

Table B-1
IP Savannah - No. 13 Power Boiler
Capital and Annual Costs Associated with Spray Dryer Absorber Retrofit

Fill in the yellow cells with the known data inputs. The resulting costs are tabulated below. Variable names are defined as outlined in the table.

Variable	Designation	Units	Value	Calculation
EPC Project?			<input type="checkbox"/> FALSE	
Unit Size	A	(MW)	124	<--- User Input (Greater than 50 MW); 1280 MMBtu/hr, assumes 33% efficiency to convert to equivalent MW output
Retrofit Factor	B		1.5	<--- User Input (An "average" retrofit has a factor = 1.0); A 1.5 retrofit factor is applied to the total capital investment as an engineering study has not been performed, space constraints exist, equipment must be hardened to resist hurricanes, and production could be lost due to an extended Mill outage or unexpected delays. The retrofit factor was not applied to the landfill development cost.
Heat Rate	C	(Btu/kWh)	10348	<--- User Input: 1280 MMBtu/hr /A*1000
SO2 Rate	D	(lb/MMBtu)	1.24	<--- User Input (SDA FGD Estimation only valid up to 3 lb/MMBtu SO2 Rate)
Type of Coal	E		3	<--- User Input: Coal not fired at IP Savannah - EPA tool set to Bituminous so that Coal Factor equals 1 and therefore does not increase cost when multiplied by other inputs.
Coal Factor	F		1	BF = 1.0, PRB = 1.05, Lig = 1.07
Heat Rate Factor	G		1.035	C/10000
Heat Input	H	(Btu/hr)	1.28E+09	A*C*1000
Capacity Factor	I	(%)	58.55	<--- User Input
Operating SO2 Removal	J	(%)	90	<--- User Input (Used to adjust actual operating costs)
Design Lime Rate	K	(ton/hr)	1.1	(0.6702*(D^2)+13.42*D)/A*G/2000 (Based on 95% SO2 removal)
Design Waste Rate	L	(ton/hr)	2.6	(0.8016*(D^2)+31.1917*D)/A*G/2000 (Based on 95% SO2 removal)
Aux Power Include in VOM? <input checked="" type="checkbox"/>	M	(%)	1.35	(0.000547*D^2+0.00649*D+1.3)*F*G
Makeup Water Rate	N	(1000 gph)	7	(0.04898*D^2+0.5925*D+55.11)*A*F*G/1000
Lime Cost	P	(\$/ton)	260	<--- User Input 2022 cost
Waste Disposal Cost	Q	(\$/ton)	40	<--- User Input Onsite disposal in landfill expansion
Aux Power Cost	R	(\$/kWh)	0.037	<--- User Input 2022 cost
Makeup Water Cost	S	(\$/gal)	0.272	<--- User Input 2022 cost
Operating Labor Rate	T	(\$/hr)	50.74	<--- User Input (2022 Labor cost including all benefits)

