CH2MHILL

CH2M HILL

9193 South Jamaica Street
Englewood, CO 80112-5946

Tel 303.771.0900
Fax 720.286.9250

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DEPARTMENT OF ECOLOGY
AIR QUALITY PROGRAM

March 31, 2010

Mr. Richard L. Griffith
1580 Lincoln Street, Suite 700
Denver, CO 80203

Subject: Centralia BART Control Technology Analysis
Second Response to Department of Ecology Questions

Dear Mr. Griffith:

This letter provides responses to Washington Department of Ecology's (Ecology) Questions 4 and 5, regarding the Centralia BART analysis. Also included is additional cost estimating background information for SCR and SNCR, in response to Ecology's request.

A response to Ecology Question 2, which was prepared by TransAlta, is also included in this response. Therefore, CH2M HILL does not have knowledge of, or accept responsibility for, the information presented within the Question 2 response.

In response to the last bullet of Question 2, we are submitting on behalf of TransAlta confidential, proprietary documents that are enclosed in a separate envelope marked "Confidential Business Information." Pursuant to RCW 43.21A.160, TransAlta certifies that the Alstom Power Instruction Manual, TransAlta Centralia Generation LLC, Centralia Plant Unit 2, cover page and p. 1-3 (Rev. 1, 06/21/01) relate to processes of production unique to TransAlta or may affect adversely the competitive position of TransAlta if released to the public or to a competitor. Accordingly, TransAlta requests that those records be made available only to the Director and appropriate personnel of the Department of Ecology.

We believe this transmittal completes CH2M Hill's responses to Ecology questions.

Please contact us if you have any questions.

Sincerely,

CH2M HILL

Robert Pearson, Ph.D
Vice President

Cc: Mr. Alan Newman, State of Washington Department of Ecology
Mr. Richard DeBolt, TransAlta USA
Mr. Gary MacPherson, TransAlta USA

Attachments:

CENTRALIA BART
RESPONSES TO ECOLOGY QUESTIONS

Question 2 (Response prepared by TransAlta):

A copy of all reports on combustion analyses performed on the installed LNC3 combustion control system. Include a copy of the original LNC3 burner system specifications and vendor/contractual guarantee for the system currently installed. The information supplied needs to assist Ecology in answering specific comments on the proposed BART determination related to the NO_x reduction effectiveness of the installed combustion control system.

Response: TransAlta is not aware of any reports on combustion analyses performed on the LNC3 system.

Specific questions needing to be evaluated include:

- All analyses and test programs to improve the effectiveness of the installed system to reduce thermal NO_x emissions since the equipment installed in the boilers. Reports could have been produced by TransAlta or by PacifiCorp prior to the ownership change.

  Response: TransAlta is not aware of such analyses or reports.

- Any specific analysis that addresses the ability or inability of the system to meet the EPA presumptive BART emission limitation must be included (whether performed by or for TransAlta or PacifiCorp).

  Response: TransAlta is not aware of any such analysis.

- Design intent of the original LNC3 installation and whether the installation of LNC3 met its design intent.

Response: For original design specifications, see attached Alstom Power Instruction Manual, TransAlta Centralia Generation LLC, Centralia Plant Unit 2, cover page and p. 1-3 (Rev. 1, 06/21/01) (These pages are enclosed in a separate envelope marked "Confidential Business Information." Pursuant to RCW 43.21A.160, TransAlta is requesting that these documents not be released to the public.) The same design specifications apply to Unit 1. The Instruction Manual, p. 1-3, estimates emissions from the "low NO_x concentric firing system level III" installed at the Centralia Plant to range from: (a) 0.33 lb/mmBTU NO_x for eastern bituminous coal with a nitrogen content of about 1.48 lb/mmBTU and an oxygen to nitrogen content ratio of 5, and (b) about 0.35 lb/mmBTU for western subbituminous coal with a nitrogen content of about 0.82 lb/mmBTU and an oxygen to nitrogen content ratio of 20.

