



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
REGION 8

1595 Wynkoop Street  
DENVER, CO 80202-1129  
Phone 800-227-8917  
<http://www.epa.gov/region08>

Ref: 8ENF-L

OCT 17 2008



Via Federal Express & Electronic Mail

Mr. Terry O'Clair  
Director, Air Quality Division  
North Dakota Department of Health  
918 E. Divide Avenue  
Bismarck, ND 58501-1947

Re: Transmittal of EPA's Response to  
Minnkota's Letter on Public Comments  
Received for the North Dakota Department  
of Health's Preliminary NO<sub>x</sub> BACT  
Determination for Milton R. Young Station

Dear Mr. O'Clair:

This letter responds to a letter from Minnkota Power Cooperative, Incorporated (Minnkota) addressed to the North Dakota Department of Public Health (NDDH) dated September 22, 2008. Minnkota's letter and enclosure were, in part, a response to comments submitted by the United States Environmental Protection Agency's ("EPA") to NDDH on the Preliminary Best Available Control Technology (BACT) Determination for Nitrogen Oxides (NO<sub>x</sub>) for Milton R. Young Station (MRYS), Units 1 and 2<sup>1</sup> (the NDDH preliminary BACT determination). EPA received an electronic version of Minnkota's letter on September 26, 2008. Although Minnkota submitted its comments nearly two months after the public comment period closed, EPA understands that NDDH intends to include Minnkota's response in the administrative record for the final BACT determination.

EPA understands that NDDH needs to close the record so that a final BACT determination can be made, but some portions of Minnkota's letter need to be clarified and corrected. To assist NDDH in developing an accurate administrative record for the final BACT determination and as part of the EPA-NDDH consultation process described in paragraph 66 of the Consent Decree (Civil Action No. 1:06-CV-034, United States of America and State of North Dakota v. Minnkota Power Cooperative, Inc. and Square Butte Electric Cooperative),<sup>2</sup> EPA is submitting

<sup>1</sup> Per July 8, 2008 letter from NDDH to EPA, the public comment period closed on August 1, 2008.

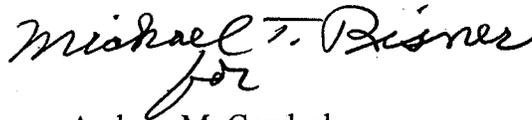
<sup>2</sup> "After consultation with EPA, NDDH shall provide to the Parties its BACT Determination for NO<sub>x</sub> emissions from each existing coal-fired Unit at the Milton R. Young Station."

this response and additional information. I respectfully request that this information be included in the administrative record for NDDH's final BACT determination.

EPA provided NDDH significant evidence that selective catalytic reduction (SCR) as a control option is technically feasible, particularly in a tail-end configuration. Minnkota and its contractors failed to address this point or provide any additional data or facts substantiating the claim that SCR is technically infeasible. In fact, in Appendix A to Minnkota's letter, Burns & McDonnell's subcontractor, Mr. Volker Rummenhohl of Tackticks LLC, never states that SCR would be technically infeasible at MRYS. In addition, Minnkota's dismissal of the statements made by catalyst vendors and SCR system suppliers provided by EPA regarding performance guarantees for tail-end SCR is tenuous and inconsistent with EPA's "Top-Down" BACT procedure, as outlined under Chapter B of the "New Source Review Workshop Manual--- Prevention of Significant Deterioration and Nonattainment Area Permitting," (Draft October 1990), (EPA's NSR Manual).<sup>3</sup> Vendor responses and actual operating examples<sup>4</sup> related to tail-end SCR presented by EPA strongly indicate that SCR is a technically feasible option. Therefore, EPA continues to believe that the NDDH's preliminary BACT determination of technical infeasibility for SCR is not supported by the record.

Enclosed is a detailed response, prepared by Mr. Hartenstein, Principal and Co-owner of E&EC, an energy and environmental consulting firm, correcting inaccurate information and refuting the conclusions submitted by Minnkota. Thank you for considering the information and clarifications to the administrative record enclosed herein in the final NDDH BACT determination. If you would like to discuss any of these matters, please call Cynthia Reynolds at (303) 312-62006 or Brenda Morris at (303) 312-6891.

Sincerely,



Andrew M. Gaydosh  
Assistant Regional Administrator  
Office of Enforcement, Compliance and  
Environmental Justice

Enclosures: Hartenstein Report & References (2 copies on cd)

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<sup>3</sup> "Vendor guarantees may provide an indication of commercial availability and technical feasibility of a control technique and could contribute to a determination of technical feasibility or technical infeasibility, depending on the circumstances." (see page B.20)

<sup>4</sup> According to EPA's NSR Manual, available control options include "technologies in application outside the United States to the extent that the technologies have been successfully demonstrated in practice on full scale operations." (see page B.11-12)

cc: David Glatt, NDDH (w/o Enclosure),  
Dean Haas, NDDH (w/o Enclosure),  
Jerry MacLaughlin, USDOJ (w/o Enclosure),  
Jeff Kodish, OECA, (w/o Enclosure),  
Ron Rutherford, EPA (w/o Enclosure),  
Cindy Reynolds, EPA (w/o Enclosure)  
Brenda Morris, EPA  
Hans Buenning, EPA

**Remarks to the “Comments and Responses to NDHH Regarding U.S. EPA Region  
8’s July 31, 2008 Comments and Plains Justice July 30, 2008 Comments on NDHH  
Preliminary NOx BACT Determination for Milton R. Young Station (MRYS)”  
dated September 22, 2008**

**by Hans Hartenstein**

**ON BEHALF OF THE**

**UNITED STATES DEPARTMENT OF JUSTICE**

October 2008

## **General Remarks**

This report was prepared after reviewing the “Comments and Responses to NDHH Regarding U.S. EPA Region 8’s July 31, 2008 Comments and Plains Justice July 30, 2008 Comments on NDHH Preliminary NOx BACT Determination for Milton R. Young Station (MRYS)” prepared by Burns & McDonnell dated September 22, 2008 (referred to hereafter as the “Document”).

Even though many detailed comments, corrections, rectifications, clarifications and remarks are being provided in this report, I would like to offer a few general comments. The Document does not provide any new, previously unknown facts or offer any new technical arguments. Again, the majority of the Document is directed at HDSCR and still doesn’t adequately substantiate the claim why TESCR is considered technically infeasible. While the Document discusses the various types of deactivation mechanisms in minute scientific detail, which were never disputed per se, it fails to address the rate at which this catalyst deactivation occurs in a TESCR system. This however is the most critical issue and no data is provided to answer this fundamental question.

Burns & McDonnell, who claims extensive SCR experience and expertise, retained an additional SCR consultant (Tackticks LLC) in order to provide technical comments concerning the SCR technology. Unfortunately, Burns & McDonnell’s SCR consultant only provided one reference for the numerous claims and statements made in Appendix A of the Document.

