Addendum to Dave Johnston Unit 4 BART Report

PREPARED FOR: Wyoming Division of Air Quality

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Introduction

In compliance with the Regional Haze Rule (40 Code of Federal Regulations [CFR] 51), the Wyoming Division of Air Quality (WDAQ) required PacifiCorp Energy to conduct a detailed Best Available Retrofit Technology (BART) review to analyze the effects to visibility in nearby Class I areas from plant emissions, both for baseline and for reasonable control technology scenarios. PacifiCorp submitted these evaluations to WDAQ in January 2007. A revised report was submitted in October 2007.

On January 3, 2008, PacifiCorp Energy personnel met with WDAQ staff to discuss the status of the BART reviews. At that time, the state requested that additional modeling scenarios for several of the PacifiCorp facilities be performed to aid in their BART review. This memorandum presents the economics analysis for one scenario previously modeled, referred to as Scenario A, and new model results for Scenario B and described as follows:

- Scenario A: PacifiCorp committed controls at permitted rates—low nitrogen oxide (NO_x) burners (LNBs) with over-fire air (OFA), dry flue gas desulfurization (FGD), new fabric filter
- Scenario B: PacifiCorp committed controls and selective catalytic reduction (SCR) at permitted rates

The CALPUFF modeling system (v. 5.711a) was used for this analysis. All technical options and model triggers used in CALMET, CALPUFF, and CALPOST are consistent with those used for the previous BART analyses and described in the BART report submitted in October 2007.

Stack Parameters, Emissions Information, and Capital Cost

Table 1 summarizes the control equipment for Scenarios A and B as well as the current equipment installed at the plant. The overall capital cost of installing these options is also shown.

TABLE 1
Control Scenario Summary
Dave Johnson Unit 4

	Equipment Type			Capital Cost
	NO_x	**SO_2**	**PM_{10}**	**Million dollars**
Baseline	LNB	Lime—add Venturi scrubber	Venturi scrubber	—
Scenario A	LNB with OFA	Dry FGD	Fabric Filter	$251.0
Scenario B	LNB with OFA and SCR	Dry FGD	Fabric Filter	$395.0

Emissions were modeled for the following pollutants:

- Sulfur dioxide (SO_2)
- NO_x
- Coarse particulate ($PM_{2.5}$<diameter<PM_{10})
- Fine particulate (diameter<$PM_{2.5}$)
- Sulfates

Table 2 shows stack parameters and emission rates that were used for the Dave Johnston Unit 4 BART modeling and analysis.

TABLE 2
Calpuff Model Inputs
Dave Johnston Unit 4

	BART Comparison[d]		
Model Input Data	**Baseline**	**Scenario A [e]**	**Scenario B [f]**
Hourly Heat Input (mmBtu/hour)	4,100	4,100	4,100
Sulfur Dioxide (SO_2) Stack Emissions (lb/hr)	2,050	615	615
Nitrogen Oxide (NO_x) Stack Emissions (lb/hr)	1,640	615	287
PM_{10} Stack Emissions (lb/hr)	250	61.5	61.5
Coarse Particulate ($PM_{2.5}$ <diameter< PM_{10}) Stack Emissions (lb/hr)[a]	108	35.1	35.1
Fine Particulate (diameter<$PM_{2.5}$) Stack Emissions (lb/hr)[b]	143	26.4	26.4
Sulfuric Acid (H_2SO_4) Stack Emissions (lb/hr)	37.7	3.8	5.8
Ammonium Sulfate [$(NH_4)_2SO_4$] Stack Emissions (lb/hr)	—	—	0.8
$(NH_4)HSO_4$ Stack Emissions (lb/hr)	—	—	1.4
H_2SO_4 as Sulfate (SO_4) Stack Emissions (lb/hr)	37	3.7	5.6
$(NH_4)_2SO_4$ as SO_4 Stack Emissions (lb/hr)	—	—	0.6
$(NH_4)HSO_4$ as SO_4 Stack Emissions (lb/hr)	—	—	1.2

TABLE 2
Calpuff Model Inputs
Dave Johnston Unit 4

		BART Comparison[d]	
Model Input Data	**Baseline**	**Scenario A [e]**	**Scenario B [f]**
Total Sulfate (SO_4) (lb/hr)[c]	37	3.7	7.4
Stack Conditions			
Stack Height (meters)	76	152	152
Stack Exit Diameter (meters)	9.75	5.79	5.79
Stack Exit Temperature (Kelvin)	322	350	350
Stack Exit Velocity (meters per second)	8.53	25.7	25.7

NOTES:
[a] Based on AP-42, Table 1.1-6, the coarse particulates are counted as a percentage of PM_{10}. This equates to 43% ESP and 57% Baghouse. PM_{10} and $PM_{2.5}$ refer to particulate matter less than 10 and 2.5 micrometers, respectively, in aerodynamic diameter.
[b] Based on AP-42, Table 1.1-6, the fine particulates are counted as a percentage of PM_{10}. This equates to 57% ESP and 43% Baghouse.
[c] Total Sulfate (SO_4) (lb/hr) = H_2SO_4 as Sulfate (SO_4) Stack Emissions (lb/hr) + $(NH_4)_2SO_4$ as SO_4 Stack Emissions (lb/hr) + $(NH_4)HSO_4$ as SO_4 Stack Emissions (lb/hr)
[d] SO_2, NO_x, and PM rates are expressed in terms of permitted emission rates. Actual emissions will be less than the permitted rates.
[e] PacifiCorp Committed Controls @ permitted rates: LNB with OFA, Dry FGD, New Fabric Filter
[f] PacifiCorp Committed Controls and SCR @ permitted rates

Economic Analysis

In completing this additional analysis to supplement the previous BART study, technology alternatives were investigated and potential reductions in NO_x, SO_2, and PM_{10} emissions rates were identified.

