Contents

F-1.0 User Input Sheet

This worksheet contains all of the necessary user inputs needed to run the model (CUECost). The inputs are separated into six different topics: 1) air pollution control (APC) technology choices, 2) general plant technical inputs, 3) economic inputs, 4) limestone forced oxidation (LSFO) inputs, 5) lime spray dryer (LSD) inputs, and 6) particulate control inputs. The worksheet is arranged so five different cases can be run simultaneously; however, the user can also run only one case if desired.

F-1.1 Air Pollution Control Technology Choices

This first section of the worksheet allows the user to choose what air pollution control technologies to model. This section contains: 1) input title, 2) units, 3) range, 4) default values, 5) input columns (five cases can be run), and 6) comments. The comments column provides the user with background information and directions needed for the input.

	A	*B*	*C*	*D*	*E*	*K*
	APC Technology Choices					
Row No.	**Description**	**Units**	**Suggested Range**	**Default Values**	**Input 1**	***Comments***
45	FGD Process	Integer	1 or 2	1	1	*User can choose LSFO or LSD. PM control upstream of LSFO & downstream of LSD.*
46	(1 = LSFO, 2 = LSD)					
47	Particulate Control	Integer	1 or 2	1	1	*User can choose ESP or fabric filter.*
48	(1 = Fabric Filter, 2 = ESP)					
49	NOx Control	Integer	1 - 4	1	1	*User can choose one of four NOx comtrol technologies.*
50	(1 = SCR, 2 = SNCR, 3 = LNBs, 4 = NGR)					

F-1.2 General Plant Technical Inputs

This section of the worksheet contains the general plant inputs required for all air pollution control technologies (capacity, net plant heat rate, ambient conditions, etc.). These inputs are used to perform the combustion calculations.

Appendix F. Workbook Documentation

	A	B	C	D	E	K
	INPUTS					
Row No.	**Description**	**Units**	**Suggested Range**	**Default Values**	**Input 1**	***Comments***
56						
57	***General Plant Technical Inputs***					
58						
59	Location - State	Abbrev.	All States	PA	PA	*User should input the two-letter US postal abbreviation.*
60	MW Equivalent of Flue Gas to Control System	MW	100-2000	500	500	*Gross Plant Generation (MW) minus auxiliary power requirements. Prior to control system retrofit.*
61	Net Plant Heat Rate (w/o APC)	Btu/kWhr		10,500	10,500	*User to input based on plant data.*
62	Plant Capacity Factor	%	40-90%	65%	65%	*User to input based on plant data.*
63	Percent Excess Air in Boiler	%		120%	120%	*Excess O2. Typical value is 120%.*
64	Air Heater Inleakage	%		12%	12%	*Based on plant data. Typical value is 12%.*
65	Air Heater Outlet Gas Temperature	°F		300	300	*Based on plant data. Typical value is 300.*
66	Inlet Air Temperature	°F		80	80	*ABMA boiler efficiency ref temp is 80 °F. Recommended use this value.*
67	Ambient Absolute Pressure	In. of Hg		29.4	29.4	*User to input based on plant data.*
68	Pressure After Air Heater	In. of H2O		-12	-12	*A typical value is -12. Used to calculate actual cubic feet of flue gas.*
69	Moisture in Air	lb/lb dry air		0.013	0.013	*User should consult a psychometric chart, otherwise use 0.013.*
70	Ash Split:					
71	Fly Ash	%		80%	80%	*Percent ash going to bottom ash.*
72	Bottom Ash	%		20%	20%	*Calculated based on bottom ash %.*
73	Seismic Zone	Integer	1-5	1	1	*User to consult map.*
74	Retrofit Factor	Integer	1.0-3.0	1.3	1.3	*User to input integer between 1 & 3.*
75	(1.0 = new, 1.3 = medium, 1.6 = difficult)					
76	Select Coal	Integer	1-8	1	1	*User to select coal (integer) from coal library.*
77	Is Selected Coal a Powder River Basin Coal?	Yes / No	See Column K	Yes	Yes	*User to specify whether coal is from Powder River Basin. (Used in ESP sizing)*

F-1.3 Economic Inputs

This section of the worksheet contains the economic inputs required in calculating capital and operating and maintenance (O&M) costs. User should use site specific information for these inputs.

	A	B	C	D	E	K
Row No.	**Description**	**Units**	**Suggested Range**	**Default Values**	**Input 1**	***Comments***
86						
87	***Economic Inputs***					
88						
89	Cost Basis -Year Dollars	Year		1998	1998	*Date of Startup.*
90	Sevice Life (levelization period)	Years		30	30	*User to input service life (in years) of plant.*
91	Inflation Rate	%		3.00%	3.00%	*User input.*
92	After Tax Discount Rate (current $'s)	%		9.20%	9.20%	*User input.*
93	AFDC Rate (current $'s)	%		10.80%	10.80%	*User input.*
94	First-year Carrying Charge (current $'s)	%		22.30%	22.30%	*User input.*
95	Levelized Carrying Charge (current $'s)	%		16.90%	16.90%	*User input.*
96	First-year Carrying Charge (constant $'s)	%		15.70%	15.70%	*User input.*
97	Levelized Carrying Charge (constant $'s)	%		11.70%	11.70%	*User input.*
98	Sales Tax	%		6%	6%	*Sales tax applies to material only. If labor needs to be taxed user should increase appropriately.*
99	Escalation Rates:					
100	Consumables (O&M)	%		3%	3%	*Escalation rate to be input by user.*
101	Capital Costs:					
102	Is Chem. Eng. Cost Index available?	Yes / No		Yes	Yes	*User input.*
103	If "Yes" input cost basis CE Plant Index.	Integer		388	388	*User to refer to most recent Chemical Engineering magazine.*
104	If "No" input escalation rate.	%		3%	3%	*Escalation rate to be input by user.*
105	Construction Labor Rate	$/hr		$35	$35	*User input.*
106	Prime Contractor's Markup	%		3%	3%	*Fee on Construction Labor.*
107	Operating Labor Rate	$/hr		$30	$30	*User input.*
108	Power Cost	Mills/kWh		25	25	*User input.*
109	Steam Cost	$/1000 lbs		3.5	3.5	*User input.*

F-1.4 Limestone Forced Oxidation (LSFO) Inputs

This section of the worksheet contains all necessary inputs needed for sizing and costing a limestone forced oxidation system.

	A	*B*	*C*	*D*	*E*	*K*
Row No.	**Description**	**Units**	**Suggested Range**	**Default Values**	**Input 1**	***Comments***
110						
111	***Limestone Forced Oxidation (LSFO) Inputs***					
112						
113	SO2 Removal Required	%	90-98%	95%	95%	*User Input.*
114	L/G Ratio	gal / 1000 acf	95-160	125	125	*User Input.*
115	Design Scrubber with Dibasic Acid Addition?	Integer	1 or 2	2	2	*User Input.*
116	(1 = yes, 2 = no)					
117	Adiabatic Saturation Temperature	°F	100-170	127	127	*User Input.*
118	Reagent Feed Ratio	Factor	1.0-2.0	1.05	1.05	*User Input. (mole CaCO3/moleSO2 removed)*
119	(Mole CaCO3 / Mole SO2 removed)					
120	Scrubber Slurry Solids Concentration	Wt. %		15%	15%	*User Input.*
121	Stacking, Landfill, Wallboard	Integer	1,2,3	1	1	*User to choose method of product disposal: stacking, landfill, or wallboard.*
122	(1 = stacking, 2 = landfill, 3 = wallboard)					
123	Number of Absorbers	Integer	1-6	1	1	*Maximum capacity for an absorber is 700 MW. User input.*
124	(Max. Capacity = 700 MW per absorber)					
125	Absorber Material	Integer	1 or 2	1	1	*User choose either alloy or rubber lined carbon steel (RLCS).*
126	(1 = alloy, 2 = RLCS)					
127	Absorber Pressure Drop	in. H2O		6	6	*User input. Typical value 6.*
128	Reheat Required ?	Integer	1 or 2	1	1	*User to decide whether reheat is required.*
129	(1 = yes, 2 = no)					
130	Amount of Reheat	°F	0-50	25	25	*If reheat required user to input how much.*
131	Reagent Bulk Storage	Days		60	60	*User input. Typical value60 days.*
132	Reagent Cost (delivered)	$/ton		$15	$15	*User input.*
133	Landfill Disposal Cost	$/ton		$30	$30	*User input.*
134	Stacking Disposal Cost	$/ton		$6	$6	*User input.*
135	Credit for Gypsum Byproduct	$/ton		$2	$2	*User input.*

136	Maintenance Factors by Area (% of Installed Cost)					
137	Reagent Feed	%		5%	5%	*These percentages are applied to the total cost of the system.*
138	SO2 Removal	%		5%	5%	*These percentages are applied to the total cost of the system.*
139	Flue Gas Handling	%		5%	5%	*These percentages are applied to the total cost of the system.*
140	Waste / Byproduct	%		5%	5%	*These percentages are applied to the total cost of the system.*
141	Support Equipment	%		5%	5%	*These percentages are applied to the total cost of the system.*
142	Contingency by Area (% of Installed Cost)					
143	Reagent Feed	%		20%	20%	*These percentages are applied on a system basis.*
144	SO2 Removal	%		20%	20%	*These percentages are applied on a system basis.*
145	Flue Gas Handling	%		20%	20%	*These percentages are applied on a system basis.*
146	Waste / Byproduct	%		20%	20%	*These percentages are applied on a system basis.*
147	Support Equipment	%		20%	20%	*These percentages are applied on a system basis.*
148	General Facilities by Area (% of Installed Cost)					
149	Reagent Feed	%		10%	10%	*These percentages are applied on a system basis.*
150	SO2 Removal	%		10%	10%	*These percentages are applied on a system basis.*
151	Flue Gas Handling	%		10%	10%	*These percentages are applied on a system basis.*
152	Waste / Byproduct	%		10%	10%	*These percentages are applied on a system basis.*
153	Support Equipment	%		10%	10%	*These percentages are applied on a system basis.*
154	Engineering Fees by Area (% of Installed Cost)					
155	Reagent Feed	%		10%	10%	*These percentages are applied on a system basis.*
156	SO2 Removal	%		10%	10%	*These percentages are applied on a system basis.*
157	Flue Gas Handling	%		10%	10%	*These percentages are applied on a system basis.*
158	Waste / Byproduct	%		10%	10%	*These percentages are applied on a system basis.*
159	Support Equipment	%		10%	10%	*These percentages are applied on a system basis.*

F-1.5 Lime Spray Dryer (LSD) Inputs

This section of the worksheet contains all necessary inputs needed for sizing and costing a lime spray dryer system.

	A	*B*	*C*	*D*	*E*	*K*
Row No.	**Description**	**Units**	**Suggested Range**	**Default Values**	**Input 1**	***Comments***
160						
161	***Lime Spray Dryer (LSD) Inputs***					
162						
163	SO2 Removal Required	%	90-95%	90%	90%	*User input.*
164	Adiabatic Saturation Temperature	°F	100-170	127	127	*User input.*
165	Flue Gas Approach to Saturation	°F	10.-50	20	20	*User input.*
166	Spray Dryer Outlet Temperature	°F	110-220	147	147	*Calculated from adiabatic saturation temp and approach to adsat.*
167	Reagent Feed Ratio	Factor	Calc. Based on %S	0.90	0.92	*Calculated from data supplied by LSD vendors. (mole CaO/mole inlet SO2)*
168	(Mole CaO / Mole Inlet SO2)					
169	Recycle Rate	Factor	Calculated	30	30	*Calculated from %S in coal. Lookup value from Recycle Rate Lookup Table in model*
170	(lb recycle / lb lime feed)					
171	Recycle Slurry Solids Concentration	Wt. %	10-50	35%	35%	*User input. Typical value 35%.*
172	Number of Absorbers	Integer	1-7	2	2	*Maximum capacity for an absorber is 300 MW. User input.*
173	(Max. Capacity = 300 MW per spray dryer)					
174	Absorber Material	Integer	1 or 2	1	1	*User choose either alloy or rubber lined carbon steel (RLCS).*
175	(1 = alloy, 2 = RLCS)					
176	Spray Dryer Pressure Drop	in. H2O		5	5	*User input. Typical value 5*
177	Reagent Bulk Storage	Days		60	60	*User input. Typical value 60 days*
178	Reagent Cost (delivered)	$/ton		$65	$65	*User input.*
179	Dry Waste Disposal Cost	$/ton		$30	$30	*User input.*

180	Maintenance Factors by Area (% of Installed Cost)					
181	Reagent Feed	%		5%	5%	*These percentages are applied to the total cost of the system.*
182	SO2 Removal	%		5%	5%	*These percentages are applied to the total cost of the system.*
183	Flue Gas Handling	%		5%	5%	*These percentages are applied to the total cost of the system.*
184	Waste / Byproduct	%		5%	5%	*These percentages are applied to the total cost of the system.*
185	Support Equipment	%		5%	5%	*These percentages are applied to the total cost of the system.*
186	Contingency by Area (% of Installed Cost)					
187	Reagent Feed	%		20%	20%	*These percentages are applied on a system basis.*
188	SO2 Removal	%		20%	20%	*These percentages are applied on a system basis.*
189	Flue Gas Handling	%		20%	20%	*These percentages are applied on a system basis.*
190	Waste / Byproduct	%		20%	20%	*These percentages are applied on a system basis.*
191	Support Equipment	%		20%	20%	*These percentages are applied on a system basis.*
192	General Facilities by Area (% of Installed Cost)					
193	Reagent Feed	%		10%	10%	*These percentages are applied on a system basis.*
194	SO2 Removal	%		10%	10%	*These percentages are applied on a system basis.*
195	Flue Gas Handling	%		10%	10%	*These percentages are applied on a system basis.*
196	Waste / Byproduct	%		10%	10%	*These percentages are applied on a system basis.*
197	Support Equipment	%		10%	10%	*These percentages are applied on a system basis.*
198	Engineering Fees by Area (% of Installed Cost)					
199	Reagent Feed	%		10%	10%	*These percentages are applied on a system basis.*
200	SO2 Removal	%		10%	10%	*These percentages are applied on a system basis.*
201	Flue Gas Handling	%		10%	10%	*These percentages are applied on a system basis.*
202	Waste / Byproduct	%		10%	10%	*These percentages are applied on a system basis.*
203	Support Equipment	%		10%	10%	*These percentages are applied on a system basis.*

F-1.6 Particulate Control Inputs

This section of the worksheet contains all of the inputs needed for sizing and costing fabric filters (reverse-gas or pulse-jet) and electrostatic precipitators (ESP).

	A	B	C	D	E	K
Row No.	Description	Units	Suggested Range	Default Values	Input 1	Comments
204						
205	***Particulate Control Inputs***					
206						
207	**Outlet Particulate Emission Limit**	lbs/MMBtu		0.03	0.03	*User input.*
208	**Fabric Filter:**					
209	Pressure Drop	in. H2O		6	6	*User input.*
210	Type (1 = Reverse Gas, 2 = Pulse Jet)	Integer		2	2	*User input.*
211	Gas-to-Cloth Ratio	ACFM/ft^2		3.5	3.5	*User input.*
212	Bag Material (RGFF fiberglass only)	Integer		2	2	*User input.*
213	(1 = Fiberglass, 2 = Nomex, 3 = Ryton)					
214	Bag Diameter	inches	5 - 14	6	6	*User input.*
215	Bag Length	feet	15 - 35	20	20	*User input.*
216	Bag Reach			3	3	*User input.*
217	Compartments out of Service	%		10%	10%	*User input.*
218	Bag Life	Years	1 - 10	5	5	*User input.*
219	Maintenance (% of installed cost)	%		5%	5%	*User input.*
220	Contingency (% of installed cost)	%		20%	20%	*User input.*
221	General Facilities (% of installed cost)	%		10%	10%	*User input.*
222	Engineering Fees (% of installed cost)	%		10%	10%	*User input.*
223	**ESP:**					
224	Strength of the electric field in the ESP = *E*	kV/cm		10.0	10.0	*User input.*
225	Plate Spacing	in.		12	12	*User input.*
226	Plate Height	ft.		36	36	*User input.*
227	Pressure Drop	in. H2O		3	3	*User input.*
228	Maintenance (% of installed cost)	%		5%	5%	*User input.*
229	Contingency (% of installed cost)	%		20%	20%	*User input.*
230	General Facilities (% of installed cost)	%		10%	10%	*User input.*
231	Engineering Fees (% of installed cost)	%		10%	10%	*User input.*

F-1.7 NOx Control Inputs

This section of the worksheet contains all of the inputs needed for sizing and costing the NOx control technologies (Selective Catalytic Reduction, Selective Non-Catalytic Reduction, Low NOx Burners, and Natural Gas Reburning).

Users unsure of an input can input ”D” and this worksheet will insert a default value in the calculations.

	A	B	C	D	E	K
Row No.	Description	Units	Suggested Range	Default Values	Input 1	*Comments*
232						
233	***NOx Control Inputs***					
234						
235	***Selective Catalytic Reduction (SCR) Inputs***					
236						
237	NH3/NOX Stoichiometric Ratio	NH3/NOX	0.7-1.0	0.9	D	*IAPCS Names and a list of sources are contained in columns L, M, and N.*
238	NOX Reduction Efficiency	Fraction	0.60-0.90	0.70	D	"
239	Inlet NOx	lbs/MMBtu		0.9	D	"
240	Space Velocity (Calculated if zero)	1/hr		0	D	"
241	Overall Catalyst Life	years	2-5	3	D	"
242	Ammonia Cost	$/ton		206	D	"
243	Catalyst Cost	$/ft3		356	D	"
244	Solid Waste Disposal Cost	$/ton		11.48	D	"
245	Maintenance (% of installed cost)	%		1.5%	D	"
246	Contingency (% of installed cost)	%		20%	D	"
247	General Facilities (% of installed cost)	%		5%	D	"
248	Engineering Fees (% of installed cost)	%		10%	D	"
249	Number of Reactors	integer		2	D	"
250	Number of Air Preheaters	integer		1	D	"
251						
252	***Selective NonCatalytic Reduction (SNCR) Inputs***					
253						
254	Reagent	integer	1:Urea 2:Ammonia	1	D	"
255	Number of Injector Levels	integer		3	D	"
256	Number of Injectors	integer		18	D	
257	Number of Lance Levels	integer		0	D	"
258	Number of Lances	integer		0	D	
259	Steam or Air Injection for Ammonia	integer	1: Steam, 2: Air	1	D	"

260	NOX Reduction Efficiency	fraction	0.30-0.70	0.50	D	“
261	Inlet NOx	lbs/MMBtu		0.9	D	“
262	NH3/NOX Stoichiometric Ratio	NH3/NOX	0.8-2.0	1.2	D	“
263	Urea/NOX Stoichiometric Ratio	Urea/NOX	0.8-2.0	1.2	D	“
264	Urea Cost	$/ton		225	D	“
265	Ammonia Cost	$/ton		206	D	“
266	Water Cost	$/1,000 gal		0.4	D	“
267	Maintenance (% of installed cost)	%		1.5%	D	“
268	Contingency (% of installed cost)	%		20%	D	“
269	General Facilities (% of installed cost)	%		5%	D	“
270	Engineering Fees (% of installed cost)	%		10%	D	“
271						
272	***Low NOX Burner Technology Inputs***					
273						
274	NOX Reduction Efficiency	fraction	0.15-0.60	0.35	D	“
275	Boiler Type	T:T-fired, W:Wall		T	D	“
276	Retrofit Difficulty	L:Low, A:Average, H:High		A	D	“
277	Maintenance Labor (% of installed cost)	%		0.8%	D	“
278	Maintenance Materials (% of installed cost)	%		1.2%	D	“
279						
280	***Natural Gas Reburning Inputs***					
281						
282	NOX Reduction Efficiency	fraction	0.55-0.65	0.61	D	“
283	Gas Reburn Fraction	fraction	0.08 - 0.20	0.15	D	“
284	Waste Disposal Cost	$/ton		11.48	D	“
285	Natural Gas Cost	$/MMBtu		2.31	D	“
286	Maintenance (% of installed cost)	%		1.5%	D	“
287	Contingency (% of installed cost)	%		20%	D	“
288	General Facilities (% of installed cost)	%		2%	D	“
289	Engineering Fees (% of installed cost)	%		10%	D	“

F-2.0 Input and Calculation Summary Sheet

This worksheet contains a summary of all of the technical and economic inputs and a summary of the calculated costs. If a default value is needed this worksheet inserts it to the calculation sequence. This worksheet is separated into two major categories: 1) summary of inputs and 2) summary of costs. Again, five cases are presented simultaneously in the model; however, only one case is presented here.

F-2.1 Summary of Inputs

This first section of the worksheet summarizes the user supplied inputs from the first worksheet. Users unsure of an input can input "D" and this worksheet will insert a default value in the calculations. The following table shows the equations and results for one case.

	A	*B*	*C*	
	APC Technology Choices			
			Case 1	
Row No.	**Description**	**Units**	**Results**	**Equation**
5				
6	FGD Process	Integer	1	=IF('User Input Sheet'!E45'="D",Def_FGD,'User Input Sheet'!E45)
7	(1 = LSFO, 2 = LSD)			
8	Particulate Control	Integer	1	=IF('User Input Sheet'!E47'="D",Def_PartControl,'User Input Sheet'!E47)
9	(1 = Fabric Filter, 2 = ESP)			
10	NOx Control	Integer	1	=IF('User Input Sheet'!E49'="D",Def_NOx,'User Input Sheet'!E49)
11	(1 = SCR, 2 = SNCR, 3 = LNBs, 4 = NGR)			
12				

	A	B	C	
	INPUTS			
			Case 1	
Row No.	Description	Units	Results	Equation
17				
18	***General Plant Technical Inputs***			
19				
20	Location – State	Abbrev.	PA	=IF('User Input Sheet'!E59'="D",Def_State,'User Input Sheet'!E59)
21	MW Equivalent of Flue Gas to Control System	MW	500	=IF('User Input Sheet'!E60'="D",Def_MW,'User Input Sheet'!E60)
22	Net Plant Heat Rate	Btu/kWhr	10,500	=IF('User Input Sheet'!E61'="D",Def_NPHR,'User Input Sheet'!E61)
23	Plant Capacity Factor	%	65%	=IF('User Input Sheet'!E62'="D",Def_CapFact,'User Input Sheet'!E62)
24	Total Air Downstream of Economizer	%	120%	=IF('User Input Sheet'!E63'="D",Def_TotAir,'User Input Sheet'!E63)
25	Air Heater Leakage	%	12%	=IF('User Input Sheet'!E64'="D",Def_AHLeak,'User Input Sheet'!E64)
26	Air Heater Outlet Gas Temperature	°F	300	=IF('User Input Sheet'!E65'="D",Def_AHOutTemp,'User Input Sheet'!E65)
27	Inlet Air Temperature	°F	80	=IF('User Input Sheet'!E66'="D",Def_InAirTemp,'User Input Sheet'!E66)
28	Ambient Absolute Pressure	In. of Hg	29.4	=IF('User Input Sheet'!E67'="D",Def_AmbPress,'User Input Sheet'!E67)
29	Pressure After Air Heater	In. of H2O	-12	=IF('User Input Sheet'!E68'="D",Def_AHoutPress,'User Input Sheet'!E68)
30	Moisture in Air	lb/lb dry air	0.013	=IF('User Input Sheet'!E69'="D",Def_AirH2O,'User Input Sheet'!E69)
31	Ash Split:			
32	Fly Ash	%	80%	=IF('User Input Sheet'!E71'="D",Def_FlyAsh,'User Input Sheet'!E71)
33	Bottom Ash	%	20%	=IF('User Input Sheet'!E72'="D",Def_BotAsh,'User Input Sheet'!E72)
34	Seismic Zone	Integer	1	=IF('User Input Sheet'!E73'="D",Def_SeisZone,'User Input Sheet'!E73)
35	Retrofit Factor	Integer	1.3	=IF('User Input Sheet'!E74'="D",Def_RetroFact,'User Input Sheet'!E74)
36	(1.0 = new, 1.3 = medium, 1.6 = difficult)			
37	Select Coal	Integer	1	=IF('User Input Sheet'!E76'="D",Def_Coal,'User Input Sheet'!E76)
38	Is Selected Coal a Powder River Basin Coal?	Yes / No	Yes	=IF('User Input Sheet'!E77'="D",Def_PRB,'User Input Sheet'!E77)
39				

40	***Economic Inputs***			
41				
42	Cost Basis -Year Dollars	Year	1998	=IF('User Input Sheet'!E89'="D",Def_CostBasis,'User Input Sheet'!E89)
43	Sevice Life (levelization period)	Years	30	=IF('User Input Sheet'!E90'="D",Def_SerLife,'User Input Sheet'!E90)
44	Inflation Rate	%	3%	=IF('User Input Sheet'!E91'="D",Def_MAR,'User Input Sheet'!E91)
45	After Tax Discount Rate (current $'s)	%	9%	=IF('User Input Sheet'!E92'="D",Def_DiscRate,'User Input Sheet'!E92)
46	AFDC Rate (current $'s)	%	11%	=IF('User Input Sheet'!E93'="D",Def_AFDC,'User Input Sheet'!E93)
47	First-year Carrying Charge (current $'s)	%	22%	=IF('User Input Sheet'!E94'="D",Def_FYCC_curr,'User Input Sheet'!E94)
48	Levelized Carrying Charge (current $'s)	%	17%	=IF('User Input Sheet'!E95'="D",Def_LCC_curr,'User Input Sheet'!E95)
49	First-year Carrying Charge (constant $'s)	%	16%	=IF('User Input Sheet'!E96'="D",Def_FYCC_const,'User Input Sheet'!E96)
50	Levelized Carrying Charge (constant $'s)	%	12%	=IF('User Input Sheet'!E97'="D",Def_LCC_const,'User Input Sheet'!E97)
51	Sales Tax	%	6%	=IF('User Input Sheet'!E98'="D",Def_SalesTax,'User Input Sheet'!E98)
52	Escalation Rates:			
53	Consumables (O&M)	%	3%	=IF('User Input Sheet'!E100'="D",Def_Esc_Consum,'User Input Sheet'!E100)
54	Capital Costs:			
55	Is Chem. Eng. Cost Index available?	Yes / No	Yes	=IF('User Input Sheet'!E102'="D",Def_Cap_Esc,'User Input Sheet'!E102)
56	If "Yes" input cost basis CE Plant Index.	Integer	388	=IF('User Input Sheet'!E103'="D",Def_CEIndex,'User Input Sheet'!E103)
57	If "No" input escalation rate.	%	3%	=IF('User Input Sheet'!E104'="D",Def_Cap_ER,'User Input Sheet'!E104)
58	Construction Labor Rate	$/hr	$35	=IF('User Input Sheet'!E105'="D",Def_CnstrLabor,'User Input Sheet'!E105)
59	Prime Contractor's Markup	%	3%	=IF('User Input Sheet'!E106'="D",Def_PCMarkup,'User Input Sheet'!E106)
60	Operating Labor Rate	$/hr	$30	=IF('User Input Sheet'!E107'="D",Def_OperLabor,'User Input Sheet'!E107)
61	Power Cost	Mills/kWh	25	=IF('User Input Sheet'!E108'="D",Def_PowerCost,'User Input Sheet'!E108)
62	Steam Cost	$/1000 lbs	3.5	=IF('User Input Sheet'!E109'="D",Def_SteamCost,'User Input Sheet'!E109)
63				
64	***Limestone Forced Oxidation (LSFO) Inputs***			
65				
66	SO2 Removal Required	%	95%	=IF('User Input Sheet'!E113'="D",LSFO_SO2Rem,'User Input Sheet'!E113)
67	L/G Ratio	gal / 1000 acf	125	=IF('User Input Sheet'!E114'="D",LSFO_LGRatio,'User Input Sheet'!E114)
68	Design Scrubber with Dibasic Acid Addition?	Integer	2	=IF('User Input Sheet'!E115'="D",LSFO_DBA,'User Input Sheet'!E115)
69	(1 = yes, 2 = no)			