- What are the physical differences and similarities between these specific boilers and other similar boilers that have been able to achieve the presumptive BART limit of 0.15 Ib/MMBtu through the use of LNC3 control?

Response: A major engineering study by an engineering firm would be required to answer this. Ecology agreed not to require such a study.

- What can be done to the configuration of overfire air ports or by replacing the low NO_x burners to reduce thermal NO_x formation?

Response: TransAlta considered these types of controls and boiler reconstruction but did not identify any that would achieve the presumptive BART levels or that would be more cost-effective than Flex Fuel or SNCR.

Follow-up Information to Question 3:

While an initial response to Question #3 was previously prepared and submitted, Ecology requested additional detail regarding vendor information. As previously noted, CH2M HILL utilized a factored approach in the development of SCR costs for the Centralia BART analysis. In addition, previous CH2M HILL and other BART analysis SCR costs were considered when completing the cost estimates. In response to Ecology's request, a compilation of SCR BART analysis information was prepared and presented in Attachment 1. Previous project information was considered in applying a factored approach to developing SCR costs.

In addition, an updated SCR Economic Analysis Summary was prepared which clarifies responses regarding the EPA Cost Manual Basis for Total Fixed O&M Costs. The revised summary is presented as Attachment 2.

The following information provides additional explanation regarding the CH2M HILL cost estimating approach for the Centralia BART analysis:

Centralia Capital Cost Estimating Approach

For the Centralia BART analysis, CH2M HILL cost estimates were developed for the SCR and SNCR NO_x control technology alternatives. As explained within the BART analysis, the level of accuracy of the cost estimate can be broadly classified as "Order of Magnitude", which can be categorized as a -20/+50 percent estimate.

The approach utilized for Centralia is consistent with previous BART analyses completed by CH2M HILL; where the level of accuracy of cost estimating matches the preliminary nature of the level of BART engineering and design. In depth design information for each emissions control technology was not completed for Centralia, due to time and resource limitations. In addition, the accuracy of BART study estimates is only intended to allow economic comparison of alternatives. In order to increase the level of accuracy of the estimate, a preliminary engineering design would have been needed that would require significantly greater site information, more engineering effort, firm vendor quotations, a thorough constructability review, and a definitive estimating approach.

CH2M HILL visited the Centralia site to examine boiler outlet ductwork configuration, space availability for new equipment, and construction requirements and potential limitations. A restricted site impacted the SCR cost estimate primarily due to the limited space to install an SCR catalyst reactor vessel. Since each unit has separate flue gas exhaust trains, the resultant design has one SCR system for each outlet exhaust duct from the economizer that would be located on top of the existing electrostatic precipitators. The congested site with limited access would also significantly influence construction costs and schedule. Therefore, as an overall assessment, the Centralia site was considered to be a difficult retrofit for an SCR installation with a resulting higher cost compared to other power plant units of similar size.

Background estimating information was assembled through re-evaluation of historical information, updated with current project equipment, material, and construction costs. Construction costs were estimated for the Centralia area, and were developed from preliminary engineering sketches.

In addition to consideration of the site specific information, a factored approach was utilized in developing the Centralia SCR and SNCR cost estimates. With this approach, common historical cost basis from previous projects are used to develop an estimate for the project under consideration. For example, a common cost comparison factor for an SCR installation between different project sites may be based on size of unit ($/Kilowatt) or flue gas flow rate ($/Actual Cubic Feet Minute). This factor from a baseline unit is then utilized to calculate the approximate cost for another unit.

For the Centralia BART analysis, a $/KW factor was primarily utilized in calculating the total project cost estimate. In estimating the SCR equipment and installation costs, a factor of approximately $200/KW was used. This factor was based on other project cost information, with allowance for specific Centralia site information retrofit considerations. Centralia was considered to be a very difficult SCR retrofit installation, and this was reflected in the ultimate cost estimate.