A comparison of Scenarios A and B on the basis of costs, design control efficiencies, and tons of pollutant removed is summarized in Tables 3 through 5. Capital costs were provided by PacifiCorp. The complete economic analyses for these two scenarios are provided as Attachment 1.

TABLE 3
Scenario A Control Cost
Dave Johnston Unit 4

	NO_x Control	SO_2 Control	PM_{10} Control	Scenario A
	LNB with OFA	**Dry FGD**	**Fabric Filter**	**Control Cost**
Total Installed Capital Costs (million dollars)	$7.90	$243.1	—	$251.0
Annualized First-Year Capital Costs	$0.75	$23.13	—	$23.88
First Year Fixed and Variable O&M Costs (million dollars)	$0.09	$5.32	—	$5.41
Total First Year Annualized Costs (million dollars) [a]	$0.84	$28.77	—	$29.61
Power Consumption (MW)	—	4.45	—	4.54
Annual Power Usage (Million kWh/Yr)	—	35.79	—	35.79
Permitted Emission Rate (lb/mmBtu)	0.15	0.15	0.02	—
Additional Tons of Pollutant Removed per Year over Baseline	4,041	5,657	743	10,441
First Year Average Control Cost ($/Ton of Pollutant Removed)	208	5,028	—	2,805

NOTE:
[a] First year annualized costs include power consumption costs.

TABLE 4
Scenario B Control Cost
Dave Johnston Unit 4

	NO_x Control	SO_2 Control	PM_{10} Control	Scenario B
	LNB with OFA & SCR	**Dry FGD**	**Fabric Filter**	**Control Cost**
Total Installed Capital Costs (million dollars)	$151.9	$243.1	—	$395.0
Annualized First-Year Capital Costs	$14.45	$23.13	—	$37.58
First Year Fixed & Variable O&M Costs (million dollars)	$1.98	$5.32	—	$7.30
Total First Year Annualized Costs (million dollars) [a]	$16.43	$28.44	—	$44.87
Power Consumption (MW)	2.29	4.54	—	6.83
Annual Power Usage (Million kWh/Yr)	18.05	35.79	—	53.85
Permitted Emission Rate (lb/mmBtu)	0.07	0.15	0.02	—
Additional Tons of Pollutant Removed per Year over Baseline	5,334	5,657	743	11,734
First Year Average Control Cost ($/Ton of Pollutant Removed)	3,081	5,028	—	3,824

NOTE:
[a] First year annualized costs include power consumption costs.

TABLE 5
Incremental Control Costs, Scenario B compared to Scenario A
Dave Johnston Unit 4

	NO_x Control	SO_2 Control	PM_{10} Control	Total Control Cost
Incremental Installed Capital Costs (million dollars)	$144.0	0	0	$144.0
Incremental Annualized First-Year Capital Costs	$13.70	0	0	$13.70
Incremental First Year Fixed & Variable O&M Costs (million dollars)	$1.89	0	0	$1.89
Incremental First Year Annualized Costs (million dollars) [a]	$15.59	0	0	$15.59
Incremental Power Consumption (MW)	2.29	0	0	2.29
Incremental Annual Power Usage (Million kWh/Yr)	18.05	0	0	18.05
Incremental Improvement in Emission Rate (lb/mmBtu)	0.08	0	0	—
Incremental Tons of Pollutant Removed	1,293	0	0	1,293
Incremental First Year Average Control Cost ($/Ton of Pollutant Removed)	12,056	0	0	12,056

NOTE:
[a] Incremental first year annualized costs include power consumption costs.

Modeling Results and Least-Cost Envelope Analysis

CH2M HILL modeled Dave Johnston Unit 4 for two post-control scenarios. The results determine the change in deciview based on each alternative at the Class I areas specific to the project. The Class I areas potentially affected are Badlands National Park and Wind Cave National Park for this unit.

Modeled Scenarios

Current operations (baseline) and two alternative control scenarios were modeled to cover the range of effectiveness for the combination of the individual NO_x, SO_2, and PM control technologies being evaluated. The modeled scenarios include the following:

- Baseline: Current operations with LNB and Venturi Scrubber
- Scenario A: LNB with OFA, Dry FGD, new fabric filter
- Scenario B: Scenario A with SCR

Summary of Visibility Analysis

Tables 6 and 7 present a summary of the modeling period (2001–2003) results for each scenario and Class I area.

