Appendix C

Screening Level Cost Summary for SO_2 Emission Control Measures

PUBLIC

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-1: Cost Summary

SO_2 Control Cost Summary										
Control Technology	Uncontrolled Emissions T/y	Baseline Emissions T/y	Control Eff %	Controlled Emissions Ton/Yr	Emission Reduction Ton/Yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Incremental Control Cost $/ton	Non-Air Env Impacts?	Comments
Spray Dryer Absrober (SDA)		23.22	90.0%	2.32	20.90	$6,787,653	$3,193,737	$152,800	Solid Waste	
Wet Scrubber with Lime		23.22	98.0%	0.46	22.76	$28,500,905	$5,071,587	$222,900	Waste-water	
Dry Sorbent Injection (DSI)		23.22	50.0%	11.61	11.61	$2,077,596	$1,007,871	$86,800	Solid Waste	
Process Inherent Scrubbing (Baseline)	232.20			23.22	208.98					

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-2: Emissions Data

Operating Unit: Peerless Rotary Kilns
Emission Unit Number EP-069, EP-070, EP-071
Stack/Vent Number Varies

Operating Information

Unit Annual Oper Hours		hr/yr	Source Type for Cost Calc	Industrial Coal	
Control Equip Oper Hrs		hr/yr	Coal/Fuel Type for CoalF	Coal / Coke blend	
Combined Op Hours (Top)		hr/yr	NPHR (utilities Net Plant Heat Rate, if known)	10	*MMBtu/MW*
Control Equipment Life	20	yrs	Hourly Heat Input (Q_b) or Equivalent		*MMBtu/hr HHV*
Exhaust Temperature	400	Deg F	Basis Q_b and Capacity Factor (% Utilization)	Heat Input: Design vs. Actual	
Exhaust Moisture Content	6.0%		Maximum Hourly Production Rate		
Plant Elevation	560	ft	Annual Average Production Rate		
Atmos Press at Elvation	14.41	psia	Energy Use per Unit of Production		
Standardized Flow Rate		scfm @ 68° F	Maximum Hourly Heat Input (firing) Rate		*MMBtu/hr HHV*
Dry Std Flow Rate		dscfm @ 68° F	Annual Average Heat Input (firing) Rate		*MMBtu/hr HHV*
Actual Flow Rate		acfm	Maximum Hourly Fuel Use Rate		scf/hr
Elevation Factor	1.02		Annual Fuel Use Rate		scf/yr
			Capacity Factor (CF) / Utilization	100.0%	
Fuel Sulfur Content		wt %	Fuel Heating Value (0 if not known)		Btu/lb
Uncontrolled SO_2 Emission Rate		lb SO2/MMBtu			

Process Inherent Scrubbing (Baseline)	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		232.20	% Removal					23.22	-

	Max Emissions		Uncontrolled Concentration		
Pollutant	lb/Hr	ton/yr			
Sulfur Dioxide (SO_2)		23.22	22.0	ppm dry	

Dry Sorbent Injection w/ BGHS	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		23.22	% Removal	50%				11.61	-

Spray Dry Absorber w/ BGHS	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		23.22	% Removal	90%				2.32	-

Wet Scrubber w/ Lime	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		23.22	% Removal	98%				0.46	-

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-3: Summary of Utility, Chemical and Supply Costs

Operating Unit: Peerless Rotary Kilns **Study Year** 2019
Emission Unit Number EP-069, EP-070, EP-071
Stack/Vent Number Varies

Item	Unit Cost	Units, k=1,000 M=1,000,000	Reference Cost	Year	Data Source	Notes
Operating Labor	37.00	$/hr			Mississippi Lime Company	Actual cost of Operator Labor per Mississippi Lime Company
Maintenance Labor	53.00	$/hr			Mississippi Lime Company	Actual cost of Maintenance Labor per Mississippi Lime Company
Utilities						
Electricity	0.074	$/kW-h			U.S. Energy Information Administration	Average Price for Missouri Industrial customers, June 2020
Water	0.33	$/kgal	0.20	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2.6.1.2.	Example Problems uses $0.20/1000 gal. Cost adjusted for 3% inflation Sec 5.2 Ch 1 also lists $0.20/1,000 gal.
Wastewater Disposal Neutralization	2.48	$/kgal	1.50	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 5 Chapter 1.	Section 2 lists $1- $2/1000 gal. Cost adjusted for 3% inflation. Sec 6 Ch 3 lists $1.30 - $2.15/1,000 gal.
Solid Waste Disposal	18.45	$/ton	15.00	2012	EPA Air Pollution Control Cost Manual May	Paragraph 1.5 Example calculations - price for ash disposal. Cost
	N/A	N/A				
Chemicals & Supplies						
Lime	[redacted]	$/ton			Mississippi Lime Company	Actual cost of reagent per Mississippi Lime Company
Catalyst & Replacement Parts						
Other						
Sales Tax	6.50%					
Interest Rate	7.00%				EPA policy specifies 7% interest for BACT review cost calculations	

Total Costs

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-4: SO2 Control - Dry Sorbent Injection

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-069, EP-070, EP-071		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	400	Deg F
Combined Operating Hours	[redacted]	hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			**1,139,456**
Purchased Equipment Total (B)			**1,181,023**
Installation - Standard Costs			431,256
Installation - Site Specific Costs			0
Installation Total			431,256
Total Direct Capital Cost, DC			1,612,279
Total Indirect Capital Costs, IC			465,317
Total Capital Investment (TCI) = DC + IC			**2,077,596**
Operating Costs			
Total Annual Direct Operating Costs	Labor, supervision, materials, replacement parts, utilities, etc.		715,722
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost		292,149
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**1,007,871**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	23.22	% Removal	50%			11.61	11.61	$86,800

Notes & Assumptions

1. Dry Sorbent Injection: Mississippi Lime Company actual installation costs for lime injection system and adjusted for inflation based on Chemical Engineering Plant Cost Index
2. Used 0.6 power law factor to adjust price to calculated acfm from bid basis of 150,000 acfm
3. Cost for Dry Sorbent Injection System only
4. Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1
5. Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT.

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-4: SO2 Control - Dry Sorbent Injection

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (A) [1]		**1,139,456**
Purchased Equipment Costs (A) - Injection System + auxiliary equipment, EC		
Instrumentation		25,979
State Sales Taxes		-
Freight		15,588
Purchased Equipment Total (B)		**1,181,023**
Installation		
Foundations & supports		270,185
Handling & erection		135,092
Electrical		25,979
Piping		-
Installation Subtotal Standard Expenses		**431,256**
Site Preparation, as required	N/A Site Specific	-
Buildings, as required	N/A Site Specific	-
Site Specific - Other	N/A Site Specific	-
Total Site Specific Costs		N/A
Installation Total		**431,256**
Total Direct Capital Cost, DC		**1,612,279**
Indirect Capital Costs		
Engineering, supervision		51,959
Construction & field expenses	20% of purchased equip cost (B)	236,205
Contractor fees	10% of purchased equip cost (B)	118,102
Start-up	1% of purchased equip cost (B)	11,810
Performance test	1% of purchased equip cost (B)	11,810
Model Studies	N/A of purchased equip cost (B)	-
Contingencies	3% of purchased equip cost (B)	35,431
Total Indirect Capital Costs, IC		**465,317**
Total Capital Investment (TCI) = DC + IC		**2,077,596**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost		**2,077,596**
OPERATING COSTS		
Direct Annual Operating Costs, DC		
Operating Labor		
Operator	N/A	5,370
Supervisor	15% $/Hr, 0.5 hr/8 hr shift, 145 hr/yr	805
Maintenance		
Maintenance Labor	N/A	7,692
Maintenance Materials	100% % of Maintenance Labor	7,692
Utilities, Supplies, Replacements & Waste Management		
Electricity	0.074 $/kW-h, 317.6 kW-hr, 737,541 kWh/yr, 100% utilization	54,799
Solid Waste Disposal	18.45 $/ton, 0.8 ton/hr, 1,906 kWh/yr, 100% utilization	35,162
Lime	[redacted]	604,202
Total Annual Direct Operating Costs		**715,722**
Indirect Operating Costs		
Overhead	60% of total labor and material costs	12,935
Administration (2% total capital costs)	2% of total capital costs (TCI)	41,552
Property tax (1% total capital costs)	1% of total capital costs (TCI)	20,776
Insurance (1% total capital costs)	1% of total capital costs (TCI)	20,776
Capital Recovery	0.0944 for a 20-year equipment life and a 7% interest rate	196,110
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost	**292,149**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**1,007,871**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-4: SO2 Control - Dry Sorbent Injection

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow	dP in H_2O	Efficiency	HP	kW
Sorbent Injection Pump/Airlock	[redacted]	12			317.6
Total					317.6

Reagent Use & Other Operating Costs

Sorbent Use	1641.70 lb/hr Caustic

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	2,322

Item	Unit Cost $	Unit of Measure	Use Rate	Unit of Measure	Annual Use*		Annual Cost	Comments
Operating Labor								
Op Labor	37.00	$/Hr	0.5	hr/8 hr shift	145	$	5,370	37.00 $/Hr, 0.5 hr/8 hr shift, 145 hr/yr
Supervisor	15%	of Op Labor			NA	$	805	15% of Operator Costs
Maintenance								
Maint Labor	53.00	$/Hr	0.5	hr/8 hr shift	145	$	7,692	$/Hr, 0.5 hr/8 hr shift, 145 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$	7,692	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management								
Electricity	0.074	$/kW-h	317.6	kW-hr	737,541	$	54,799	0.074 $/kW-h, 317.6 kW-hr, 737,541 kWh/yr, 100% utilization
Solid Waste Disposal	18.45	$/ton	0.82	ton/hr	1,906	$	35,162	18.45 $/ton, 0.8 ton/hr, 1,906 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.82	ton/hr	1,906	$	604,202	[redacted]

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-5: SO2 Control Spray Dry Absorber (SDA)

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-069, EP-070, EP-071		Stack/Vent Number	Varies	
Design Capacity		MMBtu/hr HHV	Standardized Flow Rate		scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	400	Deg F
Combined Operating Hours		hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate		acfm
Control Equipment Life	20	yrs	Standardized Flow Rate		scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate		dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			2,558,659
Purchased Equipment Total (B)	15%	of control device cost (A)	**2,942,458**
Installation - Standard Costs	85%	of purchased equip cost (B)	2,501,089
Installation - Site Specific Costs			20,000
Installation Total			2,521,089
Total Direct Capital Cost, DC			5,463,547
Total Indirect Capital Costs, IC	45%	of purchased equip cost (B)	1,324,106
Total Capital Investment (TCI) = DC + IC			6,787,653
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	2,216,785
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	976,953
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**3,193,737**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)		23.22	% Removal	90%			2.32	20.90	$152,800

Notes & Assumptions

1. SDA: 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT and adjusted for inflation based on Chemical Engineering Plant Cost Index
2. Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT
3. Cost includes SDA and Lime Slaking System only
4. Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-5: SO2 Control Spray Dry Absorber (SDA)

