ETS, INC.

NO_X RECLAIM BARCT INDEPENDENT EVALUATION OF COST ANALYSIS PERFORMED BY SCAQMD STAFF FOR BARCT IN THE NON-REFINERY SECTOR

TASK 1a/1b/1c:

FINAL REPORT

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SCAQMD CONTRACT NO. 15343

ETS, INC. CONTRACT # 14-1907-C

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I. STATEMENT OF WORK

ETS, Inc. has been commissioned by the South Coast Air Quality Management District (SCAQMD) to provide an independent evaluation of the cost analysis performed by SCAQMD staff for best available retrofit control technology (BARCT) in the non-refinery sector. The scope of work for Tasks 1a, 1b, and 1c are outlined below.

Task 1a – Review SCAQMD staff's BARCT Feasibility and Cost Effectiveness Analysis

SCAQMD staff has conducted BARCT feasibility and cost effectiveness analysis for each category identified below in the non-refinery sector:

- Cement
- Container Glass Melting Furnace
- Sodium Silicate Furnace
- Metal Heat Treating Furnace above 150 MMBTU/hr
- Gas Turbines (non-power plant)
- IC Engines (non-power plant, non-offshore)
- Boilers

BARCT is defined in Health and Safety Code section 40406 as an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy, and cost impacts. ETS, Inc. has been tasked with conducting a review of SCAQMD staff's BARCT analysis which includes costs, emissions estimates, and cost effectiveness calculations and providing comments on topics including, but not limited to, technical feasibility, costs and implementation schedule. ETS, Inc. may recommend an alternative BARCT level if warranted to address additional potential emission reductions, technical feasibility and costs with sufficient supporting information (e.g. technical studies, manufacturers' data).

Task 1b – Field Visit and Reassessment of Feasibility and Costs

ETS, Inc. shall conduct a field visit to the facilities to assess the situations that may impact the feasibility and costs of additional emission control assessed in Task 1a after receiving a list of facilities for visit from the SCAQMD.

Task 1c – Field Visit and Reassessment of Feasibility and Costs

ETS, Inc. shall provide the following supporting documentation, if necessary, for Task 1a and 1b on the following topics:

1. Emission Reductions Levels. ETS, Inc. shall make a recommendation on the maximum emission reduction levels that can be achieved.
2. Implementation Date. ETS, Inc. shall make a recommendation on the earliest date that the control technology can feasibly be implemented to achieve emission reductions as early as possible.

3. Costs and Performance Warranty. ETS, Inc. shall provide equipment cost information and performance warranty information based on information gathered from the control equipment vendors or manufacturers.
4. Cost Effectiveness Analysis. ETS, Inc. shall estimate costs of installing new equipment or modifying existing equipment, and annual operating costs to meet the emission reduction levels recommended; and shall conduct a cost effectiveness analysis based on the methodology provided by the SCAQMD.

II. GENERAL COMMENTS ON DRAFT STAFF REPORTS, BARCT FEASIBILITY, AND COST EFFECTIVENESS ANAYLSIS

It was assumed that the 2011 NOx facility-specific emissions data (2008 in the case of the cement sector) utilized as the baseline in the NOx RECLAIM cost effectiveness analysis for each non-refinery sector were the appropriate baseline numbers, since the facility-specific NOx emissions data was not a part of the ETS review. An additional assumption was that 2000/2005 BARCT levels used for the incremental cost effectiveness analysis did not warrant review by ETS.

It was noted in all of the Draft Staff Reports received to date (all except for Boilers), that the written equations for Levelized Cash Flow (LCF) are missing a set of parentheses around the TIC and AC in order to be calculated in the same manner as the equations utilized in the costing spreadsheets.

The costing information presented for each non-refinery sector is generally straightforward and compatible with ETS' experience at this level of project scope. Additional comments pertaining to topics such as emissions reduction levels, cost effectiveness analysis, and performance warranty are included within each non-refinery sector.

III. FIELD VISITS AND REASSESSMENT OF FEASIBILITY AND COSTS

Based on the BARCT feasibility and cost effectiveness analysis conducted by SCAQMD staff and the preliminary ETS, Inc. independent review of that work in Task 1a, it was determined that field visits were only required to two of the facilities evaluated in the NOx RECLAIM non-refinery sector. ETS, Inc., along with SCAQMD staff, visited both the cement manufacturing plant and the container glass manufacturing plant on October 16, 2014. The specific details of those field visits may be found in Sections IV.A. and IV.B. and Confidential Appendices A and B.