Interestingly enough, Burns & McDonnell’s SCR consultant – contrary to Burns & McDonnell – did not arrive at the same conclusion, namely that SCR is technically infeasible for MRYS, but correctly concluded that “the possible application of any SCR technology at Milton R. Young is not standard, due to special considerations pertaining to lignite, boiler operating temperatures, flue gas reheating, among others.” I agree with the statement that this SCR application is not “standard” in the sense that it exactly replicates the standard type of HDSCR used up to now in the U.S. However, this by no means supports the Document’s ultimate claim that SCR is technically infeasible for MRYS as proven by the wide varieties of SCR applications and extensive experience worldwide.

## **Specific Comments to the Document’s Section “Corrections, Clarifications and Omissions of Hartenstein and EPA Comments”:**

My comments to the statements made in the Document are offered in the following, each of which is preceded by the statements presented in the Document for easier reference.

1. Hartenstein implies that lignite-fired boilers are significantly represented among the 30,000 MW of SCR systems installed in Europe. This is misleading and substantially incorrect. Very few of the many SCRs retrofit in Europe were installed on lignite-fired utility boilers. Tackticks has advised that to the best of their knowledge, they are aware of SCR being originally installed at only two plants, and neither of these plants is operational today.

1. My report is not intended to imply that “lignite-fired boilers are significantly represented among the 30,000 or so MW of SCR systems installed in Europe.” The fact of the matter is that Europe has over 62,000 MW of SCRs installed, of which approximately 35,000 MW are in Germany. Again about 40% of these 35,000 MW are TESCRs. At least five HDSCRs were installed on lignite fired units, namely: Bayer Dormagen Unit 7, E.ON Schwandorf Units B, C and D and Voitsberg 3. All units were operated for between 10 and 16 years and four of them were decommissioned in the early 2000s for purely economic reasons resulting from deregulation of the German utility market<sup>1</sup>. Voitsberg 3 was temporarily shut down in 2006 as the supplying lignite mine ran out of coal. It is currently being converted to a blend of bituminous coal and biomass and is expected to start up again in the near future with the same HDSCR<sup>2</sup>.
2. The EPA argues that NDDH’s preliminary BACT Determination does not properly compare the emissions from other coal-fired boilers with high fuel sodium content to other boilers that successfully operate SCRs firing Powder River Basin (PRB) coal with high dust SCRs in the United States and are comparable to the Young Station boilers for their flyash alkali contents. The EPA ignored the Department’s supporting detailed information by EERC that explains why SCRs are not able to tolerate the higher levels of alkali species contained in flue gas such as exhausted from the MRYS boilers as compared to the PRB coal fired boilers..
2. EERC’s outline as to “why SCRs are not able to tolerate the higher levels of alkali species contained in flue gas such as exhausted from MRYS boilers” is based on the assumption that HDSCR is used where significantly more fly ash gets into contact with the catalyst than in a TESCR installation. No data substantiating the claims for catalyst deactivation in a TESCR application, where virtually no residual fly ash is present, is presented by the Department.
3. In addition, the EPA and Hartenstein did not provide any substantial technical information that demonstrates that effective solutions to prevent or remove pore pluggage and blinding of SCR catalyst from sodium- and potassium-rich species present in the flue gas stream exhausted from a North Dakota lignite-fired cyclone boiler, whether installed in a conventional hot-side or cold-side application downstream of a wet scrubber, have been developed by catalyst vendors.

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<sup>1</sup> Co-firing of biomass - evaluation of fuel procurement and handling in selected existing plants and exchange of information (COFIRING) - Part 2, Kraftwerk Schwandorf, Germany, Alterne ABV-NET V, Ruth Brökeland, C.A.R.M.E.N.

<sup>2</sup> <http://www.wirtschaftsblatt.at/home/oesterreich/unternehmen/steiermark/337197/index.do>

3. My report is not directed towards demonstrating effective solutions to prevent pore pluggage and blinding of HDSCR catalyst from sodium- and potassium-rich species present in the flue gas stream exhausted from North Dakota lignite-fired cyclone boilers. The only data presented by the Department showing such pore pluggage was obtained during the Coyote Pilot Testing. This, however, was an HDSCR arrangement and not a TESCO arrangement, which means that the data does neither properly represent the types of deactivation mechanisms nor the rate of catalyst deactivation that can be expected in a TESCO, where virtually no residual fly ash is present anymore. Therefore, the amount of particles available for pore pluggage and the formation of a surface blinding layer as well as the amount of sodium- and potassium rich ash particles is greatly reduced, which in return greatly reduces the catalyst's deactivation rate. The Document misses the point that only the rate of catalyst deactivation remains in question rather than the undisputed fact that among other physical and chemical deactivation mechanisms pore pluggage and surface blinding can cause catalyst deactivation.

TESCOs have a proven track record of very little to no pore pluggage and/or surface blinding occurring. Initially, isolated events of silicon fluoride ( $\text{SiF}_4$ ) blinding in bituminous coal-fired units were reported but only persisted for a very short period of time<sup>3</sup>. Several mitigation methods were quickly developed and  $\text{SiF}_4$  blinding has not been an issue for more than a decade in TESCOs. Furthermore, extensive experience has been gathered with the removal of pore pluggage and blinding of SCR catalyst from sodium- and potassium rich species by means of in-situ, on-site as well as off-site regeneration of HDSCR catalyst exposed to flue gases from i.e. 100% biomass combustion containing high quantities of sodium- and potassium-rich species. Simple catalyst washing either in-situ or on site is an effective method to quickly remove alkali poisoning from the catalyst. This has been demonstrated for more than a decade and is currently regularly used for units with HDSCRs burning biomass in Europe (i.e. Elsam's Avedoere Unit 2)<sup>4, 5, 6, 7</sup>.

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<sup>3</sup> Personal discussion with plant personnel at Evonik's Herne, Lünen, Marl, Walsum and Voerde Generating Stations

<sup>4</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>5</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, 2007 NOx Round Table, Cincinnati, Ohio

<sup>6</sup> Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehrnschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia

<sup>7</sup> Mobile Katalysatorregeneration in der praktischen Bewährung, Dr. Herwig Maier et. al. EnBW Kraftwerke AG, VGB Konferenz Chemie im Kraftwerk, 2006

4. Hartenstein did not demonstrate he had an understanding of Center lignite characteristics and variability issues. Specifically, he did not understand how soluble sodium is used to define the abundance of organically associated sodium in lignite and how sodium will vary because of the abundance of other ash forming components in the coal. The abundance of sodium and other ash forming components vary dramatically and uniquely in North Dakota (Fort Union region) lignite coal and result in operational challenges. Hartenstein does not understand the differences between Fort Union lignite and Texas lignite. He indicates that the installations of SCR on Powder River Basin (PRB) subbituminous coal and testing on Texas lignite indicate feasibility for SCR on ND lignite even though the levels of sodium in typical PRB coal and Texas lignites are very low (0.7 to 1.5% Na<sub>2</sub>O) as compared to 4.4 % Na<sub>2</sub>O for Center lignite. The amount and form of alkali species in the coal along with combustion processes influence their ability to be enriched in the aerosol and fine particle fraction of the fly ash. The size and composition of the particle along with gas velocity determines their ability to penetrate and deposit on SCR catalyst passages and in pores and cause plugging, blinding, and poisoning.