CAPITAL COSTS			
Direct Capital Costs			
Purchased Equipment (A) [1]			**2,558,659**
Purchased Equipment Costs (A) - SDA + auxiliary equipment, EC			
Instrumentation	10%	of control device cost (A)	255,866
State Sales Taxes	0.0%	of control device cost (A)	-
Freight	5%	of control device cost (A)	127,933
Purchased Equipment Total (B)	15%		**2,942,458**
Installation			
Foundations & supports	12%	of purchased equip cost (B)	353,095
Handling & erection	40%	of purchased equip cost (B)	1,176,983
Electrical, piping, insulation, painting	33%	of purchased equip cost (B)	971,011
Installation Subtotal Standard Expenses	85%		**2,501,089**
Site Preparation, as required	N/A	Site Specific	-
Buildings, as required	Yes	Site Specific	20,000
Site Specific - Other	N/A	Site Specific	-
Total Site Specific Costs			20,000
Installation Total			**2,521,089**
Total Direct Capital Cost, DC			**5,463,547**
Indirect Capital Costs			
Engineering, supervision	10%	of purchased equip cost (B)	294,246
Construction & field expenses	20%	of purchased equip cost (B)	588,492
Contractor fees	10%	of purchased equip cost (B)	294,246
Start-up	1%	of purchased equip cost (B)	29,425
Performance test	1%	of purchased equip cost (B)	29,425
Model Studies	N/A	of purchased equip cost (B)	-
Contingencies	3%	of purchased equip cost (B)	88,274
Total Indirect Capital Costs, IC	45%	of purchased equip cost (B)	**1,324,106**
Total Capital Investment (TCI) = DC + IC			**6,787,653**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost			**6,787,653**
OPERATING COSTS			
Direct Annual Operating Costs, DC			
Operating Labor			
Operator	37.00		53,696
Supervisor	15%	$/Hr, 1.5 hr/8 hr shift, 435 hr/yr	8,054
Maintenance			
Maintenance Labor	53.00		23,075
Maintenance Materials	100%	% of Maintenance Labor	23,075
Utilities, Supplies, Replacements & Waste Management			
Electricity	0.074	$/kW-h, 262.0 kW-hr, 608,366 kWh/yr, 100% utilization	45,202
Water	0.33	$/kgal, 270.0 kgal/hr, 626,933 kWh/yr, 100% utilization	207,245
Wastewater Disposal Neutralization	2.48	$/kgal, 270.0 kgal/hr, 626,933 kWh/yr, 100% utilization	1,554,337
Lime	[redacted]		302,101
Total Annual Direct Operating Costs			**2,216,785**
Indirect Operating Costs			
Overhead	60%	of total labor and material costs	64,740
Administration (2% total capital costs)	2%	of total capital costs (TCI)	135,753
Property tax (1% total capital costs)	1%	of total capital costs (TCI)	67,877
Insurance (1% total capital costs)	1%	of total capital costs (TCI)	67,877
Capital Recovery	0.0944	for a 20-year equipment life and a 7% interest rate	640,706
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	**976,953**
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**3,193,737**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-5: SO2 Control Spray Dry Absorber (SDA)

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow		dP in H_2O	Efficiency	HP	kW	
Blower, Scrubber	[redacted]		10	0.7	-	244.4	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.48
	Flow	**Liquid SPGR**	**dP in H_2O**	**Efficiency**	**HP**	**kW**	
Circ Pump	1064 gpm	1	60	0.7	-	17.1	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
H2O WW Disch	27 gpm	1	60	0.7	-	0.4	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
Other							
Other							
Other							
Total						**262.0**	

Reagent Use & Other Operating Costs

Lime Use	20.00	lb/hr SO_2	41.04	lb Lime/lb SO_2	820.85 lb/hr Lime
Liquid/Gas ratio	10.0	* L/G = Gal/1,000 acf			
Circulating Water Rate	1,064	gpm			
Water Makeup Rate/WW Disch =			2.5%	of circulating water rate =	27 gpm
Scrubber Outlet Flow	[redacted]	acfm			
Scrubber Outlet Temp	120	°F			
Evap H2O Loss	243.4	gpm			
Water Makeup Rate	**270**	**gpm**			

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	2,322				
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Operating Labor							
Op Labor	37.00	$/Hr	5.0	hr/8 hr shift	1,451	$ 53,696	$/Hr, 5.0 hr/8 hr shift, 1,451 hr/yr
Supervisor	15%	of Op Labor			NA	$ 8,054	% of Operator Costs
Maintenance							
Maint Labor	53.00	$/Hr	1.5	hr/8 hr shift	435	$ 23,075	$/Hr, 1.5 hr/8 hr shift, 435 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$ 23,075	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management							
Electricity	0.074	$/kW-h	262.0	kW-hr	608,366	$ 45,202	0.074 $/kW-h, 262.0 kW-hr, 608,366 kWh/yr, 100% utilization
Water	0.33	$/kgal	270.0	kgal/hr	626,933	$ 207,245	0.33 $/kgal, 270.0 kgal/hr, 626,933 kWh/yr, 100% utilization
Wastewater Disposal Neutralization	2.48	$/kgal	270.0	kgal/hr	626,933	$1,554,337	2.48 $/kgal, 270.0 kgal/hr, 626,933 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.41	ton/hr	953	$ 302,101	317.00 $/ton, 0.4 ton/hr, 953 kWh/yr, 100% utilization
Solid Waste Disposal	18.45	$/ton	0.41	ton/hr	953	$ 17,581	18.45 $/ton, 0.4 ton/hr, 953 kWh/yr, 100% utilization

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-6: SO2 Control - Wet Scrubber with Lime Addition

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-069, EP-070, EP-071		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Temperature	400	Deg F
Annual Operating Hours	[redacted]	hr/yr	Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2017	567.5
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.07

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			10,662,516
Purchased Equipment Total (B)	22%	of control device cost (A)	**12,954,957**
Installation - Standard Costs	85%	of purchased equip cost (B)	11,011,713
Installation - Site Specific Costs			0
Installation Total			11,011,713
Total Direct Capital Cost, DC			23,966,670
Total Indirect Capital Costs, IC	35%	of purchased equip cost (B)	4,534,235
Total Capital Investment (TCI) = DC + IC			**28,500,905**
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	837,667
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	4,233,920
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**5,071,587**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Ef %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	23.22	% Removal	98%			0.46	22.76	$222,900

Notes & Assumptions

1 Wet Scrubber: 2012 Capital Cost Estimate from Mississippi Lime Company Prairie du Rocher, IL BACT and adjusted for inflation based on Chemical Engineering Plant Cost Inde
2 Lime Injection: Capital Cost Estimate from Mississippi Lime Company's 2017 scrubber project and adjusted for inflation based on Chemical Engineering Plant Cost Index
3 Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2
4 Scrubber operating and maintenance costs are based on actual maintenance and operating costs from 2018 and 2019.

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-6: SO2 Control - Wet Scrubber with Lime Addition

CAPITAL COSTS			
Direct Capital Costs			
Purchased Equipment (A) [1]			**10,662,516**
Purchased Equipment Costs (A)			
Instrumentation	10%	of control device cost (A)	1,066,252
Sales Taxes	6.5%	of control device cost (A)	693,064
Freight	5%	of control device cost (A)	533,126
Purchased Equipment Total (B)	22%		**12,954,957**
Installation			
Foundations & supports	12%	of purchased equip cost (B)	1,554,595
Handling & erection	40%	of purchased equip cost (B)	5,181,983
Electrical	1%	of purchased equip cost (B)	129,550
Piping	30%	of purchased equip cost (B)	3,886,487
Insulation	1%	of purchased equip cost (B)	129,550
Painting	1%	of purchased equip cost (B)	129,550
Installation Subtotal Standard Expenses	85%		**11,011,713**
Site Preparation, as required	N/A	Site Specific	-
Buildings, as required	N/A	Site Specific	-
Site Specific - Other	N/A	Site Specific	-
Total Site Specific Costs			0
Installation Total			**11,011,713**
Total Direct Capital Cost, DC			**23,966,670**
Indirect Capital Costs			
Engineering, supervision	10%	of purchased equip cost (B)	1,295,496
Construction & field expenses	10%	of purchased equip cost (B)	1,295,496
Contractor fees	10%	of purchased equip cost (B)	1,295,496
Start-up	1%	of purchased equip cost (B)	129,550
Performance test	1%	of purchased equip cost (B)	129,550
Model Studies	N/A	of purchased equip cost (B)	-
Contingencies	3%	of purchased equip cost (B)	388,649
Total Indirect Capital Costs, IC	35%	of purchased equip cost (B)	**4,534,235**
Total Capital Investment (TCI) = DC + IC			**28,500,905**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost			**28,500,905**
OPERATING COSTS			
Direct Annual Operating Costs, DC			
Operating Costs			
Operating Costs			636,000
Maintenance Costs			
Maintenance Costs			36,667
Utilities, Supplies, Replacements & Waste Management			
Solid Waste Disposal	Actual average disposal costs (2018 - 2019)		165,000
N/A	N/A		-
N/A	N/A		-
Total Annual Direct Operating Costs			**837,667**
Indirect Operating Costs			
Overhead	60%	of total labor and material costs	403,600
Administration (2% total capital costs)	2%	of total capital costs (TCI)	570,018
Property tax (1% total capital costs)	1%	of total capital costs (TCI)	285,009
Insurance (1% total capital costs)	1%	of total capital costs (TCI)	285,009
Capital Recovery	0.0944	for a 20-year equipment life and a 7% interest rate	2,690,284
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	**4,233,920**
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**5,071,587**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-6: SO2 Control - Wet Scrubber with Lime Addition

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Operating Cost Calculations

Utilization Rate	100%	Annual Operating Hours		2,322			
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Utilities, Supplies, Replacements & Waste Management							
Solid Waste Disposal						$ 165,000	Actual average disposal costs (2018 - 2019)

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-7: Cost Summary

SO_2 Control Cost Summary										
Control Technology	Uncontrolled Emissions T/y	Baseline Emissions T/y	Control Eff %	Controlled Emissions Ton/Yr	Emission Reduction Ton/Yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Incremental Control Cost $/ton	Non-Air Env Impacts?	Comments
Spray Dryer Absrober (SDA)		174.58	90.0%	17.46	157.13	$4,130,652	$6,459,380	$41,100	Solid Waste	
Wet Scrubber with Lime		174.58	98.0%	3.49	171.09	$3,185,698	$1,669,402	$9,800	Waste-water	
Dry Sorbent Injection (DSI)		174.58	50.0%	87.29	87.29	$1,473,668	$1,011,652	$11,600	Solid Waste	
Process Inherent Scrubbing (Baseline)	1,745.83			174.58	1571.25					

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-8: Emissions Data

Operating Unit: Mississippi Rotary Kilns
Emission Unit Number: EP-180H, EP-186N, EP-187N
Stack/Vent Number: Varies

Operating Information

Unit Annual Oper Hours		hr/yr	Source Type for Cost Calc	Industrial Coal	
Control Equip Oper Hrs		hr/yr	Coal/Fuel Type for CoalF	Coal / Coke blend	
Combined Op Hours (Top)		hr/yr	NPHR (utilities Net Plant Heat Rate, if known)	10	*MMBtu/MW*
Control Equipment Life	20	yrs	Hourly Heat Input (Q_b) or Equivalent		*MMBtu/hr HHV*
Exhaust Temperature	155	Deg F	Basis Q_b and Capacity Factor (% Utilization)	Heat Input: Design vs. Actual	
Exhaust Moisture Content	6.0%		Maximum Hourly Production Rate		
Plant Elevation	560	ft	Annual Average Production Rate		
Atmos Press at Elvation	14.41	psia	Energy Use per Unit of Production		
Standardized Flow Rate		scfm @ 68° F	Maximum Hourly Heat Input (firing) Rate		*MMBtu/hr HHV*
Dry Std Flow Rate		dscfm @ 68° F	Annual Average Heat Input (firing) Rate		*MMBtu/hr HHV*
Actual Flow Rate		acfm	Maximum Hourly Fuel Use Rate		scf/hr
Elevation Factor	1.02		Annual Fuel Use Rate		scf/yr
			Capacity Factor (CF) / Utilization	100.0%	
Fuel Sulfur Content		wt %	Fuel Heating Value (0 if not known)		Btu/lb
Uncontrolled SO_2 Emission Rate		lb SO2/MMBtu			