Costs are all based on 2016 dollars, scaled to 2021 dollars using CEPCI

Capital Cost Calculation	Example	Comments
Includes - Equipment, installation, buildings, foundations, electrical, and retrofit difficulty.		
BMR (\$) = if (A>600 then (A*98000)/(A^0.716))^(B*(F*G)^0.6*(D/4)^0.01	\$ 30,352,000	Base module absorber island cost
BMF (\$) = if (A>600 then (A*52000)/(A^0.716))^(B*(G*D)^0.2	\$ 16,780,000	Base module reagent preparation and waste recycle/handling cost
BMB (\$) = if (A>600 then (A*138000)/(A^0.716))^(B*(G*F)^0.4	\$ 43,044,000	Base balance of plant costs including: ID or booster fans, piping, ductwork modifications and strengthening, electrical, etc....
BM (\$) = BMR + BMF + BMB	\$ 90,176,000	Total base module cost including retrofit factor
BM (\$/kW) =	729	Base cost per kW
Total Project Cost		
A1 = 10% of BM	\$ 9,018,000	Engineering and Construction Management costs
A2 = 10% of BM	\$ 9,018,000	Labor adjustment for 6 x 10 hour shift premium, per diem, etc....
A3 = 10% of BM	\$ 9,018,000	Contractor profit and fees
CECC (\$) = BM + A1 + A2 + A3	\$ 117,230,000	Capital, engineering and construction cost subtotal
CECC (\$/kW) =	948	Capital, engineering and construction cost subtotal per kW
B1 = 2% of CECC if EPC TRUE, else 5% of CECC	\$ 5,862,000	Owners costs including all "home office" costs (owners engineering, management, and procurement activities)
TPC' (\$) - Includes Owner's Costs = CECC + B1	\$ 123,092,000	Total project cost without AFUDC
TPC' (\$/kW) - Includes Owner's Costs	995	Total project cost per kW without AFUDC
B2 = 10% of (CECC + B1)	\$ -	AFUDC (Zero)
C1 = if EPC = TRUE, 15% of (CECC+B1), else 0	\$ -	EPC fees of 15%
Cost to expand onsite landfill for solid waste disposal	\$ 31,877,434	2007 URS Corporation cost to expand landfill: \$1,218,750/acre times 19.41 acres, scaled from 2007 (525.4) to 2021 (708.0) dollars using the Chemical Engineering Plant Cost Index (CEPCI).
TPC (\$) = Includes Owner's Costs and AFUDC = CECC + B1 + B2 + C1	\$ 192,758,246	Total project cost: Scaled from 2016 (541.7) to 2021 (708.0) using the CEPCI. Includes landfill capital cost.
TPC (\$/kW) = Includes Owner's Costs and AFUDC	1558	Total project cost per kW
Fixed O&M Cost		
FOMO (\$/kW yr) = (B operators)*2080*T/(A*1000)	\$ 6.83	Fixed O&M additional operating labor costs
FOMM (\$/kW yr) = (BM*0.015)/(B*A*1000)	\$ 7.29	Fixed O&M additional maintenance material and labor costs
FOMA (\$/kW yr) = 0.03*(FOMO + 0.4*FOMM)	\$ 0.29	Fixed O&M additional administrative labor costs
FOM (\$/kW yr) = FOMO + FOMM + FOMA	\$ 14.41	Total Fixed O&M costs
Variable O&M Cost		
VOMR (\$/MWh) = K*P/(A*J)*98	\$ 2.25	Variable O&M costs for limestone reagent
VOMW (\$/MWh) = L*Q/(A*J)*98	\$ 0.78	Variable O&M costs for waste disposal
VOMP (\$/MWh) = M*R*10	\$ 0.50	Variable O&M costs for additional auxiliary power required including additional fan power (Refer to Aux Power % above)
VOMM (\$/MWh) = N*S/A	\$ 0.02	Variable O&M costs for makeup water
VOM (\$/MWh) = VOMR + VOMW + VOMP + VOMM	\$ 3.55	Total Variable O&M costs
Annual Capacity Factor = 59%		
Annual MWhts = 634,460		
Annual Heat Input MMBtu = 6,565,620		
Annual Tons SO2 Created = 4,082	Projected Actual SO2 emissions from Power Boiler 13.	
Annual Tons SO2 Removed = 3,674	at removal efficiency = 90%	
Annual Tons SO2 Emission = 408		
Annual Avg SO2 Emission Rate, lb/MMBtu = 0.124	Value is AT or ABOVE a 0.06 floor rate	
Annual Capital Recovery Factor = 0.0786	Based on 4.75% interest rate, 20 year life	
Annual Capital Cost (Including AFUDC), \$ = 15,141,000		
Annual FOM Cost, \$ = 1,782,000		
Annual VOM Cost, \$ = 2,254,000		
Total Annual Cost, \$ = 19,177,000		
Capital Cost, \$/MWh = 23.86		
FOM Cost, \$/MWh = 2.81		
VOM Cost, \$/MWh = 3.55		
Total Cost, \$/MWh = 30.23		
Capital Cost, \$/ton = 4,121		
FOM Cost, \$/ton = 485		
VOM Cost, \$/ton = 614		
Total Cost, \$/ton = 5,220		