TABLE 6
Costs and Visibility Modeling Results as Applicable to Badlands National Park
Dave Johnston Unit 4

Scenario	Controls	Total First Year Annualized Cost	Highest ΔdV	98th Percentile ΔdV	Maximum Annual Number of Days Above 0.5 dV
Baseline	Current Operations with FGD and Venturi Scrubber	—	3.610	1.291	49
Scenario A	Scenario A: PacifiCorp Committed Controls	$29,285,200	1.291	0.435	7
Scenario B	Scenario B: PacifiCorp Committed Controls and SCR	$44,873,886	0.938	0.302	4

TABLE 7
Costs and Visibility Modeling Results as Applicable to Wind Cave National Park
Dave Johnston Unit 4

Scenario	Controls	Total First Year Annualized Cost	Highest ΔdV	98th Percentile ΔdV	Maximum Annual Number of Days Above 0.5 dV
Baseline	Current Operations with FGD and Venturi Scrubber	—	4.304	1.695	47
Scenario A	Scenario A: PacifiCorp Committed Controls	$29,285,200	1.727	0.543	9
Scenario B	Scenario B: PacifiCorp Committed Controls and SCR	$44,873,886	1.260	0.374	7

Results

Tables 8 and 9 present a summary of the costs and modeling results for each scenario and Class I area.

TABLE 8
Incremental Costs and Incremental Visibility Improvements Relative to Badlands National Park
Dave Johnston Unit 4

Scenario Comparison	Controls	Incremental Annualized Cost (Million$)	Reduction in 98th Percentile maximum dV	Reduction in Number of Days Above 0.5 dV	Cost per dV Reduction (Million$/dV Reduced)	Cost per Day to Achieve a Reduction in the Days above 0.5 dV (Million$/Day)
Scenario A Compared to Baseline	Scenario A: PacifiCorp Committed Controls	$29.29	0.856	42	$34.21	$0.70
Scenario B Compared to Baseline	Scenario B: PacifiCorp Committed Controls and SCR	$44.87	0.989	45	$45.37	$1.00
Scenario B Compared To Scenario A	Addition of SCR	$15.59	0.133	3	$117.21	$5.20

TABLE 9
Incremental Costs and Incremental Visibility Improvements Relative to Wind Cave National Park
Dave Johnston Unit 4

Scenario Comparison	Controls	Incremental Annualized Cost (Million$)	Reduction in 98th Percentile maximum dV	Reduction in Number of Days Above 0.5 dV	Cost per dV Reduction (Million$/dV Reduced)	Cost per Day to Achieve a Reduction in the Days above 0.5 dV (Million$/Day)
Scenario A Compared to Baseline	Scenario A: PacifiCorp Committed Controls	$29.29	1.152	38	$25.42	$0.77
Scenario B Compared to Baseline	Scenario B: PacifiCorp Committed Controls and SCR	$44.87	1.321	40	$33.97	$1.12
Scenario B Compared To Scenario A	Addition of SCR	$15.59	0.169	2	$92.24	$7.79

Least-Cost Envelope Analysis

The least-cost envelope graphs for Badlands National Park are shown in Figures 1 and 2 and for Wind Cave National Park are shown in Figures 3 and 4.