Process Inherent Scrubbing (Baseline)	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		1745.83	% Removal					174.58	-

	Max Emissions		Uncontrolled Concentration		
Pollutant	lb/Hr	ton/yr			
Sulfur Dioxide (SO_2)		174.58	129.3	ppm dry	

Dry Sorbent Injection	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		174.58	% Removal	50%				87.29	-

Spray Dry Absorber	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		174.58	% Removal	90%				17.46	-

Wet Scrubber w/ Lime	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		174.58	% Removal	98%				3.49	-

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-9: Summary of Utility, Chemical and Supply Costs

Operating Unit: Mississippi Rotary Kilns **Study Year** 2019
Emission Unit Number EP-180H, EP-186N, EP-187N
Stack/Vent Number Varies

Item	Unit Cost	Units, k=1,000 M=1,000,000	Reference Cost	Year	Data Source	Notes
Operating Labor	37.00	$/hr			Mississippi Lime Company	Actual cost of Operator Labor per Mississippi Lime Company
Maintenance Labor	53.00	$/hr			Mississippi Lime Company	Actual cost of Maintenance Labor per Mississippi Lime Company
Utilities						
Electricity	0.074	$/kW-h			U.S. Energy Information Administration	Average Price for Missouri Industrial customers, June 2020
Water	0.33	$/kgal	0.20	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2.6.1.2.	Example Problems uses $0.20/1000 gal. Cost adjusted for 3% inflation Sec 5.2 Ch 1 also lists $0.20/1,000 gal.
Wastewater Disposal Neutralization	2.48	$/kgal	1.50	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 5 Chapter 1.	Section 2 lists $1- $2/1000 gal. Cost adjusted for 3% inflation. Sec 6 Ch 3 lists $1.30 - $2.15/1,000 gal.
Solid Waste Disposal	18.45	$/ton	15.00	2012	EPA Air Pollution Control Cost Manual May	Paragraph 1.5 Example calculations - price for ash disposal. Cost
	N/A	N/A				
Chemicals & Supplies						
Lime	[redacted]	$/ton			Mississippi Lime Company	Actual cost of reagent per Mississippi Lime Company
Catalyst & Replacement Parts						
Other						
Sales Tax	6.50%					
Interest Rate	7.00%				EPA policy specifies 7% interest for BACT review cost calculations	

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-10: SO2 Control - Dry Sorbent Injection

Total Costs

Operating Unit: **Mississippi Rotary Kilns**

Emission Unit Number	EP-180H, EP-186N, EP-187N		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	155	Deg F
Combined Operating Hours	[redacted]	hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs									
Direct Capital Costs									
Purchased Equipment (A)									**692,102**
Purchased Equipment Total (B)									**733,669**
Installation - Standard Costs									431,256
Installation - Site Specific Costs									0
Installation Total									431,256
Total Direct Capital Cost, DC									1,164,925
Total Indirect Capital Costs, IC									308,743
Total Capital Investment (TCI) = DC + IC									**1,473,668**
Operating Costs									
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.							774,987
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost							236,665
Total Annual Cost (Annualized Capital Cost + Operating Cost)									**1,011,652**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	174.58	% Removal	50%			87.29	87.29	$11,600

Notes & Assumptions

1 Dry Sorbent Injection: Mississippi Lime Company actual installation costs for lime injection system and adjusted for inflation based on Chemical Engineering Plant Cost Index
2 Used 0.6 power law factor to adjust price to calculated acfm from bid basis of 150,000 acfm
3 Cost for Dry Sorbent Injection System only
4 Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1
5 Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT.

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-10: SO2 Control - Dry Sorbent Injection

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (A) [1]		**692,102**
Purchased Equipment Costs (A) - Injection System + auxiliary equipment, EC		
Instrumentation		25,979
State Sales Taxes		-
Freight		15,588
Purchased Equipment Total (B)		**733,669**
Installation		
Foundations & supports		270,185
Handling & erection		135,092
Electrical		25,979
Piping		-
Installation Subtotal Standard Expenses		**431,256**
Site Preparation, as required	N/A Site Specific	-
Buildings, as required	N/A Site Specific	-
Site Specific - Other	N/A Site Specific	-
Total Site Specific Costs		N/A
Installation Total		**431,256**
Total Direct Capital Cost, DC		**1,164,925**
Indirect Capital Costs		
Engineering, supervision		51,959
Construction & field expenses	20% of purchased equip cost (B)	146,734
Contractor fees	10% of purchased equip cost (B)	73,367
Start-up	1% of purchased equip cost (B)	7,337
Performance test	1% of purchased equip cost (B)	7,337
Model Studies	N/A of purchased equip cost (B)	-
Contingencies	3% of purchased equip cost (B)	22,010
Total Indirect Capital Costs, IC		**308,743**
Total Capital Investment (TCI) = DC + IC		**1,473,668**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost		**1,473,668**
OPERATING COSTS		
Direct Annual Operating Costs, DC		
Operating Labor		
Operator	N/A	16,030
Supervisor	15% $/Hr, 0.5 hr/8 hr shift, 433 hr/yr	2,404
Maintenance		
Maintenance Labor	N/A	22,962
Maintenance Materials	100% % of Maintenance Labor	22,962
Utilities, Supplies, Replacements & Waste Management		
Electricity	0.074 $/kW-h, 138.4 kW-hr, 959,162 kWh/yr, 100% utilization	71,266
Solid Waste Disposal	18.45 $/ton, 0.3 ton/hr, 1,906 kWh/yr, 100% utilization	35,162
Lime	[redacted]	604,202
Total Annual Direct Operating Costs		**774,987**
Indirect Operating Costs		
Overhead	60% of total labor and material costs	38,614
Administration (2% total capital costs)	2% of total capital costs (TCI)	29,473
Property tax (1% total capital costs)	1% of total capital costs (TCI)	14,737
Insurance (1% total capital costs)	1% of total capital costs (TCI)	14,737
Capital Recovery	0.0944 for a 20-year equipment life and a 7% interest rate	139,104
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost	**236,665**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**1,011,652**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-10: SO2 Control - Dry Sorbent Injection

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow	dP in H_2O	Efficiency	HP	kW
Sorbent Injection Pump/Airlock	[redacted]	12			138.4
Total					138.4

Reagent Use & Other Operating Costs

Sorbent Use	549.93 lb/hr Caustic

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	6,932				
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Operating Labor							
Op Labor	37.00	$/Hr	0.5	hr/8 hr shift	433	$ 16,030	37.00 $/Hr, 0.5 hr/8 hr shift, 433 hr/yr
Supervisor	15%	of Op Labor			NA	$ 2,404	15% of Operator Costs
Maintenance							
Maint Labor	53.00	$/Hr	0.5	hr/8 hr shift	433	$ 22,962	$/Hr, 0.5 hr/8 hr shift, 433 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$ 22,962	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management							
Electricity	0.074	$/kW-h	138.4	kW-hr	959,162	$ 71,266	0.074 $/kW-h, 138.4 kW-hr, 959,162 kWh/yr, 100% utilization
Solid Waste Disposal	18.45	$/ton	0.27	ton/hr	1,906	$ 35,162	18.45 $/ton, 0.3 ton/hr, 1,906 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.27	ton/hr	1,906	$ 604,202	[redacted]

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-11: SO2 Control Spray Dry Absorber (SDA)

Operating Unit: **Mississippi Rotary Kilns**

Emission Unit Number	EP-180H, EP-186N, EP-187N		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	155	Deg F
Combined Operating Hours	[redacted]	hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			1,554,122
Purchased Equipment Total (B)	15%	of control device cost (A)	**1,787,240**
Installation - Standard Costs	85%	of purchased equip cost (B)	1,519,154
Installation - Site Specific Costs			20,000
Installation Total			1,539,154
Total Direct Capital Cost, DC			3,326,394
Total Indirect Capital Costs, IC	45%	of purchased equip cost (B)	804,258
Total Capital Investment (TCI) = DC + IC			4,130,652
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	5,710,983
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	748,397
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**6,459,380**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	174.58	% Removal	90%			17.46	157.13	$41,100

Notes & Assumptions

1. SDA: 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT and adjusted for inflation based on Chemical Engineering Plant Cost Index
2. Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT
3. Cost includes SDA and Lime Slaking System only
4. Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-11: SO2 Control Spray Dry Absorber (SDA)

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (A) [1]		**1,554,122**
Purchased Equipment Costs (A) - SDA + auxiliary equipment, EC		
Instrumentation	10% of control device cost (A)	155,412
State Sales Taxes	0.0% of control device cost (A)	-
Freight	5% of control device cost (A)	77,706
Purchased Equipment Total (B)	15%	**1,787,240**
Installation		
Foundations & supports	12% of purchased equip cost (B)	214,469
Handling & erection	40% of purchased equip cost (B)	714,896
Electrical, piping, insulation, painting	33% of purchased equip cost (B)	589,789
Installation Subtotal Standard Expenses	85%	**1,519,154**
Site Preparation, as required	N/A Site Specific	-
Buildings, as required	Yes Site Specific	20,000
Site Specific - Other	N/A Site Specific	-
Total Site Specific Costs		20,000
Installation Total		**1,539,154**
Total Direct Capital Cost, DC		**3,326,394**
Indirect Capital Costs		
Engineering, supervision	10% of purchased equip cost (B)	178,724
Construction & field expenses	20% of purchased equip cost (B)	357,448
Contractor fees	10% of purchased equip cost (B)	178,724
Start-up	1% of purchased equip cost (B)	17,872
Performance test	1% of purchased equip cost (B)	17,872
Model Studies	N/A of purchased equip cost (B)	-
Contingencies	3% of purchased equip cost (B)	53,617
Total Indirect Capital Costs, IC	45% of purchased equip cost (B)	**804,258**
Total Capital Investment (TCI) = DC + IC		**4,130,652**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost		**4,130,652**
OPERATING COSTS		
Direct Annual Operating Costs, DC		
Operating Labor		
Operator	37.00	160,297
Supervisor	15% $/Hr, 1.5 hr/8 hr shift, 1,300 hr/yr	24,045
Maintenance		
Maintenance Labor	53.00	68,885
Maintenance Materials	100% % of Maintenance Labor	68,885
Utilities, Supplies, Replacements & Waste Management		
Electricity	0.074 $/kW-h, 116.2 kW-hr, 805,395 kWh/yr, 100% utilization	59,841
Water	0.33 $/kgal, 258.1 kgal/hr, 1,789,044 kWh/yr, 100% utilization	591,404
Wastewater Disposal Neutralization	2.48 $/kgal, 258.1 kgal/hr, 1,789,044 kWh/yr, 100% utilization	4,435,526
Lime	[redacted]	302,101
Total Annual Direct Operating Costs		**5,710,983**
Indirect Operating Costs		
Overhead	60% of total labor and material costs	193,267
Administration (2% total capital costs)	2% of total capital costs (TCI)	82,613
Property tax (1% total capital costs)	1% of total capital costs (TCI)	41,307
Insurance (1% total capital costs)	1% of total capital costs (TCI)	41,307
Capital Recovery	0.0944 for a 20-year equipment life and a 7% interest rate	389,904
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost	**748,397**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**6,459,380**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-11: SO2 Control Spray Dry Absorber (SDA)