IV. REVIEW OF DRAFT STAFF REPORTS, TECHNICAL FEASIBILITY AND COST EFFECTIVE ANALYSIS BY NON-REFINERY SECTOR

A. Cement

Introduction

The purpose of this section is to review estimated costs of selective catalytic reduction (SCR) control for a cement plant having twin kilns. Primary documents reviewed include records of communication among SCAQMD personnel, vendors, and plant operators; and spreadsheets showing itemized costing steps for each of three SCR control system vendors. Included in the spreadsheets are capital and annual costs for an SCR on each kiln. Also included are present worth values (PWV) and capital recovery factor (CRF) values (to provide a levelized cash flow) of the entire control system. Estimated capital and operating costs are divided by expected emission reductions to obtain performance measures in dollars per ton of NOx removed. These measures are given in terms of cost/ton of NOx removed beyond the currently required removal.

Preliminary Comments on Technical Feasibility and Cost Effectiveness Analysis

The spreadsheet models were concise and contained sufficient information to estimate PWVs based on total installed costs (TIC), which include equipment and installation costs, and annual costs (AC). Two values of cost effectiveness were developed, both with units of \$/ton of NOx removed. One value was based on the PWV divided by 25 years of accumulated NOx removed and the second was based on a CRF applied to annual costs and NOx removal for a levelized cash flow value. The two cost effectiveness values differed by 60 percent on each spreadsheet.

In review of the costing spreadsheets, questions which were asked and answered include:

1. Why are there so few line items and mostly no indirect capital costs or indirect annual costs?
2. Is costing useful when based on one number for capital cost and one number for annual cost, both with only one significant digit and without any description?
3. What equipment is needed and what is supplied? Is dust control needed, SO_2 control, or other equipment (spreadsheet mentions scrubbers, a heat exchanger system, and soot blowers)?
4. Is space readily available for locating the new control system or will long duct runs be required or existing equipment require relocation?
5. Do annual costs for catalyst change-out include transportation, taxes, waste disposal, or equipment costs for handling the catalyst?
6. Should annual costs for catalyst change-outs be treated as a series of short-term, single payment PWV events as is done with, for example, changing out sets of bags in a baghouse rather than just averaging the costs across three years?

7. Is there a waste heat boiler problem?
8. Why is there a two-to-one spread in capital cost and five to one in annual cost across the three spreadsheets, and is the spread reasonable?
9. Why does a 60-percent spread exist between the two types of cost effectiveness estimates, and how should a reader unfamiliar with SCAQMD practices interpret the numbers?

These questions were answered in the project documentation as described below:

1. The *EPA Air Pollution Control Cost Manual, Sixth Edition, January 2002* in its chapter on SCRs says that the indirect costs are generally too small to include. However, some costing in other reports is done using either individual indirect costs or lumping them together. For lumped indirect capital costs, 60 percent of the purchased equipment cost has been used.
2. When the person supplying a "ball-park" estimate is a vendor familiar with his product and well informed of the specifics of an intended project, his or her estimate should be worth considering, especially when the numbers are in line with other vendor estimates.
3. Project documentation shows much contact and discussion with some willing vendors on the subjects of potential problems and steps for resolving them. Problems and concerns were presented by the facility and were factored into the costing, e.g. adding caustic scrubbers, a heat exchanger system, and soot blowers.
4. Pictures, drawings, and contact with the facility allowed discussion of equipment relocation and probable removal of an existing baghouse and other steps.
5. So far, it is not clear if ancillary costs for catalyst are part of its replacement or are significant.
6. Treating the catalyst change-outs as PWV events might reduce the overall cost by a percent or so.
7. Waste heat boilers (WHB's) were discussed with the vendor and facility; costing includes a heat exchanger to resolve temperature problems associated with the WHB.
8. A two-to-one spread is not unusual. The five-to-one spread seems to be caused largely by one item, caustic. However, the reason for having a wet caustic scrubber for SO_2 is explained as Vendor 3's design compared to another Vendor 2's design for a dry scrubbing system with lower costs.
9. Explanation of the cost effectiveness numbers and their meaning would be useful if it is not already planned. The present worth value (PWV) is the dollar amount today that can become a larger amount in the future when invested at some interest rate over a period of time. SCAQMD uses the PWV of the initial investment as one way to estimate cost effectiveness of controls. A second method, levelized cash flow, can also be used, but is based on the larger future value (not given on the spreadsheet) that is the sum of all payments including interest. For an interest rate of 4 percent over 25 years, the difference between the two methods is 60 percent.

After a preliminary review of the SCAQMD staff's BARCT feasibility and cost effectiveness analysis, it was determined that a field visit to the cement plant was needed to assess the situations that may impact the feasibility and costs of the additional emission controls assessed. An ETS representative, along with the SCAQMD staff visited the plant on the morning of October 16, 2014. The notes from the site visit along with the detailed comments on the technical feasibility and cost effectiveness analysis may be found in Confidential Appendix A.

Comments on Emission Reduction Levels

Based on the analysis conducted by SCAQMD and the review of vendor technical information, ETS concurs that the control technology to achieve the proposed BARCT levels for gray cement kilns is either SCR or the dry scrubbing ceramic filter system. The emission reductions should be technically feasible with any of the three vendor control technologies evaluated.