70	Adiabatic Saturation Temperature	°F	127	=IF('User Input Sheet'!E117'="D",LSFO_AdSat,'User Input Sheet'!E117)
71	Reagent Feed Ratio	Factor	1.05	=IF('User Input Sheet'!E118'="D",LSFO_ReagRatio,'User Input Sheet'!E118)
72	(Mole CaCO3 / Mole SO2 removed)			
73	Scrubber Slurry Solids Concentration	Wt. %	15%	=IF('User Input Sheet'!E120'="D",LSFO_ScrubSlurry,'User Input Sheet'!E120)
74	Stacking, Landfill, Wallboard	Integer	1	=IF('User Input Sheet'!E121'="D",LSFO_Disposal,'User Input Sheet'!E121)
75	(1 = stacking, 2 = lanfill, 3 = wallboard)			
76	Number of Absorbers	Integer	1	=IF('User Input Sheet'!E123'="D",LSFO_NoAbsorb,'User Input Sheet'!E123)
77	(Max. Capacity = 700 MW per absorber)			
78	Absorber Material	Integer	1	=IF('User Input Sheet'!E125'="D",LSFO_AbsorbMatl,'User Input Sheet'!E125)
79	(1 = alloy, 2 = RLCS)			
80	Absorber Pressure Drop	in. H2O	6	=IF('User Input Sheet'!E127'="D",LSFO_AbsorbDelP,'User Input Sheet'!E127)
81	Reheat Required ?	Integer	1	=IF('User Input Sheet'!E128'="D",LSFO_Reheat,'User Input Sheet'!E128)
82	(1 = yes, 2 = no)			
83	Amount of Reheat	°F	25	=IF(C81'=2,0,IF('User Input Sheet'!E130'="D",LSFO_ReheatTemp,'User Input Sheet'!E130))
84	Reagent Bulk Storage	Days	60	=IF('User Input Sheet'!E131'="D",LSFO_ReagStor,'User Input Sheet'!E131)
85	Reagent Cost (delivered)	$/ton	$15	=IF('User Input Sheet'!E132'="D",LSFO_ReagCost,'User Input Sheet'!E132)
86	Landfill Disposal Cost	$/ton	$30	=IF('User Input Sheet'!E133'="D",LSFO_LandfillCost,'User Input Sheet'!E133)
87	Stacking Disposal Cost	$/ton	$6	=IF('User Input Sheet'!E134'="D",LSFO_StackCost,'User Input Sheet'!E134)
88	Credit for Gypsum Byproduct	$/ton	$2	=IF('User Input Sheet'!E135'="D",LSFO_GypsumCredit,'User Input Sheet'!E135)
89	Maintenance Factors by Area (% of Installed Cost)			
90	Reagent Feed	%	5%	=IF('User Input Sheet'!E137'="D",LSFO_Maint1,'User Input Sheet'!E137)
91	SO2 Removal	%	5%	=IF('User Input Sheet'!E138'="D",LSFO_Maint2,'User Input Sheet'!E138)
92	Flue Gas Handling	%	5%	=IF('User Input Sheet'!E139'="D",LSFO_Maint3,'User Input Sheet'!E139)
93	Waste / Byproduct	%	5%	=IF('User Input Sheet'!E140'="D",LSFO_Maint4,'User Input Sheet'!E140)
94	Support Equipment	%	5%	=IF('User Input Sheet'!E141'="D",LSFO_Maint5,'User Input Sheet'!E141)
95	Contingency by Area (% of Installed Cost)			
96	Reagent Feed	%	20%	=IF('User Input Sheet'!E143'="D",LSFO_Conting1,'User Input Sheet'!E143)
97	SO2 Removal	%	20%	=IF('User Input Sheet'!E144'="D",LSFO_Conting2,'User Input Sheet'!E144)

98	Flue Gas Handling	%	20%	=IF('User Input Sheet'!E145'="D",LSFO_Conting3,'User Input Sheet'!E145)
99	Waste / Byproduct	%	20%	=IF('User Input Sheet'!E146'="D",LSFO_Conting4,'User Input Sheet'!E146)
100	Support Equipment	%	20%	=IF('User Input Sheet'!E147'="D",LSFO_Conting5,'User Input Sheet'!E147)
101	General Facilities by Area (% of Installed Cost)			
102	Reagent Feed	%	10%	=IF('User Input Sheet'!E149'="D",LSFO_Facil1,'User Input Sheet'!E149)
103	SO2 Removal	%	10%	=IF('User Input Sheet'!E150'="D",LSFO_Facil2,'User Input Sheet'!E150)
104	Flue Gas Handling	%	10%	=IF('User Input Sheet'!E151'="D",LSFO_Facil3,'User Input Sheet'!E151)
105	Waste / Byproduct	%	10%	=IF('User Input Sheet'!E152'="D",LSFO_Facil4,'User Input Sheet'!E152)
106	Support Equipment	%	10%	=IF('User Input Sheet'!E153'="D",LSFO_Facil5,'User Input Sheet'!E153)
107	Engineering Fees by Area (% of Installed Cost)			
108	Reagent Feed	%	10%	=IF('User Input Sheet'!E155'="D",LSFO_EngHO1,'User Input Sheet'!E155)
109	SO2 Removal	%	10%	=IF('User Input Sheet'!E156'="D",LSFO_EngHO2,'User Input Sheet'!E156)
110	Flue Gas Handling	%	10%	=IF('User Input Sheet'!E157'="D",LSFO_EngHO3,'User Input Sheet'!E157)
111	Waste / Byproduct	%	10%	=IF('User Input Sheet'!E158'="D",LSFO_EngHO4,'User Input Sheet'!E158)
112	Support Equipment	%	10%	=IF('User Input Sheet'!E159'="D",LSFO_EngHO5,'User Input Sheet'!E159)
113				
114	***Lime Spray Dryer (LSD) Inputs***			
115				
116	SO2 Removal Required	%	90%	=IF('User Input Sheet'!E163'="D",LSD_SO2Rem,'User Input Sheet'!E163)
117	Adiabatic Saturation Temperature	°F	127	=IF('User Input Sheet'!E164'="D",LSD_AdSat,'User Input Sheet'!E164)
118	Flue Gas Approach to Saturation	°F	20	=IF('User Input Sheet'!E165'="D",LSD_ApptoSat,'User Input Sheet'!E165)
119	Spray Dryer Outlet Temperature	°F	147	=IF('User Input Sheet'!E166'="D",LSD_OutTemp,'User Input Sheet'!E166)
120	Reagent Feed Ratio	Factor	0.92	=IF('User Input Sheet'!E167'="D",LSD_ReagRatio,'User Input Sheet'!E167)
121	(Mole CaO / Mole Inlet SO2)			
122	Recycle Rate	Factor	30	=IF('User Input Sheet'!E169'="D",LSD_Recycle,'User Input Sheet'!E169)
123	(lb recycle / lb lime feed)			
124	Recycle Slurry Solids Concentration	Wt. %	35%	=IF('User Input Sheet'!E171'="D",LSD_RecycleConc,'User Input Sheet'!E171)
125	Number of Absorbers	Integer	2	=IF('User Input Sheet'!E172'="D",LSD_NoAbsorb,'User Input Sheet'!E172)
126	(Max. Capacity = 300 MW per spray dryer)			

127	Absorber Material	Integer	1	=IF('User Input Sheet'!E174'="D",LSD_AbsorbMatl,'User Input Sheet'!E174)
128	(1 = alloy, 2 = RLCS)			
129	Spray Dryer Pressure Drop	in. H2O	5	=IF('User Input Sheet'!E176'="D",LSD_DelP,'User Input Sheet'!E176)
130	Reagent Bulk Storage	Days	60	=IF('User Input Sheet'!E177'="D",LSD_ReagStor,'User Input Sheet'!E177)
131	Reagent Cost (delivered)	$/ton	$65	=IF('User Input Sheet'!E178'="D",LSD_ReagCost,'User Input Sheet'!E178)
132	Dry Waste Disposal Cost	$/ton	$30	=IF('User Input Sheet'!E179'="D",LSD_DispCost,'User Input Sheet'!E179)
133	Maintenance Factors by Area (% of Installed Cost)			
134	Reagent Feed	%	5%	=IF('User Input Sheet'!E181'="D",LSD_Maint1,'User Input Sheet'!E181)
135	SO2 Removal	%	5%	=IF('User Input Sheet'!E182'="D",LSD_Maint2,'User Input Sheet'!E182)
136	Flue Gas Handling	%	5%	=IF('User Input Sheet'!E183'="D",LSD_Maint3,'User Input Sheet'!E183)
137	Waste / Byproduct	%	5%	=IF('User Input Sheet'!E184'="D",LSD_Maint4,'User Input Sheet'!E184)
138	Support Equipment	%	5%	=IF('User Input Sheet'!E185'="D",LSD_Maint5,'User Input Sheet'!E185)
139	Contingency by Area (% of Installed Cost)			
140	Reagent Feed	%	20%	=IF('User Input Sheet'!E187'="D",LSD_Conting1,'User Input Sheet'!E187)
141	SO2 Removal	%	20%	=IF('User Input Sheet'!E188'="D",LSD_Conting2,'User Input Sheet'!E188)
142	Flue Gas Handling	%	20%	=IF('User Input Sheet'!E189'="D",LSD_Conting3,'User Input Sheet'!E189)
143	Waste / Byproduct	%	20%	=IF('User Input Sheet'!E190'="D",LSD_Conting4,'User Input Sheet'!E190)
144	Support Equipment	%	20%	=IF('User Input Sheet'!E191'="D",LSD_Conting5,'User Input Sheet'!E191)
145	General Facilities by Area (% of Installed Cost)			
146	Reagent Feed	%	10%	=IF('User Input Sheet'!E193'="D",LSD_Facil1,'User Input Sheet'!E193)
147	SO2 Removal	%	10%	=IF('User Input Sheet'!E194'="D",LSD_Facil2,'User Input Sheet'!E194)
148	Flue Gas Handling	%	10%	=IF('User Input Sheet'!E195'="D",LSD_Facil3,'User Input Sheet'!E195)
149	Waste / Byproduct	%	10%	=IF('User Input Sheet'!E196'="D",LSD_Facil4,'User Input Sheet'!E196)
150	Support Equipment	%	10%	=IF('User Input Sheet'!E197'="D",LSD_Facil5,'User Input Sheet'!E197)
151	Engineering Fees by Area (% of Installed Cost)			
152	Reagent Feed	%	10%	=IF('User Input Sheet'!E199'="D",LSD_EngHO1,'User Input Sheet'!E199)
153	SO2 Removal	%	10%	=IF('User Input Sheet'!E200'="D",LSD_EngHO2,'User Input Sheet'!E200)
154	Flue Gas Handling	%	10%	=IF('User Input Sheet'!E201'="D",LSD_EngHO3,'User Input Sheet'!E201)
155	Waste / Byproduct	%	10%	=IF('User Input Sheet'!E202'="D",LSD_EngHO4,'User Input Sheet'!E202)

156	Support Equipment	%	10%	=IF('User Input Sheet'!E203'="D",LSD_EngHO5,'User Input Sheet'!E203)
157				
158	***Particulate Control Inputs***			
159				
160	**Outlet Particulate Emission Limit**	lbs/MMBtu	0.03	=IF('User Input Sheet'!E207'="D",Def_PartLimit,'User Input Sheet'!E207)
161	**Fabric Filter:**			
162	Pressure Drop	in. H2O	6	=IF('User Input Sheet'!E209'="D",FF_PDrop,'User Input Sheet'!E209)
163	Type (1 = Reverse Gas, 2 = Pulse Jet)	Integer	2	=IF('User Input Sheet'!E210'="D",Def_FF,'User Input Sheet'!E210)
164	Gas-to-Cloth Ratio	ACFM/ft^2	3.5	=IF('User Input Sheet'!E211'="D",Def_GastoCloth,'User Input Sheet'!E211)
165	Bag Material (RGFF fiberglass only)	Integer	2	=IF('User Input Sheet'!E212'="D",Def_FabType,'User Input Sheet'!E212)
166	(1 = Fiberglass, 2 = Nomex, 3 = Ryton)			
167	Bag Diameter	Inches	6	=IF('User Input Sheet'!E214'="D",Def_BagDia,'User Input Sheet'!E214)
168	Bag Length	Feet	20	=IF('User Input Sheet'!E215'="D",Def_BagLength,'User Input Sheet'!E215)
169	Bag Reach		3	=IF('User Input Sheet'!E216'="D",Def_BagReach,'User Input Sheet'!E216)
170	Compartments out of Service	%	10%	=IF('User Input Sheet'!E217'="D",Def_FFSparing,'User Input Sheet'!E217)
171	Bag Life	Years	5	=IF('User Input Sheet'!E218'="D",Def_BagLife,'User Input Sheet'!E218)
172	Maintenance (% of installed cost)	%	5%	=IF('User Input Sheet'!E219'="D",Def_FFMaint,'User Input Sheet'!E219)
173	Contingency (% of installed cost)	%	20%	=IF('User Input Sheet'!E220'="D",Def_FFCont,'User Input Sheet'!E220)
174	General Facilities (% of installed cost)	%	10%	=IF('User Input Sheet'!E221'="D",Def_FFGenFac,'User Input Sheet'!E221)
175	Engineering Fees (% of installed cost)	%	10%	=IF('User Input Sheet'!E222'="D",Def_FFEng,'User Input Sheet'!E222)
176	**ESP:**			
177	Strength of the electric field in the ESP = *E*	KV/cm	10.0	=IF('User Input Sheet'!E224'="D",Def_ESP_EFS,'User Input Sheet'!E224)
178	Plate Spacing	In.	12	=IF('User Input Sheet'!E225'="D",Def_Plate_Space,'User Input Sheet'!E225)
179	Plate Height	Ft.	36	=IF('User Input Sheet'!E226'="D",Def_Plate_Ht,'User Input Sheet'!E226)
180	Pressure Drop	In. H2O	3	=IF('User Input Sheet'!E227'="D",ESP_PDrop,'User Input Sheet'!E227)
181	Maintenance (% of installed cost)	%	5%	=IF('User Input Sheet'!E228'="D",Def_ESPMaint,'User Input Sheet'!E228)
182	Contingency (% of installed cost)	%	20%	=IF('User Input Sheet'!E229'="D",Def_ESPCont,'User Input Sheet'!E229)
183	General Facilities (% of installed cost)	%	10%	=IF('User Input Sheet'!E230'="D",Def_ESPGenFac,'User Input Sheet'!E230)
184	Engineering Fees (% of installed cost)	%	10%	=IF('User Input Sheet'!E231'="D",Def_ESPEng,'User Input Sheet'!E231)
185				

186	***NOx Control Inputs***			
187				
188	***Selective Catalytic Reduction (SCR) Inputs***			
189				
190	NH3/NOX Stoichiometric Ratio	NH3/NOX	0.9	=IF('User Input Sheet'!E237'="D",'User Input Sheet'!$D237,'User Input Sheet'!E237)
191	NOX Reduction Efficiency	Fraction	0.70	=IF('User Input Sheet'!E238'="D",'User Input Sheet'!$D238,'User Input Sheet'!E238)
192	Inlet NOx	lbs/MMBtu	0.9	=IF('User Input Sheet'!E239'="D",'User Input Sheet'!$D239,'User Input Sheet'!E239)
193	Space Velocity (Calculated if zero)	1/hr	0	=IF('User Input Sheet'!E240'="D",'User Input Sheet'!$D240,'User Input Sheet'!E240)
194	Overall Catalyst Life	Years	3	=IF('User Input Sheet'!E241'="D",'User Input Sheet'!$D241,'User Input Sheet'!E241)
195	Ammonia Cost	$/ton	205.66	=IF('User Input Sheet'!E242'="D",'User Input Sheet'!$D242,'User Input Sheet'!E242)
196	Catalyst Cost	$/ft3	356.34	=IF('User Input Sheet'!E243'="D",'User Input Sheet'!$D243,'User Input Sheet'!E243)
197	Solid Waste Disposal Cost	$/ton	11.48	=IF('User Input Sheet'!E244'="D",'User Input Sheet'!$D244,'User Input Sheet'!E244)
198	Maintenance (% of installed cost)	%	1.5%	=IF('User Input Sheet'!E245'="D",'User Input Sheet'!$D245,'User Input Sheet'!E245)
199	Contingency (% of installed cost)	%	20%	=IF('User Input Sheet'!E246'="D",'User Input Sheet'!$D246,'User Input Sheet'!E246)
200	General Facilities (% of installed cost)	%	5%	=IF('User Input Sheet'!E247'="D",'User Input Sheet'!$D247,'User Input Sheet'!E247)
201	Engineering Fees (% of installed cost)	%	10%	=IF('User Input Sheet'!E248'="D",'User Input Sheet'!$D248,'User Input Sheet'!E248)
202	Number of Reactors	Integer	2	=IF('User Input Sheet'!E249'="D",'User Input Sheet'!$D249,'User Input Sheet'!E249)
203	Number of Air Preheaters	Integer	1	=IF('User Input Sheet'!E250'="D",'User Input Sheet'!$D250,'User Input Sheet'!E250)
204				
205	***Selective NonCatalytic Reduction (SNCR) Inputs***			
206				
207	Reagent	1:Urea 2:Ammonia	1	=IF('User Input Sheet'!E254'="D",'User Input Sheet'!$D254,'User Input Sheet'!E254)
208	Number of Injector Levels	Integer	3	=IF('User Input Sheet'!E255'="D",'User Input Sheet'!$D255,'User Input Sheet'!E255)
209	Number of Injectors	Integer	18	=IF('User Input Sheet'!E256'="D",'User Input Sheet'!$D256,'User Input Sheet'!E256)
210	Number of Lance Levels	Integer	0	=IF('User Input Sheet'!E257'="D",'User Input Sheet'!$D257,'User Input Sheet'!E257)
211	Number of Lances	Integer	0	=IF('User Input Sheet'!E258'="D",'User Input Sheet'!$D258,'User Input Sheet'!E258)
212	Steam or Air Injection for Ammonia	Integer	1	=IF('User Input Sheet'!E259'="D",'User Input Sheet'!$D259,'User Input Sheet'!E259)
213	NOX Reduction Efficiency	Fraction	0.50	=IF('User Input Sheet'!E260'="D",'User Input Sheet'!$D260,'User Input Sheet'!E260)

214	Inlet NOx	lbs/MMBtu	0.9	=IF('User Input Sheet'!E261'="D",'User Input Sheet'!$D261,'User Input Sheet'!E261)
215	NH3/NOX Stoichiometric Ratio	NH3/NOX	1.2	=IF('User Input Sheet'!E262'="D",'User Input Sheet'!$D262,'User Input Sheet'!E262)
216	Urea/NOX Stoichiometric Ratio	Urea/NOX	1.2	=IF('User Input Sheet'!E263'="D",'User Input Sheet'!$D263,'User Input Sheet'!E263)
217	Urea Cost	$/ton	225	=IF('User Input Sheet'!E264'="D",'User Input Sheet'!$D264,'User Input Sheet'!E264)
218	Ammonia Cost	$/ton	205.66	=IF('User Input Sheet'!E265'="D",'User Input Sheet'!$D265,'User Input Sheet'!E265)
219	Water Cost	$/1,000 gal	0.407	=IF('User Input Sheet'!E266'="D",'User Input Sheet'!$D266,'User Input Sheet'!E266)
220	Maintenance (% of installed cost)	%	1.5%	=IF('User Input Sheet'!E267'="D",'User Input Sheet'!$D267,'User Input Sheet'!E267)
221	Contingency (% of installed cost)	%	20%	=IF('User Input Sheet'!E268'="D",'User Input Sheet'!$D268,'User Input Sheet'!E268)
222	General Facilities (% of installed cost)	%	5%	=IF('User Input Sheet'!E269'="D",'User Input Sheet'!$D269,'User Input Sheet'!E269)
223	Engineering Fees (% of installed cost)	%	10%	=IF('User Input Sheet'!E270'="D",'User Input Sheet'!$D270,'User Input Sheet'!E270)
224				
225	***Low NOX Burner Technology Inputs***			
226				
227	NOX Reduction Efficiency	fraction	0.35	=IF('User Input Sheet'!E274'="D",'User Input Sheet'!$D274,'User Input Sheet'!E274)
228	Boiler Type	T:T-fired, W:Wall	T	=IF('User Input Sheet'!E275'="D",'User Input Sheet'!$D275,'User Input Sheet'!E275)
229	Retrofit Difficulty	L:Low, A:Average, H:High	A	=IF('User Input Sheet'!E276'="D",'User Input Sheet'!$D276,'User Input Sheet'!E276)
230	Maintenance Labor (% of installed cost)	%	0.8%	=IF('User Input Sheet'!E277'="D",'User Input Sheet'!$D277,'User Input Sheet'!E277)
231	Maintenance Materials (% of installed cost)	%	1.2%	=IF('User Input Sheet'!E278'="D",'User Input Sheet'!$D278,'User Input Sheet'!E278)
232				
233	***Natural Gas Reburning Inputs***			
234				
235	NOX Reduction Efficiency	fraction	0.61	=IF('User Input Sheet'!E282'="D",'User Input Sheet'!$D282,'User Input Sheet'!E282)
236	Gas Reburn Fraction	fraction	0.15	=IF('User Input Sheet'!E283'="D",'User Input Sheet'!$D283,'User Input Sheet'!E283)
237	Waste Disposal Cost	$/ton	11.48	=IF('User Input Sheet'!E284'="D",'User Input Sheet'!$D284,'User Input Sheet'!E284)
238	Natural Gas Cost	$/MMBtu	2.31	=IF('User Input Sheet'!E285'="D",'User Input Sheet'!$D285,'User Input Sheet'!E285)
239	Maintenance (% of installed cost)	%	1.5%	=IF('User Input Sheet'!E286'="D",'User Input Sheet'!$D286,'User Input Sheet'!E286)
240	Contingency (% of installed cost)	%	20%	=IF('User Input Sheet'!E287'="D",'User Input Sheet'!$D287,'User Input Sheet'!E287)
241	General Facilities (% of installed cost)	%	2%	=IF('User Input Sheet'!E288'="D",'User Input Sheet'!$D288,'User Input Sheet'!E288)
242	Engineering Fees (% of installed cost)	%	10%	=IF('User Input Sheet'!E289'="D",'User Input Sheet'!$D289,'User Input Sheet'!E289)

F-2.2 Summary of Costs

This section of the worksheet contains the summary of calculated costs for all three air pollution control technologies. Total capital requirement is presented in total dollars ($) and also dollars per kilowatt ($/kW). First year costs, levelized current dollars, and levelized constant dollars are also presented. Levelized costs are presented as dollars per kilowatt-year ($/kW-yr) and mills per kilowatt-hour (Mills/kWH). The following table shows the equations and results for one case.

	A	B	C	
	SUMMARY OF COSTS			
			Case 1	
Row No.	**Description**	**Units**	**Results**	**Equation**
259				
260	***APC Technologies***			
261	NOx Control		SCR	=IF(C10'=1,"SCR",IF(C10'=2,"SNCR",IF(C10'=3,"LNCFS and LNBs","NGR")))
262	Particulate Control		PJFF	=IF(C8'=2,"ESP",IF(C163'=1,"RGFF","PJFF"))
263	SO2 Control		LSFO	=IF(C6'=1,"LSFO","LSD")
264				
265	***NOx Control Costs***		SCR	=C261
266	**Total Capital Requirement (TCR)**	$	$38,520,826	=IF(C10'=1,'NOX Cost & Tech. Results'!D43,IF(C10'=2,'NOX Cost & Tech. Results'!D97,IF(C10'=3,'NOX Cost & Tech. Results'!D121,'NOX Cost & Tech. Results'!D166)))
267		$/kW	$77.0	=IF(C10'=1,'NOX Cost & Tech. Results'!D44,IF(C10'=2,'NOX Cost & Tech. Results'!D98,IF(C10'=3,'NOX Cost & Tech. Results'!D122,'NOX Cost & Tech. Results'!D167)))
268	**First Year Costs**			
269	*Fixed O&M*	$	$511,694	=IF(C$10'=1,'NOX Cost & Tech. Results'!D56+'NOX Cost & Tech. Results'!D57,IF(C$10'=2,'NOX Cost & Tech. Results'!D105+'NOX Cost & Tech. Results'!D106,IF(C$10'=3,'NOX Cost & Tech. Results'!D129+'NOX Cost & Tech. Results'!D130+'NOX Cost & Tech. Results'!D131
270		$/kW-Yr	1.02	=C269/(C$21*1000)
271		Mills/kWH	0.18	=C269/(C$21*1000*8760*C$23)*1000
272		$/ton NOx removed	$180	=C269/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Constants_CC!E
273	*Variable O&M*	$	$4,722,209	=IF(C$10'=1,'NOX Cost & Tech. Results'!D51+'NOX Cost & Tech. Results'!D52+'NOX Cost

	A	B	C	
				& Tech. Results'!D53+'NOX Cost & Tech. Results'!D54+'NOX Cost & Tech. Results'!D55,IF(C$10'=2,'NOX Cost & Tech. Results'!D107+'NOX Cost & Tech. Results'!D108+'NOX Cost & T
274		$/kW-Yr	9.44	=C273/(C$21*1000)
275		Mills/kWH	1.66	=C273/(C$21*1000*8760*C$23)*1000
276		$/ton NOx removed	$1,662	=C273/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Constants_CC!E
277	*Fixed Charges*	$	$8,590,144	=C266*C$47
278		$/kW-Yr	17.18	=C277/(C$21*1000)
279		Mills/kWH	3.02	=C277/(C$21*1000*8760*C$23)*1000
280		$/ton NOx removed	$3,024	=C277/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Constants_CC!E
281	*TOTAL*	$	$13,824,048	=C269+C273+C277
282		$/kW-Yr	27.65	=C270+C274+C278
283		Mills/kWH	4.86	=C271+C275+C279
284		$/ton NOx removed	$4,866	=C272+C276+C280
285	**Levelized Current Dollars**			
286	*Fixed O&M*	$/kW-Yr	1.39	=C270*Constants_CC!E$537
287		Mills/kWH	0.24	=C271*Constants_CC!E$537
288		$/ton NOx removed	$245	=C286*C$21*1000/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Cons
289	*Variable O&M*	$/kW-Yr	12.85	=C274*Constants_CC!E$537
290		Mills/kWH	2.26	=C275*Constants_CC!E$537
291		$/ton NOx removed	$2,262	=C289*C$21*1000/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Cons

292	*Fixed Charges*	$/kW-Yr	13.02	=C278/C$47*C$48
293		Mills/kWH	2.29	=C279/C$47*C$48
294		$/ton NOx removed	$2,292	=C$280/C$47*C$48
295	*TOTAL*	$/kW-Yr	27.26	=C286+C289+C292
296		Mills/kWH	4.79	=C287+C290+C293
297		$/ton NOx removed	$4,799	=C288+C291+C294
298	**Levelized Constant Dollars**			
299	*Fixed O&M*	$/kW-Yr	1.02	=C270*Constants_CC!E$547
300		Mills/kWH	0.18	=C271*Constants_CC!E$547
301		$/ton NOx removed	$180	=C299*C$21*1000/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Cons
302	*Variable O&M*	$/kW-Yr	9.44	=C274*Constants_CC!E$547
303		Mills/kWH	1.66	=C275*Constants_CC!E$547
304		$/ton NOx removed	$1,662	=C302*C$21*1000/IF(C$10'=1,C$191*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=2,C$213*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,IF(C$10'=3,C$227*Constants_CC!E$410*Constants_CC!E$491*8760/2000*C$23,C$235*Constants_CC!E$410*Cons
305	*Fixed Charges*	$/kW-Yr	12.80	=C278/C$49*C$50
306		Mills/kWH	2.25	=C279/C$49*C$50
307		$/ton NOx removed	$2,254	=C$280/C$49*C$50
308	*TOTAL*	$/kW-Yr	23.27	=C299+C302+C305
309		Mills/kWH	4.09	=C300+C303+C306
310		$/ton NOx removed	$4,096	=C301+C304+C307
311				

312	***Particulate Control Costs***		PJFF	=C262
313	**Total Capital Requirement (TCR)**	$	$29,940,372	=IF(C$8'=2,'FF ESP Cost & Tech. Results'!D228,'FF ESP Cost & Tech. Results'!D82)
314		$/kW	$60	=IF(C$8'=2,'FF ESP Cost & Tech. Results'!D229,'FF ESP Cost & Tech. Results'!D83)
315	**First Year Costs**			
316	*Fixed O&M*	$	$1,056,102	=IF(C$8'=2,'FF ESP Cost & Tech. Results'!D240,'FF ESP Cost & Tech. Results'!D94)
317		$/kW-Yr	2.11	=C316/(C$21*1000)
318		Mills/kWH	0.37	=C316/(C$21*1000*8760*C$23)*1000
319		$/ton PM removed	$13.1	=C316/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
320	*Variable O&M*	$	$1,464,667	=IF(C$8'=2,'FF ESP Cost & Tech. Results'!D239,'FF ESP Cost & Tech. Results'!D95+'FF ESP Cost & Tech. Results'!D93)
321		$/kW-Yr	2.93	=C320/(C$21*1000)
322		Mills/kWH	0.51	=C320/(C$21*1000*8760*C$23)*1000
323		$/ton PM removed	$18.2	=C320/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
324	*Fixed Charges*	$	$6,676,703	=C313*C$47
325		$/kW-Yr	13.35	=C324/(C$21*1000)
326		Mills/kWH	2.35	=C324/(C$21*1000*8760*C$23)*1000
327		$/ton PM removed	$83.1	=C324/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
328	*TOTAL*	$	$9,197,472	=C316+C320+C324
329		$/kW-Yr	18.39	=C317+C321+C325
330		Mills/kWH	3.23	=C318+C322+C326
331		$/ton PM removed	$114.4	=C319+C323+C327
332	**Levelized Current Dollars**			
333	*Fixed O&M*	$/kW-Yr	2.87	=C317*Constants_CC!E$537
334		Mills/kWH	0.50	=C318*Constants_CC!E$537
335		$/ton PM removed	$17.9	=C333*C$21*1000/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)