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow		dP in H_2O	Efficiency	HP	kW	
Blower, Scrubber	63,707 acfm		10	0.7	-	106.5	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.48
	Flow	**Liquid SPGR**	**dP in H_2O**	**Efficiency**	**HP**	**kW**	
Circ Pump	588 gpm	1	60	0.7	-	9.5	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
H2O WW Disch	15 gpm	1	60	0.7	-	0.2	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
Other							
Other							
Other							
Total						**116.2**	

Reagent Use & Other Operating Costs

Lime Use	50.37 lb/hr SO_2	5.46 lb Lime/lb SO_2		274.97 lb/hr Lime
Liquid/Gas ratio	10.0 * L/G = Gal/1,000 acf			
Circulating Water Rate	588 gpm			
Water Makeup Rate/WW Disch =		2.5% of circulating water rate =	15 gpm	
Scrubber Outlet Flow	[redacted] acfm			
Scrubber Outlet Temp	120 °F			
Evap H2O Loss	243.4 gpm			
Water Makeup Rate	**258 gpm**			

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	6,932			
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Operating Labor							
Op Labor	37.00	$/Hr	5.0	hr/8 hr shift	4,332	$ 160,297	$/Hr, 5.0 hr/8 hr shift, 4,332 hr/yr
Supervisor	15%	of Op Labor			NA	$ 24,045	% of Operator Costs
Maintenance							
Maint Labor	53.00	$/Hr	1.5	hr/8 hr shift	1,300	$ 68,885	$/Hr, 1.5 hr/8 hr shift, 1,300 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$ 68,885	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management							
Electricity	0.074	$/kW-h	116.2	kW-hr	805,395	$ 59,841	0.074 $/kW-h, 116.2 kW-hr, 805,395 kWh/yr, 100% utilization
Water	0.33	$/kgal	258.1	kgal/hr	1,789,044	$ 591,404	0.33 $/kgal, 258.1 kgal/hr, 1,789,044 kWh/yr, 100% utilization
Wastewater Disposal Neutralization	2.48	$/kgal	258.1	kgal/hr	1,789,044	$ 4,435,526	2.48 $/kgal, 258.1 kgal/hr, 1,789,044 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.14	ton/hr	953	$ 302,101	[redacted]
Solid Waste Disposal	18.45	$/ton	0.14	ton/hr	953	$ 17,581	18.45 $/ton, 0.1 ton/hr, 953 kWh/yr, 100% utilization

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-12: SO2 Control - Wet Scrubber with Lime Addition

Operating Unit: **Mississippi Rotary Kilns**

Emission Unit Number	EP-180H, EP-186N, EP-187N		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Temperature	155	Deg F
Annual Operating Hours	[redacted]	hr/yr	Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2017	567.5
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.07

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			1,191,806
Purchased Equipment Total (B)	22%	of control device cost (A)	**1,448,044**
Installation - Standard Costs	85%	of purchased equip cost (B)	1,230,838
Installation - Site Specific Costs			0
Installation Total			1,230,838
Total Direct Capital Cost, DC			2,678,882
Total Indirect Capital Costs, IC	35%	of purchased equip cost (B)	506,816
Total Capital Investment (TCI) = DC + IC			**3,185,698**
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	837,667
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	831,735
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**1,669,402**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	174.58	% Removal	98%			3.49	171.09	$9,800

Notes & Assumptions

1 Capital Cost Estimate for Lime Injection System on existing wet scrubber from Mississippi Lime Company's 2017 scrubber project. Adjusted for inflation based on Chemical Engineering
2 Plant Cost Index.
3 Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2
4 Scrubber operating and maintenance costs are based on actual maintenance and operating costs from 2018 and 2019.

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-12: SO2 Control - Wet Scrubber with Lime Addition

CAPITAL COSTS			
Direct Capital Costs			
Purchased Equipment (A) [1]			**1,191,806**
Purchased Equipment Costs (A)			
Instrumentation	10%	of control device cost (A)	119,181
Sales Taxes	6.5%	of control device cost (A)	77,467
Freight	5%	of control device cost (A)	59,590
Purchased Equipment Total (B)	22%		**1,448,044**
Installation			
Foundations & supports	12%	of purchased equip cost (B)	173,765
Handling & erection	40%	of purchased equip cost (B)	579,218
Electrical	1%	of purchased equip cost (B)	14,480
Piping	30%	of purchased equip cost (B)	434,413
Insulation	1%	of purchased equip cost (B)	14,480
Painting	1%	of purchased equip cost (B)	14,480
Installation Subtotal Standard Expenses	85%		**1,230,838**
Site Preparation, as required	N/A	Site Specific	-
Buildings, as required	N/A	Site Specific	-
Site Specific - Other	N/A	Site Specific	-
Total Site Specific Costs			0
Installation Total			**1,230,838**
Total Direct Capital Cost, DC			**2,678,882**
Indirect Capital Costs			
Engineering, supervision	10%	of purchased equip cost (B)	144,804
Construction & field expenses	10%	of purchased equip cost (B)	144,804
Contractor fees	10%	of purchased equip cost (B)	144,804
Start-up	1%	of purchased equip cost (B)	14,480
Performance test	1%	of purchased equip cost (B)	14,480
Model Studies	N/A	of purchased equip cost (B)	-
Contingencies	3%	of purchased equip cost (B)	43,441
Total Indirect Capital Costs, IC	35%	of purchased equip cost (B)	**506,816**
Total Capital Investment (TCI) = DC + IC			**3,185,698**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost			**3,185,698**
OPERATING COSTS			
Direct Annual Operating Costs, DC			
Operating Costs			
Operating Costs			636,000
Maintenance Costs			
Maintenance Costs			36,667
Utilities, Supplies, Replacements & Waste Management			
Solid Waste Disposal	Actual average disposal costs (2018 - 2019)		165,000
N/A	N/A		-
N/A	N/A		-
Total Annual Direct Operating Costs			**837,667**
Indirect Operating Costs			
Overhead	60%	of total labor and material costs	403,600
Administration (2% total capital costs)	2%	of total capital costs (TCI)	63,714
Property tax (1% total capital costs)	1%	of total capital costs (TCI)	31,857
Insurance (1% total capital costs)	1%	of total capital costs (TCI)	31,857
Capital Recovery	0.0944	for a 20-year equipment life and a 7% interest rate	300,707
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	**831,735**
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**1,669,402**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-12: SO2 Control - Wet Scrubber with Lime Addition

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Operating Cost Calculations

Utilization Rate	100%	Annual Operating Hours		6,932			
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Utilities, Supplies, Replacements & Waste Management							
Solid Waste Disposal						$ 165,000	Actual average disposal costs (2018 - 2019)

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-13: Cost Summary

SO_2 Control Cost Summary										
Control Technology	Uncontrolled Emissions T/y	Baseline Emissions T/y	Control Eff %	Controlled Emissions Ton/Yr	Emission Reduction Ton/Yr	Installed Capital Cost $	Annualized Operating Cost $/yr	Incremental Control Cost $/ton	Non-Air Env Impacts?	Comments
Spray Dryer Absrober (SDA)		17.26	90.0%	1.73	15.53	$8,418,723	$8,759,997	$564,000	Solid Waste	
Wet Scrubber with Lime		17.26	98.0%	0.35	16.91	$35,369,899	$5,994,731	$354,500	Waste-water	
Dry Sorbent Injection (DSI)		17.26	50.0%	8.63	8.63	$2,448,333	$1,372,769	$159,100	Solid Waste	
Process Inherent Scrubbing (Baseline)	172.57			17.26	155.31					

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-14: Emissions Data

Operating Unit: Peerless Rotary Kilns
Emission Unit Number EP-640 & EP-645
Stack/Vent Number Varies

Operating Information

Unit Annual Oper Hours		hr/yr	Source Type for Cost Calc	Industrial Coal	
Control Equip Oper Hrs		hr/yr	Coal/Fuel Type for CoalF	Coal / Coke blend	
Combined Op Hours (Top)		hr/yr	NPHR (utilities Net Plant Heat Rate, if known)	10	*MMBtu/MW*
Control Equipment Life	20	yrs	Hourly Heat Input (Q_b) or Equivalent		*MMBtu/hr HHV*
Exhaust Temperature	422	Deg F	Basis Q_b and Capacity Factor (% Utilization)	Heat Input: Design vs. Actual	
Exhaust Moisture Content	6.0%		Maximum Hourly Production Rate		
Plant Elevation	560	ft	Annual Average Production Rate		
Atmos Press at Elvation	14.41	psia	Energy Use per Unit of Production		
Standardized Flow Rate		scfm @ 68° F	Maximum Hourly Heat Input (firing) Rate		*MMBtu/hr HHV*
Dry Std Flow Rate		dscfm @ 68° F	Annual Average Heat Input (firing) Rate		*MMBtu/hr HHV*
Actual Flow Rate		acfm	Maximum Hourly Fuel Use Rate		scf/hr
Elevation Factor	1.02		Annual Fuel Use Rate		scf/yr
			Capacity Factor (CF) / Utilization	100.0%	
Fuel Sulfur Content		wt %	Fuel Heating Value (0 if not known)		Btu/lb
Uncontrolled SO_2 Emission Rate		lb SO2/MMBtu			

Process Inherent Scrubbing (Baseline)	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		172.57	% Removal					17.26	-

	Max Emissions		Uncontrolled Concentration		
Pollutant	lb/Hr	ton/yr			
Sulfur Dioxide (SO_2)		17.26	3.5	ppm dry	

Dry Sorbent Injection w/ BGHS	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		17.26	% Removal	50%				8.63	-

Spray Dry Absorber w/ BGHS	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		17.26	% Removal	90%				1.73	-

Wet Scrubber w/ Lime	Uncontrolled		Controlled						
Pollutant	lb/hr	ton/yr	Calculation Method	Cont Eff %	Performance Basis	Units	lb/hr	ton/yr	Calculated Cont Eff Performance Basis
Sulfur Dioxide (SO_2)		17.26	% Removal	98%				0.35	-

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-15: Summary of Utility, Chemical and Supply Costs

Operating Unit: Peerless Rotary Kilns **Study Year** 2019
Emission Unit Number EP-640 & EP-645
Stack/Vent Number Varies

Item	Unit Cost	Units, k=1,000 M=1,000,000	Reference Cost	Year	Data Source	Notes
Operating Labor	37.00	$/hr			Mississippi Lime Company	Actual cost of Operator Labor per Mississippi Lime Company
Maintenance Labor	53.00	$/hr			Mississippi Lime Company	Actual cost of Maintenance Labor per Mississippi Lime Company
Utilities						
Electricity	0.074	$/kW-h			U.S. Energy Information Administration	Average Price for Missouri Industrial customers, June 2020
Water	0.33	$/kgal	0.20	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2.6.1.2.	Example Problems uses $0.20/1000 gal. Cost adjusted for 3% inflation Sec 5.2 Ch 1 also lists $0.20/1,000 gal.
Wastewater Disposal Neutralization	2.48	$/kgal	1.50	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 5 Chapter 1.	Section 2 lists $1- $2/1000 gal. Cost adjusted for 3% inflation. Sec 6 Ch 3 lists $1.30 - $2.15/1,000 gal.
Solid Waste Disposal	18.45	$/ton	15.00	2012	EPA Air Pollution Control Cost Manual May	Paragraph 1.5 Example calculations - price for ash disposal. Cost
	N/A	N/A				
Chemicals & Supplies						
Lime	[redacted]	$/ton			Mississippi Lime Company	Actual cost of reagent per Mississippi Lime Company
Catalyst & Replacement Parts						
Other						
Sales Tax	6.50%					
Interest Rate	7.00%				EPA policy specifies 7% interest for BACT review cost calculations	