Comments on Performance Warranty

Correspondence reviewed between Vendor 1 and the SCAQMD regarding the SCR budgetary pricing quotes indicated that the systems are designed to remove 80% of the NOx, but removal can be even higher and approach 90-95%. Vendor 3 also provided a performance guarantee of ≥ 80% NOx reduction.

Conclusions

1. The original estimates from Vendor 1, Vendor 2, and Vendor 3 did not include a project scope contingency. Conceptual estimates of this type would typically have a contingency factor of at least 15% applied to the total direct and indirect capital costs.
2. There appears to be sufficient plot space at the facility for the installation of additional control equipment.
3. While the facility-specific and technical considerations of process temperatures and process chemistry regarding the Vendor 1 SCR installation are all very important issues, they would require more definitive process data from the facility as well as a much more detailed engineering evaluation than allotted as part of this BARCT review. ETS believes that the installation of either an SCR system or a dry scrubbing and ceramic filter system is technically feasible based on vendor correspondence reviewed as part of the SCAQMD's efforts and cost effective for this facility based on the SCAQMD's criteria.

The following table compares the major components from the SCAQMD's cost effectiveness analysis with the ETS revised estimates for the same components.

Table 1. ETS Revisions to DCF and LCF Cost Effectiveness (C.E.) for Cement Kilns Subject to BARCT

Vendor 1: SCR system installed between waste heat boiler and baghouse. NOx removal only.			
Vendor 2: Dry scrubbing and ceramic filter system installed after the waste heat boiler and replacing the baghouse. NOx, SOx, and PM removal.			
Vendor 3: Wet gas scrubber and SCR system with heat exchanger installed after the waste heat boiler and replacing the baghouse. NOx, SOx, and PM removal.			
	Vendor 1	**Vendor 2**	**Vendor 3**
	AQMD (ETS)	AQMD (ETS)	AQMD (ETS)
Capital Costs ($)	14,950,000 (17,192,500)	30,000,000 (34,500,000)	31,938,838 (36,729,664)
Annual Costs ($)*	1,220,500	1,000,000	4,818,537
Present Worth Value ($)	34,016,651 (36,259,151)	45,622,000 (50,122,000)	107,214,017 (112,004,843)
Emission reductions (tpd)*	1.287	1.287	1.287
DCF Cost Effectiveness ($/ton)	2,897 (3,088)	3,885 (4,268)	9,130 (9,538)
LCF Cost Effectiveness ($/ton)	4,635 (4,941)	6,216 (6,829)	14,609 (15,262)

*No revisions made by ETS.

To achieve an 80% NOx emissions reduction, the cost effectiveness ranges for the cement kilns should be increased to $3,100/ton - $9,500/ton ($4,900/ton to $15,300/ton, using LCF). All of these scenarios are still considered cost effective based on SCAQMD's criteria.

B. Container Glass Melting Furnace

Introduction

Two technologies were considered for NOx control for the facility; (Vendor 1) a multi-pollutant control technology utilizing a ceramic filtration process (embedded with catalyst) that incorporates dry sorbent injection for SO2 emissions reduction as well as SCR with 19% aqueous ammonia for NOx emissions reduction, and; (Vendor 2) SCR (Selective Catalytic Reduction) using 19% aqueous ammonia as the reagent. In addition, the facility provided an estimate for retrofitting one furnace that was based on the EPA cost manual for SCR installations for NOx removal (Vendor 3).

The facility, as diagrammed, shows 2 glass melting furnaces each of which exits into a dry scrubbing system. The exhaust from the dry scrubbing systems then exits into duct manifolds that can direct the furnace gases into any one of three ESP's. Each of the ESP's has its own stack for discharging the gases to the atmosphere. Vendor 1's ceramic filter system was estimated for one unit for each of the two furnaces, located after the furnaces, replacing the dry scrubbers and ESP's. The Vendor 2 cost estimates presented in the spreadsheets show 2 furnace emission treatment scenario's; (Option 1) one large SCR reactor that is designed to treat the exhaust gases from both furnaces and located after the ESP's, and; (Option 2) three individual SCR reactors placed at the outlet of the three existing ESP's. The following two Vendor 3 scenarios were considered for this analysis: (Option 1) two SCR systems, each sized to handle the exhaust of one furnace, manifolded to the existing three ESP's and (Option 2) three SCR systems, each sized to handle the exhaust of one furnace. Each SCR would handle the exhaust from each ESP.

