Supplemental NPS Comments on Best Available Retrofit Technology (BART) Analysis of Control Options For Tri-State Generation & Transmission Association, Inc. – Craig Station Units 1 & 2 and Reasonable Progress Analysis of Control Options For Craig Station Unit 3
December 15, 2010

Process Description

The Tri-State Generation & Transmission Association, Inc. (Tri-State) Craig Station is located in Moffat County approximately 2.5 miles southwest of the town of Craig, Colorado. This facility is a coal-fired power plant with a total net electric generating capacity of 1,264 MW, consisting of three units. Of 1,228 plants, EPA Clean Air Markets (CAM) data for 2008 rank the Craig facility #304 for SO_2 and #43 for NO_X. The cumulative impacts of the Craig Station across the eleven Class I areas modeled is greater than 10 dv, which ranks this facility among the highest[1] of any we have evaluated under the BART program.

On December 9, 2010, CDPHE provided “Exhibit 16 - Craig Stations 1, 2, and 3 November 2010 Black & Veatch Report” which is essentially an updated and expanded version of Tri-State’s 2006 BART submittal and its 12/09 – 7/10 RP submittals, and “Exhibit 19 - J.E. Cichanowicz Overview of Information on Project Control Technology Costs – Oc” and “Exhibit 20 - J.E. Chichanowicz Report Current Capital Cost and Cost Effectiveness - January 20” which provide new information on SO_2 and NO_X control costs.

Units 1 and 2

Units 1 and 2 are similar 428 MW coal-fired steam-electric generating units (EGUs) equipped with dry-bottom wall-fired coal boilers and are subject to BART. Of 3,558 EGUs, 2008 CAM data rank Units 1 and 2 at #910 and #883, respectively for SO_2, and #170 and #147, respectively for NO_X. CDPHE modeling data show that Craig Units 1 and 2 have the greatest impact of any Colorado BART source on visibility.

Unit 3

Unit 3 is a dry-bottom wall-fired coal boiler rated at 4,600 MMBtu/hour (net 408 MW) and was placed in service in 1984 and is evaluated under the Reasonable Progress provisions of the Regional Haze Rule. Of 3,558 EGUs, 2008 CAM data rank Unit 3 at #788 for SO_2 and #116 for NO_X. CDPHE modeling data show that Craig Unit 3 has a maximum impact at Mt. Zirkel Wilderness Area of 4.99 dv.

NO_x BART/RP Analysis

Step 3: Evaluate Control Effectiveness of Remaining Technologies
For its cost-effectiveness analysis, CDPHE has estimated that LNB+OFA+SCR can achieve 0.07 lb/mmBtu on an annual basis, which represents a 74% - 75% reduction by SCR from the

[1] The highest are Cholla Generating Station, Coronado Generating Station, Four Corners Power Plant, Navajo Generating Station, Centralia, PGE Boardman, and San Juan Generating Station.

emission rate to be achieved by LNB+OFA alone. It is generally assumed that SCR can achieve at least 90% NO_X reduction,[2] and we have presented evidence in our General BART Comments[3] demonstrating that SCR can achieve 0.05 lb/mmBtu (or lower) on similar wall-fired boilers. Subsequent to our initial submittal of comments on Craig, Tri-State has submitted additional analyses[4] of application of SCR at Craig which is based upon an assumption that SCR can achieve 0.05 lb/mmBtu. We also note that Salt River Project (SRP) assumed that addition of SCR to the Navajo Generating Station[5] could achieve 0.05 lb/mmBtu on an annual basis. The combination of the real-world examples we have previously presented plus the assumptions by Tri-State and SRP should provide sufficient weight-of-evidence for CDPHE to conclude that SCR can reasonably be expected to achieve 0.05 lb/mmBtu (or better) on an annual basis.

We conclude that CDPHE has underestimated the ability of a modern SCR retrofit to reduce NO_X emissions. Because such an underestimate adversely affects the cost-benefit analysis, we conducted our analysis as discussed in our General BART Comments[3] and below.

Step 4: Evaluate Impacts and Document Results

Our review of Tri-State's BART & RP submittals for SCR leads us to conclude that Tri-State's SCR costs are greatly inflated.

Tri-State has not provided for our review a detailed cost estimate. Instead, the estimates provided by Tri-State are simply its consultant's rough estimates based upon developing a Total Purchased Equipment Cost (PEC) or Direct Capital Cost (DCC) and applying its standardized "black-box cookbook" estimation factors to the PEC/DCC as illustrated below.