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-16: SO2 Control - Dry Sorbent Injection

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-640 & EP-645		Stack/Vent Number	Varies	
Design Capacity		MMBtu/hr HHV	Standardized Flow Rate		scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	422	Deg F
Combined Operating Hours		hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate		acfm
Control Equipment Life	20	yrs	Standardized Flow Rate		scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate		dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			**1,414,076**
Purchased Equipment (A)			**1,455,643**
Purchased Equipment Total (B)			
Installation - Standard Costs			431,256
Installation - Site Specific Costs			0
Installation Total			431,256
Total Direct Capital Cost, DC			1,886,899
Total Indirect Capital Costs, IC			561,434
Total Capital Investment (TCI) = DC + IC			**2,448,333**
Operating Costs			
Total Annual Direct Operating Costs	Labor, supervision, materials, replacement parts, utilities, etc.		997,455
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost		375,314
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**1,372,769**

Emission Control Cost Calculation

	Max Emis	Annual	Calculation	Cont Eff	Performance	Conc.	Cont Emis	Reduction	Cont Cost
Pollutant	**Lb/Hr**	**Ton/Yr**	**Method**	**%**	**Basis**	**Units**	**Ton/Yr**	**Ton/Yr**	**$/Ton Rem**
Sulfur Dioxide (SO2)		17.26	% Removal	50%			8.63	8.63	$159,100

Notes & Assumptions

1. Dry Sorbent Injection: Mississippi Lime Company actual installation costs for lime injection system and adjusted for inflation based on Chemical Engineering Plant Cost Index
2. Used 0.6 power law factor to adjust price to calculated acfm from bid basis of 150,000 acfm
3. Cost for Dry Sorbent Injection System only
4. Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1
5. Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT.

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-16: SO2 Control - Dry Sorbent Injection

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (A) [1]		**1,414,076**
Purchased Equipment Costs (A) - Injection System + auxiliary equipment, EC		
Instrumentation		25,979
State Sales Taxes		-
Freight		15,588
Purchased Equipment Total (B)		**1,455,643**
Installation		
Foundations & supports		270,185
Handling & erection		135,092
Electrical		25,979
Piping		-
Installation Subtotal Standard Expenses		**431,256**
Site Preparation, as required	N/A Site Specific	-
Buildings, as required	N/A Site Specific	-
Site Specific - Other	N/A Site Specific	-
Total Site Specific Costs		N/A
Installation Total		**431,256**
Total Direct Capital Cost, DC		**1,886,899**
Indirect Capital Costs		
Engineering, supervision		51,959
Construction & field expenses	20% of purchased equip cost (B)	291,129
Contractor fees	10% of purchased equip cost (B)	145,564
Start-up	1% of purchased equip cost (B)	14,556
Performance test	1% of purchased equip cost (B)	14,556
Model Studies	N/A of purchased equip cost (B)	-
Contingencies	3% of purchased equip cost (B)	43,669
Total Indirect Capital Costs, IC		**561,434**
Total Capital Investment (TCI) = DC + IC		**2,448,333**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost		**2,448,333**
OPERATING COSTS		
Direct Annual Operating Costs, DC		
Operating Labor		
Operator	N/A	19,210
Supervisor	15% $/Hr, 0.5 hr/8 hr shift, 519 hr/yr	2,882
Maintenance		
Maintenance Labor	N/A	27,517
Maintenance Materials	100% % of Maintenance Labor	27,517
Utilities, Supplies, Replacements & Waste Management		
Electricity	0.074 $/kW-h, 455.2 kW-hr, 3,781,497 kWh/yr, 100% utilization	280,965
Solid Waste Disposal	18.45 $/ton, 0.2 ton/hr, 1,906 kWh/yr, 100% utilization	35,162
Lime	[redacted]	604,202
Total Annual Direct Operating Costs		**997,455**
Indirect Operating Costs		
Overhead	60% of total labor and material costs	46,275
Administration (2% total capital costs)	2% of total capital costs (TCI)	48,967
Property tax (1% total capital costs)	1% of total capital costs (TCI)	24,483
Insurance (1% total capital costs)	1% of total capital costs (TCI)	24,483
Capital Recovery	0.0944 for a 20-year equipment life and a 7% interest rate	231,105
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost	**375,314**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**1,372,769**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-16: SO2 Control - Dry Sorbent Injection

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow	dP in H_2O	Efficiency	HP	kW
Sorbent Injection Pump/Airlock	[redacted]	12			455.2
Total					455.2

Reagent Use & Other Operating Costs

Sorbent Use	458.89 lb/hr Caustic

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	8,307				
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Operating Labor							
Op Labor	37.00	$/Hr	0.5	hr/8 hr shift	519	$ 19,210	37.00 $/Hr, 0.5 hr/8 hr shift, 519 hr/yr
Supervisor	15%	of Op Labor			NA	$ 2,882	15% of Operator Costs
Maintenance							
Maint Labor	53.00	$/Hr	0.5	hr/8 hr shift	519	$ 27,517	$/Hr, 0.5 hr/8 hr shift, 519 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$ 27,517	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management							
Electricity	0.074	$/kW-h	455.2	kW-hr	3,781,497	$ 280,965	0.074 $/kW-h, 455.2 kW-hr, 3,781,497 kWh/yr, 100% utilization
Solid Waste Disposal	18.45	$/ton	0.23	ton/hr	1,906	$ 35,162	18.45 $/ton, 0.2 ton/hr, 1,906 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.23	ton/hr	1,906	$ 604,202	[redacted]

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-17: SO2 Control Spray Dry Absorber (SDA)

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-640 & EP-645		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32° F
Utilization Rate	100%		Exhaust Temperature	422	Deg F
Combined Operating Hours	[redacted]	hr/yr	Exhaust Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2012	584.6
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.04

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			3,175,321
Purchased Equipment Total (B)	15%	of control device cost (A)	**3,651,619**
Installation - Standard Costs	85%	of purchased equip cost (B)	3,103,876
Installation - Site Specific Costs			20,000
Installation Total			3,123,876
Total Direct Capital Cost, DC			6,775,495
Total Indirect Capital Costs, IC	45%	of purchased equip cost (B)	1,643,228
Total Capital Investment (TCI) = DC + IC			8,418,723
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	7,396,970
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	1,363,027
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**8,759,997**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)	[redacted]	17.26	% Removal	90%			1.73	15.53	$564,000

Notes & Assumptions

1. SDA: 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT and adjusted for inflation based on Chemical Engineering Plant Cost Index
2. Lime consumption per 2012 Cost Estimate for Mississippi Lime Company Prairie du Rocher, IL BACT
3. Cost includes SDA and Lime Slaking System only
4. Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 1

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-17: SO2 Control Spray Dry Absorber (SDA)

CAPITAL COSTS			
Direct Capital Costs			
Purchased Equipment (A) [1]			**3,175,321**
Purchased Equipment Costs (A) - SDA + auxiliary equipment, EC			
Instrumentation	10%	of control device cost (A)	317,532
State Sales Taxes	0.0%	of control device cost (A)	-
Freight	5%	of control device cost (A)	158,766
Purchased Equipment Total (B)	15%		**3,651,619**
Installation			
Foundations & supports	12%	of purchased equip cost (B)	438,194
Handling & erection	40%	of purchased equip cost (B)	1,460,648
Electrical, piping, insulation, painting	33%	of purchased equip cost (B)	1,205,034
Installation Subtotal Standard Expenses	85%		**3,103,876**
Site Preparation, as required	N/A	Site Specific	-
Buildings, as required	Yes	Site Specific	20,000
Site Specific - Other	N/A	Site Specific	-
Total Site Specific Costs			20,000
Installation Total			**3,123,876**
Total Direct Capital Cost, DC			**6,775,495**
Indirect Capital Costs			
Engineering, supervision	10%	of purchased equip cost (B)	365,162
Construction & field expenses	20%	of purchased equip cost (B)	730,324
Contractor fees	10%	of purchased equip cost (B)	365,162
Start-up	1%	of purchased equip cost (B)	36,516
Performance test	1%	of purchased equip cost (B)	36,516
Model Studies	N/A	of purchased equip cost (B)	-
Contingencies	3%	of purchased equip cost (B)	109,549
Total Indirect Capital Costs, IC	45%	of purchased equip cost (B)	**1,643,228**
Total Capital Investment (TCI) = DC + IC			**8,418,723**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost			**8,418,723**
OPERATING COSTS			
Direct Annual Operating Costs, DC			
Operating Labor			
Operator	37.00		192,100
Supervisor	15%	$/Hr, 1.5 hr/8 hr shift, 1,558 hr/yr	28,815
Maintenance			
Maintenance Labor	53.00		82,551
Maintenance Materials	100%	% of Maintenance Labor	82,551
Utilities, Supplies, Replacements & Waste Management			
Electricity	0.074	$/kW-h, 372.9 kW-hr, 3,097,479 kWh/yr, 100% utilization	230,143
Water	0.33	$/kgal, 277.6 kgal/hr, 2,305,721 kWh/yr, 100% utilization	762,201
Wastewater Disposal Neutralization	2.48	$/kgal, 277.6 kgal/hr, 2,305,721 kWh/yr, 100% utilization	5,716,508
Lime	[redacted]		302,101
Total Annual Direct Operating Costs			**7,396,970**
Indirect Operating Costs			
Overhead	60%	of total labor and material costs	231,610
Administration (2% total capital costs)	2%	of total capital costs (TCI)	168,374
Property tax (1% total capital costs)	1%	of total capital costs (TCI)	84,187
Insurance (1% total capital costs)	1%	of total capital costs (TCI)	84,187
Capital Recovery	0.0944	for a 20-year equipment life and a 7% interest rate	794,668
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	**1,363,027**
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**8,759,997**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-17: SO2 Control Spray Dry Absorber (SDA)

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Electrical Use

	Flow		dP in H_2O	Efficiency	HP	kW	
Blower, Scrubber	209,584 acfm		10	0.7	-	350.3	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.48
	Flow	**Liquid SPGR**	**dP in H_2O**	**Efficiency**	**HP**	**kW**	
Circ Pump	1367 gpm	1	60	0.7	-	22.0	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
H2O WW Disch	34 gpm	1	60	0.7	-	0.6	EPA Cont Cost Manual 6th ed Section 5.2 Chapter 1 Eq 1.49
Other							
Other							
Other							
Total						**372.9**	

Reagent Use & Other Operating Costs

Lime Use	4.15 lb/hr SO_2	55.23 lb Lime/lb SO_2	229.44 lb/hr Lime	
Liquid/Gas ratio	10.0 * L/G = Gal/1,000 acf			
Circulating Water Rate	1,367 gpm			
Water Makeup Rate/WW Disch =		2.5% of circulating water rate =	34 gpm	
Scrubber Outlet Flow	[redacted] acfm			
Scrubber Outlet Temp	120 °F			
Evap H2O Loss	243.4 gpm			
Water Makeup Rate	**278 gpm**			