Preliminary Comments on Technical Feasibility and Cost Effectiveness Analysis

The proposed arrangement for operating 3 SCR units for the two furnaces is that an ESP/SCR combination can be taken off-line and another ESP/SCR combination can be brought on-line to keep the furnaces in operation. It must be pointed out that the removal efficiency of typical Vanadium-based SCR catalysts is highly temperature dependent (Figure 1[1]). Accordingly, in the time period when the furnace gas stream is switched to an off-line SCR and the catalyst in the SCR reactor can be heated up to a proper operating temperature, the NOx removal efficiency of the SCR may be below the design target.

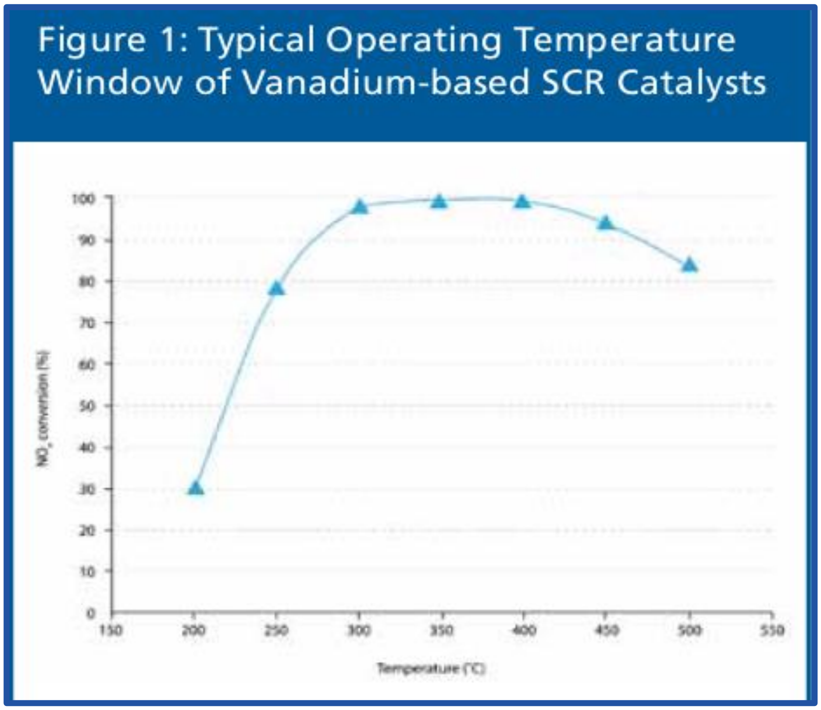

Figure 1: Typical Operating Temperature Window of Vanadium-based SCR Catalysts

Figure 1

Regarding the cost estimates as shown in the spreadsheet, Container Glass.xlsx, the following are comments based on the spreadsheet review and information initially received from SCAQMD:

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[1] Global Emissions Management – Focus on Selective Catalytic Reduction – Johnson Matthey, February 2012

1. Vendor 1 Ceramic Filter System – The treatment system estimate is based on a proposal, dated February 4, 2014 for a glass furnace with a given tons per day maximum pull rate, and was adjusted to reflect the heat inputs of the 2 glass furnaces under consideration.

   1.1. No contingency percentage was applied to the estimate from Vendor 1, which would be appropriate for a conceptual estimate with its lack of detail. Conceptual estimates of this type would typically have a contingency factor of at least 15% applied to the capital costs.

   1.2. The calculation of installation costs (40% of the equipment costs) for Furnace 1 and Furnace 2 does not follow the logic of the facility Basis. 40% of the sum of the emission control system and the infrastructure equipment for Furnace 1 is \$517,240, not \$529,451 (which was ratio'd on the heat inputs.) Similarly, 40% of the sum of the emission control system and the infrastructure equipment for Furnace 2 is \$702,750, not \$882,418 (which was ratio'd on the heat inputs).

2. Vendor 2 SCR Systems – The treatment system costs and input information are based on Vendor 2 e-mails of June 26, 2014 and June 27, 2014.

   2.1. For the single SCR chamber (Option 1) it should be noted that an SCR requires a gas temperature range of 480°F to 850°F for optimal operation. Consequently, the best location for the SCR, from a technical standpoint, may need to be as close in proximity to the ESP outlets as possible. A better understanding of the process temperatures is needed to adequately address these issues.

   2.2. Total installed costs do not appear to include a contingency factor applied to the capital costs in either Option 1 or Option 2. Conceptual estimates of this type would typically have a contingency factor of at least 15% applied to the capital costs.

   2.3. Annual catalyst replacement costs do not appear to include the labor (12 - 15 man days) to replace the catalyst or the recycle/disposal costs for the spent catalyst in either Option.

   2.4. SCR-Vendor 2 annual operating costs do not include electricity. Estimating a 5” wc pressure drop across the SCR plus related duct work and a 29,000 acfm gas flow (Source – CONFIDENTIAL EPA Cost Effectiveness Calc spreadsheet) the booster fan required for the SCR gas flow would have a 21 kW motor. This power consumption would (at \$50/Mw-hr) increase the annual operating cost by \$8,278. It should be noted that both the Vendor 3 operating costs and the Vendor 1 operating costs estimate the annual electrical costs to be \$73,000 - \$87,000/year, so the fan is only a minor component of the electrical consumption.

