

Appendix C
Air Quality

**Potential to Emit
Phase I and Phase II**

Pollutant	Emission Rate per Power Generation Unit stack		Emission Rate per Auxiliary Boiler stack	Emission Rate per Diesel Generator stack	Annual PTE (TPY) Four PGUs including 130 Startup/Shutdown Cycles per Year per PGU	Annual PTE (TPY) Two Auxiliary Boilers	Annual PTE (TPY) Two Diesel Generators	Annual PTE TPY (Four PGUs including 130 Startup/Shutdown Cycles per Year per PGU, two Cooling Towers, two Auxiliary Boilers, and two Diesel Generators)
	With Duct Firing Natural Gas ppm (gr/dscf for PM)	With Duct Firing Natural Gas lb/hr (lb/day for PM)	lb/hr (lb/day for PM)	lb/hr (lb/day for PM)				
NOx	2.5	21.7	1.03	10.19	580.2	2.6	5.1	588
NH3	5	16.1	0	0	282.1	0.0	0.0	282
CO	2	10.6	1.07	12.55	873.7	2.7	6.3	883
SO2	0.11	1.3	0.03	0.27	22.8	0.1	0.1	23
VOCs	2.78	8.4	0.47	1.48	193.2	1.2	0.7	195
PM ("front and back half")	0.0037	583.2	7.03	14.16	425.7	0.7	0.3	436

Notes:

1. Cooling Tower PM Emissions (TPY each):
4.51
2. Hours for Each PGU:
8760
Hours with Duct Firing:
8760
3. Hours for Each Auxiliary Boiler:
2500
4. Hours for Each Diesel Generator
500
5. Startup/Shutdown Emissions for each pair of PGUs based on 130 cycles per year for each PGU:
NOx 100
CO 344
VOCs 23
6. Number of PGUs with Duct Firing: 4
7. Number of Pairs of PGUs: 2
8. Number of Auxiliary Boilers: 2
9. Number of Cooling Towers: 2
10. Number of Diesel Generators: 2
11. Emission rates based on 0.2 gr S/100 scf natural gas and 30% sulfate conversion.

SCR Costs (per gas turbine/HRSG)			
Description of Cost	Cost Factor	Cost (\$)	Notes
Direct Capital Costs (DC):			
Purchased Equip. Cost (PE):			
Basic Equipment:			
Auxiliary Equipment: HRSG tube/fin modification			
Instrumentation: SCR controls			
Ammonia storage system			
Taxes and freight			
PE Total:		\$1,581,200	1
Direct Install. Costs (DI):			
Foundation & supports			9
Handling and erection			9
Electrical:			9
Piping:			9
Insulation:			9
Painting:			9
DI Total:		\$395,300	1
Site preparation for ammonia tanks (included in PE cost)		\$0	1
DC Total (PE+DI):		\$1,976,500	
Indirect Costs (IC):			
Engineering:	0.10 PE	\$158,120	2
Construction and field expenses	0.05 PE	\$79,060	2
Contractor fees:	0.10 PE	\$158,120	2
Start-up:	0.02 PE	\$31,624	2
Performance testing	0.01 PE	\$15,812	2
Contingencies	0.05 PE	\$79,060	1
IC Total:		\$521,796	
Less: Capital cost of initial catalyst charge		-\$752,000	
Total Capital Investment (TCI = DC + IC):		\$1,746,296	
Direct Annual Costs (DAC): 0.5 hr/SCR per shift			
Operating Costs (O):	0.5 hr/SCR per shift		
Operator:	hr/shift: 2.0	operator pay (\$/hr) 39.20	\$85,613 2
Supervisor:	15% of operator		\$12,842 2
Maintenance Costs (M):	0.5 hr/SCR per shift		
Labor:	hr/shift: 2.0	labor pay (\$/hr): 39.2	\$85,613 2
Material:	% of labor cost 100%		\$85,613 2
Utility Costs:			
Perf. loss:	(kwh/unit): 0.0	SCONOx losses are shown as incremental to SCR losses	1
Electricity cost	(\$/kwh):		9
Ammonia	based on 120.7 lbs/hr of 28% wt aqueous ammonia, \$440/to		\$232,613 4
Catalyst replace:	based on 3 year catalyst life		\$250,667 1
Catalyst dispose:	based on 2,750 ft ² catalyst, \$15/ft ² , 3 yr. Life		\$13,750 1
Total DAC:			\$766,710
Indirect Annual Costs (IAC):			
Overhead:	60% of O&M		\$161,808 2
Administrative:	0.02 TCI		\$34,926 2
Insurance:	0.01 TCI		\$17,463 2
Property tax:	0.01 TCI		\$17,463 2
Total IAC:			\$231,660
Total Annual Cost (DAC + IAC):		\$998,370	
Capital Recovery (CR):			
Capital recovery:	interest rate (%): 10		
	period (years): 15	0.1315	\$229,592 2
Total Annualized Costs		\$1,227,962	
Total TPY of NOx Removed with SCR System per Turbine/HRSG:		361	
Cost per Ton of NOx Removed:		\$3,402	