4. The Document seems to erroneously assume that the purpose of my report was to demonstrate my understanding of Center lignite characteristics and variability issues. Again, the arguments presented are solely directed towards HDSCR. Organically associated sodium and potassium compounds are also present in high quantities in flue gases from biomass combustion in Europe either in combination with coal or without. HDSCRs have been successfully applied for such flue gases from boilers firing up to 100% biomass (i.e. Elsam's Avedoere Unit 2<sup>8</sup>, Wienstrom's Simmering Unit 1<sup>10</sup>).

My report is directed towards the SCR technology and its technical applicability. No data substantiating the claims for catalyst deactivation in a TESCO application, where virtually no residual fly ash is present, is presented in the Document.

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<sup>8</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>2</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, 2007 NOx Round Table, Cincinnati, Ohio

<sup>10</sup> Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehrmschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia

5. Hartenstein did not address the issue of the partitioning of ash-forming species between the slag and fly ash components in cyclone-fired systems that result in an enrichment of sodium and other flame-volatilized species in the flue gas. These flame-volatilized species will condense homogeneously to produce abundant sodium and potassium-rich aerosols because of the lower level of entrained solid ash particles in cyclone combustion-derived flue gases relative to pulverized coal combustion derived flue gas.
5. The purpose of my report was not to discuss the partitioning of ash-forming species between the slag and fly ash components in cyclone-fired systems that result in an enrichment of sodium and other flame-volatilized species in the flue gas. Again the arguments presented are solely directed towards HDSCR. No data substantiating the claims for catalyst in a TESCO application is presented. Since virtually no residual fly ash remains in the flue gas downstream of an ESP and wet scrubber, these issues are of little if any relevance for the deactivation of TESCO catalyst by fly ash particle-bound compounds.
6. Hartenstein did not address the formation of aerosols and how that can impact SCR performance. The key issue for high sodium Fort Union (North Dakota lignite) coals fired in cyclone-fired boilers is the abundance of alkali-rich aerosols in the flue gas that can penetrate into the pores of SCR catalyst, causing blinding and poisoning. This is an issue for high dust and low dust / tail-end SCR applications. He appears to not be familiar with the diffusion mechanism of transport of aerosols deep into the SCR catalysts that can cause poisoning and plugging. Hartenstein appears to confuse the importance of catalyst pitch relative to pore plugging and blinding. He incorrectly suggests that catalyst pitch will solve the pore plugging and blinding problem. Using wider pitch catalyst does not eliminate the penetration of alkali-rich aerosols deep into SCR catalyst causing pore plugging and blinding problems. The impact of such aerosols that pass through the electrostatic precipitator (ESP) on the performance of low dust SCR applications was not discussed by Hartenstein. This fine ash that escapes from the ESP is finer than the bulk flyash and has a higher catalyst plugging potential due to a higher tendency to agglomerate. In addition, Hartenstein did not consider information provided on Powerspan barrier discharge reactor pilot slipstream testing that showed alkali rich accumulations downstream of the Unit 1 ESP at the MRY station.
6. The Document erroneously claims that I suggested that "catalyst pitch will solve the pore plugging and blinding problems." However, the fact remains and was reiterated also by catalyst suppliers and SCR system vendors that proper catalyst selection is a critical issue in order to avoid or at least minimize problems. No data was presented that shows any

such pore plugging and blinding problems of catalyst in a TESCO application. As a matter of fact, absolutely no data was offered to substantiate the claimed impact of aerosols on TESCO catalyst. No representative data quantifying and/or characterizing such aerosols downstream of an ESP and wet scrubber was provided (see also pages A 41 – A 45 of my original report). The data referenced from the Powerspan barrier discharge reactor pilot slipstream testing is not relevant for TESCO as it was obtained on MRYS Unit 1 downstream of the ESP rather than on MRYS Unit 2 downstream of the wet FGD. Even though I never disputed that these aerosols will impact the catalyst in a TESCO, the quantity of such aerosols entering a TESCO must be expected to be extremely small, which means their deactivation effect will most likely be rather slow. Therefore, it can be expected with a very high degree of confidence that the catalyst lifetime in a TESCO will most certainly exceed 10,000 hours, which was randomly defined by the Department as a minimum time for successful operation.

7. Hartenstein's knowledge of gas-solid reaction mechanisms to form sulfate and pyrosulfate phase *in situ* in SCR catalysts appears to be very limited and was not adequately addressed.
7. The gas-solid reaction mechanisms to form sulfate and pyrosulfate phase *in-situ* were not addressed since no data was provided that such formation of sulfates and pyrosulfates takes place *in-situ* in significant quantities in the catalyst in a TESCO.
8. Hartenstein did not discuss the recent literature on catalyst poisoning studies in Europe associated with cofiring high alkali (Na and K) containing biomass. This testing has showed significant poisoning of catalysts due to alkali aerosol penetration into catalysts and the subsequent reaction with catalyst active components causing poisoning.
8. Catalyst poisoning studies in Europe associated with co-firing high alkali (Na and K) containing biomass have clearly shown an accelerated catalyst deactivation in HDSCRs compared to European bituminous coal-fired units<sup>11, 12</sup>. However, neither did this lead to the conclusion that HDSCR is technically or economically infeasible nor did such accelerated catalyst deactivation occur in TESCRs<sup>13, 14</sup>. Units firing 100% biomass (i.e. wood and/or straw) with organically bound sodium and potassium contents as high or

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<sup>11</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>12</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

<sup>13</sup> Sobolewski, H, H. Hartenstein, H. Rhein, "STEAG's Long Term SCR Catalyst Experience and Cost", The 2005 EPRI Workshop on Selective Catalytic Reduction, Louisville, KY, 2005

<sup>14</sup> Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehmschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia

even higher than Center lignite have successfully operated even HDSCRs<sup>15, 16</sup>. Wet bottom boilers equipped with TESCOs have experienced no effect on catalyst deactivation as a result of co-firing biomass in Europe<sup>17, 18</sup>.

9. Hartenstein did not offer information that more than 20,000 MW of lignite fired units in Germany were not required to install SCR in order to comply with the national regulation, or that even new lignite-fired units being installed today in Germany are not equipped with SCR of any type. He did not state that Germany had only one cyclone-fired boiler operating with a LDSCR (Walsum Unit 7), or that the unit burns bituminous coal; nor did he advise that Voitsberg Unit 3, a boiler in Austria firing lignite coal, only ran for a short time with a high-dust SCR and was subsequently shutdown and demolished. He states that TESCO technology was "generally adopted as a universally applicable SCR solution for all types..." but failed to mention that there has never been another TESCO built after Siersdorf, (which was finished in early 1991 and has subsequently been decommissioned), in the United States or Europe. To the best of our knowledge, there is no TESCO anywhere in the world on a lignite-fired utility boiler. He cites "Ceram's extensive experience with lignite...", but fails to report that this consists of only one plant with Ceram catalyst having operated for a short period of time on lignite and a few pilot programs, so that it is dubious to say that this vendor has extensive experience on lignite fired boiler SCR plants (see Appendix A). There are numerous other instances of missing or factually incorrect information attributed to Mr. Hartenstein discussed in Appendix A.