3. Vendor 3 SCR Systems – The facility provided an estimate for the retrofitting of one furnace that was based on the EPA cost manual for SCR installations for NOx removal.

3.1. Assuming that 2 SCR's installed on a furnace at the same facility would cost twice the estimated capital cost of 1 SCR does not take into account any "volume" cost savings in equipment, design, and erection costs. Costs for 3 systems are too high as equipment costs, steel costs, etc. do not take into account economics of scale.

3.2. Operating labor on 3 systems is not going to be 3x operating labor of 1 system.

3.3. Since budgetary equipment costs were provided by actual equipment suppliers with expertise in the field of NOx removal (Vendors 1 and 2), the time was not expended to try to review in detail and revise the numbers estimated by Vendor 3 using the EPA cost manual method SCR systems.

After a preliminary review of the SCAQMD staff's BARCT feasibility and cost effectiveness analysis, it was determined that a field visit to the container glass plant was needed to assess the situations that may impact the feasibility and costs of the additional emission control assessed. An ETS representative, along with the SCAQMD staff visited the plant on the afternoon of October 16, 2014. The notes from the site visit along with the detailed comments on the technical feasibility and cost effectiveness analysis may be found in Confidential Appendix B.

Comments on Emission Reduction Levels

Based on the analysis conducted by SCAQMD and the review of vendor technical information, ETS concurs that the NOx emission reduction levels that can be achieved for the container glass melting furnaces is 80%. This should be feasible with either of the control technologies evaluated, SCR or the ceramic filter system.

Comments on Performance Warranty

Correspondence reviewed between Vendor 2 and the SCAQMD regarding the SCR budgetary pricing quotes for Options 1 and 2 indicated that the systems are designed to remove 80% of the NOx.

Conclusions

1. While the plot space considerations at this facility are somewhat more complex, ETS concurs that there is sufficient space for the Vendor 2 system.
2. The Vendor 1 system, that removes both SO_2 and NOx, could allow for removal of the existing dry SO_2 scrubbers thereby regaining some of the system pressure drop. The Vendor 1 system also allows for the removal of the existing ESP's.
3. A 15% contingency factor was added to the capital costs of the Vendor 1 and Vendor 2 (Options 1 and 2) total installed capital costs to properly compare all of the estimates.
4. There is a cost disparity between the SCR-Vendor 2 estimate of $2 million for a single SCR reactor to treat the gases from both furnaces versus the Vendor 3 estimate of $2 million for an SCR reactor to treat the gases from just one furnace.

5. While the facility-specific and technical considerations of how many SCR's should serve the existing 3 ESP outlets in terms of redundancy, breakdowns, extended maintenance periods, and process temperature fluctuations are all very important issues, they would require a much more detailed engineering evaluation than allotted as part of this BARCT review. ETS believes that the installation of an SCR system is both technically feasible and cost effective for this facility.

The following table compares the major components from the SCAQMD's cost effectiveness analysis with the ETS revised estimates for the same components.

Table 2. ETS Revisions to DCF and LCF Cost Effectiveness (C.E.) for Container Glass Melting Furnaces Subject to BARCT

Vendor 1: Dry scrubbing and ceramic filter system installed after the furnaces, replacing the dry scrubber and ESP. NOx, SOx, and PM removal.					
Vendor 2: SCR system installed post ESP. NOx removal only. Option 1: single chamber. Option 2: three chambers.					
Vendor 3: SCR system installed post ESP using costs provided by facility per EPA cost manual. NOx removal only. Option 1: two chambers. Option 2: three chambers.					
	Vendor 1	**Vendor 2 Option 1**	**Vendor 2 Option 2**	**Vendor 3 Option 1**	**Vendor 3 Option 2**
	AQMD (ETS)	AQMD (ETS)	AQMD (ETS)	AQMD*	AQMD*
Capital Costs ($)	5,134,891 (5,684,463)	2,070,000 (2,685,250)	5,000,000 (5,405,000)	4,096,959	6,145,439
Annual Costs ($)	567,686*	132,500 (240,909)	180,750 (360,753)	560,123	840,185
Present Worth Value ($)	14,003,287 (14,522,859)	4,139,195 (6,448,737)	7,823,677 (11,040,686)	12,847,207	19,270,811
Emission reductions (tpd)*	0.24	0.24	0.24	0.24	0.24
DCF Cost Effectiveness ($/ton)	6,442 (6,695)	1,904 (2,967)	3,599 (5,079)	5,910	8,865
LCF Cost Effectiveness ($/ton)	10,308 (10,713)	3,047 (4,747)	5,759 (8,127)	9,457	14,186

*No revisions were made by ETS to the Vendor 3 costing or the indicated fields.