Estimates from previous CH2M HILL and other BART analysis were also considered when reviewing and verifying reasonableness of the total cost estimate. A compilation of previous SCR and SNCR BART information was prepared and presented in Attachment 1—"SCR BART Cost Estimate Information", and Attachment 3---"SNCR BART Cost Estimate Information". While this previous project cost information was considered in applying a factored approach in developing the SCR cost estimate, no specific project information was utilized. Information from Attachments 1 and 3 were primarily used as a comparative check for reasonableness of estimate. Two other BART analyses, Boardman Station and Nebraska City 1, were completed by B&V and HDR respectively with SCR $/KW costs comparable to Centralia. While the Centralia SCR cost estimate of 413 $/KW is the largest value on the list, CH2M HILL considers this reasonable given the retrofit difficulty. BART analysis cost estimates from Attachment 3 demonstrate that the Centralia SNCR estimate is consistent with other units.

CH2M HILL's approach to preparing the SCR and SNCR order of magnitude cost estimate for the Centralia BART analysis may be summarized as follows:

1) Determine preliminary background information regarding each technology
2) Establish site specific information, including any limitations or restrictions
3) Review comparable project information, both internal and external, to establish factors used for estimating
4) Complete an estimating reasonableness review utilizing similar SCR and SNCR estimates

While several sources of information were used as background information in developing the SCR and SNCR cost estimates, no single piece of information was exclusively utilized as the basis for the cost estimates.

Question 4:

Ecology has requested details of the SNCR cost analysis produced by CH2M HILL, specifically the analysis contained in the July, 2008 analysis. Specific issues with the cost analysis:

- *Explanation of all cost elements in the CH2M [sic] cost estimating spreadsheet, including discussion of differences on specific cost elements from the EPA Control Cost Manual defaults, especially the cost items not explicitly included in the EPA Control Cost Manual.*

  The summary table below (Table B, Attachment 4) compares the specific cost elements of the CH2M HILL SNCR capital cost estimate with the default values from the EPA Air Pollution Control Cost Manual. Table B is intended as a response to the Ecology request.

  The cost estimating equations in Section 4.2, Chapter 2 "Selective Catalytic Reduction" of the EPA Air Pollution Control Cost Manual are based on equations developed by The Cadmus Group, Bechtel Power and SAIC in 1998 and follow the costing methodology of EPRI. CH2M HILL used alternative estimating methodologies which have extensively been utilized to develop budgetary cost estimates for utility power and air pollution control projects.

  The EPA Cost Manual methodology is generally applicable for new or existing sources, and allows inclusion of unique site-specific retrofit or lost generation costs. It should be noted that at a "study" level estimate of +/- 30% accuracy, the Manual states that "a retrofit factor of as much as 50 percent can be justified". Therefore, it is difficult to make a direct comparison of all of the cost elements, since the two methodologies break down costs differently.

  Because the EPA Cost Manual contains default values which are provided for a range of general applications, CH2M HILL considers the estimating methodology utilized for the Centralia BART analysis to be more accurate since specific site information and conditions were considered. In addition, current vendor cost information was utilized in developing the estimates.

- *Basis of 16% multiplier in the calculations*

  We assume that Ecology is referring to the 15% Project Contingency in the SNCR cost estimate. When developing a cost estimate, there is always an element of uncertainty since costs are based upon several assumptions and variables. Contingency provides an amount added to an estimate, which covers project uncertainties and added costs which experience dictates will likely occur. The magnitude of the contingency used in the CH2M HILL cost estimate is typical of contingency utilized in similar budgetary estimates, and matches the default 15% Project Contingency shown in Table 1.4 "Capital Cost Factors for an SNCR Application" on page 1-32 of Section 4.2, Chapter 1 of the EPA Air Pollution Control Cost Manual, Sixth Edition.

- *Sources of 'vender quotes' referenced in the CH2M HILL documents*

  SNCR cost estimates were developed as "budgetary estimates", and preliminary vendor equipment cost and estimated NO_x reduction efficiencies were provided by Fuel Tech. CH2M HILL completed the economic analysis through a combination of utilizing a factored approach from in-house cost information, previous project information, and vendor information. A summary of previous CH2M HILL and other BART analysis SNCR costs is provided as Attachment 3. Previous project information was considered in using factored estimates in developing SNCR costs.