9. The lignite-fired units in Germany have to comply with the same NOx emission limit as all other fossil-fired units, namely 200 mg/Nm<sup>3</sup> @ 6% O<sub>2</sub> (approximately 100 ppm)<sup>19, 20</sup>.

<sup>15</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>16</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

<sup>17</sup> Sobolewski, H, H. Hartenstein, H. Rhein, "STEAG's Long Term SCR Catalyst Experience and Cost", The 2005 EPRI Workshop on Selective Catalytic Reduction, Louisville, KY, 2005

<sup>18</sup> Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehrnschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia

<sup>19</sup> Dreizehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Großfeuerungsanlagen) - 13. BImSchV. Bundesdrucksache Bundesrepublik Deutschland, 1983

<sup>20</sup> [http://www.zit.tu-darmstadt.de/cipp/tudzit/lib/all/lob/return\\_download.ticket.guest/bid.1179/check\\_table.it\\_chap\\_downl\\_embed/~/umwelttechnik.pdf](http://www.zit.tu-darmstadt.de/cipp/tudzit/lib/all/lob/return_download.ticket.guest/bid.1179/check_table.it_chap_downl_embed/~/umwelttechnik.pdf)

Due to the specifics of lignite combustion, this limit could be met by most lignite-fired units (exceptions listed under 1. above) without the addition of SCRs. However, currently the regulations are under review and it is expected that the emission limit will be reduced to 100 mg/Nm<sup>3</sup> @ 6% O<sub>2</sub> (approximately 50 ppm), which will most likely require the majority of the lignite-fired units to retrofit SCRs.

The statement that “Germany had only one cyclone-fired boiler operating with a LDSCR (Walsum Unit 7)” is incorrect. Walsum Unit 7 is a U-fired wet bottom boiler rather than a cyclone-fired boiler<sup>21</sup>.

The statement that “Voitsberg Unit 3, a boiler in Austria firing lignite coal, only ran for a short time with a high-dust SCR and was subsequently shutdown and demolished” is incorrect. Voitsberg Unit 3 operated with a HDSCR from 1990 to 2006, when it was temporarily shutdown as the lignite mine supplying the fuel ran out of coal. Voitsberg 3 is currently being converted to burning a blend of biomass and bituminous coal and is expected to restart operation in the near future<sup>22</sup>.

The statement that “there has never been another TESCO built after Siersdorf, (which was finished in 1991 and has subsequently been decommissioned)” is incorrect as i.e. VEB’s Rudow Unit 2 was started up in 1994<sup>23, 24</sup>. Legislation<sup>25</sup> had required all units to meet the new NO<sub>x</sub> emission limit of 200 mg/Nm<sup>3</sup> by 1991, which is the reason why the vast majority of the utility boilers including Siersdorf were retrofitted with SCRs by 1991. Nevertheless, additional utility units such as Rudow Unit 2 in Berlin were retrofitted with TESCRs later. Additionally, a vast variety of other combustion processes were retrofitted with TESCRs between 1991 and today due to the universal applicability of TESCRs.

The statement that CERAM’s experience with lignite “consists of only one plant with CERAM catalyst having operated for a short period of time on lignite” is insofar interesting as it probably refers to Voitsberg Unit 3. However, what is considered a “short period of time” seems to be very relative, since Voitsberg Unit 3’s HDSCR was initially

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<sup>21</sup> Personal conversation with plant personnel at Evonik’s Walsum Generating Station

<sup>22</sup> <http://www.wirtschaftsblatt.at/home/oesterreich/unternehmen/steiermark/337197/index.do>

<sup>23</sup> SCR Reference List, Fisia Babcock Environment GmbH

<sup>24</sup> <http://64.233.169.104/search?q=cache:zdIt5N-ngCwJ:www.stadtentwicklung.berlin.de/umwelt/umweltatlas/e-tab/t301e02.xls+Kraftwerk+Rudow+DeNOx&hl=de&ct=clnk&cd=8&gl=us>

<sup>25</sup> Dreizehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Großfeuerungsanlagen) - 13. BImSchV. Bundesdrucksache Bundesrepublik Deutschland, 1983

equipped with CERAM catalyst and in operation for 16 years between 1990 and 2006 while the unit burned Austrian lignite<sup>26</sup>.

10. Again, the EPA fails to recognize conclusively that ash chemical and physical properties of the Texas lignite (Wilcox formation) that TXU proposes to burn at the new Oak Grove powerplant where SCR is being installed (but has not yet begun operation) do not represent what is fired in North Dakota, and therefore technical feasibility and expected performance in a Texas lignite-fired pulverized coal boiler SCR application is not transferable to North Dakota lignite-fired cyclone burner units due to the significant differences in flue gas and ash chemical and physical properties. The composition of the Texas lignite fired at Martin Lake, where SCR mini-SCR pilot testing has been conducted, is typical of the composition of lignite fired at Sandow, with sodium oxide levels in the Texas lignite ash equal to 0.7%. The levels of sodium oxide in Center lignite average 4.4% and can be as high as 13% in as-fired samples. Hartenstein (2008) does not provide information on chemical composition of any fuels that are comparable to high sodium ND lignite where SCR installation have been installed and tested or successfully operated.

10. The fact that various units firing Texas lignite are being equipped with HDSCRs shifts the arguments to the different compositions between Texan and North Dakotan lignite. Even though biomass such as wood and straw have very similar if not higher sodium and potassium contents than ND lignite and are burned in boilers, which are equipped with HDSCRs and have successfully operated in Europe for some time<sup>27, 28, 29</sup>, it is not necessarily relevant to provide such "information on chemical composition of any fuels that are comparable to high sodium ND lignite where SCR installation have been installed and tested or successfully operated." It would be much more relevant to properly characterize the flue gas downstream of the wet scrubber of MRYS Unit 2 so that it could be compared to similar flue gases upstream of successful TESCR installations. However, such data properly characterizing the flue gas for a possible TESCR installation at MRYS was never provided.

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<sup>26</sup> <http://www.wirtschaftsblatt.at/home/oesterreich/unternehmen/steiermark/337197/index.do>

<sup>27</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>28</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

<sup>29</sup> Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehrnschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia

11. No examples were provided of on-line cleaning methods nor catalyst that would prove resistant to damage from such methods that would be effective in removing surface blinding and pore plugging deposits such as those seen in the Coyote pilot test catalyst even with the suggested edge erosion prevention measures in place. Hans Hartenstein does not address this issue in his comments. Hartenstein implies in his report (2008), that catalyst that has been poisoned by sodium compounds can be regenerated in-situ, and that this technique is well developed. There is extremely limited experience with in-situ catalyst cleaning on coal-fired units. It has never been used for blinded or chemically poisoned catalyst, but only for mechanically plugged catalyst (see Appendix A).