336	*Variable O&M*	$/kW-Yr	3.99	=C321*Constants_CC!E$537
337		Mills/kWH	0.70	=C322*Constants_CC!E$537
338		$/ton PM removed	$24.8	=C336*C$21*1000/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
339	*Fixed Charges*	$/kW-Yr	10.12	=C325/C$47*C$48
340		Mills/kWH	1.78	=C326/C$47*C$48
341		$/ton PM removed	$63.0	=C$327/C$47*C$48
342	*TOTAL*	$/kW-Yr	16.98	=C333+C336+C339
343		Mills/kWH	2.98	=C334+C337+C340
344		$/ton PM removed	$105.6	=C335+C338+C341
345	**Levelized Constant Dollars**			
346	*Fixed O&M*	$/kW-Yr	2.11	=C317*Constants_CC!E$547
347		Mills/kWH	0.37	=C318*Constants_CC!E$547
348		$/ton PM removed	$13.1	=C346*C$21*1000/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
349	*Variable O&M*	$/kW-Yr	2.93	=C321*Constants_CC!E$547
350		Mills/kWH	0.51	=C322*Constants_CC!E$547
351		$/ton PM removed	$18.2	=C349*C$21*1000/(('FF ESP Cost & Tech. Results'!D$35-(C$160*Constants_CC!E$491))*8760/2000*C$23)
352	*Fixed Charges*	$/kW-Yr	9.95	=C325/C$49*C$50
353		Mills/kWH	1.75	=C326/C$49*C$50
354		$/ton PM removed	$61.9	=C$327/C$49*C$50
355	*TOTAL*	$/kW-Yr	14.99	=C346+C349+C352
356		Mills/kWH	2.63	=C347+C350+C353
357		$/ton PM removed	$93.3	=C348+C351+C354
358				

359	***SO2 Control Costs***		LSFO	=C263
360	**Total Capital Requirement (TCR)**	$	$96,805,699	=IF(C$6'=1,'LSFO Cost & Tech. Results'!D272,'LSD Cost & Tech. Results'!D291)
361		$/kW	$194	=IF(C$6'=1,'LSFO Cost & Tech. Results'!D273,'LSD Cost & Tech. Results'!D292)
362	**First Year Costs**			
363	*Fixed O&M*	$	$6,031,531	=IF(C$6'=1,'LSFO Cost & Tech. Results'!D328,'LSD Cost & Tech. Results'!D339)
364		$/kW-Yr	12.06	=C363/(C$21*1000)
365		Mills/kWH	2.12	=C363/(C$21*1000*8760*C$23)*1000
366		$/ton SO2 removed	$472.7	=C363/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
367	*Variable O&M*	$	$3,117,407	=IF(C$6'=1,'LSFO Cost & Tech. Results'!D337,'LSD Cost & Tech. Results'!D348)
368		$/kW-Yr	6.23	=C367/(C$21*1000)
369		Mills/kWH	1.09	=C367/(C$21*1000*8760*C$23)*1000
370		$/ton SO2 removed	$244.3	=C367/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
371	*Fixed Charges*	$	$21,587,671	=C360*C$47
372		$/kW-Yr	43.18	=C371/(C$21*1000)
373		Mills/kWH	7.58	=C371/(C$21*1000*8760*C$23)*1000
374		$/ton SO2 removed	$1,691.9	=C371/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
375	*TOTAL*	$	$30,736,609	=C363+C367+C371
376		$/kW-Yr	61.47	=C364+C368+C372
377		Mills/kWH	10.80	=C365+C369+C373
378		$/ton SO2 removed	$2,409	=C374+C370+C366
379	**Levelized Current Dollars**			
380	*Fixed O&M*	$/kW-Yr	16.42	=C364*Constants_CC!E$537
381		Mills/kWH	2.88	=C365*Constants_CC!E$537
382		$/ton SO2 removed	$643.3	=C380*C$21*1000/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))

383	*Variable O&M*	$/kW-Yr	8.48	=C368*Constants_CC!E$537
384		Mills/kWH	1.49	=C369*Constants_CC!E$537
385		$/ton SO2 removed	$332.5	=C383*C$21*1000/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
386	*Fixed Charges*	$/kW-Yr	32.72	=C372/C$47*C$48
387		Mills/kWH	5.75	=C373/C$47*C$48
388		$/ton SO2 removed	$1,282.2	=C$374/C$47*C$48
389	*TOTAL*	$/kW-Yr	57.62	=C380+C383+C386
390		Mills/kWH	10.12	=C381+C384+C387
391		$/ton SO2 removed	$2,258.0	=C382+C385+C388
392	**Levelized Constant Dollars**			
393	*Fixed O&M*	$/kW-Yr	12.06	=C364*Constants_CC!E$547
394		Mills/kWH	2.12	=C365*Constants_CC!E$547
395		$/ton SO2 removed	$472.7	=C393*C$21*1000/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
396	*Variable O&M*	$/kW-Yr	6.23	=C368*Constants_CC!E$547
397		Mills/kWH	1.09	=C369*Constants_CC!E$547
398		$/ton SO2 removed	$244.3	=C396*C$21*1000/(IF(C$6'=1,C$66*'LSFO Cost & Tech. Results'!D$30*8760/2000*C$23,C$116*'LSD Cost & Tech. Results'!D$30*8760/2000*C$23))
399	*Fixed Charges*	$/kW-Yr	32.18	=C372/C$49*C$50
400		Mills/kWH	5.65	=C373/C$49*C$50
401		$/ton SO2 removed	$1,260.9	=C$374/C$49*C$50
402	*TOTAL*	$/kW-Yr	50.47	=C393+C396+C399
403		Mills/kWH	8.86	=C394+C397+C400
404		$/ton SO2 removed	$1,977.9	=C395+C398+C401

F-3.0 LSFO Cost and Technical Results Sheet

This worksheet contains all of the technical and economic calculations and results for the limestone forced oxidation (LSFO) FGD process. This worksheet uses the data from the User Input Sheet and Constants_CC Sheet to perform the necessary calculations.

The data contained in this worksheet are organized into five different areas:

a) Material balance calculations
b) Capital cost calculations
c) Maintenance cost calculations
d) O&M data and costs
e) Intermediate material balance calculations.

F-3.1 Material Balance Calculations

This first section of the LSFO worksheet calculates the material balance based on the user-supplied inputs and the results of the combustion calculation. All of the necessary streams needed to size/cost an LSFO system are calculated in this section. Five cases can be run simultaneously. One alternative design option is provided for the LSFO case, that being the option to add Dibasic Acid (DBA) to the recycle tank. The DBA buffers the SO_2 reaction with limestone in the recycled slurry, increasing its ability to remove SO_2 from the flue gas. This can result in a reduction in the size of recycle pumps, increases in removal efficiency, etc. However, results with DBA have not been consistent at all facilities. Some low sulfur coal plants have achieved only minimal or no improvement with the addition of DBA. In any case, the model modifies the LSFO system design to take advantage of the potential improvement in system performance. The user is given the option to include DBA in the initial design of the LSFO system. The following table shows the equation and results for one case.

	A	*B*	*C*	*D*	
	LSFO Material Balance - Preliminary				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
	Flue Gas, Downstream of ID Fans				
24	Temperature	°F		295	='Input & Calculation Summary'!C26-10 (duct loss)+5 (increase across fan)
25	Pressure	in. H2O		7	='Input & Calculation Summary'!C80+1 (stack draft)
26	Flow Rate	SCFM		1,307,230	=((D28/CO2_MolWt)+(D29/N2_MolWt)+(D30/SO2_MolWt)+(D31/O2_MolWt)+(D33/NO2_MolWt)+(D32/HCl_MolWt)+(D34/H2O_MolWt))*cubft_60/60 min/hr

27	Flow Rate	ACFM		1,884,489	=D26*((D24+460 (Rankine conv.)/520 (stand.conditions, °R)*(29.92 (1 atm. “Hg)/('Input & Calculation Summary'!C28+(D25/inH2O_inHg)))
28	CO2	lb/hr		1,120,920	=Constants_CC!E467*Constants_CC!E491 From Combustion Calculation Sheet
29	N2	lb/hr		4,084,072	=Constants_CC!E468*Constants_CC!E491 “
30	SO2	lb/hr		4,717	=Constants_CC!E471*Constants_CC!E491 “
31	O2	lb/hr		327,881	=Constants_CC!E466*Constants_CC!E491 “
32	HCl	lb/hr		66	=Constants_CC!E470*Constants_CC!E491 “
33	Other Gases	lb/hr		1,425	=Constants_CC!E469*Constants_CC!E491 “
34	H2O	lb/hr		450,880	=Constants_CC!E472*Constants_CC!E491 “
35	Fly Ash	lb/hr		158	='Input & Calculation Summary'!C160*Constants_CC!E491 “
36	Total (gas only)	lb/hr		5,989,962	=SUM(D28:D34)
	Flue Gas, to Absorber				
39	Temperature	°F		295	=D24
40	Pressure	in. H2O		10	=D25
41	Flow Rate	SCFM		1,307,230	=((D43/CO2_MolWt)+(D44/N2_MolWt)+(D45/SO2_MolWt)+(D46/O2_MolWt)+(D48/NO2_MolWt)+(D47/HCl_MolWt)+(D49/H2O_MolWt))*cubft_60/60 min/hr
42	Flow Rate	ACFM		1,884,489	=D41*((D39+460(Rankine conv.))/520 (stand.conditions, °R)*(29.92(1 atm. “Hg)/('Input & Calculation Summary'!C28+(D40/inH2O_inHg)))
43	CO2	lb/hr		1,120,920	=D28/'Input & Calculation Summary'!C76 From Combustion Calculation Sheet
44	N2	lb/hr		4,084,072	=D29/'Input & Calculation Summary'!C76 “
45	SO2	lb/hr		4,717	=D30/'Input & Calculation Summary'!C76 “
46	O2	lb/hr		327,881	=D31/'Input & Calculation Summary'!C76 “
47	HCl	lb/hr		66	=D32/'Input & Calculation Summary'!C76 “
48	Other Gases	lb/hr		1,425	=D33/'Input & Calculation Summary'!C76 “
49	H2O	lb/hr		450,880	=D34/'Input & Calculation Summary'!C76 “
50	Fly Ash	lb/hr		158	=D35/'Input & Calculation Summary'!C76 “
51	Total (gas only)	lb/hr		5,989,962	=SUM(D43:D49)
52					
53	***Flue Gas, from Absorbers (total)***				
54	Temperature	°F		127	='Input & Calculation Summary'!C70
55	Pressure	in. H2O		4	=D40-'Input & Calculation Summary'!C80

56	Flow Rate	SCFM		1,338,259	=((D58/CO2_MolWt)+(D59/N2_MolWt)+(D60/SO2_MolWt)+(D61/O2_MolWt)+(D63/NO_MolWt)+(D64/H2O_MolWt))*(cubft_60/60 min/hr)
57	Flow Rate	ACFM		1,522,197	=D56*((D54+460)/520)*(29.92/('Input & Calculation Summary'!C28+(D55/inH2O_inHg)))
58	CO2	lb/hr		1,124,038	=D43+D354+(D47/HCl_MolWt*CO2_MolWt/2 (moles HCl/mole H_2O formed))
59	N2	lb/hr		4,098,918	=D44+D126
60	SO2	lb/hr		236	=D45-D350
61	O2	lb/hr		331,239	=D46+D127-D362
62	HCl	lb/hr		0	0
63	Other Gases	lb/hr		1,425	=D48
64	H2O	lb/hr		527,513	=D368*H2O_MolWt+(D47/HCl_MolWt*H2O_MolWt/2)
65	Fly Ash	lb/hr		158	=D50
66	Total (gas only)	lb/hr		6,083,369	=SUM(D58:D64)
67	***Heat Capacities***				Heat Capacity Equations from D.M.Himmelblau Basic Principles and Calculations in ChE.
68	O2	Btu/lbmol°F		7.213	=6.732+((0.001505*(D83^2-D85^2))/(2*(D83-D85)))-((0.0000001791*(D83^3-D85^3))/(3*(D83-D85)))
69	CO2	Btu/lbmol°F		9.354	=18.036-((0.00004474*(D83^2-D85^2))/(2*(D83-D85)))-((158.08*(D83^0.5-D85^0.5))/(0.5*(D83-D85)))
70	N2	Btu/lbmol°F		6.999	=6.529+((0.001488*(D83^2-D85^2))/(2*(D83-D85)))-((0.0000002271*(D83^3-D85^3))/(3*(D83-D85)))
71	H2O	Btu/lbmol°F		8.069	=7.88+((0.0032*(D82^2-D84^2))/(2*(D82-D84)))-((0.0000004833*(D82^3-D84^3))/(3*(D82-D84)))
72	NO	Btu/lbmol°F		7.164	=7.05+((0.001957*(D82^2-D84^2))/(2*(D82-D84)))-((0.000000699*(D82^3-D84^3))/(3*(D82-D84)))+((0.00000000008729*(D82^4-D84^4))/(4*(D82-D84)))
73	SO2	Btu/lbmol°F		9.830	=9.299+((0.00933*(D82^2-D84^2))/(2*(D82-D84)))-((0.000007418*(D82^3-D84^3))/(3*(D82-D84)))+((0.0000000021*(D82^4-D84^4))/(4*(D82-D84)))
74	HCl	Btu/lbmol°F		6.951	=6.962-((0.0003206*(D82^2-D84^2))/(2*(D82-D84)))+((0.000002322*(D82^3-D84^3))/(3*(D82-D84)))-((0.000000001*(D82^4-D84^4))/(4*(D82-D84)))
75	O2	Btu/lb°F		0.225	=D68/O2_MolWt
76	CO2	Btu/lb°F		0.213	=D69/CO2_MolWt
77	N2	Btu/lb°F		0.250	=D70/N2_MolWt
78	H2O	Btu/lb°F		0.448	=D71/H2O_MolWt
79	NO	Btu/lb°F		0.239	=D72/NO_MolWt

80	SO2	Btu/lb°F		0.153	=D73/SO2_MolWt
81	HCl	Btu/lb°F		0.191	=D74/HCl_MolWt
82	Reheated Gas Temperature:	°C		66.7	=((D54+(IF('Input & Calculation Summary'!C81'=1,'Input & Calculation Summary'!C83,0)))-32)/1.8 (Fahrenheit to centigrade conv.)
83		K		339.7	=D82+273
84	FGD Outlet Temperature:	°C		52.8	=(D54-32)/1.8
85		K		325.8	=D84+273
86	Total Btu/hr	Btu/hr		39,352,032	=((D58*D76+D59*D77+D60*D80+D61*D75+D63*D79+D64*D78)*((D54+'Input & Calculation Summary'!C83)-D54))
87					
88	***Hot Reheat Air***				
89	Temperature	°F		440	440
90	Pressure	in. H2O		1	1
91	Flow Rate	SCFM		120,817	=((D93/N2_MolWt+D94/O2_MolWt+D95/H2O_MolWt)*(cubft_60/60 min/hr))
92	Flow Rate	ACFM		212,274	=D91*((D89+460 (Rankine conv.))/520 (stand temp., °R)*(29.92 (stand. press., "Hg)/('Input & Calculation Summary'!C28+(D90/inH2O_inHg)))
93	N2	lb/hr		414,522	=0.7683 (N_2 fraction)*(1-'Input & Calculation Summary'!C30)*D96
94	O2	lb/hr		125,010	=0.2317 (O_2 fraction)*(1-'Input & Calculation Summary'!C30)*D96
95	H2O	lb/hr		7,106	=D96*'Input & Calculation Summary'!C30
96	Total	lb/hr		546,638	=(D86/((0.7683*(1-'Input & Calculation Summary'!C30)*D113+0.2317*(1-'Input & Calculation Summary'!C30)*D112+'Input & Calculation Summary'!C30*D114)*(D89-(D54+'Input & Calculation Summary'!C83))))
97	***Heat Capacities of Hot Reheat Air***				Heat Capacity Equations from D.M.Himmelblau Basic Principles and Calculations in ChE.
98	O2	Btu/lbmol°F		7.332	=6.732+((0.001505*(D105^2-D107^2))/(2*(D105-D107)))-((0.0000001791*(D105^3-D107^3))/(3*(D105-D107)))
99	N2	Btu/lbmol°F		7.113	=6.529+((0.001488*(D105^2-D107^2))/(2*(D105-D107)))-((0.0000002271*(D105^3-D107^3))/(3*(D105-D107)))
100	H2O	Btu/lbmol°F		8.338	=7.88+((0.0032*(D104^2-D106^2))/(2*(D104-D106)))-((0.0000004833*(D104^3-D106^3))/(3*(D104-D106)))
101	O2	Btu/lb°F		0.229	=D98/O2_MolWt
102	N2	Btu/lb°F		0.254	=D99/N2_MolWt
103	H2O	Btu/lb°F		0.463	=D100/H2O_MolWt

104	Heated Temperature:	°C		226.7	=(D89-32)/1.8 (Fahrenheit to centigrade conv.)
105		K		499.7	=D104+273
106	FGD Outlet Temperature:	°C		66.7	=(D54+'Input & Calculation Summary'!C83-32)/1.8
107		K		339.7	=D106+273
108	***Heat Capacities of Inlet Reheat Air***				Heat Capacity Equations from D.M.Himmelblau Basic Principles and Calculations in ChE.
109	O2	Btu/lbmol°F		7.304	=6.732+((0.001505*(D116^2-D118^2))/(2*(D116-D118)))-((0.0000001791*(D116^3-D118^3))/(3*(D116-D118)))
110	N2	Btu/lbmol°F		7.087	=6.529+((0.001488*(D116^2-D118^2))/(2*(D116-D118)))-((0.0000002271*(D116^3-D118^3))/(3*(D116-D118)))
111	H2O	Btu/lbmol°F		8.276	=7.88+((0.0032*(D115^2-D117^2))/(2*(D115-D117)))-((0.0000004833*(D115^3-D117^3))/(3*(D115-D117)))
112	O2	Btu/lb°F		0.228	=D109/O2_MolWt
113	N2	Btu/lb°F		0.253	=D110/N2_MolWt
114	H2O	Btu/lb°F		0.459	=D111/H2O_MolWt
115	Heated Temperature:	°C		226.7	=(D89-32)/1.8
116		K		499.7	=D115+273
117	Inlet Air Temperature:	°C		26.7	=('Input & Calculation Summary'!C27-32)/1.8
118		K		299.7	=D117+273
119	***Required Heat***	Btu/hr		49,190,039	=(D93*D113+D94*D112+D95*D114)*(D89-'Input & Calculation Summary'!C27)
120					
121	***Oxidation Air (total)***				
122	Temperature	°F		60	60
123	Pressure	in. H2O		0	0
124	Flow Rate	SCFM		4,326	=((D126/N2_MolWt)+(D127/O2_MolWt)+(D128/H2O_MolWt))*(cubft_60/60)
125	Flow Rate	ACFM		4,402	=D124*((D122+460)/520)*(29.92/('Input & Calculation Summary'!C28+(D123/inH2O_inHg)))
126	N2	lb/hr		14,845	=D127/0.2317*0.7683
127	O2	lb/hr		4,477	=D345*2 (moles O_2 /mole SO_2 removed)*O2_MolWt
128	H2O	lb/hr		251	=(D126+D127)*'Input & Calculation Summary'!C30
129	Total (gas only)	lb/hr		19,573	=SUM(D126:D128)
130					

131	***Limestone to Ball Mill***				
132	Temperature	°F		80	='Input & Calculation Summary'!C27
133	Wt.% Solids	wt. %		100%	100%
134	Inerts	lb/hr		363	=D135/(Constants_CC!$D$53/100 (% conv.))*((100-Constants_CC!$D$53)/100)
135	CaCO3	lb/hr		7,352	=IF(((D30/SO2_MolWt*'Input & Calculation Summary'!C71*CaCO3_MolWt*'Input & Calculation Summary'!C66)-D351)-(D32/HCl_MolWt*CaCO3_MolWt/2)<0,D30/SO2_MolWt*'Input & Calculation Summary'!C71*CaCO3_MolWt*'Input & Calculation Summary'!C66+D32/HCl_MolWt*CaCO3_MolWt/2,D30/SO2_MolWt*'Input & Calculation Summary'!C71*CaCO3_MolWt*'Input & Calculation Summary'!C66)
136	Total	lb/hr		7,715	=D135+D134
137					
138	***Limestone Slurry to Limestone Slurry Tank***				
139	Temperature	°F		90	90
140	Flow Rate	GPM		27.5	=D145/(8.34*(1+D141))/60 min/hr
141	Wt.% Solids	wt. %		40%	40%
142	Inerts	lb/hr		363	=D134
143	CaCO3	lb/hr		7,352	=D135
144	H2O	lb/hr		11,572	=(D143+D142)/D141*(1-D141)
145	Total	lb/hr		19,286	=SUM(D142:D144)
146					
147	***Limestone Slurry to Reaction Mix Tank (total)***				
148	Temperature	°F		68	68
149	Flow Rate	GPM		64.2	=D154/(8.34*(1+D150))/60 min/hr
150	Wt.% Solids	wt. %		20%	20%
151	Inerts	lb/hr		363	=D142
152	CaCO3	lb/hr		7,352	=D143
153	H2O	lb/hr		30,858	=(D152+D151)/D150*(1-D150)
154	Total	lb/hr		38,573	=SUM(D151:D153)
155					

156	***Slurry to Absorber***				
157	Temperature	°F		126	126
158	Flow Rate	GPM		187,950	=D57/(29.92/('Input & Calculation Summary'!C28+(D55/inH2O_inHg)))*(29.92/('Input & Calculation Summary'!C28+((D40-1)/inH2O_inHg)))/1000 acfm*(IF('Input & Calculation Summary'!C68'=2,'Input & Calculation Summary'!C67,70))
159	Wt.% Solids	wt. %		15%	='Input & Calculation Summary'!C73
160	CaSO3*1/2H2O	lb/hr		0	=D172/D$178*D$166
161	CaSO4*2H2O	lb/hr		15,305,569	=D173/D$178*D$166
162	Inerts	lb/hr		460,753	=D174/D$178*D$166
163	CaCl2	lb/hr		126,934	=D175/D$178*D$166
164	CaCO3	lb/hr		330,414	=D176/D$178*D$166
165	H2O	lb/hr		91,934,133	=D177/D$178*D$166
166	Total	lb/hr		108,157,803	=D158*60 min/hr*8.34 lbs H_2O/gal.*(1+D159)
167					
168	***Slurry from Rxn Tank to Thickener***				
169	Temperature	°F		126	126
170	Flow Rate	GPM		147.9	=D178/(8.34*(1+D171))/60 min/hr
171	Wt.% Solids	wt. %		15%	='Input & Calculation Summary'!C73
172	CaSO3*1/2H2O	lb/hr		0	=D353-D361
173	CaSO4*2H2O	lb/hr		12,044	=D364
174	Inerts	lb/hr		363	=D151
175	CaCl2	lb/hr		100	=(D32/HCl_MolWt*CaCl2_MolWt/2)
176	CaCO3	lb/hr		260	=(D152-D351)-(D32/HCl_MolWt*CaCO3_MolWt/2)
177	H2O	lb/hr		72,346	=SUM(D172:D176)/D171*(1-D171)
178	Total	lb/hr		85,113	=SUM(D172:D177)

F-3.2 Capital Cost Calculations

The capital cost section of the worksheet takes the results of the material balances and uses these values with Raytheon developed algorithms to cost the different pieces of equipment included in the LSFO process. The algorithms were developed from vendor-supplied information and Raytheon's design experience. The following table shows the algorithms and the results for one case:

	A	*B*	*C*	*D*	
	LSFO Equipment Capital Costs				
Row			**Sizing**	**Case 1**	
No.	**Title / Description**	**Units**	**Criteria**	**Results**	**Equation**
184	*Cost Basis (Year)*			*1998*	='Input & Calculation Summary'!C42 **Capital Cost Algorithms - Constants Derived from Database**
186	Reagent Feed System	$	Kpph Reag.	$7,615,854	=((-0.0034*(D136/1000)^4)+(2.1128*(D136/1000)^3)-(494.55*(D136/1000)^2)+(68164.7*(D136/1000))+7118470)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
187	Ball Mill & Hydroclone System	$	TPH Reag.	$1,941,841	=(32.90*(D136/2000)^2+22412*(D136/2000)+1854902))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
188	DBA Acid Tank (pump, heater, agitator)	$	Gpm DBA	$0	=IF('Input & Calculation Summary'!C68'=2,0,(364627*D373^0.283)))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
189	SO2 Removal System	$	kpph SO2	$2,065,415	=((0.8701*(D30/1000)^3)-(188.2*(D30/1000)^2)+(34809*(D30/1000))+1905302))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))

190	Absorber Tower	$	KACFM	$16,158,565	=(IF('Input & Calculation Summary'!C78'=1,(230064*(D42/1000)^0.5638),(173978*(D42/1000)^0.5575))*'Input & Calculation Summary'!C76))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
191	Spray Pumps	$	Slurry gpm	$2,412,210	=((910.85*(D158/K191)^0.5954*K191))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
192	Flue Gas Handling System	$	*	$6,778,862	=(((-0.1195*(D42/1000)^2)+(777.76*(D42/1000))+238203)+((-0.2009*(D57/1000/'Input & Calculation Summary'!C76)^2)+(1266.4*(D57/1000/'Input & Calculation Summary'!C76))+420141)+((0.000012*(D27/1000)^3)-(0.1651*(D27/1000)^2)+(1288.82*(D27/1000))+559693)+(IF('Input & Calculation Summary'!C81=1,22995*'Input & Calculation Summary'!C83+559686,0)))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
193	ID Fans	$	ACFM	$2,318,006	=((91.24*((K194)^0.6842))*K195)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
194	Waste / Byproduct Handling System	$	Kpph SO2	$89,045	=(IF('Input & Calculation Summary'!C74'=1,(-4.0567*(D30/1000)^2+1788*(D30/1000)+80700),IF('Input & Calculation Summary'!C74'=2,(0.325*(D30/1000)^3-168.77*(D30/1000)^2+29091*(D30/1000)+773243),(0.325*(D30/1000)^3-168.77*(D30/1000)^2+29091*(D30/1000)+773243)*1.25)))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))

195	Thickener System	$	TPH solids	$172,133	=(9018.7*((D178-D177)/2000)+114562)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
196	Support Equipment	$	MW	$1,945,399	=(0.0003*'Input & Calculation Summary'!C20^3-1.0667*'Input & Calculation Summary'!C20^2+1993.8*'Input & Calculation Summary'!C20+1177674))*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
197	Chimney	$	ACFM	$4,662,722	=IF('Input & Calculation Summary'!C81=1,40208*D57^0.3339,23370*D57^0.3908)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42 ,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55="Yes", IF('Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D184-1998)))))
198	**TOTAL**	$		$46,160,051	=SUM(D186:D197)
199	* *Based on flue gas flow and reheat temperature.*				
200					
201	***Capital Costs with Retrofit Factors***				
202	Reagent Feed System	$		$9,900,611	=D186*'Input & Calculation Summary'!C$35
203	Ball Mill & Hydroclone System	$		$2,524,393	=D187*'Input & Calculation Summary'!C$35
204	DBA Acid Tank (pump, heater, agitator)	$		$0	=D188*'Input & Calculation Summary'!C$35
205	SO2 Removal System	$		$2,685,039	=D189*'Input & Calculation Summary'!C$35
206	Absorber Tower	$		$21,006,134	=D190*'Input & Calculation Summary'!C$35
207	Spray Pumps	$		$3,135,873	=D191*'Input & Calculation Summary'!C$35
208	Flue Gas Handling System	$		$8,812,521	=D192*'Input & Calculation Summary'!C$35
209	ID Fans	$		$3,013,407	=D193*'Input & Calculation Summary'!C$35

