



August 12, 2013

Via Personal Delivery

Jeff Derouen
Case No. 2012-00063
Kentucky Public Service Commission
211 Sower Blvd.
Frankfort, KY 40601

Re: Case No. 2012-00063 Sierra Club Comments on Big Rivers Electric Corporation
Mercury and Air Toxic Standards Testing

Dear Mr. Derouen,

Enclosed please find one original and ten (10) copies of Sierra Club Comments on Big Rivers Electric Corporation Mercury and Air Toxic Standards Testing, filed today via personal delivery and served on all parties via FedEx. Please let me know if you have any questions.

Sincerely,

Kristin A. Henry
Staff Attorney
Sierra Club
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AUG 12 2013

PUBLIC SERVICE
COMMISSION

COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION

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AUG 12 2013

PUBLIC SERVICE
COMMISSION

In the Matter of:

Application of Big Rivers Electric Cooperative for Approval of)
its 2012 Environmental Compliance Plan, Approval of its) CASE NO. 2012-00063
Amended Environmental Cost Recovery Surcharge Tariffs,)
and for the Certificates of Public Convenience and Necessity,)
and the Authority to Establish a Regulatory Account)

SIERRA CLUB COMMENTS ON BIG RIVERS ELECTRIC CORPORATION
MERCURY AND AIR TOXIC STANDARDS TESTING

Under Section 1.03 of the Stipulation and Recommendation that was approved by the Public Service Commission on October 1, 2013, in the above-captioned action, Big Rivers Electric Corporation was required to perform testing to demonstrate that its proposal would achieve compliance with the Mercury Air Toxics Standards Rule ("MATS"). Under the Stipulation and Recommendation, parties are allowed to submit comments on this testing report within 30 days of when it is filed with the Commission. Attached is an expert witness report of Dr. Ranajit ("Ron") Sahu and two attachments, which are incorporated by reference in their entirety into these comments, and represent Sierra Club's comments on the MATS testing performed by Big Rivers Electric Corporation.

Respectfully submitted,



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Dated: August 12, 2013

CERTIFICATE OF SERVICE

I certify that I mailed a copy of this Sierra Club Comments on Big Rivers Electric Corporation Mercury Air Toxics Standards Testing Reprint by first class mail on August 12, 2013 to the following:

James M. Miller, Esq.
Tyson Kamuf
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Kristin Henry

Commonwealth of Kentucky

Before the Public Service Commission

In the Matter of:

APPLICATION OF BIG RIVERS ELECTRIC)
CORPORATION FOR APPROVAL OF ITS)
2012 ENVIRONMENTAL COMPLIANCE)
PLAN, FOR APPROVAL OF ITS)
AMENDED ENVIRONMENTAL COST)
RECOVERY SURCHARGE TARIFF, FOR)
CERTIFICATES OF PUBLIC)
CONVIENENCE AND NECESSITY, AND)
FOR AUTHORITY TO ESTABLISH A)
REGULATORY ACCOUNT.)

Case No. 2012-00063

**EXPERT REPORT OF
DR. RANAJIT (“RON”) SAHU**

**On Behalf of
Sierra Club**

Public Version

August 12, 2013

1. INTRODUCTION AND QUALIFICATIONS

My name is Dr. Ranajit (“Ron”) Sahu and I have over twenty four years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment; soils and groundwater remediation; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving the federal Clean Air Act, Clean Water Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, Comprehensive Environmental Response, Compensation, and Liability Act, Superfund Amendments and Reauthorization Act, Occupational Health and Safety Act, National Environmental Policy Act, as well as various implementing regulations and related state statutes and rules); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality New Source Review permitting, Clean Air Act Title V permitting, Clean Water Act National Pollutant Discharge Elimination System permitting for industrial and storm water discharges, Resource Conservation and Recovery Act permitting, and others.); multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

I have a B.S., M.S., and Ph.D. in Mechanical Engineering, the first from the Indian Institute of Technology (Kharagpur, India) and the latter two from the California Institute of Technology (Caltech) in Pasadena, California. My research specialization was in the combustion of coal and, among other things, understanding air pollution aspects of coal combustion in power plants.