FIGURE 1

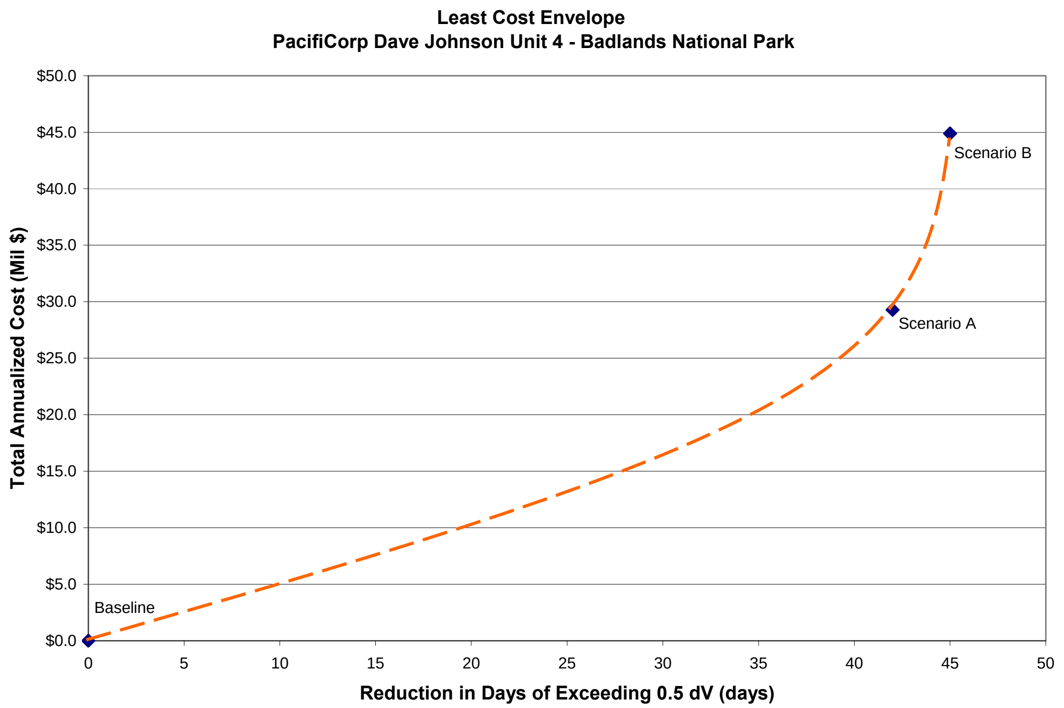


FIGURE 2

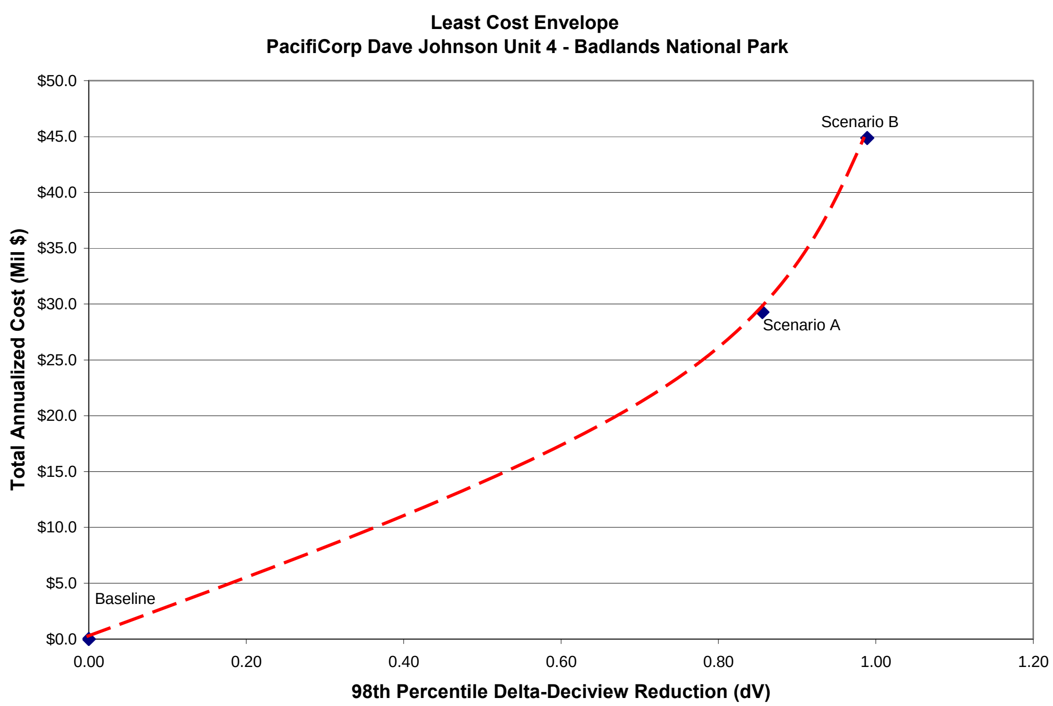