To achieve an 80% NOx emissions reduction, the cost effectiveness ranges for the container glass melting furnaces should be increased to $3,000/ton - $8,900/ton ($4,700/ton - $14,200/ton, using LCF). All of these scenarios are still considered cost effective based on SCAQMD's criteria.

C. Sodium Silicate Furnace

Introduction

Two technologies were considered for NOx control for the single Sodium Silicate Furnace. The Vendor 1 technology is a SCR (Selective Catalytic Reduction) system using 19% aqueous ammonia as the reagent. The Vendor 2 technology is a ceramic filter system which utilizes 19% aqueous ammonia injected in the flue gas that mixes with the gas and permeates across the ceramic fiber filter walls that are embedded with a catalyst for NOx removal. The system can also incorporate dry sorbent injection for SO2 emissions reduction as well.

The facility operates one glass melting furnace that uses blower air staging, but operates without downstream controls. This unit produces liquid sodium silicate from soda ash and sand. It was noted, however, that the furnace is not a SOx source. The Vendor 1 cost estimate presented in the spreadsheet indicates a single chamber SCR system that is designed to treat the exhaust gases from the furnace. The Vendor 2 system was also estimated for one ceramic filtration unit located at the outlet of the furnace.

Comments on Technical Feasibility and Cost Effectiveness Analysis

Since SCR reactors have the capability to provide long-term, continuous, service in high dust atmospheres (such as coal-fired boiler or cement kiln exhausts), the location of the SCR reactor at the furnace exhaust should not be an issue. Based on the stack temperature supplied for the facility of 700°F, the SCR system should also be technically capable of achieving an 80% NOx reduction.

In review of the ceramic filter system vendor technology literature provided and website, there are approximately 12 ceramic filter systems worldwide that are operational or on order that utilize the ceramic filter technology. These systems are operating in flat glass, container glass, and tableware facilities.

The following comments are based on the Sodium Silicate Furnace.xls costing spreadsheet, two vendor evaluations, and the Draft Staff Report on the Sodium Silicate Furnace received on October 3, 2014.

1. Vendor 1 SCR - Single Chamber DeNOx System – The treatment system costs and input information are based on Vendor 2 e-mails of June 26, 2014 and July 8, 2014.

    1.1. Based on the stack temperature supplied for the facility of 700°F, the SCR chamber should be capable of 80% removal efficiency since the traditional optimum gas temperature for the operation of SCR has been 480°F to 850°F.

    1.2. No contingency percentage was applied to the estimate from Vendor 1, which would be appropriate for a conceptual estimate with its lack of detail. Conceptual estimates of this type would typically have a contingency factor of at least 15% applied to the capital costs.

2. Vendor 2 Ceramic Filter System – The treatment system estimate is based on a budgetary price estimate, dated February 4, 2014 for a glass melting furnace.

    2.1. It was noted to the vendor that the facility is not a SOx source; however, costs for SO_2 control and sorbent injection ($170,709) were included in the Vendor 2 budgetary price estimate and were consequently included with the total equipment cost in the SCAQMD costing spreadsheet. This amount was deducted from the "emission control system" total equipment cost.
    2.2. No contingency percentage was applied to the estimate from Vendor 2, which would be appropriate for a conceptual estimate with its lack of detail. Conceptual estimates of this type would typically have a contingency factor of at least 15% applied to the capital costs.
    2.3. The Vendor 2 estimates for annual costs for the dry sorbent for SO_2 control were appropriately listed as $0 in the Vendor 2 budgetary price estimate and were not included in the costing spreadsheet since this facility is not a SOx source.

Comments on Emission Reduction Levels

Based on the analysis conducted by SCAQMD and the review of vendor technical information, ETS concurs that the NOx emission reduction levels that can be achieved for the sodium silicate furnace is 80%. This should be technically feasible with either of the control technologies evaluated, SCR or the ceramic filter system.

Comments on Performance Warranty

Correspondence reviewed between Vendor 1 and the SCAQMD regarding the SCR budgetary pricing quote indicated that the system is designed to remove 80% of the NOx.

Conclusions

1. The costing is generally straightforward and it is understood that there are no site-specific considerations that would increase the installation costs dramatically.
2. Both technologies evaluated for reducing NOx for the sodium silicate furnace are considered technically feasible.

The following table compares the major components from the SCAQMD's cost effectiveness analysis with the ETS revised estimates for the same components.