1 I have over twenty two years of project management experience and have
2 successfully managed and executed numerous projects in this time period. This includes
3 basic and applied research projects, design projects, regulatory compliance projects,
4 permitting projects, energy studies, risk assessment projects, and projects involving the
5 communication of environmental data and information to the public.

6 I have provided consulting services to numerous private sector, public sector and
7 public interest group clients. My major clients over the past eighteen years include
8 various steel mills, petroleum refineries, cement companies, aerospace companies, power
9 generation facilities, lawn and garden equipment manufacturers, spa manufacturers,
10 chemical distribution facilities, and various entities in the public sector including EPA,
11 the states of New York, New Jersey, and New Mexico, the U.S. Dept. of Justice,
12 California Department of Toxic Substances Control, and various municipalities. I have
13 performed projects in 48 U.S. states, numerous local jurisdictions and internationally.

14 In addition to consulting, I have taught courses in several Southern California
15 universities including UCLA (air pollution), UC Riverside (air pollution, process hazard
16 analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous
17 waste management) for the past seventeen years. In this time period I have also taught at
18 Caltech, my alma mater, at USC (air pollution) and at Cal State Fullerton (transportation
19 and air quality).

20 I have and continue to provide expert witness services in a number of environmental
21 areas discussed above in both state and federal courts as well as before administrative
22 bodies.

1 Additional details regarding my background and experience can be found
2 Attachment A, which includes my resume, list of publications and presentations
3 provided, a statement of compensation and my previous expert witness experience,
4 respectively.

5 Sierra Club retained my services to review the testing report filed by Big Rivers
6 Electric Corporation (“Big Rivers” or the “Company”), which purports to show that the
7 Company’s activated carbon injection/dry sorbent injection (“ACI/DSI”) proposal would
8 achieve compliance with the MATS rule without necessitating additional upgrades at
9 Green, Wilson, and Coleman power plants.

10 **2. SUMMARY OF OPINIONS**

11 **A. General**

12 Plants/Units Description

13 Green Units 1 and 2 are almost identical and have flue gas desulfurization (“FGD”)
14 controls. Wilson has an FGD and a Selective Catalytic Reduction control. Coleman 1/2
15 are identical but only Unit 1 has Rotating Over-Fire Air. Coleman Unit 3 is similar in
16 size to Units 1/2. All 3 Coleman units connect to a single FGD, with a common stack.

17 Baseline Data

18 The review did not focus on the baseline tests that are reported, only the test data
19 obtained using the DSI and ACI controls at the various units. However, it should be
20 noted that at the Wilson unit, there was barely any reduction in mercury from baseline
21 (average 0.509 lb/TBtu) to controlled conditions (0.465 lb/TBtu, 0.528 lb/TBtu) runs.
22 Perhaps ACI may not have been used since baseline was below MATS. But this could
23 not be confirmed.

Missing information.

The review of the test results was significantly compromised because the test reports provided are not complete. Field notes, calibration data, data reduction calculations etc. are missing. In addition, significant process data are missing. Examples include:

- Missing coal information, including mercury concentrations, and coal flow rates
- Missing minute-by-minute generation (MW) during tests
- Missing minute-by-minute FGD operating parameters (slurry flow rate, gas flow rate) during tests

B. Review of Mercury Test Data

The table below shows the test run data (all values in lb/TBtu), collected using Method 30B (modified) as reported and also the date of each run.

Plant/Unit	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	99 UPL
Green 1 (no spec.)	3/26	3/26	3/27	3/27	3/28	3/28	
	0.988	0.693	0.935	0.938	1.08	0.865	1.227
Green 2 (all elemental)	3/20	3/20	3/20	3/21	3/21		
	1.10	1.18	1.09	1.16	0.944		1.348
Green-Both							1.256
Wilson (sig. oxidized)	4/13	4/13	4/13	4/14	4/14	4/14	
	0.401	0.488	0.504	0.492	0.599	0.494	0.646
Coleman 1 (18% oxd)	5/31	5/31	5/31				
	0.929	1.00	0.846				1.363
Coleman 2 (29% oxd)	6/8	6/8	6/10				
	0.695	0.817	0.986 (9% oxd)				1.663
Coleman 3 (22% oxd)	4/29	4/29	4/29				
	0.991	1.05	0.910				1.383
Coleman-All							1.13