210	Waste / Byproduct Handling System	$		$115,758	=D194*'Input & Calculation Summary'!C$35
211	Thickener System	$		$223,773	=D195*'Input & Calculation Summary'!C$35
212	Support Equipment	$		$2,529,019	=D196*'Input & Calculation Summary'!C$35
213	Chimney	$		$6,061,539	=D197*'Input & Calculation Summary'!C$35
214	**TOTAL**	$		$60,008,067	=SUM(D202:D213)
215					
216	***General Facilities***				
217	Reagent Feed System	$		$990,061	=D202*'Input & Calculation Summary'!C102
218	Ball Mill & Hydroclone System	$		$252,439	=D203*'Input & Calculation Summary'!C102
219	DBA Acid Tank (pump, heater, agitator)	$		$0	=D204*'Input & Calculation Summary'!C102
220	SO2 Removal System	$		$268,504	=D205*'Input & Calculation Summary'!C103
221	Absorber Tower	$		$2,100,613	=D206*'Input & Calculation Summary'!C103
222	Spray Pumps	$		$313,587	=D207*'Input & Calculation Summary'!C103
223	Flue Gas Handling System	$		$881,252	=D208*'Input & Calculation Summary'!C104
224	ID Fans	$		$301,341	=D209*'Input & Calculation Summary'!C104
225	Waste / Byproduct Handling System	$		$11,576	=D210*'Input & Calculation Summary'!C105
226	Thickener System	$		$22,377	=D211*'Input & Calculation Summary'!C105
227	Support Equipment	$		$252,902	=D212*'Input & Calculation Summary'!C106
228	Chimney	$		$606,154	=D213*'Input & Calculation Summary'!C106
229	**TOTAL**	$		$6,000,807	=SUM(D217:D228)
230					
231	***Engineering Fees***				
232	Reagent Feed System	$		$990,061	=D202*'Input & Calculation Summary'!C108
233	Ball Mill & Hydroclone System	$		$252,439	=D203*'Input & Calculation Summary'!C108
234	DBA Acid Tank (pump, heater, agitator)	$		$0	=D204*'Input & Calculation Summary'!C108
235	SO2 Removal System	$		$268,504	=D205*'Input & Calculation Summary'!C109
236	Absorber Tower	$		$2,100,613	=D206*'Input & Calculation Summary'!C109

237	Spray Pumps	$		$313,587	=D207*'Input & Calculation Summary'!C109
238	Flue Gas Handling System	$		$881,252	=D208*'Input & Calculation Summary'!C110
239	ID Fans	$		$301,341	=D209*'Input & Calculation Summary'!C110
240	Waste / Byproduct Handling System	$		$11,576	=D210*'Input & Calculation Summary'!C111
241	Thickener System	$		$22,377	=D211*'Input & Calculation Summary'!C111
242	Support Equipment	$		$252,902	=D212*'Input & Calculation Summary'!C112
243	Chimney	$		$606,154	=D213*'Input & Calculation Summary'!C112
244	**TOTAL**	$		$6,000,807	=SUM(D232:D243)
245					
246	***Contingency***				
247	Reagent Feed System	$		$1,980,122	=D202*'Input & Calculation Summary'!C96
248	Ball Mill & Hydroclone System	$		$504,879	=D203*'Input & Calculation Summary'!C96
249	DBA Acid Tank (pump, heater, agitator)	$		$0	=D204*'Input & Calculation Summary'!C96
250	SO2 Removal System	$		$537,008	=D205*'Input & Calculation Summary'!C97
251	Absorber Tower	$		$4,201,227	=D206*'Input & Calculation Summary'!C97
252	Spray Pumps	$		$627,175	=D207*'Input & Calculation Summary'!C97
253	Flue Gas Handling System	$		$1,762,504	=D208*'Input & Calculation Summary'!C98
254	ID Fans	$		$602,681	=D209*'Input & Calculation Summary'!C98
255	Waste / Byproduct Handling System	$		$23,152	=D210*'Input & Calculation Summary'!C99
256	Thickener System	$		$44,755	=D211*'Input & Calculation Summary'!C99
257	Support Equipment	$		$505,804	=D212*'Input & Calculation Summary'!C100
258	Chimney	$		$1,212,308	=D213*'Input & Calculation Summary'!C100
259	**TOTAL**	$		$12,001,613	=SUM(D247:D258)
260					
261	***Total Plant Cost (TPC)***	$		$84,011,293	=D214+D229+D244+D259
262	TPC w/ Prime Contractors Markup	$		$86,531,632	=D261*(1+'Input & Calculation Summary'!C$59)
263	***Total Cash Expended (TCE)***	$		$84,035,762	=D262*VLOOKUP(Constants_CC!E528,Constants_CC!$C$557:$E$562,3)

264					
265	***Allow. for Funds During Constr. (AFDC)***	$		$9,214,163	=D262*VLOOKUP(Constants_CC!E528,Constants_CC!$C$557:$E$562,2)
266					
267	***Total Plant Investment (TPI)***	$		$93,249,925	=D263+D265
268					
269	*Preproduction Costs*	$		$2,764,994	=(D328+D337/'Input & Calculation Summary'!C23)/12+0.02*D267
270	*Inventory Capital*	$		$83,317	=(D313/2000 lbs/ton)*24 hrs/day*'Input & Calculation Summary'!C84*'Input & Calculation Summary'!C85
271					
272	***Total Capital Requirement (TCR)***	$		**$96,098,236**	**=D267+D269+D270**
273		$/kW		$192	=D272/('Input & Calculation Summary'!C21*1000 kW/MW)

F-3.3 Maintenance Cost Calculations

The first year maintenance costs for the LSFO system are calculated in this section of the worksheet. The retrofit factor is first backed out of the total plant cost (TPC), which is calculated in the capital cost section of the worksheet. A user-supplied maintenance factor is then applied to the resulting cost. The following table provides the equations and results for one case.

	A	*B*	*C*	*D*	
	Maintenance Cost by Area				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
278	***TPC w/o Retrofit Factor***				
279	Reagent Feed System	$		$10,966,830	=(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D186+('Input & Calculation Summary'!C96*(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D186)
280	Ball Mill & Hydroclone System	$		$2,796,250	=(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D187+('Input & Calculation Summary'!C96*(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D187)
281	DBA Acid Tank (pump, heater, agitator)	$		$0	=(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D188+('Input & Calculation Summary'!C96*(1+'Input & Calculation Summary'!C102+'Input & Calculation Summary'!C108)*D188)
282	SO2 Removal System	$		$2,974,198	=(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D189+('Input & Calculation Summary'!C97*(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D189)
283	Absorber Tower	$		$23,268,333	=(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D190+('Input & Calculation Summary'!C97*(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D190)
284	Spray Pumps	$		$3,473,583	=(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D191+('Input & Calculation Summary'!C97*(1+'Input & Calculation Summary'!C103+'Input & Calculation Summary'!C109)*D191)
285	Flue Gas Handling System	$		$9,761,562	=(1+'Input & Calculation Summary'!C104+'Input & Calculation Summary'!C110)*D192+('Input & Calculation Summary'!C98*(1+'Input & Calculation Summary'!C104+'Input & Calculation Summary'!C110)*D192)

286	ID Fans	$		$3,337,928	=(1+'Input & Calculation Summary'!C104+'Input & Calculation Summary'!C110)*D193+('Input & Calculation Summary'!C98*(1+'Input & Calculation Summary'!C104+'Input & Calculation Summary'!C110)*D193)
287	Waste / Byproduct Handling System	$		$128,224	=(1+'Input & Calculation Summary'!C105+'Input & Calculation Summary'!C111)*D194+('Input & Calculation Summary'!C99*(1+'Input & Calculation Summary'!C105+'Input & Calculation Summary'!C111)*D194)
288	Thickener System	$		$247,871	=(1+'Input & Calculation Summary'!C105+'Input & Calculation Summary'!C111)*D195+('Input & Calculation Summary'!C99*(1+'Input & Calculation Summary'!C105+'Input & Calculation Summary'!C111)*D195)
289	Support Equipment	$		$2,801,375	=(1+'Input & Calculation Summary'!C106+'Input & Calculation Summary'!C112)*D196+('Input & Calculation Summary'!C100*(1+'Input & Calculation Summary'!C106+'Input & Calculation Summary'!C112)*D196)
290	Chimney	$		$6,714,320	=(1+'Input & Calculation Summary'!C106+'Input & Calculation Summary'!C112)*D197+('Input & Calculation Summary'!C100*(1+'Input & Calculation Summary'!C106+'Input & Calculation Summary'!C112)*D197)
291	**TOTAL**	$		$66,470,474	=SUM(D279:D290)
292					
293	***First Year Maintenance Costs***				
294	Reagent Feed System	$		$548,342	=D279*'Input & Calculation Summary'!C90
295	Ball Mill & Hydroclone System	$		$139,813	=D280*'Input & Calculation Summary'!C90
296	DBA Acid Tank (pump, heater, agitator)	$		$0	=D281*'Input & Calculation Summary'!C90
297	SO2 Removal System	$		$148,710	=D282*'Input & Calculation Summary'!C91*(IF('Input & Calculation Summary'!C68'=2,1,0.95))
298	Absorber Tower	$		$1,163,417	=D283*'Input & Calculation Summary'!C91*(IF('Input & Calculation Summary'!C68'=2,1,0.95))
299	Spray Pumps	$		$173,679	=D284*'Input & Calculation Summary'!C91*(IF('Input & Calculation Summary'!C68'=2,1,0.95))
300	Flue Gas Handling System	$		$488,078	=D285*'Input & Calculation Summary'!C92
301	ID Fans	$		$166,896	=D286*'Input & Calculation Summary'!C92

302	Waste / Byproduct Handling System	$		$6,411	=D287*'Input & Calculation Summary'!C93
303	Thickener System	$		$12,394	=D288*'Input & Calculation Summary'!C93
304	Support Equipment	$		$140,069	=D289*'Input & Calculation Summary'!C94
305	Chimney	$		$335,716	=D290*'Input & Calculation Summary'!C94
306	**TOTAL**	$		$3,323,524	=SUM(D294:D305)

F-3.4 O&M Data and Costs

The LSFO O&M data and costs are summarized in this section of the worksheet. This information is derived from the material balance calculations and the user-supplied inputs.

	A	B	C	D	
	LSFO O&M Data and Costs				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
311	Cost Basis (Year)			1998	='Input & Calculation Summary'!C42
312	**Parameters**				
313	Reagent Required	lbs/hr		7,715	=D136
314		lbs/MMBtu		1.469	=D313/Constants_CC!E491
315	DBA Required	lbs/hr		0.0	=D372
316	Percent SO2 Removal	%		95%	='Input & Calculation Summary'!C66
317	FGD Sludge to Disposal	lbs/hr, dry		12,767	=IF('Input & Calculation Summary'!C74'=3,0,D178-D177)
318	Steam to FGD System	lbs/hr		57,523	=D119/855.14 Btu/lb
319	Total FGD Power Consumption	kW		10,000	=0.02*(1000*'Input & Calculation Summary'!C21)*(IF('Input & Calculation Summary'!C68'=2,1,0.8231 (power reduction due to use of DBA versus standard LSFO)))
320	FGD Byproduct	lbs/hr		0	=IF('Input & Calculation Summary'!C74'=3,(D178-D177),0)
321					
322	**Fixed O&M Costs**				
323	Number of Operators - algorithm from database			28	=41.69041*'Input & Calculation Summary'!C21^(-0.322307)*'Input & Calculation Summary'!C21/100
324	based on 40 hrs/week				
325	Operating Labor Cost	$/yr		$1,755,068	=('Input & Calculation Summary'!C60*D323*40*52)
326	Maint. Labor & Matls. Cost	$/yr		$3,323,524	=D306
327	Admin. & Support Labor	$/yr		$925,343	=0.3 (admin&support frac. of oper. & maint. labor)*((D306*0.4 (maint. labor frac.)+D325)
328	TOTAL	$/yr		$6,003,934	=SUM(D325:D327)

329					
330	**Variable Operating Costs**				
331	Reagent Costs	$/yr		$329,449	=(D313/2000 lbs/ton*'Input & Calculation Summary'!C23*8760*'Input & Calculation Summary'!C85)
332	DBA Costs	$/yr		$0	=(D315/2000 lbs/ton*'Input & Calculation Summary'!C23*8760*430)
333	Disposal Costs	$/yr		$218,086	=(IF('Input & Calculation Summary'!C74'=1,'Input & Calculation Summary'!C87,'Input & Calculation Summary'!C86)*'Input & Calculation Summary'!C23*8760*'LSFO Cost & Tech. Results'!D317/2000 lbs/ton)
334	Credit for Byproduct	$/yr		$0	=(D320/2000 lbs/ton*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C88)
335	Steam Costs	$/yr		$1,146,372	=(D318/1000 lbs*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C62)
336	Power Costs	$/yr		$1,423,500	=(D319/1000 lbs*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61)
337	TOTAL	$/yr		$3,117,407	=SUM(D331:D336)

F-3.5 Intermediate Material Balance Calculations

This section of the worksheet is used to perform intermediate calculations required by the material balance. These values are not directly used in sizing and costing the FGD equipment. The following table shows the equations and results for one case.

	A	*B*	*C*	*D*	
	Intermediate Material Balance Calcs.				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
344	***Sulfite Reaction***				
345	SO2	lbmole/hr		69.96	=D30/SO2_MolWt*'Input & Calculation Summary'!C66
346	CaCO3	lbmole/hr		69.96	=D345
347	H2O	lbmole/hr		34.98	=D345*0.5 mole H_2O/mole sulfite produced
348	CaSO3*1/2H2O	lbmole/hr		69.96	=D345
349	CO2	lbmole/hr		69.96	=D345

350	SO2	lb/hr		4,482	=D345*SO2_MolWt
351	CaCO3	lb/hr		7,002	=D346*CaCO3_MolWt
352	H2O	lb/hr		630	=D347*H2O_MolWt
353	CaSO3*1/2H2O	lb/hr		9,024	=D348*CaSO3halfH2O_MolWt
354	CO2	lb/hr		3,079	=D349*CO2_MolWt
355					
356	***Sulfate Reaction***				
357	CaSO3*1/2H2O	lbmole/hr		69.96	=D348
358	O2	lbmole/hr		34.98	=D357/2
359	H2O	lbmole/hr		104.93	=D357*1.5 Mole H_2O added/mole of sulfate produced
360	CaSO4*2H2O	lbmole/hr		69.96	=D357
361	CaSO3*1/2H2O	lb/hr		9,024	=D357*CaSO3halfH2O_MolWt
362	O2	lb/hr		1,119	=D358*O2_MolWt
363	H2O	lb/hr		1,890	=D359*H2O_MolWt
364	CaSO4*2H2O	lb/hr		12,044	=D360*CaSO4_2H2O_MolWt
365					
366	***Water in Absorber***				
367	Mole Fraction H2O in Absorber	%		0.1389	=VLOOKUP('Input & Calculation Summary'!C70,Constants_CC!$B$168:$C$193,2)/('Input & Calculation Summary'!C28+((D40-1)/inH2O_inHg))
368	Moles H2O in Absorber	lbmole		29,280.42	=D367*(D43/CO2_MolWt+D44/N2_MolWt+D45/SO2_MolWt+D46/O2_MolWt+D48/38.0056 (aver. mole-wt. of other gases))/(1-D367)
369					
370	***DBA Feed Calculations***				
371	SO2 Removed	lbs/hr		4,482	=D45-D60
372	DBA Added	lbs/hr		0.00	=(IF('Input & Calculation Summary'!C68'=2,0,(D371/2000 lbs/ton*20 lbs DBA/ton SO_2 removed)))
373	DBA Added	GPM		0.00	=D372/(8.34 lbs/gal*(1+0.5 (density correction for 50% solution)))/60 min/hr

F-4.0 LSD Cost and Technical Results Sheet

This worksheet contains all of the technical and economic calculations and results for the lime spray dryer (LSD) FGD process. This worksheet uses the data from the User Input Sheet and Constants_CC Sheet to perform the necessary calculations.

The data contained in this worksheet are organized into five different areas: 1) material balance calculations, 2) capital cost calculations, 3) maintenance cost calculations, 4) O&M data and costs, and 5) intermediate material balance calculations.

F-4.1 Material Balance Calculations

This first section of the worksheet performs a material balance based on the user-supplied inputs and the results of the combustion calculation. All of the necessary streams needed to size/cost an LSD system are calculated in this section. Five cases can be run simultaneously. The following table shows the equation and results for one case.

	A	*B*	*C*	*D*	
	LSD Material Balance – Preliminary				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
23	***Flue Gas, Downstream of Air Heater***				
24	Temperature	°F		300	='Input & Calculation Summary'!C26
25	Pressure	in. H2O		-12	='Input & Calculation Summary'!C29
26	Flow Rate	SCFM		1,307,230	=((D28/CO2_MolWt)+(D29/N2_MolWt)+(D30/SO2_MolWt)+(D31/O2_MolWt)+(D33/NO2_MolWt)+(D32/HCl_MolWt)+(D34/H2O_MolWt))*cubft_60/60
27	Flow Rate	ACFM		2,004,451	=D26*((D24+460(Rankine conv.))/520(stand. temp. °R)*(29.92(stand. press. “Hg)/('Input & Calculation Summary'!C28+(D25/inH2O_inHg)))
28	CO2	lb/hr		1,120,920	=Constants_CC!E467*Constants_CC!E491
29	N2	lb/hr		4,084,072	=Constants_CC!E468*Constants_CC!E491
30	SO2	lb/hr		4,717	=Constants_CC!E471*Constants_CC!E491
31	O2	lb/hr		327,881	=Constants_CC!E466*Constants_CC!E491
32	HCl	lb/hr		66	=Constants_CC!E470*Constants_CC!E491
33	Other Gases	lb/hr		1,425	=Constants_CC!E469*Constants_CC!E491

34	H2O	lb/hr		450,880	=Constants_CC!E472*Constants_CC!E491
35	Fly Ash	lb/hr		28,389	=Constants_CC!E519*2000
36	Total (gas only)	lb/hr		5,989,962	=SUM(D28:D34)
37					
38	***Flue Gas, to Spray Dryer***				
39	Temperature	°F		300	=D24
40	Pressure	in. H2O		-12	=D25
41	Flow Rate	SCFM		653,615	=((D43/CO2_MolWt)+(D44/N2_MolWt)+(D45/SO2_MolWt)+(D46/O2_MolWt)+(D48/NO2_MolWt)+(D47/HCl_MolWt)+(D49/H2O_MolWt))*cubft_60/60 min/hr
42	Flow Rate	ACFM		1,002,225	=D41*((D39+460)/520)*(29.92/('Input & Calculation Summary'!C28+(D40/inH2O_inHg)))
43	CO2	lb/hr		560,460	=D28/'Input & Calculation Summary'!C125
44	N2	lb/hr		2,042,036	=D29/'Input & Calculation Summary'!C125
45	SO2	lb/hr		2,359	=D30/'Input & Calculation Summary'!C125
46	O2	lb/hr		163,941	=D31/'Input & Calculation Summary'!C125
47	HCl	lb/hr		33	=D32/'Input & Calculation Summary'!C125
48	Other Gases	lb/hr		713	=D33/'Input & Calculation Summary'!C125
49	H2O	lb/hr		225,440	=D34/'Input & Calculation Summary'!C125
50	Fly Ash	lb/hr		14,195	=D35/'Input & Calculation Summary'!C125
51	Total (gas only)	lb/hr		2,994,981	=SUM(D43:D49)
52					
53	***Flue Gas, from Spray Dryers (total)***				
54	Temperature	°F		147	='Input & Calculation Summary'!C119
55	Pressure	in. H2O		-17	=D40-'Input & Calculation Summary'!C129
56	Flow Rate	SCFM		1,400,493	=((D58/CO2_MolWt)+(D59/N2_MolWt)+(D60/SO2_MolWt)+(D61/O2_MolWt)+(D63/NO_MolWt)+(D64/H2O_MolWt))*(cubft_60/60 min/hr)
57	Flow Rate	ACFM		1,737,513	=D56*((D54+460(rankine conv.))/520(stand.temp. °R)*(29.92(stand.press. "Hg)/('Input & Calculation Summary'!C28+(D55/inH2O_inHg)))
58	CO2	lb/hr		1,120,920	=D43*'Input & Calculation Summary'!C125
59	N2	lb/hr		4,084,072	=D44*'Input & Calculation Summary'!C125
60	SO2	lb/hr		1,321	=(D45-D360-D371)*'Input & Calculation Summary'!C125
61	O2	lb/hr		327,669	=(D46-D372)*'Input & Calculation Summary'!C125

62	HCl	lb/hr		0	0
63	Other Gases	lb/hr		1,425	=D48*'Input & Calculation Summary'!C125
64	H2O	lb/hr		717,236	=(D49+D142-D153+D362-D373+(D47/HCl_MolWt*H2O_MolWt))*'Input & Calculation Summary'!C125
65	Fly Ash	lb/hr		142,775	=(D404-D412)*'Input & Calculation Summary'!C125
66	Total (gas only)	lb/hr		6,252,643	=SUM(D58:D64)
67					
68	***Flue Gas Downstream of Particulate Control Device***				
69	Temperature	°F		147	=D54
70	Pressure	in. H2O		-23	=D55-(IF('Input & Calculation Summary'!C8'=1,'Input & Calculation Summary'!C162,'Input & Calculation Summary'!C180))
71	Flow Rate	SCFM		1,399,380	=((D73/CO2_MolWt)+(D74/N2_MolWt)+(D75/SO2_MolWt)+(D76/O2_MolWt)+(D78/NO_MolWt)+(D79/H2O_MolWt))*(cubft_60/60 min/hr)
72	Flow Rate	ACFM		1,763,743	=D71*((D69+460(Rankine conv.)/520(stand.temp.°R))*(29.92(stand. press. “Hg)/('Input & Calculation Summary'!C28+(D70/inH2O_inHg)))
73	CO2	lb/hr		1,120,920	=D58
74	N2	lb/hr		4,084,072	=D59
75	SO2	lb/hr		472	=D60-D382-D393
76	O2	lb/hr		327,616	=D61-D394
77	HCl	lb/hr		0	=D62
78	Other Gases	lb/hr		1,425	=D63
79	H2O	lb/hr		714,337	=D64+D384-D395-(D65-D80+D396+D385-D383-D392)/0.98*0.02 (H_2O in waste)
80	Fly Ash	lb/hr		158	='Input & Calculation Summary'!C160*Constants_CC!E491
81	Total (gas only)	lb/hr		6,248,843	=SUM(D73:D79)
82					
83	***Flue Gas Downstream of ID Fans***				
84	Temperature	°F		152	=D69+5 (ID fan temp increase)
85	Pressure	in. H2O		1	1
86	Flow Rate	SCFM		1,399,380	=((D88/CO2_MolWt)+(D89/N2_MolWt)+(D90/SO2_MolWt)+(D91/O2_MolWt)+(D93/NO_MolWt)+(D94/H2O_MolWt))*(cubft_60/60 min/hr)
87	Flow Rate	ACFM		1,671,916	=D86*((D84+460(Rankine conv.))/520(stand.temp.°R))*(29.92(stand.press. “Hg)/('Input & Calculation Summary'!C28+(D85/inH2O_inHg)))

88	CO2	lb/hr		1,120,920	=D73
89	N2	lb/hr		4,084,072	=D74
90	SO2	lb/hr		472	=D75
91	O2	lb/hr		327,616	=D76
92	HCl	lb/hr		0	=D77
93	Other Gases	lb/hr		1,425	=D78
94	H2O	lb/hr		714,337	=D79
95	Fly Ash	lb/hr		158	=D80
96	Total (gas only)	lb/hr		6,248,843	=SUM(D88:D94)
97					
98	***Lime to Ball Mill***				
99	Temperature	°F		60	60
100	Wt.% Solids	wt. %		100%	100%
101	Inerts	lb/hr		413	=D102/(Constants_CC!$D$79/100)*((100-Constants_CC!$D$79)/100)
102	CaO	lb/hr		3,717	=D30*(CaO_MolWt/SO2_MolWt)*'Input & Calculation Summary'!C120
103	Total	lb/hr		4,130	=D101+D102
104					
105	***Water to Ball Mill***				
106	Temperature	°F		60	60
107	Flow Rate	GPM		27	=D110/(8.34*(1+D108))/60 min/hr
108	Wt.% Solids	wt. %		0%	0%
109	H2O	lb/hr		13,616	=D118+D102/CaO_MolWt*H2O_MolWt
110	Total	lb/hr		13,616	=D109
111					
112	***Lime Slurry to Head Tanks (Total)***				
113	Temperature	°F		110	110
114	Flow Rate	GPM		27	=D119/(8.34*(1+D115))/60 min/hr
115	Wt.% Solids	wt. %		30%	30%
116	Ca(OH)2	lb/hr		4,911	=D102/CaO_MolWt*Ca_OH_2_MolWt
117	Inerts	lb/hr		413	=D101
118	H2O	lb/hr		12,422	=(D116+D117)/D115*(1-D115)
119	Total	lb/hr		17,745	=SUM(D116:D118)

120					
121	***Lime Slurry from Head Tank***				
122	Temperature	°F		110	110
123	Flow Rate	GPM		273	=D131/(8.34 lbs/gal*(1+D124))/60 min/hr
124	Wt.% Solids	wt. %		36%	=1-D130/D131
125	CaSO3*1/2H2O	lb/hr		10,154	=D190/'Input & Calculation Summary'!C$125
126	CaSO4*2H2O	lb/hr		4,517	=D191/'Input & Calculation Summary'!C$125
127	Flyash / Inerts	lb/hr		46,243	=(D192+D117)/'Input & Calculation Summary'!C$125
128	Ca(OH)2	lb/hr		2,401	=(D193+D116)/'Input & Calculation Summary'!C$125
129	CaCl2	lb/hr		4,002	=D194/'Input & Calculation Summary'!C$125
130	H2O	lb/hr		118,855	=(D195+D118)/'Input & Calculation Summary'!C$125
131	Total	lb/hr		186,173	=SUM(D125:D130)
132					
133	***Lime Slurry to Atomizer***				
134	Temperature	°F		104	104
135	Flow Rate	GPM		300	=D143/(8.34 lbs/gal*(1+D136))/60 min/hr
136	Wt.% Solids	wt. %		34%	=1-D142/D143
137	CaSO3*1/2H2O	lb/hr		10,154	=D125
138	CaSO4*2H2O	lb/hr		4,517	=D126
139	Flyash / Inerts	lb/hr		46,243	=D127
140	Ca(OH)2	lb/hr		2,401	=D128
141	CaCl2	lb/hr		4,002	=D129
142	H2O	lb/hr		133,426	=D130+(1.4251*(D39-D54)-188.9)*1000/2
143	Total	lb/hr		200,744	=SUM(D137:D142)
144					
145	***Solids from Spray Dryers (Total)***				
146	Temperature	°F		150	150
147	Wt.% Solids	wt. %		98%	=1-0.02 (wt.% H_2O in waste)
148	CaSO3*1/2H2O	lb/hr		2,544	=D407*'Input & Calculation Summary'!C125
149	CaSO4*2H2O	lb/hr		1,132	=D408*'Input & Calculation Summary'!C125
150	Flyash / Inerts	lb/hr		12,008	=D409*'Input & Calculation Summary'!C125-(D32/HCl_MolWt*CaCl2_MolWt/2)

151	Ca(OH)2	lb/hr		81	=D410*'Input & Calculation Summary'!C125
152	CaCl2	lb/hr		100	=D32/HCl_MolWt*CaCl2_MolWt/2 (mole Cl/mole of $CaCl_2$)
153	H2O	lb/hr		324	=D411*'Input & Calculation Summary'!C125
154	Total	lb/hr		16,188	=SUM(D148:D153)
155					
156	***Baghouse/ESP Solids to Recycle***				
157	Particulate Removal Efficiency	%		99.89%	=(D65-D80)/D65
158	Temperature	°F		150	150
159	Wt.% Solids	wt. %		98%	=1-0.02(wt.% H_2O in waste)
160	CaSO3*1/2H2O	lb/hr		17,765	=D$166*D423/D428
161	CaSO4*2H2O	lb/hr		7,903	=D$166*D424/D428
162	Flyash / Inerts	lb/hr		80,066	=D$166*D425/D428
163	Ca(OH)2	lb/hr		-188	=D$166*D426/D428
164	CaCl2	lb/hr		7,903	=D$166*D424/D428
165	H2O	lb/hr		2,154	=D$166*D427/D428
166	Total	lb/hr		107,700	=('Input & Calculation Summary'!C122*D103)-D154
167					
168	***Recycle Solids to Slurry Tank***				
169	Temperature	°F		150	150
170	Wt.% Solids	wt. %		98%	=1-0.02(wt.% H_2O in waste)
171	CaSO3*1/2H2O	lb/hr		20,308	=D148+D160
172	CaSO4*2H2O	lb/hr		9,035	=D149+D161
173	Flyash / Inerts	lb/hr		92,074	=D150+D162
174	Ca(OH)2	lb/hr		-108	=D151+D163
175	CaCl2	lb/hr		8,003	=D152+D164
176	H2O	lb/hr		2,478	=D153+D165
177	Total	lb/hr		131,790	=SUM(D171:D176)
178					
179	***Blowdown Water to Recycle Solids Tank***				
180	Temperature	°F		60	60
181	Flow Rate	GPM		445	=D184/8.34 lbs/gal/60 min/hr

182	Wt.% Solids	wt. %		0%	0%
183	H2O	lb/hr		222,811	=D195-D176
184	Total	lb/hr		222,811	=D183
185					
186	***Recycle Slurry to Head Tanks (Total)***				
187	Temperature	°F		110	110
188	Flow Rate	GPM		525	=D196/(8.34 lbs/gal*(1+D189))/60 min/hr
189	Wt.% Solids	wt. %		35%	='Input & Calculation Summary'!C124
190	CaSO3*1/2H2O	lb/hr		20,308	=D171
191	CaSO4*2H2O	lb/hr		9,035	=D172
192	Flyash / Inerts	lb/hr		92,074	=D173
193	Ca(OH)2	lb/hr		-108	=D174
194	CaCl2	lb/hr		8,003	=D175
195	H2O	lb/hr		225,289	=SUM(D190:D193)/D189*(1-D189)
196	Total	lb/hr		354,602	=SUM(D190:D195)
197					
198	***Dry Solids***				
199	Temperature	°F		100	100
200	Wt.% Solids	wt. %		98%	=D159
201	CaSO3*1/2H2O	lb/hr		6,386	=D423-D160
202	CaSO4*2H2O	lb/hr		2,841	=D424-D161
203	Flyash / Inerts	lb/hr		28,682	=D425-D162-(D32/HCl_MolWt*CaCl2_MolWt/2 moles Cl/mole $CaCl_2$)
204	Ca(OH)2	lb/hr		-68	=D426-D163
205	CaCl2	lb/hr		200	=D152*2
206	H2O	lb/hr		774	=D427-D165
207	Total	lb/hr		38,816	=SUM(D201:D206)
208					
209	***Solids to Landfill***				
210	Temperature	°F		100	100
211	Wt.% Solids	wt. %		80%	80%
212	CaSO3*1/2H2O	lb/hr		6,386	=D201

213	CaSO4*2H2O	lb/hr		2,841	=D202
214	Flyash / Inerts	lb/hr		28,682	=D203
215	Ca(OH)2	lb/hr		-68	=D204
216	CaCl2	lb/hr		200	=D205
217	H2O	lb/hr		9,510	=SUM(D212:D216)/D211*(1-D211)
218	Total	lb/hr		47,552	=SUM(D212:D217)

F-4.2 Capital Cost Calculations

The capital cost section of the worksheet takes the results of the material balances and uses these values with Raytheon developed algorithms to cost the different pieces of equipment included in the LSD process. The algorithms were developed from vendor-supplied information and Raytheon’s design experience. The following table shows the algorithms and the results for one case.