Major Cost Component	Craig 1 & 2 each		% of DCC	Craig 3		% of DCC
Direct Capital Costs (DCC)	**$**	**121,800,000**		**$**	**131,868,000**	
Total Indirect Capital Costs	$	73,382,000	60%	$	79,420,000	60%
Lost Generation (Outage)	$	14,366,000	12%	$	30,302,000	23%
Total Capital Investment	**$**	**209,548,000**	**172%**	**$**	**241,590,000**	**183%**
Maintenance Labor and Materials	$	3,654,000	3%	$	3,956,000	3%
Total O&M Costs	**$**	**6,384,000**	**5%**	**$**	**6,958,000**	**5%**
Capital Recovery Costs	$	21,343,000	18%	$	24,606,000	19%
Total Annual Costs	**$**	**27,727,000**	**23%**	**$**	**31,564,000**	**24%**

The primary difference between the estimates for Craig #1 & #2 versus Craig #3 is due to the greater time needed to retrofit Craig #3 and the resulting increased "Lost Generation" cost. While this approach is very similar in style to the EPA Control Cost Manual approach for other

[2] Tri-State's Exhibit #20 also assumed 90% NO_X removal.

[3] Our General BART comments were included in our previous submittal to CDPHE dated December 2, 2010

[4] Exhibit 16 - Craig Stations 1, 2, and 3 November 2010 Black & Veatch Report, Tables 2-1, 2-1, 4-6,4-8, 7-7, 7-8, "Selective Catalytic Reduction System"

[5] Slide 36 of "***Navajo Generating Station Preliminary Capital Cost Estimate***" prepared by Sargent & Lundy and presented by Salt River Project to the Environmental Protection Agency – July 20, 2010, copy provided to CDPHE 12/02/10.

control technologies, it bears little resemblance to the Cost Manual approach for estimating SCR costs, and should therefore be rejected as inferior. Furthermore, the Tri-State cost estimates include over $81 million in Allowance for Funds Utilized During Construction (AFUDC), which, as noted in our General BART Comments[3], is not allowed for a utility like Tri-State.

A critical cost element is the Total Capital Investment (TCI). Based upon data presented in Tri-State's Exhibit #19, SCR costs for boilers similar in size to Craig can be expected to fall between $250 and $300/kW. Tri-State's estimates are the highest we have seen at $490 - $592/kW, and are not properly supported.

The $490 - $592/kW Total Capital Investment estimates provided by Tri-State and its inclusion of the $81 million AFUDC is indicative of the pervasive overestimates presented by Tri-State. Therefore, we have applied the Cost Manual as recommended by the BART Guidelines. CDPHE must choose between the Black & Veatch "black-box cookbook" estimate provided by Tri-State which clearly overestimates costs when compared to real-world, industry data, versus the "transparent cookbook" estimates we are providing based upon the Cost Manual and modified to produce results comparable to real-world, industry data.

NPS Cost Analysis

Although a 90% reduction from the emission rate to be achieved by LNB+OFA would lead to an annual average emission rate of 0.03 lb/mmBtu in this case, as a conservative estimate, we have assumed that SCR would achieve 0.05 lb/mmBtu (84% reduction) on an annual average basis.

In generating our SCR cost estimate, we note the following differences between our analysis and that provided by Tri-State:

Our review of 2005 – 2009 CAM data (Please see the "Unit emissions" tab of the workbooks in Appendix A[6] "Craig SCR Costs") found that actual annual average hourly heat input rates at units #1 & #2 exceed the maximum heat input rates used by CDPHE. Maximum actual total annual heat input was also greater than estimated by CDPHE, as were maximum actual annual emissions at units #1 & #2.

We used unit costs for catalyst and electricity provided by Tri-State's Exhibit #16, and rejected Tri-State's $600/ton cost for ammonia in favor of the $400/ton value presented in Tri-State's Exhibit #20.