2 Given the run-by-run variability, the table (last column) also shows the 99 UPL, a
3 metric that EPA used in setting the MACT floors, in order to account for variability.¹
4 The 99 UPL was calculated using spreadsheets similar to those used by the EPA in
5 setting the MATS floors.² Simply, the 99 UPL is the value that 99 percent of the time the
6 next run should fall under. Ideally, the 99 UPL should be below the standard. As the

¹ For more discussion on the 99 UPL in relation to the MATS rule, see the proposed rule at 76 FR 25041-25044, May 3, 2011.

² I used the same spreadsheet as EPA and re-ran the calculations many times for each case, I have included one spreadsheet as an example as Attachment B to these comments.

1 table above shows, however, the 99 UPL for all units, except for the Wilson unit, are
2 greater than the MATS mercury limit of 1.2 lb/TBtu. In addition, even when the data for
3 the multiple units at Green and Coleman are combined (because there is no reason to
4 believe that mercury emissions from these sister/identical units should be different), the
5 combined 99 UPL values for these two plants either exceed (for Green) or are close to the
6 MATS mercury limit.

7 While the averaging provisions of the MATS rule would provide for additional
8 compliance margin, given the numerous uncertainties and issues with the mercury tests,
9 as discussed below, at this stage, it is premature to conclude, based on observed run-to-
10 run variability, that the various units, except for Wilson, can actually meet the MATS
11 mercury limit.

12 Specific issues with the mercury test data are as follows.

13 1. Test reports do not provide any coal analysis data. Units burn Illinois Bituminous
14 coals. Mercury contents in these coals, like in all coals, can vary, often significantly.
15 Since no mercury data is provided for the coals that were used (during both baseline tests
16 as well as during the tests with ACI injection), one cannot be certain that future actual
17 coal mercury contents could not be higher, and therefore adversely affect the ability of
18 ACI, at the levels used, to limit mercury emissions to below the MATS levels. And, if
19 ACI injection rates end up needing to be increased, this may lead to greater PM
20 emissions.

21 2. Big Rivers' mercury tests used speciated 5-section sorbent traps which are
22 modified versions of EPA-approved Method 30B traps. Thus, the method used is not a
23 published reference method. The sampling was not performed isokinetically. In
24 addition, while it also appears that mercury CEMS were used (not clear if these were
25 used for all test runs, at all units), CEMS data are not provided in the test report. Nor is
26 there any data showing how the mercury CEMS data compared to the modified Method
27 30B data which are reported. All data collected should be reported.

1 3. While paired tubes were used, per Method 30B, the data from individual tubes
2 was not provided. Thus, the variability between these paired tubes could not be assessed.
3 Nor could data validation be conducted in the absence of these data.

4 4. The tubes themselves were analyzed in the field using a portable analyzer (Ohio
5 Lumex RA-915+ analyzer/RP 324 detector). While these types of field analyses are
6 useful for quick assessments, results from these are not the same as results that are
7 obtained by sending the Method 30B tubes to fixed laboratories for analysis. The test
8 reports do not contain data showing the side-by-side results obtained from the field
9 analyzer versus lab data – i.e., calibration or precision data for the field analyzer.
10 Without this, it cannot be presumed that the field analyzer data are accurate.

11 5. Mercury tests used temporary, portable injection methods for ACI (750 pound
12 supersacks, with temporary mixing approaches). While these temporary tests are useful
13 for diagnostic purposes, there is no discussion of how results will vary with full-scale
14 ACI implementation, especially when such injection continues over long periods of time.
15 Long term performance issues such as material handling, stratification, influence of
16 changing gas properties on the injected carbon, injection carbon particle size variability
17 and particle size distributions, effect of other trace pollutants on the injected carbon, etc.
18 cannot be assessed over the short durations over which these tests were conducted.