  For additional explanation regarding the SNCR cost estimate, please see the response to Question 3 above.

- *Whether any structural analyses were done in support of SNCR cost analysis and the results of the analyses*

  Detailed structural analyses were not performed in completing the SNCR cost analysis.

Question 5:

A number of questions specific to the SCR system have been posed which the information TransAlta has already submitted does not answer. These are:

- *Specific information about the design of the SCR system evaluated by CH2M [sic]which may include a discussion or drawings for adding SCR to the plant, including flow paths, placement of catalyst (vertical or horizontal placement), catalyst cleaning method, ducting to the Boilers and ESPs.*

Response:

The preliminary design of the SCR presented with the Centralia BART analysis assumed that the full flue gas flow would be extracted from the boiler temperature region conducive to good SCR performance (580 degrees F to 750 degrees F). This temperature region on a coal fired boiler is typically located after the boiler economizer and before the air heater. The SCR design proposed for the Centralia units was a full scale system, where the flue gas is routed to a separate SCR reactor vessel which has cross-sectional area greater than the ductwork. An expanded reactor vessel allows lower flue gas velocity through the catalyst, as opposed to an in-duct SCR where the catalyst is placed in the existing ductwork with resulting higher velocity.

The flue gas would be extracted the boiler ductwork at the appropriate temperature region, pass through the SCR system, and then would be returned to the boiler discharge ductwork at a point just downstream of the extraction point. If space allows, an in-duct configuration may also include an expanded ductwork reaction chamber in order to reduce flue gas velocity and increase residence time.

For the Centralia BART analysis it was assumed that the full scale SCR catalyst would be installed in a horizontal configuration, with the flue entering the catalyst from the top of the catalyst and exiting from the bottom. Ammonia would be introduced ahead of the catalyst. For purposes of the conceptual layout and budgetary estimate for BART analysis, no detailed design was completed regarding catalyst cleaning methodology.

- *A discussion of alternate locations to install an SCR system such as in the duct from the ESPs to the wet scrubber. This location would include and need an evaluation of gas stream reheat requirements and costs. Include an evaluation of how much catalyst could be placed inside the duct at its current dimensions and the NO_x reduction which could be accomplished without expanding the existing ducts.*

Response:

The flue gas from the Centralia ESPs to the wet scrubber is approximately 300 degrees F, which is well below the desired temperature range of 580 to 750 degrees F. Operating an SCR system outside of the optimum temperature window will significantly decrease NO_x reduction efficiency. After the ESPs, the particulate loading in the flue gas has been reduced which would lessen the potential for SCR catalyst erosion. Consistent with typical utility design, the current ESP to scrubber full load ductwork flue gas velocity is assumed to be approximately 60 ft/sec. As requested, this analysis was based on utilizing the current ductwork dimensions, which maintains existing ductwork flue gas velocity.

In order to allow the in-duct SCR system to within the optimum temperature window, increasing the flue gas temperature ahead of the SCR would be required. This could be achieved through the installation of a flue gas heating system such as a regenerative heat exchanger or duct burner arrangement. While implementing a flue gas reheat system is a technically feasible alternative, utilizing this approach in the duct work from the ESPs to the scrubber creates significant operating concerns for an SCR system in this location.

If the flue gas is reheated to approximately 700 degrees F, the calculated velocity in the existing ductwork would be increased from 60 ft/sec to approximately 90 ft/sec.

Typical catalyst flue gas velocity design values are generally in the range of 15 to 20 ft/sec, which is approximately one-fifth of the reheated flue gas velocity. From discussions with an SCR catalyst supplier, a 90 ft/sec velocity level would render the SCR essentially ineffective. The primary ramifications from higher SCR velocities are greater potential for catalyst erosion, less time available for chemical reactions to occur, and increased pressure drop across the SCR system. From a catalyst vendor response, this configuration was considered infeasible.