Operating Cost Calculations

Utilization Rate	100%	Combined Operating Hours	8,307				
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Operating Labor							
Op Labor	37.00	$/Hr	5.0	hr/8 hr shift	5,192	$ 192,100	$/Hr, 5.0 hr/8 hr shift, 5,192 hr/yr
Supervisor	15%	of Op Labor			NA	$ 28,815	% of Operator Costs
Maintenance							
Maint Labor	53.00	$/Hr	1.5	hr/8 hr shift	1,558	$ 82,551	$/Hr, 1.5 hr/8 hr shift, 1,558 hr/yr
Maint Mtls	100%	of Maintenance Labor			NA	$ 82,551	100% of Maintenance Labor
Utilities, Supplies, Replacements & Waste Management							
Electricity	0.074	$/kW-h	372.9	kW-hr	3,097,479	$ 230,143	0.074 $/kW-h, 372.9 kW-hr, 3,097,479 kWh/yr, 100% utilization
Water	0.33	$/kgal	277.6	kgal/hr	2,305,721	$ 762,201	0.33 $/kgal, 277.6 kgal/hr, 2,305,721 kWh/yr, 100% utilization
Wastewater Disposal Neutralization	2.48	$/kgal	277.6	kgal/hr	2,305,721	$5,716,508	2.48 $/kgal, 277.6 kgal/hr, 2,305,721 kWh/yr, 100% utilization
Lime	[redacted]	$/ton	0.11	ton/hr	953	$ 302,101	[redacted]
Solid Waste Disposal	18.45	$/ton	0.11	ton/hr	953	$ 17,581	18.45 $/ton, 0.1 ton/hr, 953 kWh/yr, 100% utilization

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-18: SO2 Control - Wet Scrubber with Lime Addition

Operating Unit: **Peerless Rotary Kilns**

Emission Unit Number	EP-640 & EP-645		Stack/Vent Number	Varies	
Design Capacity		MMBtu/hr HHV	Standardized Flow Rate		scfm @ 32° F
Utilization Rate	100%		Temperature	422	Deg F
Annual Operating Hours		hr/yr	Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate		acfm
Control Equipment Life	20	yrs	Standardized Flow Rate		scfm @ 68° F
Plant Elevation	560	ft	Dry Std Flow Rate		dscfm @ 68° F
Atmospheric Pressure at Elevation	14.41	psia			

Chemical Engineerig Magazine Plant Cost Index		
Historical Date/Cost Index	2017	567.5
Current Date/Cost Index	2019	607.5
Inflation Adjustment		1.07

CONTROL EQUIPMENT COSTS

Capital Costs			
Direct Capital Costs			
Purchased Equipment (A)			13,232,285
Purchased Equipment Total (B)	22%	of control device cost (A)	**16,077,227**
Installation - Standard Costs	85%	of purchased equip cost (B)	13,665,643
Installation - Site Specific Costs			0
Installation Total			13,665,643
Total Direct Capital Cost, DC			29,742,869
Total Indirect Capital Costs, IC	35%	of purchased equip cost (B)	5,627,029
Total Capital Investment (TCI) = DC + IC			**35,369,899**
Operating Costs			
Total Annual Direct Operating Costs		Labor, supervision, materials, replacement parts, utilities, etc.	837,667
Total Annual Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	5,157,064
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**5,994,731**

Emission Control Cost Calculation

Pollutant	Max Emis Lb/Hr	Annual Ton/Yr	Calculation Method	Cont Eff %	Performance Basis	Conc. Units	Cont Emis Ton/Yr	Reduction Ton/Yr	Cont Cost $/Ton Rem
Sulfur Dioxide (SO2)		17.26	% Removal	98%			0.35	16.91	$354,500

Notes & Assumptions

1 Wet Scrubber: 2012 Capital Cost Estimate from Mississippi Lime Company Prairie du Rocher, IL BACT and adjusted for inflation based on Chemical Engineering Plant Cost Index
2 Lime Injection: Capital Cost Estimate from Mississippi Lime Company's 2017 scrubber project and adjusted for inflation based on Chemical Engineering Plant Cost Index
3 Calculations per EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-18: SO_2 Control - Wet Scrubber with Lime Addition

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (A) [1]		**13,232,285**
Purchased Equipment Costs (A)		
Instrumentation	10% of control device cost (A)	1,323,229
Sales Taxes	6.5% of control device cost (A)	860,099
Freight	5% of control device cost (A)	661,614
Purchased Equipment Total (B)	22%	**16,077,227**
Installation		
Foundations & supports	12% of purchased equip cost (B)	1,929,267
Handling & erection	40% of purchased equip cost (B)	6,430,891
Electrical	1% of purchased equip cost (B)	160,772
Piping	30% of purchased equip cost (B)	4,823,168
Insulation	1% of purchased equip cost (B)	160,772
Painting	1% of purchased equip cost (B)	160,772
Installation Subtotal Standard Expenses	85%	**13,665,643**
Site Preparation, as required	N/A Site Specific	-
Buildings, as required	N/A Site Specific	-
Site Specific - Other	N/A Site Specific	-
Total Site Specific Costs		0
Installation Total		**13,665,643**
Total Direct Capital Cost, DC		**29,742,869**
Indirect Capital Costs		
Engineering, supervision	10% of purchased equip cost (B)	1,607,723
Construction & field expenses	10% of purchased equip cost (B)	1,607,723
Contractor fees	10% of purchased equip cost (B)	1,607,723
Start-up	1% of purchased equip cost (B)	160,772
Performance test	1% of purchased equip cost (B)	160,772
Model Studies	N/A of purchased equip cost (B)	-
Contingencies	3% of purchased equip cost (B)	482,317
Total Indirect Capital Costs, IC	35% of purchased equip cost (B)	**5,627,029**
Total Capital Investment (TCI) = DC + IC		**35,369,899**
Adjusted TCI for Replacement Parts (Catalyst, Filter Bags, etc) for Capital Recovery Cost		**35,369,899**
OPERATING COSTS		
Direct Annual Operating Costs, DC		
Operating Costs		
Operating Costs		636,000
Maintenance Costs		
Maintenance Costs		36,667
Utilities, Supplies, Replacements & Waste Management		
Solid Waste Disposal	Actual average disposal costs (2018 - 2019)	165,000
N/A	N/A	-
N/A	N/A	-
Total Annual Direct Operating Costs		**837,667**
Indirect Operating Costs		
Overhead	60% of total labor and material costs	403,600
Administration (2% total capital costs)	2% of total capital costs (TCI)	707,398
Property tax (1% total capital costs)	1% of total capital costs (TCI)	353,699
Insurance (1% total capital costs)	1% of total capital costs (TCI)	353,699
Capital Recovery	0.0944 for a 20-year equipment life and a 7% interest rate	3,338,668
Total Annual Indirect Operating Costs	Sum indirect oper costs + capital recovery cost	**5,157,064**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**5,994,731**

See Summary page for notes and assumptions

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-18: SO2 Control - Wet Scrubber with Lime Addition

Capital Recovery Factors

Primary Installation	
Interest Rate	7.00%
Equipment Life	20 years
CRF	0.0944

Operating Cost Calculations

Utilization Rate	100%	Annual Operating Hours		8,307			
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Utilities, Supplies, Replacements & Waste Management							
Solid Waste Disposal						$ 165,000	Actual average disposal costs (2018 - 2019)

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Addendum

Response to Comments on Regional Haze Four-Factor Analysis for NO_X and SO_2 Emissions Control

Prepared for
Mississippi Lime Company
Ste. Genevieve, MO

January 18, 2022

Introduction

As requested by the Missouri Department of Natural Resources (MDNR), Air Pollution Control Program during a WebEx meeting on December 6, 2021, Mississippi Lime is providing this addendum to address external comments related to the Mississippi Lime - Ste. Genevieve Plant Regional Haze Four-Factor Analysis for NO_X and SO_2 Emissions Control. The response to each comment is included below with the comment in **bold** followed by the response.

Comment 1

Explain why 20-years, vs. the standard 30-years, was used in calculations as the remaining useful life of equipment/controls in the FFA. If 20-years cannot be justified, rework the useful life calculations using 30-years.

The four-factor analysis (FFA) cannot assign a "standard" useful emission unit or control device equipment life as there is a great deal of individual variability with respect to different industrial operations, equipment used in those operations, and the nature of the control equipment for different pollutants. Nonetheless, as noted in the four-factor analysis (Section 2.1.1.2 – page 11, note 11), the 20-year useful equipment life in the FFA was based on the EPA control cost manuals at the time of the Mississippi Lime submittal. The lone exception was for SO_2 controls which use 20 years in lieu of 15 years to be consistent with the NO_X controls.

The control cost manual versions at the time of analysis were:

EPA Control Cost Manual, Section 4 – NO_X Controls, Chapter 1 – Selective Noncatalytic Reduction (Published April 2019) and;
EPA Control Cost Manual, Section 5 – SO_2 Controls, Chapter 1 – Wet Scrubbing For Acid Gas (Published December 1995).

The relevant excerpts from each manual follow:

"*In responses to another ICR, 3 petroleum refiners estimated SNCR life at between 15 and 25 years [3]. Thus, an equipment lifetime of 20 years is assumed for the SNCR system in this analysis.*" EPA Control Cost Manual, Section 4 – NOx Controls, Chapter 1 – Selective Noncatalytic Reduction, Section 1.4.2; Total Annual Costs (Pages 1-53 and 1-54).

"The system capital recovery cost, CRC, is based on an estimated 15-year equipment life. (See Section 1 of this manual for a discussion of the capital recovery cost.) For a 15-year life and an interest rate of

> *7 percent, the capital recovery factor is 0.1098."* Section 1.5.2 Indirect Annual Costs (Pages 1-30) from EPA Control Cost Manual, Section 5 – SO_2 Controls, Chapter 1 – Wet Scrubbing For Acid Gas.

Further, the SNCR control cost manual spreadsheet that was updated in March 2021 uses 20 years as the "estimated equipment life". Therefore, no change is necessary to useful NO_X control equipment life.

In addition, the May 2021 updates to the SO_2 control discussion (Section 5, Chapter 1 of the Control Cost Manual in Section 1.1.6) provides the following:

> *"Acid gas scrubbers are relatively reliable systems that have been demonstrated to be exceedingly durable. In the past, the EPA has generally used equipment life estimates of 20 to 30 years for analyses involving acid gas scrubbers, although these estimates are recognized to be low for many installations. Many FGD systems installed in the 1970s and 1980s have operated for more than 30 years (e.g., Coyote Station; H.L. Spurlock Unit 2 in Maysville, KY; East Bend Unit 2 in Union, KY; and Laramie River Unit 3 in Wheatland, WY) ".*

As part of industrial comments on the equipment life estimates, the following was summarized by EPA –

> *"Several commenters noted that the equipment life was based on data drawn for utility units and said that life expectancies can be as low as 5 to 10 years for certain acid gas scrubbers installed on industrial processes. The commenters said that a 30-year lifetime is not appropriate for contemporary FGD applications and suggested a life of approximately 15 years would be more appropriate."*

EPA did not respond to these comments with respect to equipment life for relatively pristine utility boiler operation vs. industrial operations involving process chemical reactions and extreme temperatures (i.e., lime kilns). Mississippi Lime continues to believe that the useful life for new SO_2 control equipment on the lime kilns is best estimated at 20 years as operation beyond that would require new and extensive capital to maintain and repair the equipment. Therefore, no change is necessary to useful SO_2 control equipment life.