Oxidation Catalyst and Summary of Proposed Control Technology	
TOTAL ANNUALIZED COSTS FOR EACH OXIDATION CATALYST SYSTEM:	\$500,000
Total TPY of CO Removed with Oxidation Catalyst System per Turbine/HRSG:	279
Cost per Ton of CO Removed:	\$1,792
Total TPY of VOC Removed with Oxidation Catalyst System per Turbine/HRSG:	23
Cost per Ton of VOC Removed:	\$21,739
TOTAL ANNUALIZED COSTS FOR SCR SYSTEM:	\$1,227,962
Total TPY of NOx Removed with SCR System per Turbine/HRSG:	361
Cost per Ton of NOx Removed:	\$3,402
Total TPY of Pollutants Removed with Proposed System per Turbine/HRSG:	640
Cost per Ton of Pollutant Removed:	\$2,700

The proposed system is SCR and CO catalytic oxidation.
The cost for VOC control is too excessive and is therefore eliminated from the final analysis.

Multi-Pollutant SCONox Cost and Adjusted Cost (per gas turbine/HRSG)				Notes
Direct Capital Costs				
	Capital (less cost of initial catalyst charge)	(PE)	\$10,750,000	8
	Installation			9
Indirect Capital Costs				
	Engineering:	0.10 PE	\$1,075,000	2
	Construction and field expenses:	0.05 PE	\$537,500	2
	Contractor fees:	0.10 PE	\$1,075,000	2
	Start-up:	0.02 PE	\$215,000	2
	Performance testing:	0.01 PE	\$107,500	2
	Contingencies:	0.05 PE	\$537,500	1
	Other:			9
Total Capital Investment			\$14,297,500	
Direct Annual Costs				
	Maintenance		\$250,000	3
	Ammonia		\$0	
	Natural Gas: 2.2 MMbtu/hr @ \$4.00/MMbtu		\$77,088	7
	Pressure Drop		\$226,000	3
	Catalyst Replacement (based on 3-yr catalyst life)		\$2,100,000	5,6
	Catalyst Disposal			9
Total Direct Annual Costs			\$2,653,088	
Indirect Annual Costs				
	Overhead			9
	Administrative, Tax & Insurance		\$225,000	3
Total Indirect Annual Costs			\$225,000	
TOTAL ANNUAL COST			\$2,878,088	
Capital Recovery Factor			0.1315	2
Capital Recovery			\$1,879,746	
TOTAL ANNUALIZED COSTS			\$4,757,834	
Total TPY of NOx Removed with SCONox System per Turbine/HRSG:			380	
Cost per Ton of NOx Removed:			\$12,521	
Total TPY of CO Removed with SCONox System per Turbine/HRSG:			302	
Cost per Ton of CO Removed:			\$15,754	
Cost per Ton of CO Removed (adjusted):			\$11,688	
Total TPY of VOC Removed with SCONox System per Turbine/HRSG:			33	
Cost per Ton of VOC Removed:			\$144,177	
Cost per Ton of VOC Removed (adjusted):			\$91,814	
Tons of Ammonia not Emitted:			70	
Cost per Ton of Ammonia not Emitted:			\$67,969	
Cost per Ton of Ammonia not Emitted (adjusted):			\$43,284	
Total TPY of Pollutants Removed with SCONox System per Turbine/HRSG:			785	
Cost per Ton of Pollutant Removed:			\$6,061	

Note: "Adjusted" cost accounts for reduction in SCONox annualized cost based on proposed SCR/oxidation catalyst system cost, per Ecology request.

Notes: SCONOx Cost Effectiveness Analysis	
Note No.	Source
1	Based on information from Duke/Fluor-Daniel.
2	From EPA/OAQPS Control Cost Manual. EPA-450/3-90-006. January 1990.
3	Based on 6/15/2000 telefax from Aalborg Industries to Duke/Fluor-Daniel. SCONOx capital cost is \$36MM for four HRSGs.
4	Based on aqueous ammonia cost of \$440/ton.
5	Based on information from May 8, 2000 "Testimony of J. Phyllis Fox, Ph.D. on Behalf of the California Unions for Reliable Energy on Air Quality Impacts of the Elk Hills Power Project", cost of replacement catalyst for SCONOx is 70% of initial capital investment.
6	Based on information from May 5, 2000 letter from ABB Alstom Power to Bibb and Associates indicating that SCONOx catalyst life is guaranteed for a 3-year period.
7	Personal communication, ABB Environmental, 1/18/00
8	Based on e-mail from EmeraChem to Cascade Environmental Management stating capital cost is between \$21,000,000 and \$22,000,000 for two SCONOx systems for two GE Frame 7FA turbines.
9	Undetermined at this time.