19 6. No details are provided on the specifications of the injected carbon used (stated in
20 the test report as “ACS DEV 2012 BBB”) during the temporary tests and how Big Rivers
21 will ensure that these properties will not change in the actual, full-scale, implementation
22 of ACI at these units. Similarly specifications of the lime sorbent used in the DSI are not
23 discussed. The interaction of the DSI and the ACI are also not discussed.

24 7. As shown in the table above, there is often considerable variability in the test data
25 – reflecting all types of variability such as in coal mercury content, and variability in the
26 injected mercury, mixing, stratification, etc. The causes and impacts of this variability
27 are not discussed or explained in Big Rivers’ report

8. Even at a given plant/unit, there was significant variability observed in mercury speciation (see, in particular, Coleman data) which is not explained. This is concerning since the units appear to be operating under similar conditions during the different runs.

C. Review of Filterable PM (fPM) Test Data

The table below shows the test run data (all values in lb/MMBtu), collected using Method 5 as reported and also the date of each run. Data for the Green units are not shown since they were significantly below the MATS fPM limit of 0.03 lb/MMBtu. However, if, as a result of having to meet the mercury MATS limits, as discussed above, significantly more ACI may need to be used, the impact of this additional ACI on fPM should be reassessed.

Plant/Unit	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	99 UPL
Wilson	4/13	4/13	4/13	4/14	4/14	4/14	
	0.00925	0.0126	0.0221	0.0158	0.0216	0.0106	0.0284
Coleman 1	5/31	5/31	5/31				
	0.027	0.0218	0.0254				0.0398
Coleman 2	6/8	6/8	6/10				
	0.0243	0.0289	0.0119				0.072
Coleman 3	4/29	4/29	4/29				
	0.0127	0.0140	0.0163				0.0247
Coleman-All							0.033

Given the run-by-run variability, the table (last column) also shows the 99 UPL, a metric that EPA used in settling the MACT floors, in order to account for variability. Simply, the 99 UPL is the value that 99 percent of the time that the next run should fall under. Ideally, the 99 UPL should be below the standard. As the table above shows, however, the 99 UPL for Coleman Units 1 and 2 are greater than the MATS fPM limit of 0.03 lb/MMBtu. In addition, when the data for the three Coleman units are combined

1 (because there is no reason to believe that fPM emissions from these sister/identical units
2 should be different), the combined 99 UPL value for fPM for Coleman appears to exceed
3 the MATS fPM limit.

4 While the averaging provisions of the MATS rule would provide for additional
5 compliance margin, given the numerous uncertainties and issues noted above, at this
6 stage, it is premature to conclude, based on observed run-to-run variability, that the
7 various units, except for the Green units, can actually meet the MATS fPM limit.

8 Similar to concerns noted in the mercury data assessment, it should be noted that
9 the impact of injected ACI and DSI on fPM levels over the long-term is not assessed.
10 This impact should be addressed for the Wilson and the Coleman units.

11 This concludes my analysis of the report.

ATTACHMENT A

RANAJIT (RON) SAHU, Ph.D, QEP, CEM (Nevada)

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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Alhambra, CA 91801
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EXPERIENCE SUMMARY

Dr. Sahu has over twenty four years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment; soils and groundwater remediation; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over twenty one years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public. Notably, he has successfully managed a complex soils and groundwater remediation project with a value of over \$140 million involving soils characterization, development and implementation of the remediation strategy, regulatory and public interactions and other challenges.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty one years include various steel mills, petroleum refineries, cement companies, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including EPA, the US Dept. of Justice, California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in over 44 states, numerous local jurisdictions and internationally.

Dr. Sahu's experience includes various projects in relation to industrial waste water as well as storm water pollution compliance include obtaining appropriate permits (such as point source NPDES permits) as well development of plans, assessment of remediation technologies, development of monitoring reports, and regulatory interactions. Over the years, he has provided consulting services relating to industrial wastewater pre-treatment options and permitting aspects to a range of clients [industrial, regulatory, public interest] for a range of industries including petroleum refineries, aerospace manufacturing, chemical distribution, brass foundry, electroplating operations, jewelry manufacturing, steel mills, and coal-fired power units.