- *For the SCR option, evaluate the quantity of catalyst that can be installed in the ducts from the boiler to the ESP, and how much NO_x reduction could be accomplished with that quantity of catalyst. Also, a cost estimate for this installation location. This analysis was requested previously.*

Response:

While meeting many design criteria is necessary for good SCR operation, the following issues may be especially essential to an in-duct configuration:

- Flue gas residence time through the catalyst
- Good mixing of ammonia prior to entering SCR catalyst
- Ammonia slip, or un-reacted ammonia passing through the catalyst
- Catalyst erosion
- Maintain reasonable pressure drop

The SCR system evaluated within the BART report was located in an area between the boiler outlet and ESP inlet, in the optimal flue gas temperature region between the economizer outlet and the air heater. This system was assumed to consist of ductwork to and from an expanded SCR reactor vessel, where the flue gas velocity through the catalysts would operate at approximately 20 ft/sec.

The above question requests an evaluation for the "ducts from the boiler to the ESP", which consists of flue gas entering the air heater at approximately 700 degrees F and flue gas temperature exiting the air heater is approximately 300 degrees F. For this analysis it was assumed that the current ductwork dimensions would be maintained, and no expansion of the ductwork size was considered. Since a review of an SCR system located in the 300 degree F temperature region has been addressed in the responses to the previous question, only an in-duct SCR system utilizing the existing ductwork dimensions between the economizer outlet and the air heater inlet will be considered. The flue gas in this area would be within the optimum SCR temperature region, therefore no flue gas reheat would be required for this configuration.

The design criteria for an in-duct SCR unit were developed from information provided by TransAlta. The boiler flue gas from the economizer sections on each unit passes through two separate sections of ductwork, one for each of the two air heaters for each unit. The ductwork to the air heater appears to be tapered and expands toward the air heater, and mid-duct dimensions were estimated from general arrangement drawings to be 43 feet by 14 feet. There appears to be approximately 17 feet of ductwork length available to install catalyst.

Utilizing the tested flow rate from each unit and the estimated cross-sectional area of the ductwork, the flue gas velocity in this ductwork from the economizer to the air heater inlet was calculated to be approximately 50 to 60 ft/sec. This is approximately three times the desired SCR design target velocity. While in-duct SCR catalysts have been installed, most have been designed to operate in a "polishing" mode with upstream NO_x reduction occurring through an SNCR system. The use of this configuration allows the SCR catalyst to utilize any ammonia slip from the SNCR system. In order to achieve an overall high level of NO_x reduction, dual systems are required due to the lower anticipated NO_x reduction efficiency from a stand-alone SNCR or in-duct SCR installation.

Preliminary SCR design information, and a budgetary cost estimate, was requested and received from a catalyst vendor for the in-duct configuration described above. The catalyst vendor response confirmed that the in-duct configuration resulted in duct velocities about three times higher than recommended, which would cause significant erosion concerns. However, with this alternative one layer of catalyst was estimated to reduce NO_x emissions by approximately 5% with an additional 5 inches water gage pressure drop. Two catalyst layers were estimated to achieve about 12% NO_x reduction at an additional 10 inches water gage pressure drop. Therefore, with the anticipated low NO_x reduction potential, significant additional pressure drop, and potential for erosion, this in-duct SCR configuration is not considered a practical alternative for Centralia.

Attachments

ATTACHMENT 1
SCR BART Cost Estimate Information

Unit Name	Unit size (kW)	Total Installed Capital Cost/unit	$/kW	Source
Dave Johnston Unit 3	250000	67,000,000	268	CH2M HILL
Colstrip	307000	25,300,000	82	TRC
Wyodak	365000	99,000,000	271	CH2M HILL
Dave Johnston Unit 4	360000	99,900,000	278	CH2M HILL
Jim Bridger Unit 3	530000	120,900,000	228	CH2M HILL
Laramie River 1	550000	99,000,000	180	B&V
Boardman	584000	223,000,000	382	B&V
Nebraska City 1	650000	244,400,000	376	HDR
Navajo 1	750000	210,000,000	280	ENSR
CPP Unit 1 & 2	1405000	580,300,000	413	CH2M HILL