Table 3. ETS Revisions to DCF and LCF Cost Effectiveness (C.E.) for Sodium Silicate Furnace Subject to BARCT

Vendor 1: SCR system installed after the furnace. NOx removal only. *Vendor 2:* Dry scrubbing and ceramic filter system installed after the furnace. NOx, SOx, and PM removal.		
	Vendor 1	**Vendor 2**
	AQMD (ETS)	AQMD (ETS)
Capital Costs ($)	1,600,000 (1,840,000)	1,986,161 (2,009,243)
Annual Costs ($)*	76,315	166,016
Present Worth Value ($)	2,792,193 (3,032,193)	4,579,663 (4,602,745)
Emission reductions (tpd)*	0.09	0.09
DCF Cost Effectiveness ($/ton)	3,470 (3,768)	5,691 (5,719)
LCF Cost Effectiveness ($/ton)	5,552 (6,029)	9,106 (9,152)

*No revisions made by ETS.

To achieve an 80% NOx emissions reduction, the cost effectiveness ranges for the sodium silicate furnace should be increased to $3,800/ton - $5,700/ton ($6,000/ton - $9,200/ton, using LCF). Both of these scenarios are still considered cost effective based on SCAQMD's criteria.

D. Metal Heat Treating Furnace Above 150 MMBTU/hr

Introduction

The purpose of this section is to review estimated costs of selective catalytic reduction (SCR) control for a metal heat treating furnaces for processing steel. One existing furnace has SCR control and is currently achieving about 20 ppm NOx. A second furnace has no NOx control, but costs for providing SCR control are estimated in a spreadsheet as discussed below. A second spreadsheet has costs based on the controlled furnace, which allow comparisons with new vendor estimates. Primary documents reviewed along with the spreadsheets include records of communication among SCAQMD personnel, one vendor, and the plant operator. The spreadsheets show itemized costing steps for both SCR control systems. Included in the spreadsheets are capital and annual costs (AC) for an SCR based on each furnace, and present worth values (PWV) and capital recovery factor (CRF) values for the entire control system. Estimated capital and operating costs are divided by expected emission reductions to obtain performance measures in dollars per ton of NOx removed. These measures are given in terms of cost/ton of NOx removed beyond the currently required removal.

Comments on Technical Feasibility and Cost Effectiveness Analysis

The spreadsheet models were in abbreviated form, but contained sufficient information to estimate PWVs based on total installed costs (TIC), which include equipment and installation costs, and total annual costs (AC). Two values of cost effectiveness were developed, both with units of $/ton of NOx removed. One value was based on the PWV divided by 25 years of accumulated NOx removed. The second value was based on total capital cost times a CRF plus one year of total annualized cost. Each of these values was divided by the amount of NOx captured during their respective time base – 25 years for the PWV method and 1 year for the CRF method. The two cost effectiveness values differed by 60 percent on each spreadsheet.

Examination of the information received raised a couple of issues:

1. No process parameters were supplied regarding the existing equipment-based costs (i.e., flue gas temperature and flue gas flow rate). It was assumed that the process parameters of the two furnaces were relatively compatible, since the annual catalyst replacement costs and miscellaneous maintenance annual costs were utilized in the SCR vendor-based costing worksheet.
2. The work-by-others list in the vendor’s proposal is long; therefore it appears that a very conservative contingency value of 200 percent of the SCR equipment costs was used to estimate the installation, foundation, civil work, and other construction uncertainties.

Comments on Emission Reduction Levels

Based on the analysis conducted by SCAQMD and the review of vendor technical information, ETS concurs that the NOx emission reduction levels that can be achieved for furnaces above 150 MMBTU/hr is 80% with SCR technology.

Comments on Performance Warranty

Correspondence reviewed between Vendor 1 and the SCAQMD regarding the SCR budgetary pricing quote indicated that the system is designed to remove 80% of the NOx, which is conservative and guaranteed for this type of installation.

Conclusions

1. The spreadsheet costing follows SCAQMD procedures.
2. The amount of data supplied in the spreadsheets is small, but not deleterious to arriving at study estimate costs if those data are fairly accurate.
3. The costing is generally useful and no revisions were made.

E. IC Engines (non-power plant, non-offshore)

Comments on Technical Feasibility and Cost Effectiveness Analysis

The comments on I-C engines are based on a costing spreadsheet, a vendor e-mail dated November 15, 2013 with vendor-supplied costs, installation costs from an existing SCR installation on a lean-burn engine at Orange County Sanitation District (OCSD), and the Draft Staff Report on Non-Refinery Stationary Internal Combustion Engines dated September 19, 2014. NOx emissions reduction for I-C engines is considered to be by stand-alone SCR with a urea solution as the reactant.

