scrubbers
	Flue Gas Desulfurization	Flue Gas Desulfurization
Total Capital Cost	$512,800,000	$63,900,000
Total Annual Cost (Capital & Operating)	$5,300,000	$700,000
Current Emissions (ton/yr)	3,000	139
Control Efficiency	70%	70%
New Emission Rate (tons/yr)	900	42
Emission Reductions (tons/yr)	2,100	97
Cost-Effectiveness ($/ton)	2,524	7,194

Note: Current emissions for the Alcoa potlines were estimated using the highest reported emissions of the three potlines that operated in 2018 for all five units (600 tons x 5 potlines).