Comment 2

Explain why the interest rates of 5.5% and 7% were used for NO_X and SO_2 calculations, respectively, or rework the calculations utilizing the standard interest rate of 3.25%.

Throughout the development and use of the Control Cost Manual, there has been no consistent "standard interest rate". EPA has published cost recovery factors using 5.5% - 15% as the interest rate and continues to do so in the latest Control Cost Manual. The current version of the Control Cost Manual explains in Section 1, Chapter 2 that the applicable interest rate to be used for annualizing capital cost is either:

- the bank prime rate; or
- a specific rate that reflects the debt and equity rates for the facility owning the emission unit.

As part of the October 2020 submittal, the interest rates for NO_X and SO_2 control evaluations utilized information from the EPA Control Cost Manual at the time of the submittal.

Specifically, the following excerpts are noted:

> *"The interest rate recommended by EPA can vary by firm or industry, but the bank prime rate is a default rate that can be used for annualization of capital costs. This interest rate is 5.25 to 5.5 percent as of January 2019. For more information, please consult the cost estimation chapter of this Control Cost Manual (Section 1, Chapter 2)."* Section 1.4.2 Total Annual Costs (Page 1-53, Footnote 11) from EPA Control Cost Manual, Section 4 – NO_X Controls, Chapter 1 – Selective Noncatalytic Reduction.

> *"The system capital recovery cost, CRC, is based on an estimated 15-year equipment life. (See Section 1 of this manual for a discussion of the capital recovery cost.) For a 15-year life and an interest rate of 7 percent, the capital recovery factor is 0.1098."* Section 1.5.2 Indirect Annual Costs (Page 1-30) from EPA Control Cost Manual, Section 5 – SO_2 Controls, Chapter 1 – Wet Scrubbing for Acid Gas.

Based upon historical capital cost for projects and available guidance, Mississippi Lime has concluded that the interest rates in the four-factor analysis are consistent with the Control Cost Manual and do not need to be adjusted. Further, a change in interest rate only impacts the cost of capital investment recovery and would not impact annual operational costs. Any change to the interest rate would represent a small change in the overall cost effectiveness calculation.

Comment 3

Explain why low-sulfur coal is not feasible for use on units EP-180H, EP-186N, and EP-187N, or complete a cost analysis to switch from high-sulfur coal to low-sulfur coal.

Consistent with the initial four-factor analysis, Mississippi Lime considers "This type of operational decision (i.e., which fuel to use) is part of the business and operational strategy for Mississippi Lime. Mississippi Lime believes the review of a fuel switch is beyond the regulatory control review conducted here." Nonetheless, Mississippi Lime has completed control cost calculations for a potential fuel switch. The estimated cost for switching to lower sulfur coal at these units is $20,100/ton SO_2 removed. This estimated cost is based solely on the costs associated with switching from high sulfur to lower sulfur coal and does not include an estimate of lost revenue due to the decreased lime production associated with switching to lower sulfur coal (see updated Appendix C tables). The following updates can be viewed as a replacement for Sections 4.1.2 and 4.3 along with updated Tables 1-4 and 4-3 as included below:

Table 1-4 Summary of SO_2 Four-Factor Analysis for Mississippi Rotary Kilns

List of Emission Control Measure	Factor #1 – Cost of Compliance	Factor #2 – Time Necessary for Compliance	Factor #3 – Energy and Non-Air Quality Environmental Impacts of Compliance	Factor #4 – Remaining Useful Life of the Source	Does this Analysis Support the Installation of this Emission Control Measure?
Mississippi Rotary Kilns (EP-180H, EP-186N, EP-187N)					
DSI	$11,600/ton	2-3 years after SIP promulgation.	Negligible energy and non-air quality environmental impacts	20-year control equipment life	No – DSI is not economically feasible.
SDA	$41,100/ton	2-3 years after SIP promulgation.	Negligible energy and non-air quality environmental impacts	20-year control equipment life	No – SDA is not economically feasible.
Wet Lime Scrubber	$9,800/ton	2-3 years after SIP promulgation.	Negligible energy and non-air quality environmental impacts	20-year control equipment life	No – Wet Lime Scrubber is not economically feasible.
Low Sulfur Coal	$20,100/ton	2-2½ years after SIP promulgation	Negligible energy and non-air quality environmental impacts	N/A	No – Low Sulfur Coal is not economically feasible.

4.1.2 Mississippi Rotary Kilns

The Mississippi Rotary Kilns, EP-181H, EP-182H, and EP-183H, currently utilize wet scrubbers with lime injection for SO_2 emission control. As shown in Section 4.3, Wet Lime Scrubbers are the top ranked control technology for SO_2 emissions control. As such, a four-factor analysis is not included for these emission units since the top control technology is already being utilized.

Mississippi Rotary Kilns, EP-180H, EP-186N, and EP-187N, are equipped with wet scrubbers but no additional lime injection to control SO_2 emissions. These units benefit from the inherent scrubbing of the exhaust stream by the lime in the process and also use a higher sulfur coal-coke blend than the Peerless Rotary Kilns. However, it would be economically infeasible for these units to burn the same low-sulfur coal-coke blend in these units. The costs for switching to low-sulfur coal would be exorbitant for the limited decrease in SO_2 emissions associated with the change. This type of operational decision (i.e., which fuel to use) is part of the business and operational strategy for Mississippi Lime. Mississippi Lime believes the review of a fuel switch is beyond the regulatory control review conducted here.

However, in response to a specific request from Missouri DNR, Mississippi Lime completed an economic evaluation for the use of low-sulfur coal. The evaluation calculates the cost effectiveness of the switch associated decrease in SO_2 emissions and the increase in operating costs. The results of the analysis for EP-180H, EP-186N, and EP-187N are included in the sections below.

4.3 Factor 1 – Cost of Compliance

Mississippi Lime completed cost estimates for Wet Lime Scrubber, SDA, and DSI installation on the rotary kilns. Due to the limited time available in responding to APCP's request, conservative assumptions were made in the cost estimates for equipment costs. The capital cost estimates are considered by Mississippi Lime and Barr's engineering staff, based on their considerable experience with projects at Mississippi Lime and their informal conversations with other companies that have completed similar types of projects at other facilities, to be conservatively low. Cost summary spreadsheets for the NO_X emission control measures are provided in Appendix B.

The control efficiencies for the Wet Lime Scrubber, SDA, and DSI are as follows:

- DSI: 50%
- SDA: 90%
- Wet Lime Scrubber: 98%

The cost-effectiveness analysis compares the annualized cost of the emission control measure per ton of pollutant removed and is evaluated on dollar per ton basis using the annual cost (annualized capital cost plus annual operating costs) divided by the annual emissions reduction (tons) achieved by the control device. For purposes of this screening evaluation and consistent with the typical approach described in the EPA Control Cost Manual[16], a 20-year life (before new and extensive capital is needed to maintain and repair the equipment) at 5.5% interest is assumed in annualizing capital costs.

The resulting cost-effectiveness calculations are summarized in Table 4-3.

Table 4-3 SO_2 Control Cost Summary, per Unit Basis

Unit ID	Emission Control Measure	Installed Capital Cost ($MM)	Annualized Capital Cost ($/yr)	Annual Operating Costs ($/yr)	Total Annualized Costs ($/yr)	Annual Emissions Reduction (tpy)	Pollution Control Cost Effectiveness ($/ton)
EP-069, 070, 071	DSI	2.08	292,149	715,722	1,007,871	12	86,800
	SDA	6.79	976,953	2,216,785	3,193,737	21	152,800
	Wet Lime Scrubber	28.50	4,233,920	837,667	5,071,587	23	222,900
EP-640, 645	DSI	2.45	375,314	997,455	1,372,769	9	159,100
	SDA	8.42	1,363,027	7,396,970	8,759,997	6	564,000
	Wet Lime Scrubber	35.37	5,157,064	837,667	5,994,731	17	354,500
EP-180H, 186N, 187N	DSI	1.47	236,665	774,987	1,011,652	87	11,600
	SDA	4.13	748,397	5,710,983	6,459,380	157	41,100
	Wet Lime Scrubber	3.19	831,735	837,667	1,669,402	171	9,800
	Low Sulfur Coal	--	--	871,975	871,975	43	20,100

The cost-effectiveness values for all the SO_2 emission control measures are substantially greater than a reasonable cost-effectiveness threshold for implementation of the additional SO_2 controls. Therefore, the costs for the retrofit options are not reasonable.

Sections 4.4 through 4.6 provide a summary of the remaining three factors evaluated for the SO_2 emission control measures, understanding that these projects represent substantial capital investments that are not justified on a cost per ton or absolute cost basis.

Conclusion

As indicated above in the responses to Comments 1 and 2, no updates were required to the previously submitted four-factor analysis.

Mississippi Lime's response to Comment 3 does provide an update to include cost analysis for switching from high-sulfur coal to low-sulfur coal. These revisions are included above in the responses including updates to Table 1-4 and Table 4-3 along with updated text for Sections 4.1.2 and 4.3 Also, the technical details associated with the cost analysis are included in the public and confidential versions of Appendix C Tables C-7, C-8, and C-9, as well as the new Table C-19 as part of this submittal.

Overall, pursuant to this updated analysis, there is no change in the outcome of the four-factor analysis for SO_2 control on Mississippi Rotary Kilns EP-180H, 186N, 187N. All controls evaluated are not economically feasible and Mississippi Lime proposes to maintain the existing SO_2 emission control measures and continue to meet the 2,000 tpy SO_2 emission limit for the entire facility.

PUBLIC

Appendix C

Screening Level Cost Summary for SO_2 Emission Control Measures

(Response to Comments Update - January 2022)

PUBLIC

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-7: Cost Summary

SO_2 Control Cost Summary										
Control Technology	**Uncontrolled Emissions T/y**	**Baseline Emissions T/y**	**Control Eff %**	**Controlled Emissions Ton/Yr**	**Emission Reduction Ton/Yr**	**Installed Capital Cost $**	**Annualized Operating Cost $/yr**	**Incremental Control Cost $/ton**	**Non-Air Env Impacts?**	**Comments**
Spray Dryer Absrober (SDA)		174.58	90.0%	17.46	157.13	$4,130,652	$6,319,289	$40,200	Solid Waste	
Wet Scrubber with Lime		174.58	98.0%	3.49	171.09	$3,185,698	$897,135	$5,200	Waste-water	
Dry Sorbent Injection (DSI)		174.58	50.0%	87.29	87.29	$1,473,668	$731,470	$8,400	Solid Waste	
Low Sulfur (LS) Coal Utilization		174.58		131.15	43.44		$871,975	$20,100	N/A	
Process Inherent Scrubbing (Baseline)	1,745.83			174.58	1571.25					

Mississippi Lime Company - Ste. Genevieve

Four Factor Analysis

Table C-8: Emissions Data

Operating Unit: Mississippi Rotary Kilns
Emission Unit Number EP-180H, EP-186N, EP-187N
Stack/Vent Number Varies