FIGURE 3

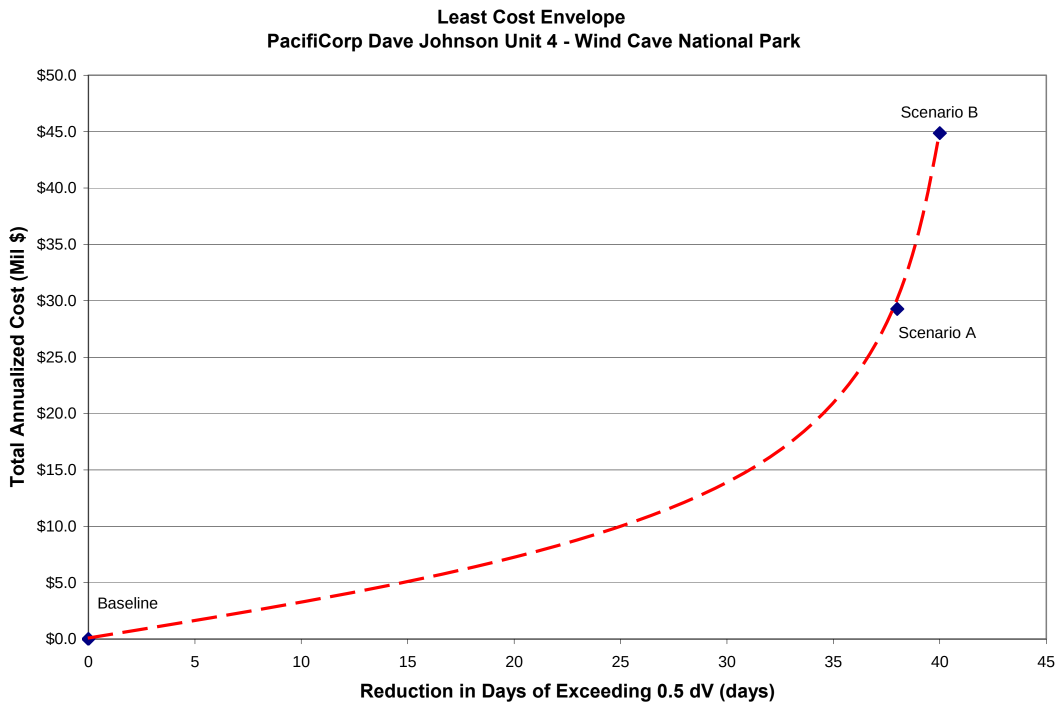
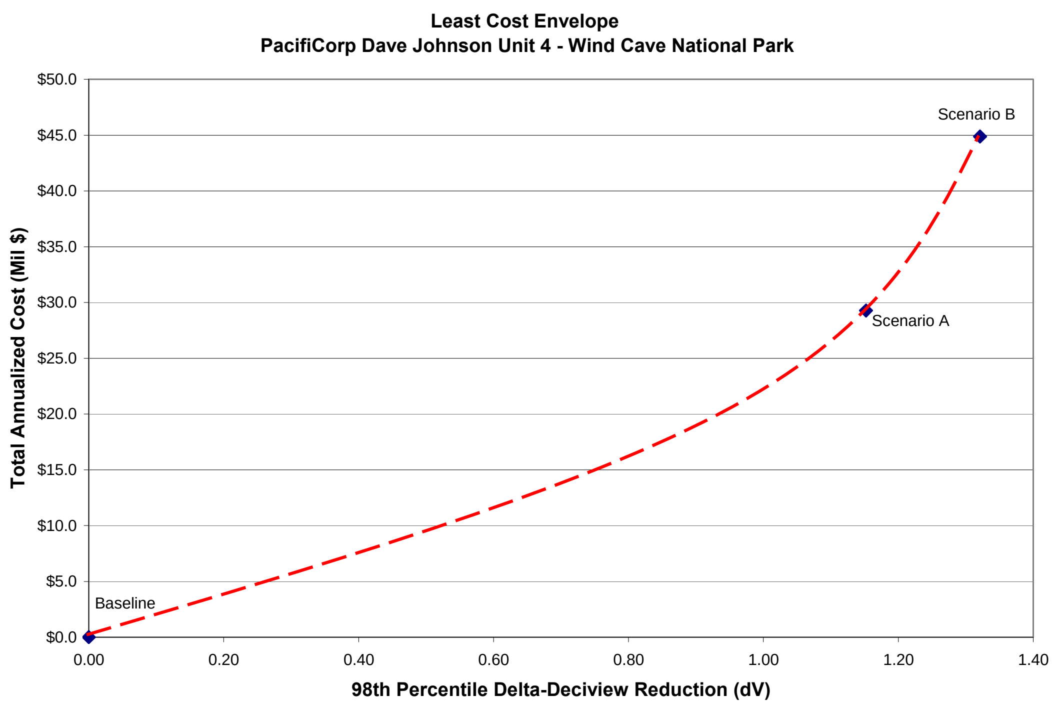