A critical cost element is the Total Capital Investment (TCI) upon which much of the EPA Cost Manual method is based. Based upon data presented in Tri-State's Exhibit #19, SCR costs for boilers similar in size to Craig can be expected to fall between $250 and $300/kW. However, a rigid application of the Cost Manual tends to produce TCI that fall toward the lower end of the expected range, and company cost estimates typically substantially exceed the upper end of the range. In this case, the Cost Manual method yields $77 - 83/kW (Please see cell L18 in the "ICC" tab[6]), which appears too low for EGUs this size and thus prompted us to over-ride the Cost Manual's TCI calculation. On the other hand, the CDPHE estimates of $490 - $592/kW

[6] Appendix A Craig SCR Costs were submitted to CDPHE on December 10, 2010

(cell O18[6]) are far more expensive than the top of the range, and no reason has been provided to justify any extraordinary costs, so further evaluation is warranted. Our next step assumed that a TCI equal to $400/kW[7] would be representative of a "worst case" for these installations (cell C7 of the "Given/Assume" tab[6]).

Annual Cost estimates are generated by a direct application of the Cost Manual method to the new TCI and other interim values. We found that CDPHE's Direct Annual Cost estimates were usually higher than the Cost Manual estimates.

	Craig Station		CDPHE
Annual Costs	NPS	CDPHE	/NPS
Annual Maintenance Cost =	$ 7,584,000	$ 11,777,000	155%
Annual Reagent Cost =	$ 2,089,048	$ 2,919,000	140%
Annual Electricity Cost =	$ 1,608,294	$ 2,850,000	177%
Annual Catalyst Cost =	$ 1,003,541	$ 2,014,000	201%
Direct Annual Cost =	$ 12,284,883	$ 19,726,000	161%
Indirect Annual Cost =	$ 47,725,063	$ 62,364,840	131%
Total Annual Cost =	$ 60,009,946	$ 76,981,417	128%
Total NOx Removed =	$ 13,438	$ 12,141	90%
SCR Cost effectiveness =	$ 4,466	$ 6,341	142%

We understand that our difference on the Annual Maintenance Costs is due to Tri-State's application of a 3% factor to the DCC as opposed to the 1.5% factor used by the EPA Control Cost Manual. Tri-State provides no explanation of how the other annual costs (reagent, electricity, catalyst) were estimated.

The combination of Tri-State's 28% higher Total Annual Cost and CDPHE's 10% lower NO_X removal results in CDPHE estimating $/ton 42% higher than our estimates.

A summary of our analyses can be found on the near-far-right tab of our workbooks[3] and below.

SCR Cost-benefit Analysis

Unit	1	2	3	Source
Rating (MW Gross) each	428	428	408	CDPHE report
Control Efficiency	82%	82%	82%	Cost Manual
Controlled emissions (lb/mmBtu)	0.05	0.05	0.05	Tri-State Exhibit 16
Controlled Emissions (tpy)	1,038	1,018	878	calculated
Emissions Reduction (tpy)	4,793	4,556	4,090	Cost Manual
Capital Cost	$ 171,200,000	$ 171,200,000	$ 163,200,000	Cost Manual
Capital Cost ($/kW)	$ 400	$ 400	$ 400	assumed
O&M Cost	$ 4,223,994	$ 4,168,036	$ 3,892,853	Cost Manual
Annualized Cost	$ 20,384,063	$ 20,328,105	$ 19,297,778	Cost Manual
Cost-Effectiveness ($/ton)	$ 4,253	$ 4,462	$ 4,719	Cost Manual

[7] This is higher than the $380/kW highest cost/kW for any SCR in the industry data discussed in our General BART Comments or provided in Tri-State's Exhibit #19.

We believe that our estimation method is more transparent and truer to the EPA Cost Manual approach than that provided by CDPHE, and that our "worst-case" $4,200 - $4,800/ton results are better-supported by real-world industry experience.

Step 5: Evaluate Visibility Results

CDPHE: CALPUFF modeling was used to determine the projected visibility improvement associated with various control technologies.

NOx Control Scenario	Boiler(s)	NOx Emission Rate (lb/MMBtu)	Output (@ 98th Percentile Impact)	98th Percentile Impact Improvement
			(dv)	(Δ dv)
Max 24-hour	1&2	0.352	3.73	---
SCR	1	0.07	2.72	1.01
	2	0.07	2.75	0.98
Combo	1&2	0.07	1.17	2.56
Max 24-hour 2nd half 2009 NOx rate	3	0.365	5.20	---
2009 New LNBs	3	0.283	4.99	0.21
SCR	3	0.070	4.41	0.79

NPS: We commend CDPHE for its modeling approach, but model results should include all impacted Class I areas as advised by EPA.[8]

Step 6: Select BART & RP Control

CDPHE: Based upon its consideration of the five factors summarized herein, the state has determined that NOx BART is SNCR controls at the following NOx emission rates:

Craig Unit 1: 0.27 lb/MMBtu (30-day rolling average)
0.24 lb/MMBtu (rolling 12-month average)

Craig Unit 2: 0.27 lb/MMBtu (30-day rolling average)
0.23 lb/MMBtu (rolling 12-month average)

For SNCR at Units 1 and 2, the cost per ton of emissions removed, coupled with the estimated visibility improvements gained, falls within the guidance criteria presented in Chapter 6 of the Regional Haze State Implementation Plan.