11. The statements that “there is extremely limited experience with in-situ catalyst cleaning on coal-fired units” and that “it has never been used for blinded or chemically poisoned catalyst, but only for mechanically plugged catalyst” are both incorrect. In-situ catalyst regeneration for chemically (mostly sodium and potassium) poisoned catalyst has been successfully used in Europe since 1996<sup>30, 31</sup> and is still used today. On-site ex-situ as well as in-situ catalyst washing is being regularly performed i.e. in Avedoere 2 in Denmark in order to reverse the alkali poisoning, pore plugging and surface blinding layers resulting from the biomass combustion<sup>32</sup>. In-situ regeneration for the removal of surface blinding layers has been used in Europe successfully even in TESCOs for several years now<sup>33, 34</sup>,<sup>35</sup> as this process is ideally suited to remove highly water soluble constituents including alkali (sodium and potassium) and sulfate compounds from the catalyst.

#### Specific Comments to the Document’s Section “SCR Technology Review and Update”:

The statement that “the reports provided by Hartenstein were not peer reviewed and were derived primarily from companies who have vested interests in the SCR technology and typically do not

<sup>30</sup> Entwicklung und Einsatz eines Regenerationsverfahrens für SCR-Katalysatoren, Dr. Herwig Maier et. al., VGB Kraftwerkstechnik 1998

<sup>31</sup> Reference List Catalyst Regeneration Integral-Umwelttechnik GmbH

<sup>32</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

<sup>33</sup> Stadtwerke Düsseldorf AG, Müllverbrennungsanlage, a presentation by Uwe Behrendt SWD, Wildeshausener Katalysatorstage 2008, Wildeshausen, Germany

<sup>34</sup> Regeneration von Katalysatoren im Rahmen einer Kapazitätssteigerung, a presentation by Dr. Jürgen Böseke, 2008 Wildeshausener Katalysatorstage, Wildeshausen, Germany

<sup>35</sup> Was kann die Katalysatorregeneration zur Temperaturabsenkung beitragen?, a presentation by Dr. Alexander Schüttig, Wildeshausener Katalysatorstage 2008, Wildeshausen, Germany

discuss problems and challenges” is incorrect. The reports and literature cited was mostly authored or co-authored by utilities, EPRI, and other reputable industry organizations. Also, the majority of Hartenstein’s publications were presented at reputable industry conferences such as the DOE SCR Conference, the EPRI SCR Workshop, the NOx Roundtable, the Mega Symposium, etc. most of which require peer reviews of the paper prior to acceptance.

The mini-survey I conducted among the exact same experienced and knowledgeable SCR system suppliers and catalyst manufacturers contacted by Burns & McDonnell was obviously derived “from companies who have vested interests in the SCR technology.” Also, the depth of the survey was not significant as time didn’t permit a more detailed interrogation of the companies. However, the depth of the survey conducted by Burns & McDonnell among the exact same companies concerning HDSCR was not much greater either. It is therefore most interesting to note that the responses of these same SCR system suppliers and catalyst manufactures to the survey conducted Burns & McDonnell concerning HDSCR were considered unquestionably valid and indisputably correct by Burns & McDonnell for inclusion in their initial report while the responses by the same companies and often even the same individuals concerning TESCO are attempted to be disqualified as coming from people who “typically do not discuss the problems and challenges.” This gives the distinct impression that the credibility and integrity of the companies and individuals, whose responses and technical comments were initially used by Burns & McDonnell’s attempt to prove the technical infeasibility of HDSCR, is now only being questioned because their responses concerning the technical feasibility of TESCO don’t seem to fit the agenda.

The entire section concerning the blinding and poisoning mechanisms including popcorn ash pluggage caused by large particle ash, pore pluggage potentially caused by very small fly ash particles, masking of the marcosurface and poisoning of the active sites as elaborated on pages 9 through 26 is certainly not being disputed concerning its scientific correctness. However, these arguments are all directed to catalyst installed in a HDSCR system and therefore largely irrelevant for catalyst installed in a TESCO system as the flue gas composition and characteristics are fundamentally different. Furthermore, even though correct, they don’t prove by any means what the catalyst deactivation rate would be neither in an HDSCR nor in a TESCO. A much better approximation for the catalyst deactivation rate to be expected can be derived from full scale HDSCR data of units burning biomass with similar alkali contents. These units equipped with HDSCRs are successfully operated in Europe and some actual full scale catalyst deactivation data has been published. Units equipped with TESCO co-firing biomass are operated successfully in Europe and some actual full scale catalyst deactivation data has also been published<sup>36</sup>.

As valid as all the described mechanisms and the presented data may be for scientifically explaining the various types of deactivation they do not allow any definitive conclusions concerning the exact deactivation rate of catalyst installed in an HDSCR and even less so in a TESCO. More broadly worded, the presented arguments and data certainly support the

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<sup>36</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

expectation that catalyst deactivation in a HDSCR will be more rapid than typically observed for most sub-bituminous coals in HDSCR. Also, it is an indisputable fact that the combustion of many bituminous coals, particularly many Southern Illinois Basin coals containing high quantities of arsenic and little calcium, result in much more rapid catalyst deactivation in HDSCRs than observed for most sub-bituminous coals<sup>37</sup>. Several units in the U.S. burning Southern Illinois Basin coal are known to have exchanged, regenerated or added catalyst in their HDSCRs well before an operating time of 10,000 hours was reached, which was randomly defined by the Department as a minimum time for successful operation. Just because the arsenic poisoning of the catalyst was more rapid than initially expected, this doesn't mean the HDSCR operation of these units has been unsuccessful and these plants continue to operate this way.

The most obvious solution for the stated problem of the claimed catalyst deactivation rate resulting from burning ND lignite results from various fly ash particle-bound mostly alkali compounds would be to remove as much of the fly ash particles as possible upstream of the SCR. This can easily be accomplished by means of an ESP or baghouse and a wet scrubber in order to minimize the effect of these fly ash particle-bound compounds. The result is a TESCR.

The biomass data provided in the Document is very useful as it offers some insight into the possible deactivation rates of a HDSCR that could be expected at MRYS. Since HDSCRs have been in operation on biomass fired boilers since 2001<sup>38, 39</sup>, this allows some composition comparison of biomass (i.e. wood) and ND lignite. The fuels listed in Tables 2 through 5 of the Document are mostly woods of various types. A comparison to ND lignite is shown in the table below. As stated in the Document, wood is similar to ND lignite in its composition and variability.