Operating Information

Unit Annual Oper Hours		hr/yr	Source Type for Cost Calc	Industrial Coal	
Control Equip Oper Hrs		hr/yr	Coal/Fuel Type for CoalF	Coal / Coke blend	
Combined Op Hours (Top)		hr/yr	NPHR (utilities Net Plant Heat Rate, if known)	10	*MMBtu/MW*
Control Equipment Life	20	yrs	Hourly Heat Input (Q_b) or Equivalent		*MMBtu/hr HHV*
Exhaust Temperature	155	Deg F	Basis Q_b and Capacity Factor (% Utilization)	Heat Input: Design vs. Actual	
Exhaust Moisture Content	6.0%		Maximum Hourly Production Rate		
Plant Elevation	560	ft	Annual Average Production Rate		
Atmos Press at Elvation	14.41	psia	Energy Use per Unit of Production		
Standardized Flow Rate		scfm @ 68º F	Maximum Hourly Heat Input (firing) Rate		*MMBtu/hr HHV*
Dry Std Flow Rate		dscfm @ 68º F	Annual Average Heat Input (firing) Rate		*MMBtu/hr HHV*
Actual Flow Rate		acfm	Maximum Hourly Fuel Use Rate		scf/hr
Elevation Factor	1.02		Annual Fuel Use Rate		scf/yr
			Capacity Factor (CF) / Utilization	100.0%	
Fuel Sulfur Content		wt %	Fuel Heating Value (0 if not known)		Btu/lb
Uncontrolled SO_2 Emission Rate		lb SO2/MMBtu			

Process Inherent Scrubbing (Baseline)	Uncontrolled		Controlled						
Pollutant	**lb/hr**	**ton/yr**	**Calculation Method**	**Cont Eff %**	**Performance Basis**	**Units**	**lb/hr**	**ton/yr**	**Calculated Cont Eff Performance Basis**
Sulfur Dioxide (SO_2)		1745.83	% Removal					174.58	-

	Max Emissions		Uncontrolled Concentration		
Pollutant	**lb/Hr**	**ton/yr**			
Sulfur Dioxide (SO_2)		174.58	129.3	ppm dry	

Dry Sorbent Injection	Uncontrolled		Controlled						
Pollutant	**lb/hr**	**ton/yr**	**Calculation Method**	**Cont Eff %**	**Performance Basis**	**Units**	**lb/hr**	**ton/yr**	**Calculated Cont Eff Performance Basis**
Sulfur Dioxide (SO_2)		174.58	% Removal	50%				87.29	-

Spray Dry Absorber	Uncontrolled		Controlled						
Pollutant	**lb/hr**	**ton/yr**	**Calculation Method**	**Cont Eff %**	**Performance Basis**	**Units**	**lb/hr**	**ton/yr**	**Calculated Cont Eff Performance Basis**
Sulfur Dioxide (SO_2)		174.58	% Removal	90%				17.46	-

Wet Scrubber w/ Lime	Uncontrolled		Controlled						
Pollutant	**lb/hr**	**ton/yr**	**Calculation Method**	**Cont Eff %**	**Performance Basis**	**Units**	**lb/hr**	**ton/yr**	**Calculated Cont Eff Performance Basis**
Sulfur Dioxide (SO_2)		174.58	% Removal	98%				3.49	-

LS Coal Utilization	Uncontrolled		Controlled						
Pollutant	**lb/hr**	**ton/yr**	**Calculation Method**	**Cont Eff %**	**Performance Basis**	**Units**	**lb/hr**	**ton/yr**	**Calculated Cont Eff Performance Basis**
Sulfur Dioxide (SO_2)		174.58						43.44	-

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-9: Summary of Utility, Chemical and Supply Costs

Operating Unit: Mississippi Rotary Kilns **Study Year** 2019
Emission Unit Number EP-180H, EP-186N, EP-187N
Stack/Vent Number Varies

Item	Unit Cost	Units, k=1,000 M=1,000,000	Reference Cost	Year	Data Source	Notes
Operating Labor	37.00	$/hr			Mississippi Lime Company	Actual cost of Operator Labor per Mississippi Lime Company
Maintenance Labor	53.00	$/hr			Mississippi Lime Company	Actual cost of Maintenance Labor per Mississippi Lime Company
Utilities						
Electricity	0.074	$/kW-h			U.S. Energy Information Administration	Average Price for Missouri Industrial customers, June 2020
Water	0.33	$/kgal	0.20	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 6 Chapter 2.6.1.2.	Example Problems uses $0.20/1000 gal. Cost adjusted for 3% inflation Sec 5.2 Ch 1 also lists $0.20/1,000 gal.
Wastewater Disposal Neutralization	2.48	$/kgal	1.50	2002	EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 5 Chapter 1.	Section 2 lists $1- $2/1000 gal. Cost adjusted for 3% inflation. Sec 6 Ch 3 lists $1.30 - $2.15/1,000 gal.
Solid Waste Disposal	18.45	$/ton	15.00	2012	EPA Air Pollution Control Cost Manual May	Paragraph 1.5 Example calculations - price for ash disposal. Cost
	N/A	N/A				
Chemicals & Supplies						
Lime	[redacted]	$/ton			Mississippi Lime Company	Actual cost of reagent per Mississippi Lime Company
High Sulfur Coal (Base case)	[redacted]	$/ton			Mississippi Lime Company	Average cost of high sulfur coal per Mississippi Lime Company (3-yr Avg)
Low Sulfur Coal (bituminous)	[redacted]	$/ton			Mississippi Lime Company	Average cost of low sulfur coal per Mississippi Lime Company (3-yr Avg)
Catalyst & Replacement Parts						
Other						
Sales Tax	6.50%					
Interest Rate	7.00%				EPA Air Pollution Control Cost Manual 6th Ed 2002, Section 5 Chapter 1.5.2.	Section 1.5.2 Indirect Annual Costs (Page 1-30)

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-19: SO2 Control - Low Sulfur Coal Utilization

Operating Unit: **Mississippi Rotary Kilns**

Emission Unit Number	EP-180H, EP-186N, EP-187N		Stack/Vent Number	Varies	
Design Capacity	[redacted]	MMBtu/hr HHV	Standardized Flow Rate	[redacted]	scfm @ 32º F
Utilization Rate	100%		Temperature	155	Deg F
Annual Operating Hours	6,932	hr/yr	Moisture Content	6.0%	
Annual Interest Rate	7.0%		Actual Flow Rate	[redacted]	acfm
Control Equipment Life	20	yrs	Standardized Flow Rate	[redacted]	scfm @ 68º F
Plant Elevation	560	ft	Dry Std Flow Rate	[redacted]	dscfm @ 68º F
Atmospheric Pressure at Elevation	14.41	psia	Typical Coal Percentage in Fuel	62%	
HS Coal Hourly Usage (base)	[redacted]	lb/hr	Typical Coke Percentage in Fuel	38%	
LS Coal Hourly Usage (alternative)	[redacted]	lb/hr			
Coke Hourly Usage	[redacted]	lb/hr			
HS Coal HHV (base)	11,000	Btu/lb			
LS Coal HHV (alternative)	11,500	Btu/lb			
Coke HHV	13,500	Btu/lb			
HS Coal Sulfur Content (base)	3.0%				
LS Coal Sulfur Content (alternative)	1.7%				
Coke Sulfur Content	5.1%	Average sulfur content in range (3.9-6.2%)			

CONTROL COSTS

Operating Costs		
Total Annual Direct Operating Costs	Utilities, Supplies, & Replacements	871,975
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**871,975**

Emission Control Cost Calculation

Sulfur Dioxide (SO2) Emission Scenarios	Coke SO2 Lb/Hr	Coal SO2 Lb/Hr	Max Emis Lb/Hr	Annual Ton/Yr	Cont Cost $/Ton Rem
HS Coal (base)	[redacted]			174.58	
LS Coal (alternative)				131.15	
Delta			**12.53**	**43.44**	**$20,100**

Notes & Assumptions

1. Coal high heating values (HHV) and sulfur content provided by vendor
2. Coal hourly usage is based on the design capacity, typical coal percentage in fuel, and the HHV of each coal type
3. Typical coal and coke percentages are based on actual average historical usage data at Mississippi Lime Company

Mississippi Lime Company - Ste. Genevieve
Four Factor Analysis
Table C-19: SO2 Control - Low Sulfur Coal Utilization

OPERATING COSTS

Utilities, Supplies, & Replacements		
Low Sulfur Coal (bituminous)	Estimated annual cost	2,471,242
High Sulfur Coal	Estimated annual cost	1,599,267
	N/A	-
Difference in Total Annual Direct Operating Costs		**871,975**
Total Annual Cost (Annualized Capital Cost + Operating Cost)		**871,975**

Operating Cost Calculations

Utilization Rate	100%		Annual Operating Hours		6,932		
Item	**Unit Cost $**	**Unit of Measure**	**Use Rate**	**Unit of Measure**	**Annual Use***	**Annual Cost**	**Comments**
Utilities, Supplies, & Replacements							
Low Sulfur Coal (bituminous)	[redacted]	$/ton	[redacted]	lb/hr	[redacted]	$ 2,471,242	Estimated annual cost
High Sulfur Coal	[redacted]	$/ton	[redacted]	lb/hr	[redacted]	$ 1,599,267	Estimated annual cost

See Summary page for notes and assumptions

*annual use rate is in same units of measurement as the unit cost factor

Summary

In conclusion, based on a review of possible and feasible options to reduce SO2 and NOx emissions at all units, the Air Program has determined that there are no cost-effective methods of SO2 and NOx reduction for this Mississippi Lime Company. All Class I areas impacted by sources in Missouri have made steady and significant improvement in visibility, and modeling shows they are projected to be below, or well below, their uniform rate of progress (URP) glidepaths in 2028. Based on the four factor analysis completed in this report, the Air Program is proposing to maintain current operational practices consistent with the parameters and limits in Mississippi Lime Company Air Pollution Control Title V Permit to Operate.

**All control cost estimate calculations for wet FGD, SDA, DSI, SNCR and low sulfur coal for both remaining useful life (RUL) scenarios are provided in the attached spreadsheets

MLC-Public-EP 69-70-71 SNCR Costs 12-14-20-EPA-RUL.xlsm
MLC-Public-EP 69-70-71 SNCR Costs 12-14-20-Original-RUL.xlsm
MLC-Public-EP 69-70-71 SO2 Costs 12-14-20-EPA-RUL.xlsx
MLC-Public-EP 69-70-71 SO2 Costs 12-14-20-Original-RUL.xlsx
MLC-Public-EP 180H-186N-187N SO2 Costs 12-14-20-EPA-RUL.xlsx
MLC-Public-EP 180H-186N-187N SO2 Costs 12-14-20-Original-RUL.xlsx
MLC-Public-EP 180H-186N-187N Units HS Coal SO2 Costs 02-09-22-EPA-RUL.xlsx
MLC-Public-EP 180H-186N-187N Units HS Coal SO2 Costs 02-09-22-Original-RUL.xlsx
MLC-Public-EP 640-645 SNCR Costs 12-14-20-EPA-RUL.xlsm
MLC-Public-EP 640-645 SNCR Costs 12-14-20-Original-RUL.xlsm
MLC-Public-EP 640-645 SO2 Costs 12-14-20-EPA-RUL.xlsx
MLC-Public-EP 640-645 SO2 Costs 12-14-20-Original-RUL.xlsx

All spreadsheets are in Missouri Regional Haze Plan for the Second Planning Period, Attachment C

https://dnr.mo.gov/sites/dnr/files/media/file/2022/06/2022-07-28-appendix-c-excel-spreadsheets-missouri-regional-haze-plan-second-planning-period.zip