	A	*B*	*C*	*D*	
	LSD Equipment Capital Costs				
Row			**Sizing**	**Case 1**	
No.	**Title / Description**	**Units**	**Criteria**	**Results**	**Equation**
223	Cost Basis (Year)			1998	='Input & Calculation Summary'!C42
224					Capital Cost Algorithms - Constants Derived from Database
225	Reagent Feed System	$	*	$4,674,756	=((170023*D103/1000+3764611)+(72338*(D114^0.3195))) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
226	SO2 Removal System	$	Wt. % S	$1,596,996	=(581877809*(Constants_CC!E324/100)^3-3653117*(Constants_CC!E324/100)^2+693335*(Constants_CC!E324/100)+214198) *'Input & Calculation Summary'!C125+(677421*(Constants_CC!E324/100)^-0.0966) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))

227	Spray Dryers	$	kACFM	$17,550,564	=(IF('Input & Calculation Summary'!C127'=1,(-4.85*(D42/1000)^2+12538*(D42/1000)+1080990),(-3.57*(D42/1000)^2+9246*(D42/1000)+791896))*'Input & Calculation Summary'!C125) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
228	Flue Gas Handling System	$	kACFM	$5,216,448	=((1721.8*(D27/1000)^0.683)+(1326.2*(D57/1000)^0.7131))*'Input & Calculation Summary'!C125+(15338*(D27/1000)^0.5)+(47680*(D57/1000)^0.5576)+(4840.4*(D72/1000)^0.5)+(2695.9*(D87/1000)^0.5) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
229	ID Fans	$	ACFM	$1,715,355	=((91.24*((L229)^0.6842))*L230) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
230	Waste / Byproduct Handling System	$	kpph SO2	$1,049,229	=(2051841884*(Constants_CC!E324/100)^2-1443163*(Constants_CC!E324/100)+1026479) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
231	Support Equipment	$	MW	$2,404,066	=(-1.211*'Input & Calculation Summary'!C21^2+2704.2*'Input & Calculation Summary'!C21+1354716.2) *(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))

232	Chimney	$	ACFM	$4,813,027	=IF('Input & Calculation Summary'!C81=1,40208*D57^0.3339,23370*D57^0.3908)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55=”Yes”, 'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D223-1998)))))
233	**TOTAL**	$		$39,038,843	=SUM(D225:D232)
234	** Based on lbs/hr of lime feed and GPM of lime slurry.*				
235					
236	***Capital Costs with Retrofit Factors***				
237	Reagent Feed System	$		$6,097,562	=D225*'Input & Calculation Summary'!C$35
238	SO2 Removal System	$		$2,076,095	=D226*'Input & Calculation Summary'!C$35
239	Spray Dryers	$		$22,815,733	=D227*'Input & Calculation Summary'!C$35
240	Flue Gas Handling System	$		$6,784,928	=D228*'Input & Calculation Summary'!C$35
241	ID Fans	$		$2,229,961	=D229*'Input & Calculation Summary'!C$35
242	Waste / Byproduct Handling System	$		$1,363,998	=D230*'Input & Calculation Summary'!C$35
243	Support Equipment	$		$3,125,286	=D231*'Input & Calculation Summary'!C$35
244	Chimney	$		$6,256,935	=D232*'Input & Calculation Summary'!C$35
245	**TOTAL**	$		$50,750,496	=SUM(D237:D244)
246					
247	***General Facilities***				
248	Reagent Feed System	$		$609,756	=D237*'Input & Calculation Summary'!C146
249	SO2 Removal System	$		$207,610	=D238*'Input & Calculation Summary'!C147
250	Spray Dryers	$		$2,281,573	=D239*'Input & Calculation Summary'!C147
251	Flue Gas Handling System	$		$678,493	=D240*'Input & Calculation Summary'!C148
252	ID Fans	$		$222,996	=D241*'Input & Calculation Summary'!C148
253	Waste / Byproduct Handling System	$		$136,400	=D242*'Input & Calculation Summary'!C149
254	Support Equipment	$		$312,529	=D243*'Input & Calculation Summary'!C150
255	Chimney	$		$625,693	=D244*'Input & Calculation Summary'!C150
256	**TOTAL**	$		$5,075,050	=SUM(D248:D255)

257					
258	***Engineering Fees***				
259	Reagent Feed System	$		$609,756	=D237*'Input & Calculation Summary'!C152
260	SO2 Removal System	$		$207,610	=D238*'Input & Calculation Summary'!C153
261	Spray Dryers	$		$2,281,573	=D239*'Input & Calculation Summary'!C153
262	Flue Gas Handling System	$		$678,493	=D240*'Input & Calculation Summary'!C154
263	ID Fans	$		$222,996	=D241*'Input & Calculation Summary'!C154
264	Waste / Byproduct Handling System	$		$136,400	=D242*'Input & Calculation Summary'!C155
265	Support Equipment	$		$312,529	=D243*'Input & Calculation Summary'!C156
266	Chimney	$		$625,693	=D244*'Input & Calculation Summary'!C156
267	**TOTAL**	$		$5,075,050	=SUM(D259:D266)
268					
269	***Contingency***				
270	Reagent Feed System	$		$1,219,512	=D237*'Input & Calculation Summary'!C140
271	SO2 Removal System	$		$415,219	=D238*'Input & Calculation Summary'!C141
272	Spray Dryers	$		$4,563,147	=D239*'Input & Calculation Summary'!C141
273	Flue Gas Handling System	$		$1,356,986	=D240*'Input & Calculation Summary'!C142
274	ID Fans	$		$445,992	=D241*'Input & Calculation Summary'!C142
275	Waste / Byproduct Handling System	$		$272,800	=D242*'Input & Calculation Summary'!C143
276	Support Equipment	$		$625,057	=D243*'Input & Calculation Summary'!C144
277	Chimney	$		$1,251,387	=D244*'Input & Calculation Summary'!C144
278	**TOTAL**	$		$10,150,099	=SUM(D270:D277)
279					
280	***Total Plant Cost (TPC)***	$		$71,050,695	=D245+D256+D267+D278
281	TPC w/ Prime Contractors Markup	$		$73,182,216	=D280*(1+'Input & Calculation Summary'!C$59)
282	***Total Cash Expended (TCE)***	$		$71,071,389	=D281*VLOOKUP(Constants_CC!E528,Constants_CC!$C$557:$E$562,3)
283					
284	***Allow. for Funds During Constr. (AFDC)***	$		$7,792,675	=D281*VLOOKUP(Constants_CC!E528,Constants_CC!$C$557:$E$562,2)
285					

286	***Total Plant Investment (TPI)***	$		$78,864,064	=D282+D284
287					
288	*Preproduction Costs*	$		$2,560,371	=(D339+D348/'Input & Calculation Summary'!C23)/12 mon/yr+0.02 (fract. TPI)*D286
289	*Inventory Capital*	$		$197,208	=(D324/2000 lbs/ton)*24 hr/day*'Input & Calculation Summary'!C130*'Input & Calculation Summary'!C131
290					
291	***Total Capital Requirement (TCR)***	$		**$81,621,644**	**=D286+D288+D289**
292		$/kW		$163	=D291/('Input & Calculation Summary'!C21*1000 kW/MW)

F-4.3 Maintenance Cost Calculations

The first year maintenance costs for the LSD system are calculated in this section of the worksheet. The retrofit factor is first backed out of the total plant cost (TPC), which is calculated in the capital cost section of the worksheet. A user-supplied maintenance factor is then applied to the resulting cost. The following table provides the equations and results for one case.

	A	*B*	*C*	*D*	
	Maintenance Cost by Area				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
297	***TPC w/o Retrofit Factor***				
298	Reagent Feed System	$		$6,754,222	=(1+'Input & Calculation Summary'!C146+'Input & Calculation Summary'!C152)*D225+('Input & Calculation Summary'!C140*(1+'Input & Calculation Summary'!C146+'Input & Calculation Summary'!C152)*D225)
299	SO2 Removal System	$		$2,299,675	=(1+'Input & Calculation Summary'!C147+'Input & Calculation Summary'!C153)*D226+('Input & Calculation Summary'!C141*(1+'Input & Calculation Summary'!C147+'Input & Calculation Summary'!C153)*D226)
300	Spray Dryers	$		$25,272,812	=(1+'Input & Calculation Summary'!C147+'Input & Calculation Summary'!C153)*D227+('Input & Calculation Summary'!C141*(1+'Input & Calculation Summary'!C147+'Input & Calculation Summary'!C153)*D227)
301	Flue Gas Handling System	$		$7,515,612	=(1+'Input & Calculation Summary'!C148+'Input & Calculation Summary'!C154)*D228+('Input & Calculation Summary'!C142*(1+'Input & Calculation Summary'!C148+'Input & Calculation Summary'!C154)*D228)
302	ID Fans	$		$2,470,111	=(1+'Input & Calculation Summary'!C148+'Input & Calculation Summary'!C154)*D229+('Input & Calculation Summary'!C142*(1+'Input & Calculation Summary'!C148+'Input & Calculation Summary'!C154)*D229)
303	Waste / Byproduct Handling System	$		$1,510,890	=(1+'Input & Calculation Summary'!C149+'Input & Calculation Summary'!C155)*D230+('Input & Calculation Summary'!C143*(1+'Input & Calculation Summary'!C149+'Input & Calculation Summary'!C155)*D230)
304	Support Equipment	$		$3,461,855	=(1+'Input & Calculation Summary'!C150+'Input & Calculation Summary'!C156)*D231+('Input & Calculation Summary'!C144*(1+'Input & Calculation Summary'!C150+'Input & Calculation Summary'!C156)*D231)

305	Chimney	$		$6,930,758	=(1+'Input & Calculation Summary'!C150+'Input & Calculation Summary'!C156)*D232+('Input & Calculation Summary'!C144*(1+'Input & Calculation Summary'!C150+'Input & Calculation Summary'!C156)*D232)
306	**TOTAL**	$		$56,215,935	=SUM(D298:D305)
307					
308	***First Year Maintenance Costs***				
309	Reagent Feed System	$		$337,711	=D298*'Input & Calculation Summary'!C134
310	SO2 Removal System	$		$114,984	=D299*'Input & Calculation Summary'!C135
311	Spray Dryers	$		$1,263,641	=D300*'Input & Calculation Summary'!C135
312	Flue Gas Handling System	$		$375,781	=D301*'Input & Calculation Summary'!C136
313	ID Fans	$		$123,506	=D302*'Input & Calculation Summary'!C136
314	Waste / Byproduct Handling System	$		$75,544	=D303*'Input & Calculation Summary'!C137
315	Support Equipment	$		$173,093	=D304*'Input & Calculation Summary'!C138
316	Chimney	$		$346,538	=D305*'Input & Calculation Summary'!C138
317	**TOTAL**	$		$2,810,797	=SUM(D309:D316)

F-4.4 O&M Data and Costs

The LSD O&M data and costs are summarized in this section of the worksheet. This information is derived from the material balance calculations and the user-supplied inputs.

	A	*B*	*C*	*D*	
	LSD O&M Data and Costs				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
322	***Cost Basis (Year)***			***1998***	***='Input & Calculation Summary'!C42***
323	**Parameters**				
324	Reagent Required	lbs/hr		4,130	=D103
325		lbs/MMBtu		0.787	=D324/Constants_CC!E491
326	Percent SO2 Removal	%		90%	='Input & Calculation Summary'!C116

327	FGD Solids - dry	lbs/hr		38,041	=D207-D206
328	- wetted	lbs/hr		47,552	=D218
329	Fresh Water to FGD	gpm		27	=D107
330	Blowdown Water to FGD	gpm		492	=(D183+(D217-D206)+(D142-D130))/8.34/60 min/hr
331	Total FGD Power Consumption	kW		3,500	=0.007 (assumed LSD power consumption as fract. of plant output)*(1000 kW/MW*'Input & Calculation Summary'!C21)
332					
333	**Fixed O&M Costs**				
334	Number of Operators			20	=(18.25-2.278*LN('Input & Calculation Summary'!C21))*'Input & Calculation Summary'!C21/100 - algorithm for operator requirement (constants from database)
335	(40 hrs/week)				
336	Operating Labor Cost	$/yr		$1,277,054	=('Input & Calculation Summary'!C60*D334*40 hr/shift*52 weeks/yr)
337	Maint. Labor & Matls. Cost	$/yr		$2,810,797	=D317
338	Admin. & Support Labor	$/yr		$720,411.90	=0.3*((D317*0.4)+D336)
339	TOTAL	$/yr		$4,808,263	=SUM(D336:D338)
340					
341	**Variable Operating Costs**				
342	Reagent Costs	$/yr		$779,794	=(D324/2000 lbs/ton*'Input & Calculation Summary'!C23*8760 hr/yr*'Input & Calculation Summary'!C131)
343	Disposal Costs	$/yr		$3,259,022	=('Input & Calculation Summary'!C23*8760*D328*D211/2000 lbs/ton*'Input & Calculation Summary'!C132)
344	Credit for Byproduct	$/yr		$0	$0
345	Steam Costs	$/yr		$0	$0
346	Fresh Water Costs	$/yr		$5,691	=($0.6/1000 gal *(D329/1000 gal)*60 min/hr*8760 hr/yr*'Input & Calculation Summary'!C23)
347	Power Costs	$/yr		$498,225	=(D331/1000 kW/MW*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61)
348	TOTAL	$/yr		$4,542,732	=SUM(D342:D347)

F-4.5 Intermediate Material Balance Calculations

This section of the worksheet is used to perform intermediate calculations required by the material balance. These values are not directly used in sizing and costing the FGD equipment. The following table shows the equations and results for one case.

	A	B	C	D	
	Intermediate Material Balance Calcs.				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
354	***FGD Reactions in Spray Dryer*** *(80% of SO2 Removal)*				
355	***Sulfite Reaction***	*60%*			
356	SO2	Lbmole/hr		19.88	=D45/SO2_MolWt*'Input & Calculation Summary'!C116*$B355
357	Ca(OH)2	Lbmole/hr		19.88	=D356
358	H2O	Lbmole/hr		9.94	=D356*0.5 (mole H_2O/mole of sulfite produced)
359	CaSO3*1/2H2O	Lbmole/hr		19.88	=D356
360	SO2	lb/hr		1,274	=D356*SO2_MolWt
361	Ca(OH)2	lb/hr		1,473	=D357*Ca_OH_2_MolWt
362	H2O	lb/hr		179	=D358*H2O_MolWt
363	CaSO3*1/2H2O	lb/hr		2,565	=D359*CaSO3halfH2O_MolWt
364	***Sulfate Reaction***	*20%*			
365	Ca(OH)2	Lbmole/hr		6.63	=D366
366	SO2	lbmole/hr		6.63	=D45/SO2_MolWt*'Input & Calculation Summary'!C116*$B364
367	O2	lbmole/hr		3.31	=D366/2 (1/2 mole O_2 required/mole of solfate)
368	H2O	lbmole/hr		6.63	=D366
369	CaSO4*2H2O	lbmole/hr		6.63	=D366
370	Ca(OH)2	lb/hr		491	=D365*Ca_OH_2_MolWt
371	SO2	lb/hr		425	=D366*SO2_MolWt
372	O2	lb/hr		106	=D367*O2_MolWt
373	H2O	lb/hr		119	=D368*H2O_MolWt
374	CaSO4*2H2O	lb/hr		1,141	=D369*CaSO4_2H2O_MolWt
375					

376	***FGD Reactions in Particulate Control*** *(20% of SO2 Removal)*				
377	***Sulfite Reaction***	*15%*			
378	SO2	lbmole/hr		9.94	=D45/SO2_MolWt*'Input & Calculation Summary'!C116*$B377*'Input & Calculation Summary'!C125
379	Ca(OH)2	lbmole/hr		9.94	=D378
380	H2O	lbmole/hr		4.97	=D378*0.5 (mole H_2O/mole of sulfite produced)
381	CaSO3*1/2H2O	lbmole/hr		9.94	=D378
382	SO2	lb/hr		637	=D378*SO2_MolWt
383	Ca(OH)2	lb/hr		737	=D379*Ca_OH_2_MolWt
384	H2O	lb/hr		90	=D380*H2O_MolWt
385	CaSO3*1/2H2O	lb/hr		1,282	=D381*CaSO3halfH2O_MolWt
386	***Sulfate Reaction***	*5%*			
387	Ca(OH)2	lbmole/hr		3.31	=D388
388	SO2	lbmole/hr		3.31	=D45/SO2_MolWt*'Input & Calculation Summary'!C116*$B386*'Input & Calculation Summary'!C125
389	O2	lbmole/hr		1.66	=D388/2 (1/2 mole O_2 required/mole of solfate)
390	H2O	lbmole/hr		3.31	=D388
391	CaSO4*2H2O	lbmole/hr		3.31	=D388
392	Ca(OH)2	lb/hr		246	=D387*Ca_OH_2_MolWt
393	SO2	lb/hr		212	=D388*SO2_MolWt
394	O2	lb/hr		53	=D389*O2_MolWt
395	H2O	lb/hr		60	=D390*H2O_MolWt
396	CaSO4*2H2O	lb/hr		571	=D391*CaSO4_2H2O_MolWt
397					
398	***Solids in Spray Dryer***				
399	CaSO3*1/2H2O	lb/hr		12,719	=D1008
400	CaSO4*2H2O	lb/hr		5,659	=D1009
401	Inerts	lb/hr		60,538	=D1010
402	Ca(OH)2	lb/hr		403	=D1011
403	H2O	lb/hr			
404	TOTAL	lb/hr		79,319	=SUM(D399:D402)
405					

406	***Spray Dryer Solids Removal***				
407	CaSO3*1/2H2O	lb/hr		1,272	=D399*0.1 (assumed fract. of solids leaving spray dryer)
408	CaSO4*2H2O	lb/hr		566	=D400*0.1 (assumed fract. of solids leaving spray dryer)
409	Inerts	lb/hr		6,054	=D401*0.1 (assumed fract. of solids leaving spray dryer)
410	Ca(OH)2	lb/hr		40	=D402*0.1 (assumed fract. of solids leaving spray dryer)
411	H2O	lb/hr		162	=SUM(D407:D410)*0.02/0.98 (wt.% solids in product)
412	TOTAL	lb/hr		7,932	=SUM(D407:D410)
413					
414	***Solids in Baghouse/ESP***				
415	CaSO3*1/2H2O	lb/hr		24,177	=(D399-D407)*'Input & Calculation Summary'!C125+D385
416	CaSO4*2H2O	lb/hr		10,756	=(D400-D408)*'Input & Calculation Summary'!C125+'LSD Cost & Tech. Results'!D396
417	Inerts	lb/hr		108,968	=(D401-D409)*'Input & Calculation Summary'!C125
418	Ca(OH)2	lb/hr		-256	=(D402-D410)*'Input & Calculation Summary'!C125-(D392+D383)
419	H2O	lb/hr			
420	TOTAL	lb/hr		143,645	=SUM(D415:D418)
421					
422	***Components of Baghouse/ESP Solids***				
423	CaSO3*1/2H2O	lb/hr		24,151	=D415*D$157
424	CaSO4*2H2O	lb/hr		10,744	=D416*D$157
425	Inerts	lb/hr		108,848	=D417*D$157
426	Ca(OH)2	lb/hr		-256	=D418*D$157
427	H2O	lb/hr		2,928	=SUM(D423:D426)*0.02/0.98 (wt.% solids in product)
428	TOTAL	lb/hr		146,415	=SUM(D423:D427)
429					
430	***Total Waste Solids Out***				
431	CaSO3*1/2H2O	lb/hr		6,412	=D363*'Input & Calculation Summary'!C125+'LSD Cost & Tech. Results'!D385
432	CaSO4*2H2O	lb/hr		2,853	=D374*'Input & Calculation Summary'!C125+D396
433	Inerts	lb/hr		28,902	=D101+D35+(D32/HCl_MolWt*CaCl2_MolWt/2)
434	Ca(OH)2	lb/hr		-67	=(D102/CaO_MolWt*Ca_OH_2_MolWt)-(D361+D370)*'Input & Calculation Summary'!C125-(D383+D392)-(D32/HCl_MolWt*Ca_OH_2_MolWt/2)
435	H2O	lb/hr		NA	NA
436	TOTAL	lb/hr		38,100	=SUM(D431:D434)

437	CaSO3*1/2H2O	wt. %		16.83%	=D431/$D$436
438	CaSO4*2H2O	wt. %		7.49%	=D432/$D$436
439	Inerts	wt. %		75.86%	=D433/$D$436
440	Ca(OH)2	wt. %		-0.18%	=D434/$D$436
441	H2O	wt. %		NA	NA
442	TOTAL	wt. %		100.00%	=SUM(D437:D440)
443					
444	***Waste Out Gas Stream***				
445	CaSO3*1/2H2O	lb/hr		26.5	=D450*D437
446	CaSO4*2H2O	lb/hr		11.8	=D450*D438
447	Inerts	lb/hr		119.5	=D450*D439
448	Ca(OH)2	lb/hr		-0.3	=D450*D440
449	H2O	lb/hr		NA	NA
450	TOTAL	lb/hr		158	=D80
451					
452	***Dry Solids***				
453	CaSO3*1/2H2O	lb/hr		6,386	=$D$458*(1-0.02)*D437
454	CaSO4*2H2O	lb/hr		2,841	=$D$458*(1-0.02)*D438
455	Inerts	lb/hr		28,782	=$D$458*(1-0.02)*D439
456	Ca(OH)2	lb/hr		-66	=$D$458*(1-0.02)*D440
457	H2O	lb/hr		774	=D458-SUM(D453:D456)
458	TOTAL	lb/hr		38,717	=(D436-D450)/(1-0.02)
459					
460	***ITERATION 1***				
461	***Assumed Composition of Recycle Solids to Slurry Tank***				
462	CaSO3*1/2H2O	lb/hr		20,433	=$D$467*D453/$D$458
463	CaSO4*2H2O	lb/hr		9,090	=$D$467*D454/$D$458
464	Inerts	lb/hr		92,099	=$D$467*D455/$D$458
465	Ca(OH)2	lb/hr		-212	=$D$467*D456/$D$458
466	H2O	lb/hr		2,478	=$D$467*D457/$D$458
467	TOTAL	lb/hr		123,887	=D103*'Input & Calculation Summary'!C122

468					
469	***Composition of Recycle Slurry to Head Tanks***				
470	CaSO3*1/2H2O	lb/hr		20,433	=D462
471	CaSO4*2H2O	lb/hr		9,090	=D463
472	Inerts	lb/hr		92,099	=D464
473	Ca(OH)2	lb/hr		-212	=D465
474	H2O	lb/hr		225,475	=SUM(D470:D473)/'Input & Calculation Summary'!C$124*(1-'Input & Calculation Summary'!C$124)
475	TOTAL	lb/hr		346,884	=SUM(D470:D474)
476					
477	***Composition of Slurry from Head Tank***				
478	CaSO3*1/2H2O	lb/hr		10,216	=D470/'Input & Calculation Summary'!C$125
479	CaSO4*2H2O	lb/hr		4,545	=D471/'Input & Calculation Summary'!C$125
480	Inerts	lb/hr		46,256	=D472/'Input & Calculation Summary'!C$125+(D$117/'Input & Calculation Summary'!C$125)
481	Ca(OH)2	lb/hr		2,349	=D473/'Input & Calculation Summary'!C$125+(D$116/'Input & Calculation Summary'!C$125)
482	H2O	lb/hr		118,948	=D474/'Input & Calculation Summary'!C$125+(D$118/'Input & Calculation Summary'!C$125)
483	TOTAL	lb/hr		182,315	=SUM(D478:D482)
484					
485	***Solids in Spray Dryer***				
486	CaSO3*1/2H2O	lb/hr		12,781	=D478+D$363
487	CaSO4*2H2O	lb/hr		5,686	=D479+D$374
488	Inerts	lb/hr		60,500	=D480+D$50+(D$32/HCl_MolWt*CaCl2_MolWt/2/'Input & Calculation Summary'!C$125)
489	Ca(OH)2	lb/hr		351	=D481-(D$361+D$370)-(D$32/HCl_MolWt*Ca_OH_2_MolWt/2/'Input & Calculation Summary'!C$125)
490	H2O	lb/hr		NA	NA
491	TOTAL	lb/hr		79,319	=SUM(D486:D489)
492					

493	***Composition of Solids from Spray Dryers***				
494	CaSO3*1/2H2O	lb/hr		1,278	=D486*0.1(assumedn fract. of solids leaving spray dryer)
495	CaSO4*2H2O	lb/hr		569	=D487*0.1(assumedn fract. of solids leaving spray dryer)
496	Inerts	lb/hr		6,050	=D488*0.1(assumedn fract. of solids leaving spray dryer)
497	Ca(OH)2	lb/hr		35	=D489*0.1(assumedn fract. of solids leaving spray dryer)
498	H2O	lb/hr		162	=SUM(D494:D497)*0.02/0.98
499	TOTAL	lb/hr		8,094	=SUM(D494:D498)
500					
501	***Solids in Baghouse/ESP***				
502	CaSO3*1/2H2O	lb/hr		24,288	=(D486-D494)*'Input & Calculation Summary'!C$125+D$385
503	CaSO4*2H2O	lb/hr		10,806	=(D487-D495)*'Input & Calculation Summary'!C$125+D$396
504	Inerts	lb/hr		108,901	=(D488-D496)*'Input & Calculation Summary'!C$125
505	Ca(OH)2	lb/hr		-349	=(D489-D497)*'Input & Calculation Summary'!C$125-(D$383+D$392)
506	H2O	lb/hr			
507	TOTAL	lb/hr		143,645	=SUM(D502:D505)
508	CaSO3*1/2H2O	wt %		16.9%	=D502/(D507-D506)
509	CaSO4*2H2O	wt %		7.5%	=D503/(D507-D506)
510	Inerts	wt %		75.8%	=D504/(D507-D506)
511	Ca(OH)2	wt %		-0.2%	=D505/(D507-D506)
512	H2O	wt %			
513	TOTAL	wt %		100.0%	=SUM(D508:D511)
514					
515	***Dry Solids***				
516	CaSO3*1/2H2O	lb/hr		6,416	=D508*(D521-D520)
517	CaSO4*2H2O	lb/hr		2,854	=D509*(D521-D520)
518	Inerts	lb/hr		28,765	=D510*(D521-D520)
519	Ca(OH)2	lb/hr		-92	=D511*(D521-D520)
520	H2O	lb/hr		774	=D521*0.02 (wt.fract. H_2O)
521	TOTAL	lb/hr		38,717	=D$458