FIGURE 4



ATTACHMENT 1

Complete Economic Analyses for Scenarios A and B

ECONOMIC ANALYSIS SUMMARY - FIRST YEAR COSTS

DJ4 **Boiler Design: Tangential-Fired PC**

TYPE OF EMISSIONS CONTROLS		NO_x Control						Scenario A	Scenario B
Technology Label	**BASE**	**A**	**B**	**C**	**D**	**F**	**G**	**A+F**	**D+F**
	Current Operation	Low NO_x Burners with Overfire Air	Rotating Overfire Air	Low NO_x Burners with Overfire Air and Non-Selective Catalytic Reduction	Low NO_x Burners with Overfire Air and Selective Catalytic Reduction	Dry FGD & Fabric Filter	Wet FGD w/ Fabric filter	LNB w/OFA, Dry Flue Gas Desulfurization and Fabric Filter Baghouse	LNB w/OFA, SCR. Dry Flue Gas Desulfurization and Fabric Filter Baghouse
CAPITAL INVESTMENT									
Total Installed Capital Costs ($)	$0	$7,900,000	$14,719,868	$17,905,780	$151,900,000	$243,100,000	$289,166,335	$251,000,000	$395,000,000
FIRST YEAR DEBT SERVICE ($/Yr)	**$0**	**$751,510**	**$1,400,269**	**$1,703,338**	**$14,449,916**	**$23,125,574**	**$27,507,764**	**$23,877,084**	**$37,575,490**
FIRST YEAR FIXED O&M Costs ($/Yr)									
Operating Labor ($/Yr)	$0	$0	$0	$0	$0	$506,128	$809,804	$506,128	$506,128
Maintenance Material ($/Yr)	$0	$36,000	$54,000	$105,000	$166,000	$1,102,288	$1,430,784	$1,138,288	$1,268,288
Maintenance Labor ($/Yr)	$0	$54,000	$81,000	$157,500	$249,000	$734,858	$953,856	$788,858	$983,858
Administrative Labor ($/Yr)	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL FIRST YEAR FIXED O&M COST	**$0**	**$90,000**	**$135,000**	**$262,500**	**$415,000**	**$2,343,274**	**$3,194,444**	**$2,433,274**	**$2,758,274**
FIRST YEAR VARIABLE O&M Costs ($/Yr)									
Makeup Water Costs ($/Yr)	$0	$0	$0	$0	$0	$142,730	$189,923	$142,730	$142,730
Reagent Costs ($/Yr)	$0	$0	$0	$45,823	$293,563	$552,256	$526,723	$552,256	$845,819
SCR Catalyst / FF Bag Costs ($/Yr)	$0	$0	$0	$0	$369,000	$186,992	$186,992	$186,992	$555,992
Waste Disposal Costs ($/Yr)	$0	$0	$0	$0	$0	$303,197	$383,582	$303,197	$303,197
Electric Power Costs ($/Yr)	$0	$0	$1,706,886	$130,086	$902,718	$1,789,668	$2,479,518	$1,789,668	$2,692,386
TOTAL FIRST YEAR VARIABLE O&M Costs ($/Yr)	**$0**	**$0**	**$1,706,886**	**$175,909**	**$1,565,281**	**$2,974,843**	**$3,766,739**	**$2,974,843**	**$4,540,124**
SUMMARY OF FIRST YEAR COSTS ($/Yr)									
First Year Debt Service ($/Yr)	$0	$751,510	$1,400,269	$1,703,338	$14,449,916	$23,125,574	$27,507,764	$23,877,084	$37,575,490
First Year Fixed O&M Costs ($/Yr)	$0	$90,000	$135,000	$262,500	$415,000	$2,343,274	$3,194,444	$2,433,274	$2,758,274
First Year Variable O&M Costs ($/Yr)	$0	$0	$1,706,886	$175,909	$1,565,281	$2,974,843	$3,766,739	$2,974,843	$4,540,124
Total First Year Costs ($/Yr)	**$0**	**$841,510**	**$3,242,155**	**$2,141,747**	**$16,430,197**	**$28,443,691**	**$34,468,947**	**$29,285,201**	**$44,873,888**
CONTROL COST COMPARISONS									
NO_x Technology Comparison									
Additional NO_x Removed From Base Case (Tons/Yr)	0	4,041	4,041	4,525	5,334				
First Year Average Control Cost ($/Ton NO_x Removed)	$0	$208	$802	$473	$3,081				
Technology Case Comparison		A-BASE	B-A	C-A	D-A				
Incremental NO_x Removed (Tons/Yr)	0	4,041	0	485	1,293				
Incremental Control Cost ($/Ton NO_x Removed)	$0	$208	#DIV/0!	$2,682	$12,056				
SO_2 Technology Comparison	58.6%					87.6%	91.7%		
Additional SO_2 Removed From Base Case (Tons/Yr)	0					5,657	6,465		
First Year Average Control Cost ($/Ton SO_2 Removed)	$0					$5,028	$5,332		
Technology Case Comparison						F-E	G-F		
Incremental SO_2 Removed (Tons/Yr)	0					-2,424	808		
Incremental Control Cost ($/Ton SO_2 Removed)	$0					-$11,197	$7,456		
PM Technology Comparison	0.0%								
Additional PM Removed From Base Case (Tons/Yr)	0					743	0		
First Year Average Control Cost ($/Ton PM Removed)	$0					$38,258	#DIV/0!		
Technology Case Comparison						F-E	G-F		
Incremental PM Removed (Tons/Yr)	0					-242	-743		
Incremental Control Cost ($/Ton PM Removed)	$0					-$111,967	-$8,104		
SCENARIO A AND B COMPARISONS									
Additional NO_x, SO_2, & PM Removed From Base Case (Tons/Yr)	**0**							**10,441**	**11,734**
First Year Average Control Cost Compared to Base Case ($/Ton Removed)	**$0**							**$2,805**	**$3,824**
Incremental Tons Removed - Scenario B vs Scenario A (Tons/Yr)	**0**								**1,293**
Incremental Control Costs - Scenario B vs Scenario A ($/Ton Removed)	**$0**								**$12,056**