ATTACHMENT 2

Table A – SCR Economic Analysis Summary

CPP

Parameter	**SCR**		
NO_x Emission Control System	SCR		
SO2 Emission Control System	Forced Oxidation Limestone Scrubber		
PM Emission Control System	Dual ESPs		
CAPITAL COST COMPONENT	**Cost**	**CH2M Hill Basis**	**EPA Control Cost Manual Basis**
Major Materials Design and Supply ($)	277,685,000	CH2M HILL factored estimate	EPA control cost manual
Eng, Startup, & Indirect ($)	57,500,000	CH2M HILL factored estimate	20% of total direct capital costs
Total Indirect Installation Costs (TIIC)	**335,185,000**		
Contingency ($)	50,277,750	15% of total indirect installation costs	15% of total indirect installation costs
Sales Tax ($)	26,814,800	8% of total indirect installation costs	Included in total direct capital costs
Plant Cost (PC)	**412,277,550**		
Margin ($)	41,227,755	10% of plant cost	No margin
Total Plant Cost (TPC)	**453,505,305**		Includes 2% of total plant cost, AFUDC and cost to store 29 wt% aqueous ammonia for 14 days
Owner's Costs ($)	45,350,531	10% of total plant cost	No owners costs
Allows for funds during construction (AFUDC) ($)	54,420,637	12% of total plant cost	No AFUCD
Lost Generation ($)	27,014,400	Calculated at $20/MW-hr and 42 days	
TOTAL INSTALLED CAPITAL COST ($)	**580,290,872**		
FIRST YEAR O&M COST ($)			
Operating Labor ($)	351,250	CH2M HILL estimate	Assumed none required for SCR
Maintenance Material ($)	702,500	CH2M HILL estimate	Combined with maintenance labor, 1.5 % of total capital cost
Maintenance Labor ($)	351,250	CH2M HILL estimate	
Administrative Labor ($)	0		
TOTAL FIXED O&M COST	**1,405,000**		
Reagent Cost	1,783,475	Anhydrous ammonia at $0.20/lb	Anhydrous ammonia at $0.058/lb[2]
SCR Catalyst	2,107,500	Catalyst cost estimated at $3000/$m^3$	Catalyst cost at $85/$ft^3$ [1]
Electric Power Cost	2,403,603	Power cost estimated at $0.05/kW-hr, 7025 kW	Power cost at $0.05/kW-hr, 1795 kW
TOTAL VARIABLE O&M COST	**6,294,577**		
TOTAL FIRST YEAR O&M COST	**7,699,577**		
FIRST YEAR DEBT SERVICE ($)	63,712,819	Calculated using 7% annual interest rate for 15 years	
TOTAL FIRST YEAR COST ($)	**71,412,396**		
Power Consumption (MW)	**7.03**		
Annual Power Usage (kW-Hr/Yr)	**48.1**		
CONTROL COST ($/Ton Removed)			
NO_x Removal Rate (%)	**72.0%**		
NO_x Removed (Tons/Yr)	**7,855**		
First Year Average Control Cost ($/Ton NO_x Rem.)	**9,091**		

Notes:

1 - Catalyst cost used for EPA Cost Manual calculations based on current cost estimate of $3000/$m^3$. Cost manual recommends using the current cost estimate for catalyst cost.

2 – Calculated based on pure anhydrous ammonia, and not a 29% solution as listed in the EPA Cost Manual.