522					
523	***Solids Out Stack***				
524	CaSO3*1/2H2O	lb/hr		27	=D508*D529
525	CaSO4*2H2O	lb/hr		12	=D509*D529
526	Inerts	lb/hr		119	=D510*D529
527	Ca(OH)2	lb/hr		0	=D511*D529
528	H2O	lb/hr			
529	TOTAL	lb/hr		158	=D$80
530					
531	***Composition of Baghouse/ESP Solids to Recycle***				
532	CaSO3*1/2H2O	lb/hr		17,846	=D502-D516-D524
533	CaSO4*2H2O	lb/hr		7,940	=D503-D517-D525
534	Inerts	lb/hr		80,016	=D504-D518-D526
535	Ca(OH)2	lb/hr		-257	=D505-D519-D527
536	H2O	lb/hr		2,154	=D537-SUM(D532:D535)
537	TOTAL	lb/hr		107,700	=SUM(D532:D535)/0.98 (wt.fract.solids)
538					
539	***Calculated Composition of Recycle Solids to Slurry Tank***				
540	CaSO3*1/2H2O	lb/hr		20,403	=D494*'Input & Calculation Summary'!C$125+D532
541	CaSO4*2H2O	lb/hr		9,077	=D495*'Input & Calculation Summary'!C$125+D533
542	Inerts	lb/hr		92,117	=D496*'Input & Calculation Summary'!C$125+D534
543	Ca(OH)2	lb/hr		-186	=D497*'Input & Calculation Summary'!C$125+D535
544	H2O	lb/hr		2,478	=D498*'Input & Calculation Summary'!C$125+D536
545	TOTAL	lb/hr		123,887	=SUM(D540:D544)
546					
547	***ITERATION 2***				
548	***Assumed Composition of Recycle Solids to Slurry Tank***				
549	CaSO3*1/2H2O	lb/hr		20,372	=IF(ABS(D540-D462)<1,D540,D540+D540-D462)
550	CaSO4*2H2O	lb/hr		9,063	=IF(ABS(D540-D462)<1,D541,D541+D541-D463)
551	Inerts	lb/hr		92,138	=IF(ABS(D540-D462)<1,D542,D542-(D540-D462+D541-D463)/2)
552	Ca(OH)2	lb/hr		-165	=IF(ABS(D540-D462)<1,D543,D543-(D540-D462+D541-D463)/2)

553	H2O	lb/hr		2,478	=D544
554	TOTAL	lb/hr		123,887	=SUM(D549:D553)
555					
556	***Composition of Recycle Slurry to Head Tanks***				
557	CaSO3*1/2H2O	lb/hr		20,372	=D549
558	CaSO4*2H2O	lb/hr		9,063	=D550
559	Inerts	lb/hr		92,138	=D551
560	Ca(OH)2	lb/hr		-165	=D552
561	H2O	lb/hr		225,475	=SUM(D557:D560)/'Input & Calculation Summary'!C$124*(1-'Input & Calculation Summary'!C$124)
562	TOTAL	lb/hr		346,884	=SUM(D557:D561)
563					
564	***Composition of Slurry from Head Tank***				
565	CaSO3*1/2H2O	lb/hr		10,186	=D557/'Input & Calculation Summary'!C$125
566	CaSO4*2H2O	lb/hr		4,532	=D558/'Input & Calculation Summary'!C$125
567	Inerts	lb/hr		46,276	=D559/'Input & Calculation Summary'!C$125+(D$117/'Input & Calculation Summary'!C$125)
568	Ca(OH)2	lb/hr		2,373	=D560/'Input & Calculation Summary'!C$125+(D$116/'Input & Calculation Summary'!C$125)
569	H2O	lb/hr		118,948	=D561/'Input & Calculation Summary'!C$125+(D$118/'Input & Calculation Summary'!C$125)
570	TOTAL	lb/hr		182,315	=SUM(D565:D569)
571					
572	***Solids in Spray Dryer***				
573	CaSO3*1/2H2O	lb/hr		12,751	=D565+D$363
574	CaSO4*2H2O	lb/hr		5,673	=D566+D$374
575	Inerts	lb/hr		60,520	=D567+D$50+(D$32/HCl_MolWt*CaCl2_MolWt/2/'Input & Calculation Summary'!C$125)
576	Ca(OH)2	lb/hr		375	=D568-(D$361+D$370)-(D$32/HCl_MolWt*Ca_OH_2_MolWt/2/'Input & Calculation Summary'!C$125)
577	H2O	lb/hr		NA	NA
578	TOTAL	lb/hr		79,319	=SUM(D573:D576)
579					

580	***Composition of Solids from Spray Dryers***				
581	CaSO3*1/2H2O	lb/hr		1,275	=D573*0.1(assumedn fract. of solids leaving spray dryer)
582	CaSO4*2H2O	lb/hr		567	=D574*0.1(assumedn fract. of solids leaving spray dryer)
583	Inerts	lb/hr		6,052	=D575*0.1(assumedn fract. of solids leaving spray dryer)
584	Ca(OH)2	lb/hr		38	=D576*0.1(assumedn fract. of solids leaving spray dryer)
585	H2O	lb/hr		162	=SUM(D581:D584)*0.02 (wt.fract.H_2O) /0.98
586	TOTAL	lb/hr		8,094	=SUM(D581:D585)
587					
588	***Solids in Baghouse/ESP***				
589	CaSO3*1/2H2O	lb/hr		24,234	=(D573-D581)*'Input & Calculation Summary'!C$125+D$385
590	CaSO4*2H2O	lb/hr		10,782	=(D574-D582)*'Input & Calculation Summary'!C$125+D$396
591	Inerts	lb/hr		108,936	=(D575-D583)*'Input & Calculation Summary'!C$125
592	Ca(OH)2	lb/hr		-306	=(D576-D584)*'Input & Calculation Summary'!C$125-(D$383+D$392)
593	H2O	lb/hr			
594	TOTAL	lb/hr		143,645	=SUM(D589:D592)
595	CaSO3*1/2H2O	wt %		16.9%	=D589/(D594-D593)
596	CaSO4*2H2O	wt %		7.5%	=D590/(D594-D593)
597	Inerts	wt %		75.8%	=D591/(D594-D593)
598	Ca(OH)2	wt %		-0.2%	=D592/(D594-D593)
599	H2O	wt %			
600	TOTAL	wt %		100.0%	=SUM(D595:D598)
601					
602	***Dry Solids***				
603	CaSO3*1/2H2O	lb/hr		6,401	=D595*(D608-D607)
604	CaSO4*2H2O	lb/hr		2,848	=D596*(D608-D607)
605	Inerts	lb/hr		28,774	=D597*(D608-D607)
606	Ca(OH)2	lb/hr		-81	=D598*(D608-D607)
607	H2O	lb/hr		774	=D608*0.02 (wt.fract.H_2O)
608	TOTAL	lb/hr		38,717	=D$458
609					

610	***Solids Out Stack***				
611	CaSO3*1/2H2O	lb/hr		27	=D595*D616
612	CaSO4*2H2O	lb/hr		12	=D596*D616
613	Inerts	lb/hr		119	=D597*D616
614	Ca(OH)2	lb/hr		0	=D598*D616
615	H2O	lb/hr			
616	TOTAL	lb/hr		158	=D$80
617					
618	***Composition of Baghouse/ESP Solids to Recycle***				
619	CaSO3*1/2H2O	lb/hr		17,806	=D589-D603-D611
620	CaSO4*2H2O	lb/hr		7,922	=D590-D604-D612
621	Inerts	lb/hr		80,042	=D591-D605-D613
622	Ca(OH)2	lb/hr		-225	=D592-D606-D614
623	H2O	lb/hr		2,154	=D624-SUM(D619:D622)
624	TOTAL	lb/hr		107,700	=SUM(D619:D622)/0.98 (wt.fract. solids)
625					
626	***Calculated Composition of Recycle Solids to Slurry Tank***				
627	CaSO3*1/2H2O	lb/hr		20,357	=D581*'Input & Calculation Summary'!C$125+D619
628	CaSO4*2H2O	lb/hr		9,056	=D582*'Input & Calculation Summary'!C$125+D620
629	Inerts	lb/hr		92,146	=D583*'Input & Calculation Summary'!C$125+D621
630	Ca(OH)2	lb/hr		-150	=D584*'Input & Calculation Summary'!C$125+D622
631	H2O	lb/hr		2,478	=D585*'Input & Calculation Summary'!C$125+D623
632	TOTAL	lb/hr		123,887	=SUM(D627:D631)
633					
634	***ITERATION 3***				

The recycle solids iteration process continues to row 1067.

F-5.0 Particulate Control Cost and Technical Results Sheet

This worksheet contains all of the technical and economic calculations and results for the particulate control technologies (fabric filter and ESP). This worksheet uses the data from the User Input Sheet and Constants_CC Sheet to perform the necessary calculations.

The data contained in this worksheet are organized into six different areas: 1) fabric filter sizing calculations, 2) fabric filter capital cost calculations, 3) fabric filter O&M data and costs, 4) ESP sizing calculations, 5) ESP capital cost calculations, and 6) ESP O&M data and costs.

F-5.1 Fabric Filter Sizing Calculations

This first section of the worksheet performs the necessary calculations needed to size a fabric filter (pulse-jet or reverse gas) based on the user-supplied inputs, the results of the combustion calculation, and whether or not there is a lime spray dryer upstream of the fabric filter. In this case, particulate removal efficiency is not a primary factor in the sizing of the FF. The primary sizing criterion for FF's is the Air-to-Cloth ratio (A/C). This parameter is equivalent to the ratio of the volumetric flue gas flow rate divided by the total bag cloth area. The A/C will typically vary depending on the type of FF being considered. The user is asked to input an A/C for the evaluation, or the default value for the type of FF selected will be used. The FF is then sized based on this value and the flue gas volumetric flow rate calculated in the combustion calculations. All other sizing calculations are derived from this total cloth area value. The following table shows the equations and results for one FF case.

	A	*B*	*C*	*D*	
	Fabric Filter – Preliminary				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
23	***Flue Gas, Upstream of Fabric Filter***				
24	Temperature	°F		300	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D24,'LSD Cost & Tech. Results'!D54)
25	Pressure	in. H2O		-12	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D25,'LSD Cost & Tech. Results'!D55)
26	Flow Rate	SCFM		1,307,230	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D26,'LSD Cost & Tech. Results'!D56)
27	Flow Rate	ACFM		2,004,451	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D27,'LSD Cost & Tech. Results'!D57)
28	CO2	lb/hr		1,120,920	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D28,'LSD Cost & Tech. Results'!D58)

29	N2	lb/hr		4,084,072	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D29,'LSD Cost & Tech. Results'!D59)
30	SO2	lb/hr		4,717	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D30,'LSD Cost & Tech. Results'!D60)
31	O2	lb/hr		327,881	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D31,'LSD Cost & Tech. Results'!D61)
32	HCl	lb/hr		66	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D32,'LSD Cost & Tech. Results'!D62)
33	Other Gases	lb/hr		1,425	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D33,'LSD Cost & Tech. Results'!D63)
34	H2O	lb/hr		450,880	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D34,'LSD Cost & Tech. Results'!D64)
35	Fly Ash	lb/hr		28,389	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D35,'LSD Cost & Tech. Results'!D65)
36	Total (gas only)	lb/hr		5,989,962	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D36,'LSD Cost & Tech. Results'!D66)
37					
38	***Total Fabric Required***	Ft^2		572,700	=D27/'Input & Calculation Summary'!C164
39					
40	***Surface Area per Bag***	Ft^2		31.4	=('Input & Calculation Summary'!C167/12 in/ft0)*3.1416(Π)*'Input & Calculation Summary'!C168
41					
42	***Required No. of Bags (no spare compartments)***			18,230	=D38/D40
43					
44	***Final No. of Bags***			20,053	=D42*(1+'Input & Calculation Summary'!C170)
45					
46	***No. of Casings***			1	=IF('Input & Calculation Summary'!C21<'=500,1,(IF('Input & Calculation Summary'!C21<'=1000,2,(IF('Input & Calculation Summary'!C21<'=1500,3,4)))))

47					
48	***Fabric Filter Dimensions (per Casing)***	Ft^2		19,687	=3.1416(Π)*('Input & Calculation Summary'!C167/2/12 in/ft)^2*(D44/D46)/(IF('Input & Calculation Summary'!C163'=2,0.2,0.3))
49	Length	Ft		198	=D50*2
50	Width	Ft		99	=(D48/2)^0.5

F-5.2 Fabric Filter Capital Cost Calculations

The fabric filter capital cost section of the worksheet uses the results of the sizing calculations and the user-supplied inputs with Raytheon developed algorithms to develop a capital cost for either a reverse gas or pulse-jet fabric filter. The algorithms were developed from vendor-supplied information and Raytheon's design experience. The following table shows the algorithms and the results for one case.

	A	*B*	*C*	*D*	
	Capital Cost				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
54	**Cost Basis (Year)**			**1998**	**='Input & Calculation Summary'!C42**
55					**Cost Algorithms - Constants developed form database**
56	Fabric Filter	$		$6,910,797	=(IF('Input & Calculation Summary'!C163'=2,((217.39*(D27/D46)^0.7088)*D46),((937.08*(D27/D46)^-0.6417)*D46))*D27*(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D54-1990)))))
57	Bags	$		$1,056,357	=(IF('Input & Calculation Summary'!C165'=2,1.7*D38,(IF('Input & Calculation Summary'!C165'=1,1*D38,2*D38)))) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D54-1990)))))
58	Ash Handling System	$		$555,275	=(D35/2000*21901+200895) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D54-1990)))))
59	ID Fan(s)	$		$841,343	=(97.41*D27^0.619) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D54-1990)))))
60	Equipment Cost Subtotal	$		$9,363,771	=SUM(D56:D59)

61	Instruments & Controls	$		$187,275	=0.02 (assumed = to 2% of equipment cost)*D60
62	Taxes	$		$561,826	=D60*'Input & Calculation Summary'!C51
63	Freight	$		$468,189	=0.05 (assumed = 5% of equipment cost)*D60
64	Purchased Equip. Cost Subtotal	$		$10,581,062	=SUM(D60:D63)
65	Installation	$		$7,089,311	=0.67 (assumed installation cost = 67% of purchased equipment cost)*D64
66	***Total Direct Cost***	$		$17,670,373	=D64+D65
67					
68	Total Direct Cost w/ Retrofit Factor	$		$22,971,485	=D66*'Input & Calculation Summary'!C35
69	General Facilities	$		$2,297,148	=D68*'Input & Calculation Summary'!C174
70	Engineering Fees	$		$2,297,148	=D68*'Input & Calculation Summary'!C175
71	Contingency	$		$4,594,297	=D68*'Input & Calculation Summary'!C173
72	***Total Plant Cost (TPC)***	$		$32,160,079	=SUM(D68:D71)
73	TPC w/ Prime Contractors Markup	$		$33,124,881	=D72*(1+'Input & Calculation Summary'!C$59)
74	***Total Cash Expended (TCE)***	$		$32,642,480	=D73*VLOOKUP(2,Constants_CC!$C$557:$E$562,3)
75					
76	***Allow. for Funds During Constr. (AFDC)***	$		$1,736,644	=D73*VLOOKUP(2,Constants_CC!$C$557:$E$562,2)
77					
78	***Total Plant Investment (TPI)***	$		$34,379,124	=D74+D76
79	*Preproduction Costs*	$		$687,582	=0.02 (assumed = 2% of TPI)*D78
80	*Inventory Capital*	$		$0	$0
81					
82	***Total Capital Requirement (TCR)***	$		**$35,066,707**	**=SUM(D78:D80)**
83		$/kW		$70.1	=D82/('Input & Calculation Summary'!C21*1000)

F-5.3 Fabric Filter O&M Data and Costs

The fabric filter O&M data and costs are derived from the user-supplied inputs and the results of the sizing calculations. This section of the worksheet summarizes the O&M data and costs. The following table shows the equations and results for one case.

	A	B	C	D	
	O&M Data and Costs				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
87	**Cost Basis (Year)**			**1998**	**='Input & Calculation Summary'!C42**
88					**Cost Algorithms - constants developed from database**
89	Power Required Excluding ID Fan(s)	kW		844	=((0.6227*D27^-0.1009*D27)+(IF('Input & Calculation Summary'!C163'=2,0.0013*1000*0.746*D38,0)))/1000
90	ID Fan Power for FF Delta P	kW		2,024	=(0.000158*D27*'Input & Calculation Summary'!C162/0.7)*0.7457 kW/hp
91	Total Power	kW		2,868	=D89+D90
92					
93	Power Cost	$/yr		$408,310	=(D91/1000*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61)
94	Maintenance Costs	$/yr		$1,233,018	=(D66+(D66*'Input & Calculation Summary'!C174)+(D66*'Input & Calculation Summary'!C175)+(D66*'Input & Calculation Summary'!C173))*'Input & Calculation Summary'!C172
95	Periodic Replacement Items	$/yr		$1,233,315	=D57
96	*First Year Cost. Bags Replaced Every*			*5 Years*	*='Input & Calculation Summary'!C171&" Years"*

F-5.4 ESP Sizing Calculations

This section of the worksheet performs the necessary calculations needed to size an ESP based on the user-supplied inputs and the results of the combustion calculation. The model begins with the user input values for collection efficiency and the coal ash analyses. The particulate collection efficiency is typically established based on the particulate emission limit for the plant. The mass emission limit is divided by the current uncontrolled particulate matter production rate and this value subtracted from 1.0 to determine the removal efficiency required for the new ESP. The efficiency typically will have some margin included so that the final outlet emission rate will be able to meet the regulated limit under all operating conditions. The ash resistivity is then calculated using a series of modified Deutsch-Anderson equations. The resistivity and ash analysis establish a set of constants which, along with the collection efficiency, are used to calculate the Specific Collection Area (SCA) for the ESP. The ESP SCA is the ratio of the total collecting plate area in the ESP to the flue gas volume This value establishes the size of the ESP. The following table shows the equations and results for one case.

	A	*B*	*C*	*D*	
	ESP				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
103	***Flue Gas, Upstream of ESP***				
104	Temperature	°F		300	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D24,'LSD Cost & Tech. Results'!D54)
105	Pressure	in. H2O		-12	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D25,'LSD Cost & Tech. Results'!D55)
106	Flow Rate	SCFM		1,307,230	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D26,'LSD Cost & Tech. Results'!D56)
107	Flow Rate	ACFM		2,004,451	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D27,'LSD Cost & Tech. Results'!D57)
108	CO2	Lb/hr		1,120,920	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D28,'LSD Cost & Tech. Results'!D58)
109	N2	Lb/hr		4,084,072	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D29,'LSD Cost & Tech. Results'!D59)
110	SO2	Lb/hr		4,717	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D30,'LSD Cost & Tech. Results'!D60)

111	O2	Lb/hr		327,881	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D31,'LSD Cost & Tech. Results'!D61)
112	HCl	Lb/hr		66	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D32,'LSD Cost & Tech. Results'!D62)
113	Other Gases	Lb/hr		1,425	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D33,'LSD Cost & Tech. Results'!D63)
114	H2O	Lb/hr		450,880	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D34,'LSD Cost & Tech. Results'!D64)
115	Fly Ash	Lb/hr		28,389	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D35,'LSD Cost & Tech. Results'!D65)
116	Total (gas only)	Lb/hr		5,989,962	=IF('Input & Calculation Summary'!C$6'=1,'LSD Cost & Tech. Results'!D36,'LSD Cost & Tech. Results'!D66)
117					
118	***Inlet Particulate Loading***	Lb/hr		28,389	=D115
119		gr/ft3		1.65	=D118/(D107*60 min/hr)*7000 grains/lb
120					
121	***Overall PM Collection Efficiency***	%	η	99.4%	=((D118/Constants_CC!E491)-'Input & Calculation Summary'!C160)/(D118/Constants_CC!E491)
122					
123	***ESP Requirements***				
124	*k*	Dimensionless		0.451	=IF('Input & Calculation Summary'!C38=”Yes”,0.451,IF(Constants_CC!E324<=1.09,0.6017-1.6347*D191,IF(Constants_CC!E324<2.6,0.6144-1.4723*D191,0.5574-0.4947*D191))
125	*E*	KV/cm		10.0	='Input & Calculation Summary'!C177
126					
127	***Ash Composition***				
128	*Na2O*	wt% in Ash		1.68	=Constants_CC!E339
129	*Fe*	wt% in Ash		6.07	=Constants_CC!E336
130	*MgO*	wt% in Ash		31.97	=Constants_CC!E338+Constants_CC!E337
131	*CaO*	wt% in Ash		0.00	0.00
132					
133	***Flue Gas Composition***				
134	*H2O*	Vol%		12.11	=(D114/H2O_MolWt)/(D116/Constants_CC!E477)*100
135	*SO2*	ppm		356	=(D110/SO2_MolWt)/(D116/Constants_CC!E477)*1000000
136	*SO3*	ppm		2.6	=0.0074 (SO_3 fract.) *D135

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137					
138	***Flue Gas Temperature***				
139	*TF*	°F		300	=D104
140	*TC*	°C		149	=5/9*(D139-32) (Fahrenheit to centigrade conversion)
141	*TK*	Kelvin		422	=D140+273.15 (Kelvin conversion)
142					
143	***Resistivity Calculations***				
144	*Volume Resistivity*				**Resistivity Calculation Algorithms**
145	*rv1*	Log10(ohm-cm)		9.13	=8.9434-1.8916*LOG10(D128)-0.9696*LOG10(D129)+1.237*(LOG10(SUM(D130:D131))-LOG10(2.5))
146	*rv2*	Log10(ohm-cm)		8.89	=D145 + (D125 - 2) * (-0.03)
147	*iv*	Log10(ohm-cm)		1.95	=D146 - 4334.5 / 625
148	*rv*	Log10(ohm-cm)		12.22	=D147 + 4334.5 / D141
149	*rv(TK=1000/2.4)*	Log10(ohm-cm)		12.35	=D147 + 4334.5 / (1000/2.4)
150	*Volume Resistivity*	ohm-cm		1.6677E+12	=10 ^ D148
151					
152	*Surface Resistivity*				
153	*rs1*	Log10(ohm-cm)		10.27	=10.7737 - 2.2334 * LOG10(D128)
154	*rs2*	Log10(ohm-cm)		9.87	=D153 + (D134 - 9) * (-0.128)
155	*rs3*	Log10(ohm-cm)		8.64	=IF(SUM(D130:D131) > 10, D154 + 0.56 - 0.056 * SUM(D130:D131), SUM(D130:D131))
156	*rs4*	Log10(ohm-cm)		8.40	=D155 + (D125 - 2) * (-0.03)
157	*rs4(with E=12)*	Log10(ohm-cm)		8.34	=D155 + (12 – 2) * (-0.03)
158	*rs0*	Log10(ohm-cm)		9.88	=D157 + LOG10(EXP(1)) * 0.00073895 * EXP(2303.3 / 385) * D134
159	*rs*	Log10(ohm-cm)		8.97	=D158 - LOG10(EXP(1)) * 0.00073895 * EXP(2303.3 / D140) * D134
160	*Surface Resistivity*	ohm-cm		9.3598E+08	=10^D159
161					
162	*rvs1*	ohm-cm		9.3546E+08	=D150*D160 / (D150 + D160)
163	*rs2(with H2O=10)*	Log10(ohm-cm)		1.01E+01	=D153 + (10 - 9) * (-0.128)
164	*rs3(with H2O=10)*	Log10(ohm-cm)		8.91	=IF(SUM(D130:D131) > 10, D163 + 0.56 - 0.056 * SUM(D130:D131), SUM(D130:D131))
165	*rs4(with H2O = 10)*	Log10(ohm-cm)		8.67	=D164 + (D125 - 2) * (-0.03)
166	*rs4(with H2O = 10, E = 12)*	Log10(ohm-cm)		8.61	=D164 + (12 - 2) * (-0.03)

167	*rs0(with H2O = 10)*	Log10(ohm-cm)	9.88	=D166 + LOG10(EXP(1)) * 0.00073895 * EXP(2303.3 / 385) * 10
168	*rs(with H2O = 10, TK = 1000/2.4)*	Log10(ohm-cm)	9.08	=D167 - LOG10(EXP(1)) * 0.00073895 * EXP(2303.3 / (1000/2.4)) * 10
169	*rvs1(with H2O=10, TK = 1000/2.4)*	ohm-cm	1.1934E+09	=10^(D149 + D168) / (10^D149 + 10^D168)
170	*rvs2*	Log10(ohm-cm)	9.32	=LOG10(D169) + (-8) * (-0.03)
171				
172	*Acid Resistivity*			
173	*ia1*	Log10(ohm-cm)	0.29	=IF(AND(SUM(D130:D131) < 5,D129 < 1), 2.6354, 0.2915)
174	*ra1*	Log10(ohm-cm)	7.44	=D173 + 0.7669 * D170
175	*sa*		-2.05	=IF(AND(SUM(D130:D131) < 5,D131 < 1), -5, -2.0502)
176	*ia2*	Log10(ohm-cm)	8.67	=D174 - D175 * LOG10(4)
177	*ra2*	Log10(ohm-cm)	7.81	=D176 + D175 * LOG10(D136)
178				
179	*acid_v*	index value	1	=IF(D136 < 2.75, 1,IF(D136>6.5,3,2))
180	*atom_v*	index value	1	=IF(AND(D128>1,SUM(D130:D131)>5),1,IF(AND(D129<1,SUM(D130:D131)<3),2, 3))
181	*sa1*		-4.74	=VLOOKUP(D179,Constants_CC!$B$260:$E$262,D180+1,FALSE)
182	*ia3*	Log10(ohm-cm)	19.18	=D177 - D181 * 2.4
183	*ra3*	Log10(ohm-cm)	7.95	=D182 + D181 * 1000 / D141
184	*ra*	Log10(ohm-cm)	7.99	=1.95 + 0.76 * D183
185	*Acid Resistivity*	ohm-cm	9.8562E+07	=10^D184
186				
187	***Total Resistivity***			
188	*rvsa*	ohm-cm	8.9167E+07	=D185*D162 / (D185 + D162)
189				
190	***Migration Velocity***			
191	w_k	1000ft/minute	0.062	=0.1232972 - 0.003323934*LN(D188)
192				
193	***Specific Collection Area***			
194	*SCA*	ft^2/10^3 acfm	**299**	**=(-LN(1-D121))^(1/D124)/D191**

195					
196	***Total Collector Plate Area***	Ft^2		598,952	=(D107/1000)*D194
197	***ESP Footprint Area***	Ft^2		16,638	=(D196/'Input & Calculation Summary'!C179)*('Input & Calculation Summary'!C178/12)

F-5.5 ESP Capital Cost Calculations

The ESP capital cost section of the worksheet uses the results of the sizing calculations and the user-supplied inputs with Raytheon developed algorithms to develop a capital cost for an ESP. The algorithms were developed from vendor-supplied information and Raytheon's design experience. The following table shows the algorithms and the results for one case.

	A	*B*	*C*	*D*	
	Capital Cost				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
201	Cost Basis (Year)			1998	='Input & Calculation Summary'!C42
202					Cost Algorithms - constants developed from database
203	ESP	$		$10,090,848	=(IF(('Input & Calculation Summary'!C178/12<'=0.751),(-2.08E-19*D107^4+0.00000000000193*D107^3-0.00000548*D107^2+8.49*D107-309000),(17.638*D107^0.8973))) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D201-1990)))))
204	Ash Handling System	$		$648,293	=(D118/2000*21901+200895) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D201-1990)))))
205	ID Fan(s)	$		$982,283	=(97.41*D107^0.619) *(IF('Input & Calculation Summary'!C42<1990,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/357.6,(IF('Input & Calculation Summary'!C55="Yes", 'Input & Calculation Summary'!C56/357.6,(1+'Input & Calculation Summary'!C57)^(D201-1990)))))

206	Equipment Cost Subtotal	$		$11,721,424	=SUM(D203:D205)
207	Instruments & Controls	$		$234,428	=0.02*D206
208	Taxes	$		$703,285	=D206*'Input & Calculation Summary'!C51
209	Freight	$		$586,071	=0.05*D206
210	Purchased Equipment Cost Subtotal	$		$13,245,209	=SUM(D206:D209)
211	Installation	$		$10,728,619	=0.81*D210
212	***Total Direct Cost***	$		$23,973,828	=D210+D211
213					
214	Total Direct Cost with Retrofit Factor	$		$31,165,976	=D212*'Input & Calculation Summary'!C35
215	General Facilities	$		$3,116,598	=D214*'Input & Calculation Summary'!C183
216	Engineering Fees	$		$3,116,598	=D214*'Input & Calculation Summary'!C184
217	Contingency	$		$6,233,195	=D214*'Input & Calculation Summary'!C182
218	***Total Plant Cost (TPC)***	$		$43,632,367	=SUM(D214:D217)
219					
220	***Total Cash Expended (TCE)***	$		$42,996,944	=D218*VLOOKUP(2,Constants_CC!$C$557:$E$562,3)
221					
222	***Allow. for Funds During Constr. (AFDC)***	$		$2,287,522	=D217*VLOOKUP(2,Constants_CC!$C$557:$E$562,2)
223					
224	***Total Plant Investment (TPI)***	$		$45,284,466	=D220+D222
225	*Preproduction Costs*	$		$905,689	=0.02*D224
226	*Inventory Capital*	$		$0	$0
227					
228	***Total Capital Requirement (TCR)***	$		**$46,190,156**	**=SUM(D224:D226)**
229		$/kW		$92.4	=D228/('Input & Calculation Summary'!C21*1000)

F-5.6 ESP O&M Data and Costs

The ESP O&M data and costs are derived from the user-supplied inputs and the results of the sizing calculations. This section of the worksheet summarizes the O&M data and costs. The following table shows the equations and results for one case.