1. The annual costs for the OCSD installation (base case used for scaling other engines in this source category by engine horsepower) were developed with catalyst replacement at 6,000 hours, but it was stated that the engine used in the base case operates at 6,000 hours because its usage is rotated among two other engines. The annual costs were then scaled up to 8,000 hours because it is a reasonable usage for an engine that is operated continuously, including downtime due to maintenance and repairs.
2. Facilities A, B, and C stated on their 2013 NOx RECLAIM Survey Questionnaire that an additional 3" of water column to the existing back pressure with the installation of after treatment would probably be acceptable with some reduced engine efficiency. However, they stated that an engineering analysis would be needed to calculate the exact effect.
3. The vendor conceptual quote for Facility D noted that the SCR application does not seem feasible due to the low engine exit gas temperatures. ETS concurs with SCAQMD that the engines in this category should not be subject to the new BARCT.
4. The vendor conceptual quote for Facility E notes that the SCR application would be very difficult due to a number of reasons including: high ash and soot discharges, lower exhaust temperatures, lower than typical maximum allowable back pressure, and changes in NOx output for 2-stroke engines that are dependent on more factors than on 4-stroke engines. ETS concurs with SCAQMD that there should be no new BARCT for power plant ICEs.

Comments on Emission Reduction Levels and Cost Effectiveness

Based on the analysis conducted by SCAQMD and the review of vendor technical information provided, ETS concurs that the NOx emission reduction levels can be achieved for non-power plant IC engines with SCR technology at 11 ppm at 15% O_2.

F. Non-Refinery, Non-Power Plant Stationary Gas Turbines

Introduction

The purpose of this section is to review estimated costs of selective catalytic reduction (SCR) control for non-refinery, non-power plant stationary gas turbines which are used primarily to drive compressors or to generate power. It was cited that there are twenty gas turbines at various facilities that are identified as either major or large source units. It was also noted that four of the units are currently utilizing some level of NOx control with SCR, six units are operated on an offshore oil drilling platform, and four units at the lower range of NOx ppm concentration currently have SCR systems installed. Primary documents reviewed along with the Draft Staff Report include the costing spreadsheet and vendor correspondence/budgetary quotes.

Comments on Draft Staff Report – Gas Turbines

1. Table 1 of the Draft Staff Report states 20 units as the "total number of units" in the non-refinery, non-power plant stationary gas turbine sector. Figure 1 is also consistent with that number in that the bar graph of NOx emission concentrations shows 20 bars. However, Table 2 and the costing spreadsheets only reflect the evaluation of 19 units. It was noted by SCAQMD that there will be further discussion at a later point for this particular gas turbine unit.

Comments on Technical Feasibility and Cost Effectiveness Analysis

1. In terms of technical feasibility, ETS concurs with the statement made by one of the vendors who supplied budgetary pricing for the SCR systems that 95% NOx reduction is the best possible NOx reduction without very specialized engineering. As stated in the Draft Staff Report, this means that a 2 ppm level would be achievable for units emitting > 40 ppm if these units would install either wet or dry combustion controls in addition to an SCR system.
2. In the costing spreadsheet, the estimated installation costs were calculated to be either double (200%) of the equipment costs or four times (400%) times the equipment costs (in the case of the unique site considerations for the offshore facilities). This is compatible with our experience and a very conservative approach to take given the variations presented by the types of facilities under evaluation in the gas turbine, non-refinery, non-power plant sector and any site-specific limitations.

Conclusions

NOx emissions reductions of 90 to 95% are technically feasible with SCR alone and ≥ 95% NOx reduction has been achieved in practice with SCR technology at a gas turbine facility in California.[2]

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[2] SCAQMD Best Available Retrofit Control Technology Assessment, TXI Riverside Cement, August 8, 2008.

G. Non-Refinery Boilers >40 MMBTU/hr

Introduction

The purpose of this section is to review estimated costs of selective catalytic reduction (SCR) control for non-refinery boilers >40 MMBTU/hr. The primary document reviewed was the costing spreadsheet with the evaluation of SCR systems at two facilities (3 boilers evaluated).

Comments on Technical Feasibility and Cost Effectiveness Analysis

The SCR system costs developed by vendor quotes from a similar sized furnace in the Sodium Silicate Furnace sector were utilized for the evaluation of the non-refinery boilers >40 MMBTU/hr. This is a reasonable practice given the 2011 emissions for this sector which were used as the baseline.

Conclusions

We concur that the achievement of the emission levels evaluated is not cost effective for the units analyzed (> $70K per ton).

V. IMPLEMENTATION DATES

It should be noted that the time for installation of control technology, specifically an SCR system, will be highly dependent upon site characteristics, the degree of retrofit, and the market demand for critical components such as SCR catalyst. The typical installation time for an SCR system is approximately 24 months **after** the selection of an engineering firm to develop the SCR specification and commence the design engineering. Depending on the selection time for the facility’s design engineering company, the total implementation time is estimated to be 27 – 30 months. For some of the smaller systems, such as an SCR for ICE Engines, the implementation dates would potentially be shorter. Assuming that rule adoption occurs in the 1st quarter of 2015, then the implementation dates are projected to be from 2017 to 2018.