	Center lignite		Biomass (woods)	
	Historical	Future	Range	average
Heating value [ $10^6$ Btu/lb]	13.2	13.4	6.8 – 9.1	8.3
Ash content [%wt.]	9.6	7.8	0.3 – 20.4	6.0
CaO [%wt. in ash]	13.2	17.0	5.8 – 49.9	20.9
K <sub>2</sub> O [%wt. in ash]	1.3	1.0	0.2 – 22.4	7.7
MgO [%wt. in ash]	4.0	5.1	1.8 – 18.4	4.3
Na <sub>2</sub> O [%wt. in ash]	4.4	5.6	0.1 – 23.5	3.1

Likewise is the association of alkali and alkaline earth elements in Center lignite similar to the associations found in biomass. Thus, it seems to be not unreasonable to expect that the catalyst

<sup>37</sup> Kramer, M., C. Gerlach, H. Hartenstein, "As<sub>2</sub>O<sub>3</sub> and SO<sub>2</sub> Testing at Hoosier Energy's Merom Generating Station", The 2007 EPRI Workshop on Selective Catalytic Reduction, Pensacola, FL, 2007

<sup>38</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>39</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

deactivation in HDSCRs installed on units burning 100% biomass of similar composition and variability should be similar to the one of catalyst in a HDSCR burning ND lignite.

The deactivation rate of the HDSCR catalyst at Elsam's Avedoere Unit 2 was found to be about 25% per 8,000 HDSCR operating hours when burning 100% biomass (mostly wood and some straw) while it was found to be only about 10 – 11% per 8,000 HDSCR operating hours when burning 100% bituminous coal<sup>40</sup>. Thus, the catalyst deactivation was found to be about 2.5 times higher for biomass than for bituminous coal. However, a catalyst deactivation of around 25% per 8,000 HDSCR operating hours has also been observed for several units in the U.S., particularly for those burning high arsenic coal without limestone mitigation. In other words the full scale HDSCR catalyst deactivation experience of a unit burning 100% biomass, which is very similar and therefore directly comparable to ND lignite, was found to be virtually identical with the full scale HDSCR catalyst deactivation of many U.S. units burning high arsenic bituminous coal. Needless to say that the catalyst deactivation to be expected in a TESCO where virtually all of the fly ash associated particle-bound compounds have been removed upstream of the catalyst will be considerably less.

There is no question that the flue gases from combusting ND lignite will cause a relatively rapid catalyst deactivation of a HDSCR catalyst. However the rate of catalyst deactivation is indisputably a function of the mass flow of catalyst poisons, which is dramatically reduced in a TESCO compared to a HDSCR.

#### **Specific Comments to the Document's Section "Variability of Lignite":**

The Document incorrectly quotes me and my "experience with German Ruhr Brown coal as described in a paper by Hartenstein and others (1999)." Besides the fact that German Ruhr coal is bituminous coal and not brown coal or lignite as incorrectly indicated in the Document, the paper describes the effect of alkali compounds on the adhesiveness of fly ash, which in combination with the incorrect catalyst selection resulted in physical pluggage problems. Catalyst deactivation due to these alkali compounds occurred only during start-up and shut down of the units when the flue gas went through the dew point. This results in the mobility of these highly water soluble compounds and the reaction with in water dissociated alkali ions ( $\text{Na}^+$ ,  $\text{K}^+$ ) with the catalyst's active compounds  $\text{V}_2\text{O}_5$ .

Neither of these two issues, however, caused the technical or economical feasibility of HDSCR to be questioned. The pluggage issue was resolved by the selection of the correct catalyst type and pitch and the catalyst deactivation was mitigated by limiting the number of times the flue gas inside SCR reactor went through the dew point. Both issues were already pointed out in my report.

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<sup>40</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

### **Specific Comments to the Document's Section "Results of the Coyote Pilot Testing":**

The Document quotes me as describing the Coyote Pilot Testing as "ill-designed." This quote is certainly correct but only repeats me quoting the Department who characterized the Coyote Pilot Testing as "ill-designed" (page 7 second line) and concluded that it "didn't provide much useful data" (page 7, first line). This view was confirmed by catalyst suppliers such as CERAM and SCR system suppliers such as Babcock Power. I agree with this view regardless of who was all involved in or reviewed the design of the test reactor and the test. The fact alone that the catalyst was too plugged for Haldor Topsoe to perform activity testing proves that not much useful data could be derived from the test. In essence the only useful result of the Coyote Pilot Tests seem to have been that it was recognized that a 6 mm pitch catalyst is not suitable for a HDSCR application featuring highly adhesive fly ash. Not surprisingly, this is a very similar result as described in my 1999 paper for E.ON's (not RWE's as erroneously claimed in the Document) Staudinger Generating Station Units 1 and 2 where the pluggage problem was solved by either a different coal blend or by installation of a 10 mm pitch catalyst as shown in Figure 11 of said paper<sup>41</sup>.

### **Specific Comments to the Document's Section "Soluble Sodium":**

This section describes in detail the effects of soluble sodium on catalyst in a HDSCR installation. While these described effects are not disputed, the section, however, fails to provide any data that allows for estimating a catalyst deactivation rate in a HDSCR. Furthermore, it doesn't even address the issue in a TESCO as most water soluble sodium compounds will be removed in the wet scrubber upstream of a TESCO and therefore are unlikely to pose a rapid deactivation threat for TESCO catalyst.

### **Specific Comments to the Document's Section "Differences in Flue Gas Composition":**

The Document fails to allude to what differences there may be between flue gases from combusting ND lignite and flue gas from combusting biomass. As a matter of fact the Document states that "the abundance of rich alkali aerosols is similar to that found in biomass combustion systems." As described earlier, HDSCRs have been in successful operation for several years in units burning 100% biomass<sup>42, 43</sup>, which renders the Document's claim invalid that no examples exist of a fuel fired in a boiler that produces a flue gas that is characteristic of flue gases produced from ND lignite where SCR has been installed and successfully operated.

<sup>41</sup> Hartenstein, H., H. Gutberlet, "Utility Experience with SCR in Germany", DOE Conference on SCR/SNCR, Pittsburgh, PA, USA 1999

<sup>42</sup> Cleaner Fossil Fuel For Sustainable Development, Co-Firing Coal and Biomass, a presentation by Henrik Noppenau, Elsam (Energie E2 until 07/01/2006), Denmark

<sup>43</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

**Specific Comments to the Document's Section "Catalyst Poisoning, Blinding and Plugging" and Applicability of SCR Development for Texas Lignite":**

Again, both of these sections refer only to HDSCR and entirely ignores that these issues are much less if not irrelevant in a TESCR application.

**Specific Comments to the Document's Section "SCR Catalyst Erosion and Cleaning":**

This section refers also only to HDSCR and ignores TESCR. However, it also incorrectly claims that catalyst does not withstand highly erosive flue gas and/or on-line cleaning measures such as aggressive sootblowing. HDSCR systems are successfully operated on boilers burning coals with up to 30% ash, which not only creates a highly erosive flue gas but also requires very aggressive sootblowing. Properly selected catalyst has been shown to withstand this without major erosion damage for many years<sup>44</sup>.