	A	*B*	*C*	*D*	
	O&M Data and Costs				
Row				**Case 1**	
No.	**Title / Description**	**Units**		**Results**	**Equation**
233	***Cost Basis (Year)***			***1998***	***='Input & Calculation Summary'!C42***
234					Power Consumption Algorithms – form database
235	Power Required Excluding ID Fan(s)	kW		368	=(IF('Input & Calculation Summary'!C160<'=0.01,(-0.000717*D194+1.00881),IF('Input & Calculation Summary'!C160<'=0.03,(-0.000691*D194+0.82042),(-0.000698*D194+0.68692))))*D196/1000
236	ID Fan Power for FF Delta P	kW		1,012	=(0.000158*D107*'Input & Calculation Summary'!C180/0.7)*0.7457
237	Total Power	kW		1,380	=D235+D236
238					
239	Power Cost	$/yr		$196,423	=(D237/1000*8760 hr/yr*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61)
240	Maintenance Costs	$/yr		$1,678,168	=(D212+(D212*'Input & Calculation Summary'!C183)+(D212*'Input & Calculation Summary'!C184)+(D212*'Input & Calculation Summary'!C182))*'Input & Calculation Summary'!C181

F-6.0 Constants and Combustion Calculations Sheet

This worksheet contains the combustion calculations and the tables, which are accessed by calculation routines in the other worksheets. Because of the size and nature of the tables, they do not lend themselves to the layout observed in the majority of the model. Instead of having Description, Units, and Calculation/Result columns as in the majority of the model, this sheet typically presents a table of numbers with either values or a description in the left hand column.

The majority of the documentation descriptions in this section also differ from the rest of the documentation; they mostly consist of a printout of the table and a reference to where the information was obtained. The documentation for the combustion calculations follows the rest of the documentation.

F-6.1 Coal Analysis Library

This table contains the reference coals. Coals 2-7 are the same as used in the IAPCS model. Coal 1 is the same analysis as used in EPRI's Technical Assessment Guidelines (TAG). Coal 8 is available for the user to specify a site specific coal analysis if available. The analyses of all coals are accessed by their index number. The coal analyses used in the model should be run of the mine coal properties. The components of the coal are input as weight percent values on a wet coal basis (not dry coal). The necessary inputs are typically provided in the ultimate analysis of the fuel. The model then takes these inputs or default values and calculates the higher heating value for the coal using the Mott-Spooner method. Based on the plant heat rate, the model then derives a series of combustion calculations to produce the flue gas flow rate and composition that serves as the basis for all subsequent material balance calculations.

COAL ANALYSIS LIBRARY									
Index Number		1	2	3	4	5	6	7	8
Coal Name		Wyoming PRB	Armstrong, PA	Jefferson, OH	Logan, WV	No. 6 Illinois	Rosebud, MT	Lignite, ND	"User Specified"
Coal Cost	$/MMBtu	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
PROXIMATE ANALYSIS (ASTM, as rec'd)									
Moisture - Enter below in Ultimate Analysis									
Volatile Matter	wt%	31.39	36.20	37.20	35.40	33.00	36.40	42.00	0.00
Fixed Carbon	wt%	33.05	48.70	44.80	43.00	39.00	30.30	20.10	0.00
Ash – Enter below in Ultimate Analysis									
		100.00	100.00	100.00	100.00	100.00	100.05	100.00	0.00

COAL ULTIMATE ANALYSIS (ASTM, as rec'd)									
Moisture	wt%	30.24	6.00	5.00	5.00	12.00	25.20	32.00	0.00
Carbon	wt%	48.18	71.55	65.72	65.99	55.35	51.52	45.06	0.00
Hydrogen	wt%	3.31	4.88	4.53	4.75	4.00	3.29	2.80	0.00
Nitrogen	wt%	0.70	1.40	1.21	0.70	1.08	0.69	1.50	0.00
Chlorine	wt%	0.01	0.00	0.10	0.10	0.10	0.10	0.10	0.00
Sulfur	wt%	0.37	2.60	3.43	0.89	4.00	0.56	0.94	0.00
Ash	wt%	5.32	9.10	13.00	16.60	16.00	8.15	5.90	0.00
Oxygen	wt%	11.87	4.47	7.01	5.97	7.47	10.49	11.70	0.00
TOTAL	wt%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Modified Mott Spooner HHV (Btu/lb) – *calc*	Btu/lb	8,227	13,100	11,922	12,058	10,100	8,789	7,500	0
COAL ASH ANALYSIS (ASTM, as rec'd)									
SiO2	wt%	35.51	46.92	51.35	50.68	50.82	27.00	29.80	0.00
Al2O3	wt%	17.11	21.00	30.00	29.00	19.06	19.00	10.00	0.00
TiO2	wt%	1.26	2.40	1.80	1.70	0.83	1.08	0.40	0.00
Fe2O3	wt%	6.07	20.20	9.00	9.00	20.00	9.00	9.00	0.00
CaO	wt%	26.67	3.25	4.50	5.50	3.43	18.50	21.40	0.00
MgO	wt%	5.30	2.65	2.00	1.00	3.07	2.40	10.50	0.00
Na2O	wt%	1.68	0.90	0.40	0.40	0.60	2.80	4.40	0.00
K2O	wt%	2.87	0.30	0.20	0.90	0.37	0.45	0.49	0.00
P2O5	wt%	0.97	0.00	0.16	0.60	0.17	0.42	0.00	0.00
SO3	wt%	1.56	1.38	0.59	1.22	1.22	18.85	14.01	0.00
Other Unaccounted for	wt%	1.00	1.00	0.00	0.00	0.43	0.50	0.00	0.00
TOTAL	wt%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00

F-6.2 Limestone Analysis

This table contains the reference limestone analysis. This analysis is the same default analysis as used in EPRI's FGD cost model. The user can replace this analysis with a site specific analysis by simply overwriting the values.

LIMESTONE ANALYSIS		
CaCO3 =	wt%	95.30
CaO =	wt%	
Ca(OH)2 =	wt%	
CaSO4 =	wt%	0.00
MgCO3 =	wt%	1.32
MgO =	wt%	
Mg(OH)2 =	wt%	
SiO2 =	wt%	0.77
Al2O3 =	wt%	0.25
Fe2O3 =	wt%	0.09
Na2O =	wt%	0.03
K2O =	wt%	0.06
TiO2 =	wt%	
P2O5 =	wt%	
SO3 =	wt%	
CO2 =	wt%	
H2O =	wt%	
Unknown =	wt%	2.18
TOTAL =	wt%	100.00

F-6.3 Lime Analysis

This table contains the reference lime analysis. This analysis is the same default analysis as used in EPRI's FGD cost model. The user can replace this analysis with a site specific analysis by simply overwriting the values.

LIME ANALYSIS		
CaCO3 =	wt%	**0.00**
CaO =	wt%	**90.00**
Ca(OH)2 =	wt%	
CaSO4 =	wt%	**0.00**
MgCO3 =	wt%	**0.00**
MgO =	wt%	**5.00**
Mg(OH)2 =	wt%	
SiO2 =	wt%	**1.26**
Al2O3 =	wt%	**3.00**
Fe2O3 =	wt%	**0.20**
Na2O =	wt%	**0.1**
K2O =	wt%	**0.02**
TiO2 =	wt%	
P2O5 =	wt%	
SO3 =	wt%	
CO2 =	wt%	
H2O =	wt%	
Unknown =	wt%	**0.42**
TOTAL =	wt%	**100.00**

F-6.4 Recycle Rate Lookup Table

The data in this table are from vendor-supplied information. This table is used to calculate the amount of recycle needed for a lime spray dryer installation.

Recycle Rate Lookup Table	% S	lb recyle/lb lime
	0	30
	0.4801	28.5
	0.5001	23.5
	0.5501	19.5
	0.6001	16.5
	0.6501	14.5
	0.7001	12.5
	0.7501	11.25
	0.8001	10
	0.8501	9
	0.9001	8.25
	0.9501	7.5
	1.0001	5.5
	1.2001	4.25
	1.4001	3.3
	1.6001	2.75
	1.8001	2.25
	2.0001	1.85
	2.2001	1.6
	2.4001	1.4
	2.6001	1.2
	2.8001	1
	3.0001	0.66
	3.5001	0.49
	4.0001	0.34
	4.5001	0.3

F-6.5 Molecular Weights

The molecular weights used by CUECost are provided below along with the respective variable name. The weights are accessed by the CUECost calculations via their name. The source for the values in this table is Basic Principles and Calculations in Chemical Engineering, 4th Edition, Himmelblau, 1982.

MOLECULAR WEIGHTS

Description	Variable Name	Molecular Weight
Air	Air_MolWt	28.8555
H2O	H2O_MolWt	18.0153
C	C_MolWt	12.0112
H2	H2_MolWt	2.0159
N2	N2_MolWt	28.0200
Cl2	Cl2_MolWt	70.9060
S	S_MolWt	32.0640
Ash	Ash_MolWt	1.0000
O2	O2_MolWt	31.9988
Ca	Ca_MolWt	40.0800
Mg	Mg_MolWt	24.3120
CO2	CO2_MolWt	44.0100
NO2	NO2_MolWt	46.0088
NO	NO_MolWt	30.0094
HCl	HCl_MolWt	36.4610
SO2	SO2_MolWt	64.0628
SO3	SO3_MolWt	80.0622
CaCO3	CaCO3_MolWt	100.0894
CaSO4	CaSO4_MolWt	136.1416
CaO	CaO_MolWt	56.0794
Ca(OH)2	Ca_OH_2_MolWt	74.0947
CaSO3*½H2O	CaSO3halfH2O_MolWt	129.1499
CaSO4*2 H2O (gypsum)	CaSO4_2H2O_MolWt	172.1723
Na	Na_MolWt	22.9900
Na2CO3	Na2CO3_MolWt	105.9894
H2SO4	H2SO4_MolWt	98.0775
CH4	CH4_MolWt	16.0430
CaCl2	CaCl2_MolWt	110.9900

F-6.6 Water Saturation Pressure Table

The data in this table are from ASME Steam Tables, 4th Edition, 1979. The data herein are used in calculations that ultimately provide the water balance for the LSFO system.

WATER SATURATION PRESSURES		
	Pressure	Pressure
Temperature, °F	" HgA	Psia
120	3.4456	1.6924
121	3.5425	1.7400
122	3.6419	1.7888
123	3.7435	1.8387
124	3.8473	1.8897
125	3.9538	1.9420
126	4.0627	1.9955
127	4.1743	2.0503
128	4.2885	2.1064
129	4.4053	2.1638
130	4.5259	2.2230
131	4.6480	2.2830
132	4.7732	2.3445
133	4.9013	2.4074
134	5.0322	2.4717
135	5.1662	2.5375
136	5.3030	2.6047
137	5.4431	2.6735
138	5.5862	2.7438
139	5.7326	2.8157
140	5.8822	2.8892
141	6.0351	2.9643
142	6.1915	3.0411
143	6.3511	3.1195
144	6.5144	3.1997
145	6.6811	3.2816

F-6.7 Saturated Steam Table

The data in this table are from ASME Steam Tables, 4th Edition, 1979. The data are reserved for future use and are not currently employed in CUECost.

SATURATION (ASME)				
	Saturation	**Water**	**Steam**	
	Temperature	**Enthalpy**	**Enthalpy**	
Pressure (psia)	**(°F)**	**(Btu/lb)**		**Index**
300	417.35	394.0	1202.9	0
400	444.60	424.2	1204.6	1
500	467.01	449.5	1204.7	2
600	486.20	471.7	1203.7	3
1500	596.20	611.7	1170.1	4
1600	604.87	624.2	1164.5	5
1700	613.13	636.5	1158.6	6
1800	621.02	648.5	1152.3	7
1900	628.56	660.4	1145.6	8
2400	662.11	719.0	1103.7	9
2500	668.11	731.7	1093.3	10
2600	673.91	744.5	1082.0	11
2700	679.53	757.3	1069.7	12
2800	684.96	770.7	1055.8	13
2900	690.22	785.1	1039.8	14
3000	695.33	801.8	1020.3	15
3100	700.28	824.0	993.3	16
3200	705.08	875.5	931.6	17
3208	705.47	906.0	906.0	18
3300	730.00	1104.1	1104.1	19
3400	730.00	1079.3	1079.3	20
3500	730.00	1048.6	1048.6	21
4000	770.00	1099.9	1099.9	22

F-6.8 Heat Capacity Results Table

The data in this table are calculated and used in determining boiler efficiencies (see combustion calculation section). The equations used in this table are from Basic Principles and Calculations in Chemical Engineering, 4th Edition, Himmelblau, 1982.

	B	C		D	E	F	G
226	**Heat Capacities; Used in Eff. Calcs**	Equation	Result	Result	Result	Result	Result
227		Case 1		Case 2	Case 3	Case 4	Case 5
228	O2 - Based on K	=6.732+((0.001505*(C236^2-C238^2))/(2*(C236-C238)))-((0.0000001791*(C236^3-C238^3))/(3*(C236-C238)))	7.251	7.251	7.251	7.251	7.251
229	CO2 - Based on K	=18.036-((0.00004474*(C236^2-C238^2))/(2*(C236-C238)))-((158.08*(C236^0.5-C238^0.5))/(0.5*(C236-C238)))	9.667	9.667	9.667	9.667	9.667
230	N2 - Based on K	=6.529+((0.001488*(C236^2-C238^2))/(2*(C236-C238)))-((0.0000002271*(C236^3-C238^3))/(3*(C236-C238)))	7.036	7.036	7.036	7.036	7.036
231	H2O - Based on °C	=7.88+((0.0032*(C235^2-C237^2))/(2*(C235-C237)))-((0.0000004833*(C235^3-C237^3))/(3*(C235-C237)))	8.157	8.157	8.157	8.157	8.157
232	NO - Based on °C	=7.05+((0.001957*(C235^2-C237^2))/(2*(C235-C237)))-((0.000000699*(C235^3-C237^3))/(3*(C235-C237)))+((0.00000000008729*(C235^4-C237^4))/(4*(C235-C237)))	7.216	7.216	7.216	7.216	7.216
233	SO2 - Based on °C	=9.299+((0.00933*(C235^2-C237^2))/(2*(C235-C237)))-((0.000007418*(C235^3-C237^3))/(3*(C235-C237)))+((0.000000002057*(C235^4-C237^4))/(4*(C235-C237)))	10.054	10.054	10.054	10.054	10.054
234	HCl - Based on °C	=6.962-((0.0003206*(C235^2-C237^2))/(2*(C235-C237)))+((0.000002322*(C235^3-C237^3))/(3*(C235-C237)))-((0.000000001036*(C235^4-C237^4))/(4*(C235-C237)))	6.954	6.954	6.954	6.954	6.954
235	STACK OUTLET TEMP, °C	=('Input & Calculation Summary'!C26-32)/1.8	148.89	148.89	148.89	148.89	148.89
236	STACK OUTLET TEMP, K	=C235+273	421.89	421.89	421.89	421.89	421.89
237	REFERENCE TEMP, °C	=(80-32)/1.8	26.67	26.67	26.67	26.67	26.67
238	REFERENCE TEMP, K	=C237+273	299.67	299.67	299.67	299.67	299.67
239							

F-6.9 ESP Sizing Lookup Tables

The following three lookup tables are used in sizing the ESP. The first is from Bill Vatavuk's CO$T-AIR worksheet, and provides the user with a recommended number of sections. The second is also from Bill Vatavuk's worksheet, and is currently not utilized in CUECOST. The third table is used in the calculation of resistivity.

ESP Section Lookup Table

Efficiency	No. of Sections
0	2
0.965	3
0.99	4
0.998	5
0.999	6

ESP SCA Ratio Lookup Table

No. of Sections	SCA Ratio (Avg.)
2	2.60
3	2.65
4	2.89
5	2.96
6	3.09

Lookup Table for Acid Resistivity Calculations

	Atom_v		
Acid_v	1	2	3
1	-4.74	-4.85	-4.85
2	-28.39	-28.39	-28.39
3	-8.67	-9.71	-10.59

F-6.10 Constants Lookup Table

The constants in this table are from Basic Principles and Calculations in Chemical Engineering, 4th Edition, Himmelblau, 1982. These constants are used in various calculations throughout the model. They have been assigned variable names for easier reference. The user may add additional constants to this table.

CONSTANTS		
	Variable	
Description	Name	Value
Kelvin Conversion	K	460
" H2O / " Hg Conversion	inH2O_inHg	13.615
Standard Atmospheric Pressure, " Hg	SAPress_inHg	29.92
Standard Atmospheric Temperature, deg. F	SATemp_degF	70
cubic feet per mole @ 60 deg F	cubft_60	379.630
cubic feet per mole @ 69 deg F	cubft_69	386.000
cubic feet per mole @ 70 deg F	cubft_70	386.704
kW per Horsepower	kW_Hp	0.746

F-6.11 Combustion Calculations

This section of the worksheet performs the combustion calculations based on the user-supplied inputs and the type of coal being fired. The methodology used in the combustion calculations is from Steam, Its Generation and Use, Babcock & Wilcox, 40th Edition, 1992. Five cases are run simultaneously. The following table shows the equation and results for one case.

	B	C	E	
FUEL AND COMBUSTION CALCULATIONS				
Row			**CASE 1**	
No.	**Title / Description**	**Units**	**Results**	**Equation**
309	***FUEL ANALYSIS FOR SPECIFIED COALS***			
310				
311	PROXIMATE ANALYSIS (wt. %)			
312	Moisture	wt%	30.24	=INDEX(LibraryCoal,$A23,'Input & Calculation Summary'!C$37)
313	Volatile Matter	wt%	31.39	=INDEX(LibraryCoal,$A17,'Input & Calculation Summary'!C$37)
314	Fixed Carbon	wt%	33.05	=INDEX(LibraryCoal,$A18,'Input & Calculation Summary'!C$37)
315	Ash	wt%	5.32	=INDEX(LibraryCoal,$A29,'Input & Calculation Summary'!C$37)
316	TOTAL		100	=SUM(E312:E315)
317				
318	COAL ULTIMATE ANALYSIS (wt. %)			
319	Moisture	wt%	30.24	=INDEX(LibraryCoal,$A23,'Input & Calculation Summary'!C$37)
320	Carbon	wt%	48.18	=INDEX(LibraryCoal,$A24,'Input & Calculation Summary'!C$37)
321	Hydrogen	wt%	3.31	=INDEX(LibraryCoal,$A25,'Input & Calculation Summary'!C$37)
322	Nitrogen	wt%	0.7	=INDEX(LibraryCoal,$A26,'Input & Calculation Summary'!C$37)
323	Chlorine	wt%	0.01	=INDEX(LibraryCoal,$A27,'Input & Calculation Summary'!C$37)
324	Sulfur	wt%	0.37	=INDEX(LibraryCoal,$A28,'Input & Calculation Summary'!C$37)
325	Ash	wt%	5.32	=INDEX(LibraryCoal,$A29,'Input & Calculation Summary'!C$37)
326	Oxygen	wt%	11.87	=INDEX(LibraryCoal,$A30,'Input & Calculation Summary'!C$37)
327	TOTAL		100	=SUM(E319:E326)
328				

329	HIGHER HEATING VALUE (HHV)			
330	Modified Mott Spooner - ***calc***	Btu/lb	8227	=INDEX(LibraryCoal,$A33,'Input & Calculation Summary'!C$37)
331	COAL COST	$/MMBtu	1.50	=INDEX(LibraryCoal,$A14,'Input & Calculation Summary'!C$37)
332	COAL ASH ANALYSIS (ASTM, as rec'd)			
333	SiO2	wt%	35.51	=INDEX(LibraryCoal,$A36,'Input & Calculation Summary'!C$37)
334	Al2O3	wt%	17.11	=INDEX(LibraryCoal,$A37,'Input & Calculation Summary'!C$37)
335	TiO2	wt%	1.26	=INDEX(LibraryCoal,$A38,'Input & Calculation Summary'!C$37)
336	Fe2O3	wt%	6.07	=INDEX(LibraryCoal,$A39,'Input & Calculation Summary'!C$37)
337	CaO	wt%	26.67	=INDEX(LibraryCoal,$A40,'Input & Calculation Summary'!C$37)
338	MgO	wt%	5.30	=INDEX(LibraryCoal,$A41,'Input & Calculation Summary'!C$37)
339	Na2O	wt%	1.68	=INDEX(LibraryCoal,$A42,'Input & Calculation Summary'!C$37)
340	K2O	wt%	2.87	=INDEX(LibraryCoal,$A43,'Input & Calculation Summary'!C$37)
341	P2O5	wt%	0.97	=INDEX(LibraryCoal,$A44,'Input & Calculation Summary'!C$37)
342	SO3	wt%	1.56	=INDEX(LibraryCoal,$A45,'Input & Calculation Summary'!C$37)
343	Other Unaccounted for	wt%	1.00	=INDEX(LibraryCoal,$A46,'Input & Calculation Summary'!C$37)
344	TOTAL	wt%	100.00	=SUM(E333:E343)
345				
346	PROXIMATE ANALYSIS (lbs/MMBtu)			
347	Moisture	lbs/MMBtu	36.76	=E312*10000/E$330
348	Volatile Matter	lbs/MMBtu	38.15	=E313*10000/E$330
349	Fixed Carbon	lbs/MMBtu	40.17	=E314*10000/E$330
350	Ash	lbs/MMBtu	6.47	=E315*10000/E$330
351	TOTAL	lbs/MMBtu	121.55	=SUM(E347:E350)
352				
353	COAL ULTIMATE ANALYSIS (lbs/MMBtu)			
354	Moisture	lbs/MMBtu	36.76	=E319*10000/E$330
355	Carbon	lbs/MMBtu	58.56	=E320*10000/E$330
356	Hydrogen	lbs/MMBtu	4.02	=E321*10000/E$330
357	Nitrogen	lbs/MMBtu	0.85	=E322*10000/E$330
358	Chlorine	lbs/MMBtu	0.01	=E323*10000/E$330

359	Sulfur	lbs/MMBtu	0.45	=E324*10000/E$330
360	Ash	lbs/MMBtu	6.47	=E325*10000/E$330
361	Oxygen	lbs/MMBtu	14.43	=E326*10000/E$330
362	TOTAL	lbs/MMBtu	121.55	=SUM(E354:E361)
363				
364	COAL ULTIMATE ANALYSIS (lbmoles/MMBtu)			
365	Moisture	lbmoles/MMBtu	2.0403	=E354/H2O_MolWt
366	Carbon	lbmoles/MMBtu	4.8757	=E355/C_MolWt
367	Hydrogen	lbmoles/MMBtu	1.9958	=E356/H2_MolWt
368	Nitrogen	lbmoles/MMBtu	0.0304	=E357/N2_MolWt
369	Chlorine	lbmoles/MMBtu	0.0002	=E358/Cl2_MolWt
370	Sulfur	lbmoles/MMBtu	0.0140	=E359/S_MolWt
371	Ash	lbmoles/MMBtu	6.4665	=E360/Ash_MolWt
372	Oxygen	lbmoles/MMBtu	0.4509	=E361/O2_MolWt
373				
374	***Flue Gas, Downstream Of Economizer***			
375	*Flue Gas (lb-moles/MMBtu)*			
376	CO2	lbmoles/MMBtu	4.851	=E366-E426
377	NOx	lbmoles/MMBtu	0.009	=E425/NO_MolWt
378	HCl	lbmoles/MMBtu	0.000	=E369*2
379	SO2	lbmoles/MMBtu	0.014	=E370
380	Total O2 Req'd - *	lbmoles/MMBtu	6.506	=(E376+E377+E379+E367*0.5-E372)*'Input & Calculation Summary'!C24
381	N2	lbmoles/MMBtu	24.500	=E380*3.7619+E368-(E377*0.5)
382	O2	lbmoles/MMBtu	1.084	=E380-(E380/'Input & Calculation Summary'!C24)
383	H20	lbmoles/MMBtu	4.681	=E365+E367+((E380+(E380*3.7619))*'Input & Calculation Summary'!C30*(Air_MolWt/H2O_MolWt))
384	Total Dry	lbmoles/MMBtu	30.459	=SUM(E376:E379)+E381+E382
385	Total Wet	lbmoles/MMBtu	35.140	=E384+E383
386				

387	*Wet Flue Gas PPMV & % Vol*			
388	% O2	% Vol	3.086	=E382*100/E385
389	% CO2	% Vol	13.806	=E376*100/E385
390	% N2	% Vol	69.720	=E381*100/E385
391	NOx	ppmv	257.468	=E377*1000000/E385
392	HCL	ppmv	9.757	=E378*1000000/E385
393	SO2	ppmv	399.156	=E379*1000000/E385
394	% H2O	% Vol	13.321	=E383*100/E385
395				
396	*Dry Flue Gas PPMV & % Vol*			
397	% O2	% Vol	3.560	=E382*100/E384
398	% CO2	% Vol	15.928	=E376*100/E384
399	% N2	% Vol	80.436	=E381*100/E384
400	NOx	ppmv	297.038	=E377*1000000/E384
401	HCL	ppmv	11.256	=E378*1000000/E384
402	SO2	ppmv	460.501	=E379*1000000/E384
403	% H2O	% Vol	0	0
404				
405	***Flue Gas, Air & Ash Downstream Of Economizer***			
406	*Flue Gas (lbs/MMBtu)*			
407	O2	lbs/MMBtu	34.696	=E382*O2_MolWt
408	CO2	lbs/MMBtu	213.508	=E376*CO2_MolWt
409	N2	lbs/MMBtu	686.481	=E381*N2_MolWt
410	NOx	lbs/MMBtu	0.272	=E377*NO_MolWt
411	HCl	lbs/MMBtu	0.013	=E378*HCl_MolWt
412	SO2	lbs/MMBtu	0.899	=E379*SO2_MolWt
413	H2O	lbs/MMBtu	84.332	=E383*H2O_MolWt
414	Gas Dry	lbs/MMBtu	935.867	=SUM(E407:E412)
415	Gas Wet	lbs/MMBtu	1020.200	=E414+E413

416	% H2O	wt%	8.266	=E413/E415*100
417	Theoretical Wet Air	lbs/MMBtu	754.627	=E418/'Input & Calculation Summary'!C24
418	Actual Total Wet Air	lbs/MMBtu	905.552	=((E380*O2_MolWt)+((E381-(E368-(E377*0.5)))*N2_MolWt))*(1+'Input & Calculation Summary'!C30)
419	Mol Wt Wet, Lb/Lb-Mol	lbs/lb-mole	29.033	=E415/E385
420				
421	Total Ash	lbs/MMBtu	6.759	=E360+E426*C_MolWt
422	Fly Ash	lbs/MMBtu	5.407	=ROUND(E421-E423,5)
423	Bottom Ash	lbs/MMBtu	1.352	=ROUND(E421*'Input & Calculation Summary'!C33,4)
424				
425	NOx - Flue Gas	lbs/MMBtu	0.272	=0.3/(E365*H2O_MolWt/30+1)+NO_MolWt*E368*0.15
426	Carbon Loss	lbmoles/MMBtu	0.024	=0.005*E366
427	* - Theoretical + Excess O2 Required for Combustion, Not O2 in Flue Gas			
428				
429	***Gases, Downstream Of Air Heater***			
430	*Flue Gas (lb-moles/MMBtu)*			
431	CO2	lbmoles/MMBtu	4.851	=E376
432	NOx	lbmoles/MMBtu	0.009	=E377
433	HCl	lbmoles/MMBtu	0.000	=E378
434	SO2	lbmoles/MMBtu	0.014	=E379
435	N2	lbmoles/MMBtu	27.763	=E381+E441*0.79
436	O2	lbmoles/MMBtu	1.952	=E382+E441*0.21
437	H2O	lbmoles/MMBtu	4.767	=E383+E442-E441
438	Total Dry Flue Gas	lbmoles/MMBtu	34.590	=E439-E437
439	Total Wet Flue Gas	lbmoles/MMBtu	39.357	=E385*(1+'Input & Calculation Summary'!C25)
440				
441	Dry Air Addition	lbmoles/MMBtu	4.131	=E442/(1+('Input & Calculation Summary'!C30*(Air_MolWt/H2O_MolWt)))
442	Wet Air Addition	lbmoles/MMBtu	4.217	=E439-E385
443				