ATTACHMENT 3
SNCR BART Cost Estimate Information

Unit Name	Unit size (kW)	Total Installed Capital Cost/unit	$/kW	Source
Navajo 1	750,000	10,000,000	13	ENSR
Coal Strip	307,000	6,076,000	20	TRC
CPP - One Unit	702,000	16,600,000	24	CH2M HILL
RG1, 2, 3	100,000	2,497,500	25	CH2M HILL
Jim Bridger Unit 3	530,000	13,273,632	25	CH2M HILL
Jim Bridger 1, 2, 4	530,000	13,427,239	25	CH2M HILL
Dave Johnston Unit 4	360,000	10,105,779	28	CH2M HILL
Boardman	584,000	17,400,000	30	B&V
Wyodak	335,000	10,195,654	30	CH2M HILL
Laramie River 1	550,000	17,777,778	32	B&V
Tracy 3	113,000	3,661,875	32	CH2M HILL
Dave Johnston Unit 3	250,000	8,135,543	33	CH2M HILL
FC 1, 2, 3	113,000	3,760,313	33	CH2M HILL
Cholla 4	425,000	14,706,000	35	CH2M HILL
Cholla 2, 3	300,000	11,610,000	39	CH2M HILL
Apache 2, 3	195,000	7,781,130	40	CH2M HILL
Tracy 2	83,000	3,661,875	44	CH2M HILL
Naughton Unit 3	356,000	15,788,530	44	CH2M HILL
Apache 1	85,000	4,250,000	50	CH2M HILL
Naughton Unit 2	226,000	12,378,764	55	CH2M HILL
Naughton Unit 1	173,000	10,226,855	59	CH2M HILL
Tracy 1	55,000	3,661,875	67	CH2M HILL

ATTACHMENT 4
Table B – SNCR Economic Analysis Summary

CPP

Parameter	SNCR		
NO_x Emission Control System	SNCR		
SO2 Emission Control System	Forced Oxidation Limestone Scrubber		
PM Emission Control System	Dual ESPs		
CAPITAL COST COMPONENT		**CH2M Hill Basis**	**EPA Control Cost Manual Basis**
Major Materials Design and Supply ($)	14,711,977	Based on quote from Fuel Tech	EPA control cost manual
Eng, Startup, & Indirect ($)	5,400,000	Based on quote from Fuel Tech	20% of total direct capital costs
Total Indirect Installation Costs (TIIC)	**20,111,977**		
Contingency ($)	3,016,797	15% of total indirect installation costs	15% of total indirect installation costs
Sales Tax ($)	1,608,958	8% of total indirect installation costs	Included in total direct capital costs
Plant Cost (PC)	**24,737,732**		
Margin ($)	2,473,773	10% of plant cost	No margin
Total Plant Cost (TPC)	**27,211,505**		Includes 2% of total plant cost, AFUDC and cost to store urea for 14 days
Owner's Costs ($)	2,721,150	10% of total plant cost	No owners costs
Allows for funds during construction (AFUDC) ($)	3,265,381	12% of total plant cost	No AFUCD
Lost Generation ($)			
TOTAL INSTALLED CAPITAL COST ($)	**33,198,036**		
FIRST YEAR O&M COST ($)			
Operating Labor ($)	281,000	CH2M HILL estimate	Assumed none required for SNCR
Maintenance Material ($)	562,000	CH2M HILL estimate	Combined with maintenance labor, 1.5 % of total capital cost
Maintenance Labor ($)	281,000	CH2M HILL estimate	
Administrative Labor ($)			
TOTAL FIXED O&M COST	**1,124,000**		
Reagent Cost	909,012	Urea at $0.185/lb	Urea at $0.85/gal
SCR Catalyst			
Electric Power Cost	480,721	Power cost estimated at $0.05/kW-hr, 1405 kW	Power cost at $0.05/kW-hr, 158 kW
TOTAL VARIABLE O&M COST	**1,389,733**		
TOTAL FIRST YEAR O&M COST	**2,513,733**		
FIRST YEAR DEBT SERVICE ($)	3,644,966	Calculated using 7% annual interest rate for 15 years	
TOTAL FIRST YEAR COST ($)	**6,158,699**		
Power Consumption (MW)	**1.41**		
Annual Power Usage (kW-Hr/Yr)	**9.6**		
CONTROL COST ($/Ton Removed)			
NO_x Removal Rate (%)	**25.0%**		
NO_x Removed (Tons/Yr)	**2,727**		
First Year Average Control Cost ($/Ton NO_x Rem.)	**2,258**		