INPUT CALCULATIONS

DJ4 Boiler Design: Tangential-Fired PC

PARAMETER	Current Operation	NO_x Control Technologies				SO_2 and PM Control Technologies		Scenario A	Scenario B
Control Technologies									
NO_x Emission Control System	Good Practices	LNB w/OFA	ROFA	LNB w/OFA & SNCR	LNB w/OFA & SCR			LNB w/OFA	LNB w/OFA & SCR
SO_2 Emission Control System	Lime addition					Dry FGD	Wet FGD w/ Fabric filter	Dry FGD	Dry FGD
PM Emission Control System	Venturi Scrubber					Fabric Filter		Fabric Filter	Fabric Filter
General Plant Design and Operating Data									
Type of Unit	PC	PC	PC	PC	PC	PC	PC	PC	PC
Annual Power Plant Capacity Factor	90%	90%	90%	90%	90%	90%	90%	90%	90%
Annual Operation (Hours/Year)	7,884	7,884	7,884	7,884	7,884	7,884	7,884	7,884	7,884
Net Power Output (kW)	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000
Net Plant Heat Rate (Btu/kW-Hr)	12,425	12,425	12,425	12,425	12,425	12,425	12,425	12,425	12,425
Boiler Heat Input, Measured by Fuel Input (MMBtu/Hr)	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100
Annual Heat Input, Measured by Fuel Input (MMBtu/Year)	32,326,371	32,326,371	32,326,371	32,326,371	32,326,371	32,326,371	32,326,371	32,326,371	32,326,371
Boiler Heat Input, Measured by CEM (MMBtu/Hr)	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100
Annual Heat Input, Measured by CEM (MMBtu/Year)	32,324,400	32,324,400	32,324,400	32,324,400	32,324,400	32,324,400	32,324,400	32,324,400	32,324,400
Plant Fuel Source									
Boiler Fuel Source	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB	Dry Fork PRB
Coal Heating Value (Btu/Lb)	7,784	7,784	7,784	7,784	7,784	7,784	7,784	7,784	7,784
Coal Sulfur Content (wt.%)	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%	0.470%	0.47%	0.47%
Coal Ash Content (wt.%)	5.01%	5.01%	5.01%	5.01%	5.01%	5.01%	5.01%	5.01%	5.01%
Coal Flow Rate (Lb/Hr)	526,754	526,754	526,754	526,754	526,754	526,754	526,754	526,754	526,754
Coal Consumed (Ton/Yr)	2,076,463	2,076,463	2,076,463	2,076,463	2,076,463	2,076,463	2,076,463	2,076,463	2,076,463
Nitrogen Oxide Emissions									
NO_x Emission Rate (Lb/MMBtu)	0.40	0.15	0.15	0.12	0.07			0.15	0.07
NO_x Emission Rate (Lb/Hr)	1,640	615	615	492	287			615	287
NO_x Emission Rate (Lb Moles/Hr)	54.65	20.49	20.49	16.39	9.56			20.49	9.56
NO_x Emission Rate (Ton/Yr)	6,465	2,424	2,424	1,939	1,131			2,424	1,131
Add'l NO_x Removed from Current Operations (Lb/Hr)	0	1,025	1,025	1,148	1,353			1,025	1,353
Add'l NO_x Removed from Current Operations (Ton/Yr)	0	4,041	4,041	4,525	5,334			4,041	5,334
Sulfur Dioxide Emissions									
Uncontrolled SO_2 (Lb/MMBtu)	1.21					1.21	1.21	1.21	1.21
Uncontrolled SO_2 (Lb/Hr)	4,946					4,946	4,946	4,946	4,946
Uncontrolled SO_2 (Lb Moles/Hr)	77.21					77.21	77.21	77.21	77.21
Uncontrolled SO_2 (Tons/Yr)	19,498					19,498	19,498	19,498	19,498
Controlled SO_2 Emission Rate (Lb/MMBtu)	0.50					0.15	0.10	0.15	0.15
SO_2 Removal Efficiency (%)	58.6%					87.6%	91.7%	87.6%	87.6%
Controlled SO_2 Emissions (Lb/Hr)	2,050					615	410	615	615
Controlled SO_2 Emissions (Ton/Yr)	8,081					2,424	1,616	2,424	2,424
SO_2 Removed (Lb/Hr)	2,896					4,331	4,536	4,331	4,331
SO_2 Removed (Ton/Yr)	11,417					17,074	17,882	17,074	17,074
Add'l SO_2 Removed from Current Operations (Lb/Hr)	0					1,435	1,640	1,435	1,435
Add'l SO_2 Removed from Current Operations (Ton/Yr)	0					5,657	6,465	5,657	5,657
Particulate Matter Emissions									
Uncontrolled Fly Ash (Lb/Hr)	21,112					21,112	21,112	21,112	21,112
Uncontrolled Fly Ash (Lb/MMBtu)	5.149					5.149	5.149	5.149	5.149
Uncontrolled Fly Ash (Tons/Yr)	83,225					83,225	83,225	83,225	83,225
Controlled Fly Ash Emission Rate (Lb/MMBtu)	0.061					0.015	0.061	0.015	0.015
Controlled Fly Ash Removal Efficiency (%)	98.8%					99.7%	98.8%	99.7%	99.7%
Controlled Fly Ash Emissions (Lb/Hr)	250					62	250	62	62
Controlled Fly Ash Emissions (Ton/Yr)	986					242	986	242	242
Fly Ash Removed (Lb/Hr)	20,862					21,051	20,862	21,051	21,051
Fly Ash Removed (Ton/Yr)	82,239					82,982	82,239	82,982	82,982
Add'l Ash Removed from Current Operation (Lb/Hr)	0					189	0	189	189
Add'l Ash Removed from Current Operation (Ton/Yr)	0					743	0	743	743
Economic Factors									
Interest Rate (%)	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%
Discount Rate (%)	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%	7.10%
Plant Economic Life (Years)	20	20	20	20	20	20	20	20	20