The Document also claims incorrectly that EnBW in Germany developed an in-situ cleaning technique, which has never been a commercial success. As pointed out earlier, simple catalyst washing either in-situ or on site is an effective method to quickly remove alkali poisoning from the catalyst. This has been demonstrated for more than a decade<sup>45, 46, 47, 48, 49</sup> and is currently regularly used for units with HDSCRs burning biomass in Europe (i.e. Elsam's Avedoere Unit 2)<sup>50</sup>. In-situ regeneration is also used within the EDF group including EnBW and numerous operators of various smaller SCR's i.e. in waste-to-energy plants<sup>51, 52, 53</sup>.

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<sup>44</sup> Personal conversations with plant personnel at Evonik's Fenne, Herne and Walsum Generating Stations

<sup>45</sup> Entwicklung und Einsatz eines Regenerationsverfahrens für SCR-Katalysatoren, Dr. Herwig Maier et. al., VGB Kraftwerkstechnik 1998

<sup>46</sup> Successful experience with In.situ Regeneration of SCR Catalyst in Coal-Fired Applications, Dr. Herwig Maier et. al., EnBW, 2000 DOE Conference on SCR / SNCR, Pittsburgh 2000

<sup>47</sup> Recent Experience with SCR Catalyst Regeneration, Dr. Herwig Maier et. al., EnBW, 2001 DOE Conference on SCR / SNCR, Pittsburgh 2000

<sup>48</sup> Reference List Catalyst Regeneration Integral Umwelttechnik GmbH

<sup>49</sup> Mobile Katalysatorregeneration in der praktischen Bewährung, Dr. Herwig Maier et. al. EnBW Kraftwerke AG, VGB Konferenz Chemie im Kraftwerk, 2006

<sup>50</sup> Washing Your Own Catalyst, a presentation Nathan White, Haldor Topsoe, NOx Round Table 2007, Cincinnati, Ohio

<sup>51</sup> Stadtwerke Düsseldorf AG. Müllverbrennungsanlage, a presentation by Uwe Behrendt SWD, Wildeshausener Katalysatorstage 2008, Wildeshausen, Germany

### **Specific Comments to the Document's Section "Pilot Testing for SCR Catalyst":**

It is interesting that Burns & McDonnell disagrees with all the catalyst suppliers and SCR vendors that pilot testing is not needed for TESCO at MRYS while Burns & McDonnell in its attempt to prove the technical infeasibility of HDSCR at MRYS relied heavily on exactly the same catalyst suppliers and SCR vendors.

### **Specific Comments to the Document's Section "Vendor Guarantees":**

Both seem to imply that vendors lightly guarantee anything without hesitation, which is inconsistent with my experience. To the contrary in my experience vendors do not lightly and without hesitation guarantee anything but carefully consider their process performance guarantees. In my opinion, the vendors would not suggest TESCO as technically feasible and available for this application if they would not be willing to provide the proper associated process performance guarantees. What benefit would the queried vendors derive from suggesting that TESCO would be technically feasible and available for MRYS if they would not be willing to provide the proper associated process performance guarantees at the same time?

### **Specific Comments to the Document's Section "Temperature Variation for HDSCR":**

As already stated in my report HDSCR will not work at MRYS without a solution for the temperature variation problem such as for example adequately modifying the boiler's economizer sections.

### **Specific Comments to the Document's Sections "Burns & McDonnell's SCR Experience" and "Comments by Sargent and Lundy on SCR Experience:**

Neither one of these two A/E firms disputes my claims that they have no SCR operating experience and have never provided any SCR system or catalyst performance guarantees of any kind.

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<sup>52</sup> Regeneration von Katalysatoren im Rahmen einer Kapazitätssteigerung, a presentation by Dr. Jürgen Böseke, 2008 Wildeshausener Katalysatorstage, Wildeshausen, Germany

<sup>53</sup> Was kann die Katalysatorregeneration zur Temperaturabsenkung beitragen?, a presentation by Dr. Alexander Schüttig, 2008 Wildeshausener Katalysatorstage, Wildeshausen, Germany

**Specific Comments to the Document's Section "Comments on Hans Hartenstein's Qualification for Expert SCR Opinions":**

No comment.

**Specific Comments to the Document's Section "Fuel Switching":**

No comment.

**Specific Comments to the Document's Section "Non-SCR NO<sub>x</sub> Controls":**

No comment.

**Specific Comments to the Document's Section "Conclusions":**

No comment.

**Specific Comments to Appendix A "Qualifications"**

The author erroneously claims that "all waste-to-energy plants in Europe have either activated carbon injection or fixed activated carbon plants", which "take out all the poisons such as all acidic components, arsenic etc. from the flue gas" upstream of the SCR. This statement is incorrect since many waste-to-energy units in Europe have:

- TESCRs directly downstream of a wet scrubber and no activated carbon injection or fixed bed activated carbon plants upstream of the SCR. The waste-to-energy plants AEZ Asdonkshof, Germany and MVA Bielefeld-Herford, Germany may serve as examples for this TESCR arrangement<sup>54, 55</sup>.
- LDSCRs directly downstream of the ESP and upstream of the acid gas removal system. The waste-to-energy plants KVA Basel, Switzerland and MVA Würzburg, Germany may serve as examples for this LDSCR arrangement<sup>56, 57</sup>.

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<sup>54</sup> <http://www.aez-asdonkshof.de/mva.html>

<sup>55</sup> Regeneration von Katalysatoren im Rahmen einer Kapazitätssteigerung, a presentation by Dr. Jürgen Böseke, 2008 Wildeshausener Katalysatortage, Wildeshausen, Germany

<sup>56</sup> <http://www.iwb.ch/site/rundgang/rundgang.php>

<sup>57</sup> <http://www.zvaws.de/verbrennung.html>

- HDSCRs directly downstream of or even integrated in the boiler. The waste-to-energy plant MHKW Mainz, Germany may serve as an example for this HGSCR arrangement<sup>58</sup>.

### Specific Comments to Appendix A "Missing Information"

The author claims that "more than 20,000 MW of lignite fired units in Germany were not required to install SCR in order to comply with the regulations." Even though this statement is correct the following statement that "these units were exempted from the regulation despite the fact that they would not achieve the required emission limit of 200 mg/Nm<sup>3</sup>" is simply incorrect. Correct is that the lignite-fired units have to meet the same NOx emission limit of 200 mg/Nm<sup>3</sup>, however have been able to achieve this with primary measures only such as low NOx burners<sup>59</sup>.

The author erroneously claims that "Germany had only one cyclone-fired (slag tap) unit with a SCR system. This unit is Walsum 7, the NOx control system is a LDSCR." Evonik's Walsum Unit 7 a U-fired and not a cyclone fired wet bottom boiler. It is equipped with a LDSCR with flue gas reheating downstream of a cold-side ESP<sup>60</sup>. However, numerous cyclone-fired units with HDSCRs and TESCRs exist in Germany. At least two units, namely E.ON's cyclone fired Staudinger Units 1 and 2 equipped with HDSCR should be known to the author as they are extensively discussed in my 1999 paper<sup>61</sup>.