In addition to consulting, Dr. Sahu has taught numerous courses in several Southern California universities including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management) for the past seventeen years. In this time period he has also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls) and at California State University, Fullerton (transportation and air quality).

Dr. Sahu has and continues to provide expert witness services in a number of environmental areas discussed above in both state and Federal courts as well as before administrative bodies (please see Annex A).

EXPERIENCE RECORD

- 2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.) public sector (such as the US Department of Justice) and public interest group clients with project management, air quality consulting, waste remediation and management consulting, as well as regulatory and engineering support consulting services.
- 1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for Air Quality/Geosciences/Hazardous Waste Groups**, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.
- Parsons ES, **Manager for Air Source Testing Services.** Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.
- 1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.
- 1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.
- 1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.
- 1988-1989 Heat Transfer Research, Inc. **Research Engineer.** Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

- 1984-1988 Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.

1984 M. S., Mechanical Engineering, Caltech, Pasadena, CA.
1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT)
Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.
"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.
"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.
"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.
"Thermodynamics and Heat Transfer," Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.
"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.
"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.
"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.
"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.
"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.
"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.
"Advanced Hazardous Waste Management" University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.
"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.
"Environmental Risk Assessment," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.
"Hazardous Waste Remediation" Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

"Air Pollution Controls," University of Southern California, Dept. of Civil Engineering, Fall 1993, Fall 1994.

"Air Pollution Fundamentals," University of Southern California, Dept. of Civil Engineering, Winter 1994.

University of California, Los Angeles

"Air Pollution Fundamentals," University of California, Los Angeles, Dept. of Civil and Environmental Engineering, Spring 1994, Spring 1999, Spring 2000, Spring 2003, Spring 2006, Spring 2007, Spring 2008, Spring 2009.

International Programs

"Environmental Planning and Management," 5 week program for visiting Chinese delegation, 1994.

"Environmental Planning and Management," 1 day program for visiting Russian delegation, 1995.

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

"Environmental Issues and Air Pollution," IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

President of India Gold Medal, IIT Kharagpur, India, 1983.

Member of the Alternatives Assessment Committee of the Grand Canyon Visibility Transport Commission, established by the Clean Air Act Amendments of 1990, 1992-present.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-present.

Air and Waste Management Association, West Coast Section, 1989-present.

PROFESSIONAL CERTIFICATIONS

EIT, California (# XE088305), 1993.

REA I, California (#07438), 2000.

Certified Permitting Professional, South Coast AQMD (#C8320), since 1993.

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2011.

LIST OF PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS (PARTIAL LIST)

"Physical Properties and Oxidation Rates of Chars from Bituminous Coals," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **67**, 275-283 (1988).

"Char Combustion: Measurement and Analysis of Particle Temperature Histories," with R.C. Flagan, G.R. Gavalas and P.S. Northrop, *Comb. Sci. Tech.* **60**, 215-230 (1988).

"On the Combustion of Bituminous Coal Chars," PhD Thesis, California Institute of Technology (1988).

"Optical Pyrometry: A Powerful Tool for Coal Combustion Diagnostics," *J. Coal Quality*, **8**, 17-22 (1989).

"Post-Ignition Transients in the Combustion of Single Char Particles," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **68**, 849-855 (1989).

"A Model for Single Particle Combustion of Bituminous Coal Char." Proc. ASME National Heat Transfer Conference, Philadelphia, **HTD-Vol. 106**, 505-513 (1989).

"Discrete Simulation of Cenospheric Coal-Char Combustion," with R.C. Flagan and G.R. Gavalas, *Combust. Flame*, **77**, 337-346 (1989).

"Particle Measurements in Coal Combustion," with R.C. Flagan, in "**Combustion Measurements**" (ed. N. Chigier), Hemisphere Publishing Corp. (1991).

"Cross Linking in Pore Structures and Its Effect on Reactivity," with G.R. Gavalas in preparation.