INPUT CALCULATIONS

DJ4 **Boiler Design:** **Tangential-Fired PC**

PARAMETER	Current Operation	NO_x Control Technologies				SO_2 and PM Control Technologies		Scenario A	Scenario B
Control Technologies									
NO_x Emission Control System	Good Practices	LNB w/OFA	ROFA	LNB w/OFA & SNCR	LNB w/OFA & SCR			LNB w/OFA	LNB w/OFA & SCR
SO_2 Emission Control System	Lime addition					Dry FGD	Wet FGD w/ Fabric filter	Dry FGD	Dry FGD
PM Emission Control System	Venturi Scrubber					Fabric Filter		Fabric Filter	Fabric Filter
Installed Capital Costs									
NO_x Emission Control System ($2006)		$7,900,000	$14,719,868	$17,905,780	$151,900,000			$7,900,000	$151,900,000
SO_2 Emission Control System ($2006)						$243,100,000	$289,166,335	$243,100,000	$243,100,000
PM Emission Control System ($2006)						$0	$0	$0	$0
Total Emission Control System Capital Costs ($2006)		$7,900,000	$14,719,868	$17,905,780	$151,900,000	$243,100,000	$289,166,335	$251,000,000	$395,000,000
NO_x Emission Control System ($/kW)		$24	$45	$54	$460			$24	$460
SO_2 Emission Control System ($/kW)						#REF!	$876	$737	$737
PM Emission Control System ($/kW)									
Total Emission Control Capital Costs ($/kW)		$24	$45	$54	$460	$737	$876	$761	$1,197
Fixed Operating & Maintenance Costs									
Operating Labor ($)		$0	$0	$0	$0	$506,128	$809,804	$506,128	$506,128
Maintenance Material ($)		$36,000	$54,000	$105,000	$166,000	$1,102,288	$1,430,784	$1,138,288	$1,268,288
Maintenance Labor ($)		$54,000	$81,000	$157,500	$249,000	$734,858	$953,856	$788,858	$983,858
Administrative Labor ($)		$0	$0	$0	$0	$0	$0	$0	$0
Total 1st Fixed Year O&M Cost ($)		$90,000	$135,000	$262,500	$415,000	$2,343,274	$3,194,444	$2,433,274	$2,758,274
Annual Fixed O&M Cost Escalation Rate (%)		2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Levelized Fixed O&M Cost ($/Yr)		$106,695	$160,043	$311,195	$491,984	$2,777,958	$3,787,023	$2,884,653	$3,269,942
Variable Operating & Maintenance Costs									
Water Cost									
Makeup Water Usage (gpm)		0	0	0	0	248	330	248	248
Unit Price ($/1000 gallons)		$1.22	$1.22	$1.22	$1.22	$1.22	$1.22	$1.22	$1.22
First Year Water Cost ($)		$0	$0	$0	$0	$142,730	$189,923	$142,730	$142,730
Annual Water Cost Escalation Rate (%)		2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Levelized Water Costs ($/Yr)		$0	$0	$0	$0	$169,207	$225,155	$169,207	$169,207
Reagent Cost									
Type of Reagent		None	None	Urea	Anhydrous NH_3	Lime	Lime	Lime	Lime & Anhydrous NH_3
Unit Cost ($/Ton)		$0.00		$370.00	$400.00	$91.25	$91.25		
Unit Cost ($/Lb)		$0.000		$0.185	$0.200	$0.046	$0.046		
Molar Stoichiometry		0.00		0.45	1.00	1.10	1.02		
Reagent Purity (Wt.%)		100%		100%	100%	90%	100%		
Reagent Usage (Lb/Hr)				31	186	1,535	1,464		
First Year Reagent Cost ($)		$0		$45,823	$293,563	$552,256	$526,723	$552,256	$845,819
Annual Reagent Cost Escalation Rate (%)		2.00%		2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Levelized Reagent Costs ($/Yr)				$54,324	$348,020	$654,701	$624,432	$654,701	$1,002,721
SCR Catalyst / Fabric Filter Bag Replacement Cost									
Material Replaced					SCR Catalyst	Bags		Bags	Bags & SCR Catalyst
Annual SCR Catalyst (m3) / No. FF Bags					123	1,798	1,798		
SCR Catalyst ($/m3) / Bag Cost ($/ea.)					$3,000	$104	$104		
First Year SCR Catalyst / Bag Replacement Cost ($)					$369,000	$186,992	$186,992	$186,992	$555,992
Annual SCR Catalyst / Bag Cost Escalation Rate (%)					2.00%	2.00%	2.00%	2.00%	2.00%
Levelized Catalyst/Fabric Fitler Bag Costs ($/Yr)					$437,451	$221,680	$221,680	$221,680	$659,130
FGD Waste Disposal Cost									
FGD Solid Waste Disposal Rate, Dry (Lb/Hr)						3,161	3,999	3,161	3,161
FGD Waste Disposal Unit Cost ($/Dry Ton)						$24.33	$24.33	$24.33	$24.33
First Year FGD Waste Disposal Cost ($)						$303,197	$383,582	$303,197	$303,197
Annual Waste Disposal Cost Esc. Rate (%)						2.00%	2.00%	2.00%	2.00%
Levelized Waste Disposal Costs ($/Yr)						$359,441	$454,738	$359,441	$359,441
Auxiliary Power Cost									
Auxiliary Power Requirement (MW)		0.00	4.33	0.33	2.29	4.54	6.29	4.54	6.83
Auxiliary Power Requirement (% of Plant Output)		0.00%	1.31%	0.10%	0.69%	1.38%	1.91%	1.38%	2.07%
Auxilliary Power Useage (MWh)		0	34,138	2,602	18,054	35,793	49,590	35,793	53,848
Unit Cost ($2006/MW-Hr)		$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
First Year Auxiliary Power Cost ($)		$0	$1,706,886	$130,086	$902,718	$1,789,668	$2,479,518	$1,789,668	$2,692,386
Annual Power Cost Escalation Rate (%)		2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Levelized Auxilliary Power Costs ($/Yr)		$0	$2,023,518	$154,217	$1,070,175	$2,121,657	$2,939,476	$2,121,657	$3,191,832