The author erroneously claims that one "cannot send saturated gas from the scrubber to the gas-gas heat exchanger (GGH) for the TESCR." In the following paragraph the author continues to erroneously claim that "there is no TESCR on any utility boiler anywhere in the world that uses this configuration successfully downstream of a wet FGD." Evonik's Marl Units 3, 4 and 5 may serve as one of many plants where exactly this has been successfully in operation for over 20 years now<sup>62</sup>. The flue gas from the wet scrubber enters an axial booster fan upstream of the TESCR GGH. In order to avoid any CaSO<sub>4</sub> deposits on the fan blades, a small amount of flue gas is recirculated from downstream of the TESCR back to upstream of the booster fan. However, many wet FGDs in Europe are equipped with GGH around the scrubber, thus cooling the flue gas prior to entering the scrubber and reheating immediately after leaving the scrubber. In all of these GGHs the wet, saturated flue gases coming from the scrubber enter the GGH's heating surfaces. Of course regular on-line washing is necessary to keep the heating surfaces clean, which, however, is no different than on-line sootblowing in a boiler. These systems have

<sup>58</sup> <http://www.mhkw-mainz.de/anlagetechnik/index.php>

<sup>59</sup> Dreizehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Großfeuerungsanlagen) - 13. BImSchV. Bundesdrucksache Bundesrepublik Deutschland, 1983

<sup>60</sup> Personal conversation with plant personnel of Evonik's Walsum Generating Station

<sup>61</sup> Hartenstein, H., H. Gutberlet, "Utility Experience with SCR in Germany", DOE Conference on SCR/SNCR, Pittsburgh, PA, 1999

<sup>62</sup> Personal conversation with plant personnel of Evonik's Marl Generating Station

been in successful operation for more than 25 years now so that this must be considered a well proven concept. Interestingly enough the author acknowledges the existence of these FGD GGHs, which are exactly the same piece of equipment as the TESCO GGH, however, he fails to explain why the FGD GGHs work well and the TESCO GGHs wouldn't.

The author also erroneously states that "the required FGD removal efficiency was about 80%." The fact of the matter is that the minimum required SOx removal efficiency has been 85% regardless of the SOx concentration in the flue gas since 1983<sup>63</sup>. Likewise the maximum permissible SOx outlet concentration at the stack was 400 mg/Nm<sup>3</sup> (~140 ppm) between 1983 and 2004 and 200 mg/Nm<sup>3</sup> (~70 ppm) since 2004<sup>64</sup>. This means that the SOx removal efficiency at full load and design coal has typically been well above 90% and in many cases above 95%, with a minimum of 85% even at very low SOx inlet concentrations.

### Specific Comments to Appendix A "Incorrect Information"

My comments mostly address only issues that weren't addressed earlier already and are relevant for the discussion.

The author claims that it is incorrect that no flue gas reheating is typically required for HDSCR and LDSCR. Since the vast majority of the coal-fired units equipped with SCRs in North America are base loaded units, they typically run at full or close to full load for the majority of the time. In this operating mode typically no flue gas reheating is required. Also, economizer bypasses or split economizers are commonly not considered as flue gas reheating since no additional heat energy is added to the flue gas but only the amount of heat energy extracted from the flue gas is limited during low load operation.

The author erroneously claims that "not a single coal-fired unit with a LDSCR or TESCO system has a heat exchanger other than rotary." This statement is incorrect and E.ON's Westerholt Power Station Units 1 & 2, which had TESCOs equipped with Balcke-Dürr plate type cross flow GGHs, may serve as an example. The 150 MW wet bottom boiler units were built in the early 1960, retrofitted with wet FGDs and TESCOs in the late 1980s and decommissioned and demolished in 2006 after almost 45 years of service<sup>65, 66</sup>.

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<sup>63</sup> Dreizehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Großfeuerungsanlagen) - 13. BImSchV. Bundesdrucksache Bundesrepublik Deutschland, 1983

<sup>64</sup> Novellierung der Dreizehnten Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über Großfeuerungs- und Gasturbinenanlagen - 13. BImSchV, Bundesdrucksache Bundesrepublik Deutschland, 2004

<sup>65</sup> Press release 10/08/200, Abstaltung des Kernkraftwerks Stade im Jahre 2003 geplant, E.ON Energie AG; Hannover, Germany

<sup>66</sup> [https://www.etde.org/etdeweb/details.jsp?osti\\_id=5422433](https://www.etde.org/etdeweb/details.jsp?osti_id=5422433)

The author obviously misunderstood my comment about the possible elimination of the heat rate penalty in case of a turbine limited unit. It is certainly correct that the more heat input is necessary for the same electrical output. What I meant to point out is that in case of turbine limited units, it is often possible to maintain the same electrical output despite using steam for reheating rather than having to reduce the electrical output of the unit as a result of the steam consumption for reheating.

The author erroneously claims that “there has never been another TESCO built after Siersdorf, which was finished in early 1991, in the U.S. or in Europe.” As already pointed out previously, VEB’s Rudow Unit 2 was retrofitted with a TESCO in 1994<sup>67</sup>. After that numerous TESOs were retrofitted to a wide variety of combustion process including at least one unit in North America, namely the waste-to-energy plant KMS Peel Units 1 through 5 in Mississauga, Ontario, which has been in successful operation since 2001<sup>68</sup>.

It is also worth noting that even though Siersdorf was shut down, the catalyst, which was installed in these TESOs still remains in operation today since no significant deactivation was observed. The TESCO catalyst originally installed in Siersdorf was installed in Evonik’s Voerde Generating Station’s Units West 1 and 2<sup>69</sup>.

#### **Specific Comments to Appendix A “Vendor Guarantees”**

No additional comment as this was already addressed previously.

#### **Specific Comments to Appendix A “Catalyst Poisons and Pilot Projects”**

No additional comment as this was already addressed previously.

#### **References and Literature Considered**

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2. Co-firing of biomass - evaluation of fuel procurement and handling in selected existing plants and exchange of information (COFIRING) - Part 2, Kraftwerk Schwandorf, Germany, Alterne ABV-NET V, Ruth Brökeland, C.A.R.M.E.N.

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<sup>67</sup> SCR Reference List, Fisia Babcock Environment GmbH

<sup>68</sup> Chandler, J., J. Gallant, H. Hartenstein, A. Licata, “Retrofit of a WTE Facility with SCR for NOx and PCDD/F Control and Na<sub>2</sub>S<sub>4</sub> Injection for Mercury Control”, DOE Conference on SCR/SNCR, Pittsburgh, PA, 1999

<sup>69</sup> Personal conversation with plant personnel at Evonik’s Voerde Generating Station

3. Considerations for Catalyst Deactivation and Regeneration When Firing Biomass, Dr. Greg Holscher, CERAM and Mark Ehrnschwender, Evonik Energy Services, 2008 NOx Round Table, Richmond, Virginia
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