"Natural Frequencies and Mode Shapes of Straight Tubes," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Optimal Tube Layouts for Kamui SL-Series Exchangers," with K. Ishihara, Proprietary Report for Kamui Company Limited, Tokyo, Japan (1990).

"HTRI Process Heater Conceptual Design," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Asymptotic Theory of Transonic Wind Tunnel Wall Interference," with N.D. Malmuth and others, Arnold Engineering Development Center, Air Force Systems Command, USAF (1990).

"Gas Radiation in a Fired Heater Convection Section," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1990).

"Heat Transfer and Pressure Drop in NTIW Heat Exchangers," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1991).

"NOx Control and Thermal Design," Thermal Engineering Tech Briefs, (1994).

"From Purchase of Landmark Environmental Insurance to Remediation: Case Study in Henderson, Nevada," with Robin E. Bain and Jill Quillin, presented at the AQMA Annual Meeting, Florida, 2001.

"The Jones Act Contribution to Global Warming, Acid Rain and Toxic Air Contaminants," with Charles W. Botsford, presented at the AQMA Annual Meeting, Florida, 2001.

PRESENTATIONS (PARTIAL LIST)

"Pore Structure and Combustion Kinetics - Interpretation of Single Particle Temperature-Time Histories," with P.S. Northrop, R.C. Flagan and G.R. Gavalas, presented at the AIChE Annual Meeting, New York (1987).

"Measurement of Temperature-Time Histories of Burning Single Coal Char Particles," with R.C. Flagan, presented at the American Flame Research Committee Fall International Symposium, Pittsburgh, (1988).

"Physical Characterization of a Cenospheric Coal Char Burned at High Temperatures," with R.C. Flagan and G.R. Gavalas, presented at the Fall Meeting of the Western States Section of the Combustion Institute, Laguna Beach, California (1988).

"Control of Nitrogen Oxide Emissions in Gas Fired Heaters - The Retrofit Experience," with G. P. Croce and R. Patel, presented at the International Conference on Environmental Control of Combustion Processes (Jointly sponsored by the American Flame Research Committee and the Japan Flame Research Committee), Honolulu, Hawaii (1991).

"Air Toxics - Past, Present and the Future," presented at the Joint AIChE/AAEE Breakfast Meeting at the AIChE 1991 Annual Meeting, Los Angeles, California, November 17-22 (1991).

"Air Toxics Emissions and Risk Impacts from Automobiles Using Reformulated Gasolines," presented at the Third Annual Current Issues in Air Toxics Conference, Sacramento, California, November 9-10 (1992).

"Air Toxics from Mobile Sources," presented at the Environmental Health Sciences (ESE) Seminar Series, UCLA, Los Angeles, California, November 12, (1992).

"Kilns, Ovens, and Dryers - Present and Future," presented at the Gas Company Air Quality Permit Assistance Seminar, Industry Hills Sheraton, California, November 20, (1992).

"The Design and Implementation of Vehicle Scrapping Programs," presented at the 86th Annual Meeting of the Air and Waste Management Association, Denver, Colorado, June 12, 1993.

"Air Quality Planning and Control in Beijing, China," presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

STATEMENT OF COMPENSATION

My compensation for work in this matter is \$140.00 per hour.

PREVIOUS EXPERT WITNESS TESTIMONY

1. Matters for which Dr. Sahu has have provided depositions and affidavits/expert reports include:

- (a) Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill
- (b) Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.
- (c) Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the US Department of Justice in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (S.D. Ohio).
- (d) Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the US Department of Justice in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (S.D. Ill.).
- (e) Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the US Department of Justice in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (M.D.N.C.).
- (f) Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the US Department of Justice in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (S.D. Ohio).
- (g) Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.
- (h) Expert reports and depositions (10/31/2005 and 11/1/2005) on behalf of the US Department of Justice in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc.*, 5:04-cv-00034-KSF (E.D. KY).
- (i) Deposition (10/20/2005) on behalf of the US Department of Justice in connection with the Cinergy NSR Case. *United States, et al. v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (S.D. Ind.).
- (j) Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.
- (k) Expert report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.
- (l) Expert report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.