444	*Wet Flue Gas PPMV & % Vol*			
445	% O2	% Vol	4.96	=E436/E439*100
446	% CO2	% Vol	12.33	=E431/E439*100
447	% N2	% Vol	70.54	=E435/E439*100
448	PPMV NOx	ppmv	229.88	=E432/E439*1000000
449	PPMV HCL	ppmv	8.71	=E433/E439*1000000
450	PPMV SO2	ppmv	356.39	=E434/E439*1000000
451	% H2O	% Vol	12.11	=E437/E439*100
452	TOTAL		100.00	=E445+E446+E447+E451+SUM(E448:E450)/10000
453				
454	*Dry Flue Gas PPMV & % Vol*			
455	% O2	% Vol	5.64	=E436/E438*100
456	% CO2	% Vol	14.03	=E431/E438*100
457	% N2	% Vol	80.26	=E435/E438*100
458	NOx	ppmv	261.57	=E432/E438*1000000
459	HCL	ppmv	9.91	=E433/E438*1000000
460	SO2	ppmv	405.51	=E434/E438*1000000
461	% H2O	% Vol	0	0
462	TOTAL		100.00	=E455+E456+E457+E461+SUM(E458:E460)/10000
463				
464	***Flue Gas & Air Downstream Of Air Heater***			
465	*Flue Gas (lbs/MMBtu)*			
466	O2	lbs/MMBtu	62.454	=E436*O2_MolWt
467	CO2	lbs/MMBtu	213.508	=E431*CO2_MolWt
468	N2	lbs/MMBtu	777.919	=E435*N2_MolWt
469	NOx	lbs/MMBtu	0.272	=E432*NO_MolWt
470	HCl	lbs/MMBtu	0.013	=E433*HCl_MolWt
471	SO2	lbs/MMBtu	0.899	=E434*SO2_MolWt
472	H2O	lbs/MMBtu	85.882	=E437*H2O_MolWt
473	Gas Dry	lbs/MMBtu	1055.063	=SUM(E466:E471)

474	Gas Wet	lbs/MMBtu	1140.945	=E473+E472
475	Wt % H2O	wt%	7.527	=E472/E474*100
476	Total Wet Air	lbs/MMBtu	1026.297	=E418+E441*Air_MolWt*(1+'Input & Calculation Summary'!C30)
477	Mol Wt Wet, Lb/Lb-Mol	lbs/lb-mole	28.990	=E474/E439
478				
479	***Boiler Losses & Efficiencies***			
480	Dry Gas	%	5.645	=(E436*C228+E431*C229+E435*C230+E432*C232+E433*C234+E434*C233)*('Input & Calculation Summary'!C26-'Input & Calculation Summary'!C27)/10000
481	Moisture	%	8.272	=(E437*C231*('Input & Calculation Summary'!C26-'Input & Calculation Summary'!C27)+(E365+E367)*1020*H2O_MolWt)/10000
482	Carbon	%	0.413	=E426*14100*C_MolWt/10000
483	Radiation	%	0.173	=('Input & Calculation Summary'!C21/1000*'Input & Calculation Summary'!C22)^(-0.229)*123/100
484	Manufacturers Margin	%	1.5	1.5
485	Ash Losses	%	0	0
486	Total Losses	%	16.003	=SUM(E480:E485)
487				
488	Boiler Efficiency	%	83.997	=100-E486
489				
490	***Coal Flow Rates***			
491	Btu Input Rate to Boiler	MMBtu/hr	5250	=('Input & Calculation Summary'!C21*'Input & Calculation Summary'!C22)/1000
492	Coal Input Rate to Boiler	tons/hr	319.1	=(E491*1000000)/E330/2000
493	Coal Input Rate to Boiler	lbs/MMBtu	121.6	=(E492*2000)/E491
494				
495	***Economizer Outlet***			
496	Flue Gas	SCFM/MMBtu	13,340	=E385*cubft_60
497	Flue Gas	SCFM	1,167,263	=E496*E491/60
498	Wet Flue Gas	lb/hr	5,356,050	=E415*E491
499	Wet Air	SCFM	1,042,446	=E418*E491*cubft_60/(Air_MolWt*60)
500	Wet Air	lb/hr	4,754,150	=E418*E491

501	Total Air	%	120%	='Input & Calculation Summary'!C24
502	Excess Air	%	20%	=E501-1
503				
504	***Air Heater Outlet***			
505	Flue Gas	SCFM/MMBtu	14,941	=E439*cubft_60
506	Flue Gas	SCFM	1,307,335	=E505*E491/60
507	Wet Flue Gas	lb/hr	5,989,962	=E474*E491
508	Wet Air	SCFM	1,181,444	=E476*E491*cubft_60/(Air_MolWt*60)
509	Wet Air	lb/hr	5,388,062	=E476*E491
510	Wet Air Leakage	SCFM	138,998	=E441*cubft_60*E491*(1+'Input & Calculation Summary'!C30)/60
511	Wet Air Leakage	lb/hr	633,912	=E441*Air_MolWt*E491*(1+'Input & Calculation Summary'!C30)
512	Equivalent Total Air	%	136.0%	=(E476/E417)
513	Equivalent Excess Air	%	36.0%	=E512-1
514	Flue Gas Temperature	°F	300	='Input & Calculation Summary'!C26
515	Pressure	in. H2O	-12	='Input & Calculation Summary'!C29
516	Flue Gas	ACFM	2,004,611	=E506*((E514+460)/520)*(29.92/('Input & Calculation Summary'!C28+(E515/inH2O_inHg)))
517				
518	***Ash Parameters***			
519	Fly Ash	tons/hr	14.19	=E422*E491/2000
520	Bottom Ash	tons/hr	3.55	=E423*E491/2000
521	Total Ash	tons/hr	17.74	=E519+E520

F-6.12 Economic Factors Tables

The following tables are used in the economic analysis of the technologies. This information is useful in comparing costs over the life of the plant.

ECONOMIC FACTORS			CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
Construction Period	Years		3	3	3	3	3
Current Dollars							
P/A Factor			10.094	10.094	10.094	10.094	10.094
A/P (Annuity) Factor			0.099	0.099	0.099	0.099	0.099
P/AE (Present Worth) Factors							
Consumables (O&M)			13.736	13.736	13.736	13.736	13.736
Capital Costs			13.736	13.736	13.736	13.736	13.736
Levelization Factors							
Consumables (O&M)			1.361	1.361	1.361	1.361	1.361
Capital Costs			1.361	1.361	1.361	1.361	1.361
Constant Dollars							
P/A Factor			13.736	13.736	13.736	13.736	13.736
A/P (Annuity) Factor			0.073	0.073	0.073	0.073	0.073
P/AE (Present Worth) Factors							
Consumables (O&M)			13.736	13.736	13.736	13.736	13.736
Capital Costs			13.736	13.736	13.736	13.736	13.736
Levelization Factors							
Consumables (O&M)			1.000	1.000	1.000	1.000	1.000
Capital Costs			1.000	1.000	1.000	1.000	1.000
Z = (1 + i) / (1 + e)			1.076	1.076	1.076	1.076	1.076

AFDC / TCE FACTORS FOR CASE 1

Unit Size, MW	Years	AFDC Factor	TCE Factor
0	1	0.0000	1.0000
160	2	0.0524	0.9854
400	3	0.1065	0.9712
725	4	0.1623	0.9572
1300	5	0.2199	0.9434
2000	6	0.2796	0.9300

AFDC / TCE FACTORS FOR CASE 2

Unit Size, MW	Years	AFDC Factor	TCE Factor
0	1	0.0000	1.0000
160	2	0.0524	0.9854
400	3	0.1065	0.9712
725	4	0.1623	0.9572
1300	5	0.2199	0.9434
2000	6	0.2796	0.9300

AFDC / TCE FACTORS FOR CASE 3

Unit Size, MW	Years	AFDC Factor	TCE Factor
0	1	0.0000	1.0000
160	2	0.0524	0.9854
400	3	0.1065	0.9712
725	4	0.1623	0.9572
1300	5	0.2199	0.9434
2000	6	0.2796	0.9300

AFDC / TCE FACTORS FOR CASE 4			
		AFDC	TCE
Unit Size, MW	Years	Factor	Factor
0	1	0.0000	1.0000
160	2	0.0524	0.9854
400	3	0.1065	0.9712
725	4	0.1623	0.9572
1300	5	0.2199	0.9434
2000	6	0.2796	0.9300

AFDC / TCE FACTORS FOR CASE 5			
		AFDC	TCE
Unit Size, MW	Years	Factor	Factor
0	1	0.0000	1.0000
160	2	0.0524	0.9854
400	3	0.1065	0.9712
725	4	0.1623	0.9572
1300	5	0.2199	0.9434
2000	6	0.2796	0.9300

F-7.0 NOx Documentation Sections

This worksheet contains all of the technical and economic calculations and results for the NOx control processes. This worksheet uses the data from the User Input Sheet and Constants_CC Sheet to perform the necessary calculations.

The data contained in this worksheet are organized into four different areas:

a) Selective catalytic reduction (SCR)
b) Selective non-catalytic reduction (SNCR)
c) Low NOx Burners
d) Natural gas reburn

F-7.1 Selective Catalytic Reduction

This first section of the NOx worksheet calculates the capital and O&M costs associated with an SCR installation.

	A	B	D	
Row			Case 1	
No.	Description	Units	Results	Equation
6	***SCR (high-dust) – Preliminary***		Case1	Case1
7				
8	Ammonia Injection Rate	lb/hr	2,274	=3.702*10^-4*'Input & Calculation Summary'!C190* 'Input & Calculation Summary'!C21* 'Input & Calculation Summary'!C22 *'Input & Calculation Summary'!C192
9	Space Velocity	1/hr	2,840	=IF('Input & Calculation Summary'!C193'=0, 6131.06 / 3 * 'Input & Calculation Summary'!C191 ^(-0.241) *'Input & Calculation Summary'!C190 ^ (-2.306),'Input & Calculation Summary'!C193)
10	Gross Catalyst Volume	ft^3	24,664	=Constants_CC!E497*60 /D9
11				
12				

14	***SCR Capital Costs***		Case1	Case1
15	***Cost Basis (Year)***		***<u>1998</u>***	***<u>='Input & Calculation Summary'!C42</u>***
16				
17	Reactor Housing and Installation	$	4,055,272	=18.65*'Input & Calculation Summary'!C202*(D10/'Input & Calculation Summary'!C202)^0.489*1000*1*388/357.3*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
18	Ammonia Handling and Injection	$	2,288,923	=50.8*(D8)^0.482*1000*388/357.3*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
19	Flue Gas Handling:Ductwork and Fans	$	5,112,798	=143.66*(Constants_CC!E497*(750+460)/(70+460))^0.694*388/314*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
20	Air Preheater Modifications	$	1,271,466	=1370*'Input & Calculation Summary'!C203*1*1000*(ABS(Constants_CC!E497*7.9*60*('Input & Calculation Summary'!C26-725)*LN(125/('Input & Calculation Summary'!C26-'Input & Calculation Summary'!C27))/0.7302/(530)/(125-'Input & Calculation Summary'!C26+'Input & Calculation Summary'!C27))/4.4/10^6/'Input & Calculation Summary'!C203)^0.8*(388/357.3)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
21	Misc. Other Direct Capital Costs	$	<u>416,262</u>	<u>=(100+300 * ('Input & Calculation Summary'!C21/550)^0.6)*1000*388/357.3*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))</u>

22	Equipment Capital Cost Subtotal	$	$13,144,721	=SUM(D17:D21)
23	Instruments & Controls	$	$262,894	=0.02*D22
24	Taxes	$	$788,683	=D22*'Input & Calculation Summary'!C51
25	Freight	$	$657,236	=0.05*D22
26	***Total Direct Cost***		$14,853,535	=SUM(D22:D25)
27				
28	**Total Direct Cost with Retrofit Factor**	$	$19,309,595	=SUM(D22:D25)*'Input & Calculation Summary'!C35
29	General Facilities	$	$965,480	=D28*'Input & Calculation Summary'!C200
30	Engineering Fees	$	$1,930,960	=D28*'Input & Calculation Summary'!C201
31	Contingency	$	$3,861,919	=D28*'Input & Calculation Summary'!C199
32	***Total Plant Cost (TPC)***	$	$26,067,953	=SUM(D28:D31)
33	***Total Plant Cost (TPC) w/ Prime Contractor's Markup***	$	$26,849,992	=D32*(1+'Input & Calculation Summary'!C$59)
34	***Total Cash Expended (TCE)***	$	$26,075,546	=D33*VLOOKUP('Input & Calculation Summary'!C21,Constants_CC!$B$557:$E$562,4)
35				
36	***Allow. for Funds During Constr. (AFDC)***	$	$2,859,072	=D33*VLOOKUP('Input & Calculation Summary'!C21,Constants_CC!$B$557:$E$562,3)
37				
38	***Total Plant Investment (TPI)***	$	$28,934,618	=D34+D36
39	*Preproduction Costs*	$	$578,692	=0.02*D38+(D56+D57)/12+D51/(12*’Input&Calc.Sum’!C23)
40	*Inventory Capital*			
41	*Initial Ammonia(60 days)*	$	$218,865	=D8*24*'Input & Calculation Summary'!C195/2000*60*'Input & Calculation Summary'!C23
42	*Initial Catalyst*	$	$8,788,650	=D$10*'Input & Calculation Summary'!C196
43	***Total Capital Requirement (TCR)***	$	**$38,520,826**	**=SUM(D38:D42)**
44		$/kW	$77	=D43/('Input & Calculation Summary'!C21*1000)
45				
46				

48	***SCR O&M Costs***		Case1	Case1
49	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
50				
51	Ammonia	$/yr	1,331,432	=8760/2000*D8*'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C195
52	Catalyst Replacement	$/yr	2,929,550	= D10*'Input & Calculation Summary'!C196/'Input & Calculation Summary'!C194
53	Catalyst Disposal	$/yr	2,265	= 48 / 2000 *D52*'Input & Calculation Summary'!C197/'Input & Calculation Summary'!C196
54	Electricity	$/yr	286,797	= (-545133 + 5.801*Constants_CC!E516) * ('Input & Calculation Summary'!C23/0.628) *'Input & Calculation Summary'!C61/1000
55	High-dust SCR Steam	$/yr	172,165	= (-14.91 + 33.29 *D8* 'Input & Calculation Summary'!C23) * 'Input & Calculation Summary'!C62
56	Operating Labor	$/yr	120,675	= (1341 + 5.363 *'Input & Calculation Summary'!C21) * 'Input & Calculation Summary'!C60
57	Maintenance	$/yr	391,019	= 'Input & Calculation Summary'!C198*D32
58	**Total O&M Costs**	$/yr	**5,233,904**	**=SUM(D51:D57)**

F-7.2 Selective Non-Catalytic Reduction

This section of the NOx worksheet calculates the capital and O&M costs associated with an SNCR installation.

	A	B	D	
Row			Case 1	
No.	Description	Units	Results	Equation
62	***SNCR - Preliminary***		Case1	Case1
63				
64	Number of Wall Injectors	integer	18	=IF('Input & Calculation Summary'!C209'=0,(8.6 + 0.03* 'Input & Calculation Summary'!C21 - 0.013* 'Input & Calculation Summary'!C213*100)* 'Input & Calculation Summary'!C208,'Input & Calculation Summary'!C209)
65	Number of Lances	integer	0	=IF('Input & Calculation Summary'!C211'=0,(2 + 0.013* 'Input & Calculation Summary'!C21)*'Input & Calculation Summary'!C210,'Input & Calculation Summary'!C211)
66	Urea Injection Rate	lb/hr	10647	=6.5*10^-4*'Input & Calculation Summary'!C216* 'Input & Calculation Summary'!C21* 'Input & Calculation Summary'!C22 *'Input & Calculation Summary'!C214
67	Ammonia Injection Rate	lb/hr	3032	=3.702*10^-4*'Input & Calculation Summary'!C215* 'Input & Calculation Summary'!C21* 'Input & Calculation Summary'!C22 *'Input & Calculation Summary'!C214
68				
70	***SNCR Capital Costs***		Case1	Case1
71	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
72				
73	**Urea Based SNCR Costs**			
74	Urea Storage & Handling	$	$734,251	=IF('Input & Calculation Summary'!C207'=1,(38143*(D66/8.7)^0.417)*(0.915),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))

75	Urea Injection	$	$304,184	=IF('Input & Calculation Summary'!C207'=1,(117809+10477*D64+53111*D65)*(0.915),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
76	Controls/Miscellaneous	$	$164,054	=IF('Input & Calculation Summary'!C207'=1,(96082+106*'Input & Calculation Summary'!C21+898*D64+2433*D65)*(0.915),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
77	Air Heater Modifications	$	$983,912	=IF('Input & Calculation Summary'!C207'=1,(11.2*(Constants_CC!E$498*0.7302/60/29*(678+460))^0.772)*(0.915),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
78	**Ammonia Based SNCR Costs**			
79	Ammonia Storage, Handling, Injection, Controls	$	$0	=IF('Input & Calculation Summary'!C207'=2,(63822*('Input & Calculation Summary'!C21)^0.6)*(0.655),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
80	Air Heater Modifications	$	<u>$0</u>	<u>=IF('Input & Calculation Summary'!C207'=2,(11.2*(Constants_CC!E$498*0.7302/60/29*(678+460))^0.772)*(0.655),0)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))</u>
81	***Total Direct Cost***	$	$2,186,401	=SUM(D74:D80)
82				

83	**Total Direct Cost with Retrofit Factor**	$	$2,842,321	=D81*'Input & Calculation Summary'!C35
84	General Facilities	$	$142,116	=D83*'Input & Calculation Summary'!C222
85	Engineering Fees	$	$284,232	=D83*'Input & Calculation Summary'!C223
86	Contingency	$	$568,464	=D83*'Input & Calculation Summary'!C221
87	***Total Plant Cost (TPC)***	$	$3,837,134	=SUM(D83:D86)
88	***Total Plant Cost (TPC) w/ Prime Contractor's Markup***	$	$3,952,248	=D87*(1+'Input & Calculation Summary'!C$59)
89	***Total Cash Expended (TCE)***	$	$3,838,251	=D88*VLOOKUP('Input & Calculation Summary'!C$21,Constants_CC!$B$557:$E$562,4)
90				
91	***Allow. for Funds During Constr. (AFDC)***	$	$420,848	=D88*VLOOKUP('Input & Calculation Summary'!C$21,Constants_CC!$B$557:$E$562,3)
92				
93	***Total Plant Investment (TPI)***	$	$4,259,099	=D89+D91
94	*Preproduction Costs*	$	$85,182	=0.02*D93+(D105+D106)/12+(D107+D109)/(12*'Input&Calc.Sum'!C23)
95	*Inventory Capital*	$	$1,724,431	=IF('Input & Calculation Summary'!C207'=1,60*24/2000*D66*'Input & Calculation Summary'!C217,IF('Input & Calculation Summary'!C207'=2,60*24/2000*D67*'Input & Calculation Summary'!C218,0))* 'Input & Calculation Summary'!C23
96				
97	***Total Capital Requirement (TCR)***	$	**$6,068,712**	**=SUM(D93:D95)**
98		$/kW	$12.1	=D97/('Input & Calculation Summary'!C21*1000)
99				
100				
102	***SNCR O&M Costs***		Case1	Case1
103	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
104				
105	Operating and Supervisory Labor	$/yr	65,700	=0.25* 8760*'Input & Calculation Summary'!C60
106	Maintenance Labor and Materials	$/yr	57,557	='Input & Calculation Summary'!C220* D87
107	Reagent	$/yr	6,818,686	=IF('Input & Calculation Summary'!C207'=1,D66*8760* 'Input & Calculation Summary'!C23/2000*'Input & Calculation Summary'!C217,IF('Input & Calculation

				Summary'!C207'=2,D67*8760* 'Input & Calculation Summary'!C23/2000*'Input & Calculation Summary'!C218,))
108	Electricity	$/yr	1,593	=IF('Input & Calculation Summary'!C207'=1,(5.97 + 0.29*D64 + 0.87*D65) *8760* 'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61/1000, IF('Input & Calculation Summary'!C207'=2, IF('Input & Calculation Summary'!C212'=1,('Input & Calculation Summary'!C21* 0.12 * 8760 * 'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61/1000),('Input & Calculation Summary'!C21 *4.23 * 8760 * 'Input & Calculation Summary'!C23*'Input & Calculation Summary'!C61/1000)),))
109	Water	$/yr	2,503	=IF('Input & Calculation Summary'!C207'=1,(1 * D64 + 2.5*D65) *60 *8760* 'Input & Calculation Summary'!C23/1000*'Input & Calculation Summary'!C219,0)
110	Steam (for steam atomization)	$/yr	-	=IF('Input & Calculation Summary'!C207'=2, IF('Input & Calculation Summary'!C212'=1,'Input & Calculation Summary'!C21 * 99.2 * 8760* 'Input & Calculation Summary'!C23/1000*'Input & Calculation Summary'!C62,0),0)
111	**Total O&M Costs**	$/yr	**6,946,039**	**=SUM(D105:D110)**

F-7.3 Low NOx Burner Technology

This section of the NOx worksheet calculates the capital and O&M costs associated with the retrofit of low NOx burners.

	A	*B*	*D*	
Row			**Case 1**	
No.	**Description**	**Units**	**Results**	**Equation**
117	***Low NOX Burner Technology Capital Costs***		Case1	Case1
118				
119	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
120				
121	Total Capital Requirement with Retrofit (TCR)	**$**	**$9,618,183**	**=IF('Input & Calculation Summary'!C228'="T",IF('Input & Calculation Summary'!C229'="H",57.04*(300/'Input & Calculation Summary'!C21)^0.679, IF('Input & Calculation Summary'!C229'="L",11.71,21.2*(300/'Input & Calculation Summary'!C21)^0.35)), IF('Input & Calculation Summary'!C228'="W",IF('Input & Calculation Summary'!C229'="H",27.72*(300/'Input & Calculation Summary'!C21)^0.573, IF('Input & Calculation Summary'!C229'="L",6.53*(300/'Input & Calculation Summary'!C21)^0.857,15.37*(300/'Input & Calculation Summary'!C21)^0.35))))*1000*'Input & Calculation Summary'!C21*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))**
122		$/kW	$19.2	=D121/('Input & Calculation Summary'!C21*1000)
123				

124				
126	***Low NOX Burner Technology O&M Costs***		Case1	Case1
127				
128	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
129	Maintenance Labor	$/yr	76,945	='Input & Calculation Summary'!C230*D121
130	Maintenance Materials	$/yr	115,418	='Input & Calculation Summary'!C231*D121
131	Control, Administration, Overhead	$/yr	23,084	=(D129)*0.3
132	**Total O&M Costs**	$/yr	**215,447**	**=SUM(D129:D131)**

F-7.4 Natural Gas Reburning

This section of the NOx worksheet calculates the capital and O&M costs associated with natural gas reburning.

	A	*B*	*D*	
Row			**Case 1**	
No.	**Description**	**Units**	**Results**	**Equation**
137	***Natural Gas Reburning - Preliminary***		Case1	Case1
138				
139	Fraction of heat input as reburn fuel	fraction	0.15	=IF(AND('Input & Calculation Summary'!C236>'=0.08,'Input & Calculation Summary'!C236<'=0.2),'Input & Calculation Summary'!C236,IF(OR('Input & Calculation Summary'!C235<55%,'Input & Calculation Summary'!C235>65%),0.15,('Input & Calculation Summary'!C235-0.48)/0.86))
140	Bottom Ash Rate	tons/yr	967	='Input & Calculation Summary'!C33*Constants_CC!E325*500/Constants_CC!E330*Constants_CC!E491*8760*'Input & Calculation Summary'!C23/2000

141				
142				
144	***Natural Gas Reburning Capital Costs***		Case1	Case1
145				
146	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
147				
148	Gas Pipeline from Fenceline to Boiler	$	$1,513,778	=372.7*EXP(0.00264*'Input & Calculation Summary'!C21)*1000*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
149	Fuel Injectors, Overfire Air Ports and Associated Piping, Valves, Windbox and Control Dampers	$	$3,389,036	=('Input & Calculation Summary'!C21/500)^0.214*('Input & Calculation Summary'!C21*3237.657+1504675)*(388/357.6)*(IF('Input & Calculation Summary'!C42<1998,VLOOKUP('Input & Calculation Summary'!C42,Constants_CC!$B$285:$C$303,2)/388,(IF('Input & Calculation Summary'!C55'="Yes",'Input & Calculation Summary'!C56/388,(1+'Input & Calculation Summary'!C57)^(D15-1998)))))
150	***Total Direct Cost***	$	$4,902,815	=SUM(D148:D149)
151				
152	**Total Direct Cost with Retrofit Factor**	$	$6,373,659	=D150*'Input & Calculation Summary'!C35
153	General Facilities	$	$127,473	=D152*'Input & Calculation Summary'!C241
154	Engineering Fees	$	$637,366	=D152*'Input & Calculation Summary'!C242
155	Contingency	$	$1,274,732	=D152*'Input & Calculation Summary'!C240
156	***Total Plant Cost (TPC)***	$	$8,413,230	=SUM(D152:D155)
157	***Total Plant Cost (TPC) w/ Prime Contractor's Markup***	$	$8,665,627	=D156*(1+'Input & Calculation Summary'!C$59)
158	***Total Cash Expended (TCE)***	$	$8,415,680	=D157*VLOOKUP('Input & Calculation Summary'!C$21,Constants_CC!$B$557:$E$562,4)
159				

160	***Allow. for Funds During Constr. (AFDC)***	$	$922,743	=D157*VLOOKUP('Input & Calculation Summary'!C$21,Constants_CC!$B$557:$E$562,3)
161				
162	***Total Plant Investment (TPI)***	$	$9,338,424	=D158+D160
163	*Preproduction Costs*	$	$186,768	=0.02*D162+D175/12+D176/(12*'Input&calc.Sum'!C23)
164	*Inventory Capital*	$	$0	$0
165				
166	***Total Capital Requirement (TCR)***	$	**$9,525,192**	**=SUM(D162:D164)**
167		$/kW	$19.1	=D166/('Input & Calculation Summary'!C21*1000)
168				
169				
171	***Natural Gas Reburning O&M Costs***		Case1	Case1
172	***Cost Basis (Year)***		***1998***	***='Input & Calculation Summary'!C42***
173				
174	Electrical Consumption Savings	$/yr	(147,925)	=-9.51 * 10^7 * Constants_CC!E491 *'Input & Calculation Summary'!C23 * D139/Constants_CC!E330 * 'Input & Calculation Summary'!C61/1000
175	Maintenance	$/yr	125,990	=('Input & Calculation Summary'!C239*D156-1387.5*D139*('Input & Calculation Summary'!C21/500)^0.6)
176	Waste Disposal Savings	$/yr	(139,444)	=- (D140 * D139 + (IF('Input & Calculation Summary'!C35>1,2,1)-1)*4.336 * D139 *Constants_CC!E519*2000 * 'Input & Calculation Summary'!C23) *'Input & Calculation Summary'!C237
177	Natural Gas Consumption	$/yr	3,632,060	=Constants_CC!E491*D139*8760*'Input & Calculation Summary'!C23*('Input & Calculation Summary'!C238-Constants_CC!E331)
178	**Total O&M Costs**		**3,470,681**	**=SUM(D174:D177)**

REFERENCES

ASME, 1979, "Steam Tables: Thermodynamic and Transport Properties of Steam," 4th Edition, New York.

Babcock & Wilcox, 1992, "Steam, Its Generation and Use," 40th Edition, New York.

Himmelblau, D.M., 1982, "Basic Principles and Calculations in Chemical Engineering," 4th Edition, Englewood Cliffs, New Jersey, Prentice Hall.

Keeth, R.J., 1991, "FGDCOST User's Manual – Version No. 1, EPRI Report GS-7525-L."

Ramachandran, G., 1989, "TAG™ Technical Assessment Guide ," EPRI Report NO. P-6587-L, Volume 1: Rev.6.

Vatavuk, W.M., 1996, Co$t-AIR Control Cost Spreadsheets, http://www.epa.gov/ttn/catc/products.html, February 13. Look for "Co$t-AIR" or "Control Equipment Costing Spreadsheet," or call 1-919-541-0800 for assistance. (Website is currently undergoing revision.)