- Unit 1: $4,877 per ton NOx removed; 0.31 deciview of improvement
- Unit 2: $4,712 per ton NOx removed; 0.31 deciview of improvement

[8] EPA has advised Colorado and Arizona in letters dated 10/26/10 ("the state needs to provide visibility information for other Class I areas") and 12/2/10 ("one should apply the $/dv metric to visibility improvement in all Class I areas within a 300 km radius of the source"), respectively.

The dollars per ton control costs, coupled with notable visibility improvements, leads the state to this determination. Although SCR achieves better emissions reductions, the expense of SCR was determined to be excessive and above the cost criteria presented above.

Based upon its consideration of the five factors summarized herein, the state has determined that NOx RP for Craig Unit 3 is SNCR control at the following NOx emission rates:

Craig Unit 3: 0.28 lb/MMBtu (30-day rolling average)
0.24 lb/MMBtu (rolling 12-month average)

For SNCR at Unit 3, the cost per ton of emissions removed, coupled with the estimated visibility improvements gained, falls with guidance cost criteria discussed in section 8.4 above.
Unit 3: $4,887 per ton NOx removed; 0.32 deciview of improvement

The dollars per ton control cost, coupled with notable visibility improvements, leads the state to this determination. Although SCR achieves better emission reductions, the expense of SCR was determined to be excessive and above the guidance cost criteria discussed in section 8.4 of the Regional Haze State Implementation Plan.

NPS: We have shown that CDPHE has underestimated the ability of SCR to reduce emissions, and presented real-world emission data showing examples of coal-fired EGU retrofits meeting 0.05 lb/mmBtu (or lower) on an annual basis. We have also shown that Black & Veatch, the consultant that prepared the Craig estimates, assumed that SCR could achieve 0.05 lb/mmBtu when evaluating retrofitting of SCR at the Craig power plant. And, Salt River Project has used 0.05 lb/mmBtu in its SCR retrofit analysis for the Navajo Generating Station. While it is certainly easy to find coal-fired SCR retrofits that are emitting at higher rates, we believe that we should be basing decisions upon what the current state-of-the-art can do,[9] and it is clear that SCR can achieve 0.05 lb/mmBtu at Craig.

We have also provided evidence indicating that Tri-State has overestimated SCR costs significantly. The Black & Veatch "black-box cookbook" approach used by Tri-State is neither transparent nor does it follow the methods described in the EPA Control Cost Manual. Instead, the B&V approach includes costs which are not appropriate, and the results are consistently higher than real-world industry data would suggest are appropriate for Craig (or any other power plant). Instead of presenting results that are contrary to actual industry data, we have modified the Cost Manual to incorporate realistic estimates of Total Capital Investment provided in Tri-State's Exhibit #19, while relying upon the Cost Manual methods to provide annual costs in a transparent manner.

The results of our transparent use of the Cost Manual methods show that addition of SCR at Craig could reduce NO_X by over 13,000 tons per year and improve visibility at Mt. Zirkel Wilderness Area by 3.35 deciviews. SCR would be cost-effective at Mt. Zirkel alone at $18 million per deciview there and $4,500 per ton. The case for SCR is even more compelling when

[9] In its 10/26/10 letter to CDPHE, EPA advised that "many boilers retrofitted with SCR are achieving an emission rate of 0.03 – 0.06 lb/mmBtu" and that the state should take current emission rates into consideration.

considering the cumulative benefit to Rocky Mountain National Park and the other impacted Class I areas.

Control strategies chosen under the BART and Reasonable Progress programs are not necessarily the most cost-effective. Instead, the primary criterion should be “which control strategy provides the most benefit at a reasonable cost?” When one considers the benefits of improving visibility in Colorado’s many national parks and wilderness areas, as well as the benefits to human and ecosystem health that would result from further NO_X reductions, SCR should be chosen for all three units at the Craig Station.