- (m) Expert report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.
- (n) Expert report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo's eight new proposed PRB-fired PC boilers located at seven TX sites.
- (o) Expert testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).
- (p) Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.
- (q) Expert reports and deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (W.D. Pennsylvania).
- (r) Expert reports and pre-filed testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.
- (s) Expert reports and deposition (October 2007) on behalf of MTD Products Inc., in connection with General Power Products, LLC v MTD Products Inc., 1:06 CVA 0143 (S.D. Ohio, Western Division)
- (t) Experts report and deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.
- (u) Expert reports, affidavit, and deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.
- (v) Affidavits (May 2010/June 2010 in the Office of Administrative Hearings)/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).
- (w) Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy et al., v Duke Energy Carolinas, LLC. in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).
- (x) Dominion Wise County MACT Declaration (August 2008)

- (y) Expert Report on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis (June 13, 2008).
- (z) Expert Report on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone's proposed Unit 3 in Texas (February 2009).
- (aa) Expert Report and deposition on behalf of MTD Products, Inc., in the matter of Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al. (June 2009, July 2009).
- (bb) Expert Report on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper's proposed Pee Dee plant in South Carolina (August 2009).
- (cc) Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.
- (dd) Expert Report (August 2009) and Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
- (ee) Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coletto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (October 2009).
- (ff) Expert Report, Rebuttal Report (September 2009) and Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.
- (gg) Expert Report (December 2009), Rebuttal reports (May 2010 and June 2010) and depositions (June 2010) on behalf of the US Department of Justice in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).
- (hh) Prefiled testimony (October 2009) and Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
- (ii) Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).
- (jj) Written Direct Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.
- (kk) Expert report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.

- (ll) Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the US EPA and US Department of Justice in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (US District Court for the Eastern District of Michigan).
- (mm) Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.
- (nn) Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).
- (oo) Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
- (pp) Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
- (qq) Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of Public Service Company of New Mexico (PNM)'s Mercury Report for the San Juan Generating Station, CIVIL NO. 1:02-CV-0552 BB/ATC (ACE). US District Court for the District of New Mexico.
- (rr) Comment Report (October 2010) on the Draft Permit Issued by the Kansas DHE to Sunflower Electric for Holcomb Unit 2. Prepared on behalf of the Sierra Club and Earthjustice.
- (ss) Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
- (tt) Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
- (uu) Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (US District Court for the Eastern District of Texas, Texarkana Division).
- (vv) Comment Report (December 2010) on the Pennsylvania Department of Environmental Protection (PADEP)'s Proposal to grant Plan Approval for the Wellington Green Energy Resource Recovery Facility on behalf of the Chesapeake Bay Foundation, Group Against

Smog and Pollution (GASP), National Park Conservation Association (NPCA), and the Sierra Club.

- (ww) Written Expert Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
- (xx) Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.
- (yy) Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (US District Court for the District of Colorado).
- (zz) Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority*, Civil Action No. 4:11-cv-00791 (US District Court for the Southern District of Texas, Houston Division).
- (aaa) Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
- (bbb) Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).
- (ccc) Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.*, Civil Action No. A-08-CA-648-LY (US District Court for the Western District of Texas, Austin Division).
- (ddd) Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.*, Case No. 3:10-cv-747 (TJM/DEP) (US District Court for the Northern District of New York).
- (eee) Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association*, Case No. 11-417-MJP (US District Court for the Western District of Washington).
- (fff) Expert Report (March 2012) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.*, Civil Action No. 4:10-cv-4969 (US District Court for the Southern District of Texas, Houston Division).

- (ggg) Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency*, Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).
- (hhh) Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plan) (Supreme Court of the State of Kansas).
- (iii) Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality*, Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).
- (jjj) Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.*, Civil Action No. 07-CV-5298 (JKG) (US District Court for the Eastern District of Pennsylvania).
- (kkk) Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project
- (lll) Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.
- (mmm) Expert report (August 2012) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.

2. Occasions where Dr. Sahu has provided Written or Oral testimony before Congress:

- (nnn) In July 2012, provided expert written and oral testimony to the House Subcommittee on Energy and the Environment, Committee on Science, Space, and Technology at a Hearing entitled "Hitting the Ethanol Blend Wall – Examining the Science on E15."

3. Occasions where Dr. Sahu has provided oral testimony at trial or in similar proceedings include the following:

- (ooo) In February, 2002, provided expert witness testimony on emissions data on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.
- (ppp) In February 2003, provided expert witness testimony on regulatory framework and emissions calculation methodology issues on behalf of the US Department of Justice in the Ohio Edison NSR Case in the US District Court for the Southern District of Ohio.
- (qqq) In June 2003, provided expert witness testimony on regulatory framework, emissions calculation methodology, and emissions calculations on behalf of the US Department of Justice in the Illinois Power NSR Case in the US District Court for the Southern District of Illinois.

- (rrr) In August 2006, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Western Greenbrier) on behalf of the Appalachian Center for the Economy and the Environment in West Virginia.
- (sss) In May 2007, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Thompson River Cogeneration) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) before the Montana Board of Environmental Review.
- (ttt) In October 2007, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Sevier Power Plant) on behalf of the Sierra Club before the Utah Air Quality Board.
- (uuu) In August 2008, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Big Stone Unit II) on behalf of the Sierra Club and Clean Water before the South Dakota Board of Minerals and the Environment.
- (vvv) In February 2009, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Santee Cooper Pee Dee units) on behalf of the Sierra Club and the Southern Environmental Law Center before the South Carolina Board of Health and Environmental Control.
- (www) In February 2009, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (NRG Limestone Unit 3) on behalf of the Sierra Club and the Environmental Integrity Project before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
- (xxx) In November 2009, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (Las Brisas Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
- (yyy) In February 2010, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (White Stallion Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
- (zzz) In September 2010 provided oral trial testimony on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (W.D. Pennsylvania).
- (aaaa) Oral Direct and Rebuttal Expert Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
- (bbbb) Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap*

and Trade Provisions, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

- (cccc) Oral Testimony (October 2010) regarding mercury and total PM/PM10 emissions and other issues on a remanded permit challenge (Las Brisas Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
- (dddd) Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.
- (eeee) Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.
- (ffff) Deposition (December 2010) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
- (gggg) Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).
- (hhhh) Oral Expert Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
- (iiii) Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (US District Court for the District of Colorado).
- (jjjj) Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
- (kkkk) Oral Testimony at Hearing (March 2012) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
- (llll) Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

UPL Calculation Example

Runs

Example Case

1	0.027
2	0.0218
3	0.0254
4	0.0243
5	0.0289
6	0.0119
7	0.0127
8	0.014
9	0.0163
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35	

UPL Calculation Example

ni = number test runs = 9 0 0 0 0 0 0 0 0 0 0 0

Number of sources = N 1

n = Total # test runs $\sum_{i=1}^N n_i$ 9

$df = \left(\sum_{i=1}^N n_i \right) - 1$ 8

This step is for QC only:

means $\bar{x}_i = \frac{1}{n_i} \sum_{k=1}^{n_i} x_{ik}$ 0.020255556

Mean = $\bar{X} = \frac{1}{n} \sum_{i=1}^N \sum_{j=1}^{n_i} x_{ij}$ 0.020255556

Pooled Variance = 4.33878E-05

$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{X})^2$

m= number future runs = 3

Term1 $\frac{1}{n} + \frac{1}{m}$ 0.444444444

Term2 $s^2 \left(\frac{1}{n} + \frac{1}{m} \right)$ 1.92835E-05

Squared root Term2 $\sqrt{s^2 \left(\frac{1}{n} + \frac{1}{m} \right)}$ 0.004391293

UPL Calculation Example

NOTE: the pvalue for the t-statistic is calculated as: $2 \cdot \alpha$, where $1 - \alpha$ is desired confidence, so if 99% confidence is desired then $\alpha = 0.01$ and $2 \cdot \alpha = 2 \cdot (0.01)$

t-statistic t_{df} = quantile t-distribution with df degrees of freedom at .99 confidence level = 2.896459448

99 UPL = 0.032974759

$$\bar{X} + t_{df, p} \sqrt{s^2 \left(\frac{1}{n} + \frac{1}{m} \right)}$$