Eskom Power Station Exceedances of Applicable Atmospheric Emission License (AEL) Limit Values for PM, SO2 & NOx During April 2016 to December 2017

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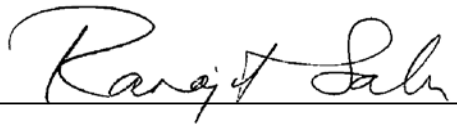

Summary

I have reviewed hardcopy monthly monitoring reports from 17 Eskom coal and gas power stations over a 21 month study period (April 2016 through December 2017). Based on my review, and after excluding the gas plants due to incomplete data, I have determined that the coal fired power stations reported nearly 3,200 exceedances of applicable daily Atmospheric Emissions Licenses (AEL) limits for particulate matter (PM), sulfur dioxide (SO2), and oxides of nitrogen (NOx). For reasons explained below, my conclusions are conservative and underestimate the true scope of the problem because I did not have access to clear and comprehensive data. The opinions provided in this report are based on my education, professional training, and twenty-eight years of experience in air pollution consulting and engineering, on behalf of clients in the private and public sector in the United States and internationally. Details of my experience are provided in my vitae provided in Attachment A.

Methodology

Each of Eskom's power stations produce monthly hardcopy emissions monitoring reports. While the reports do not appear to be standardized, most contain graphs of average daily emissions of SO2, NOx, and PM as well as corresponding plant-specific AEL limits.

I reviewed data for 14 of Eskom's 15 coal-fired power stations: Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Lethabo, Majuba, Matimba, Matla, Medupi, and Tutuka. All of

these plants have six units, except Camden, with eight units. Kusile was excluded from the analysis, as it did not come online before August 2017.

I also reviewed reports from the three gas powered stations of Acacia, Ankerlig and Gourikwa, but had to exclude them from my analysis: Acacia did not operate during the study period and Ankerlig and Gourikwa did not include daily average emissions in their monthly reports.

Twelve of the 14 reviewed stations are within the Mpumalanga Highveld airshed, which is a "priority area" in terms of the National Environmental Management Air Quality Act, 2004. (The two stations outside the Highveld Priority Area are Medupi and Matimba.) I accepted the reported data as accurate, since I do not have the capability to independently confirm the reported data. I assume that the monitors were being calibrated and maintained as needed, unless explicitly noted.

I counted the number of days from April 2016 through December 2017 where reported emissions exceeded the corresponding AEL limit value (21 recent months for which such data were available).

Occasionally some plants reported emissions as "raw" as well as "final" emissions. I did not consider raw emissions in my analysis.

Some plants also reported some exceedances as a violation of Section 30 of the National Environmental Management Act. I did not include such exceedances in my analysis.

Two plants (Ankerlig and Gourikwa) provided monthly reports but without the daily graphs. Thus I was unable to include them in my analysis of the daily emissions exceedances.

Fourteen monthly reports were missing or incomplete from a possible total of 294 for the 14 coal-fired plants: 7 from Tutuka (April through October 2017); 9 from Grootvlei (October and November 2016, and January, April, May, November and December 2017); 1 from Majuba (October 2017); and 1 from Matimba (October 2017).

Where monthly reports simply replicated all the graphs from previous months (e.g., Tutuka for October 2016, November 2016, and November 2017, as well as Tutuka for January 2017 and February 2017), I considered data from only one of these months – making my analysis conservative. I note that submittal of the exact same reports by a plant for multiple months without any corrections indicates that monitoring and reporting is incomplete and unreliable.

Finally, where reports had unreasonably high numbers (e.g., Grootvlei April 2016 and May 2016 for SO2 and NOx), I excluded such exceedances, again making my analysis conservative.

Results

Based on my analysis the power stations reported 3,181 violations of their applicable air emissions limits just during the April 2016 to December 2017 (21 months) time period. Details of the exceedances by plant and pollutant are presented in Figures 1-4 below.

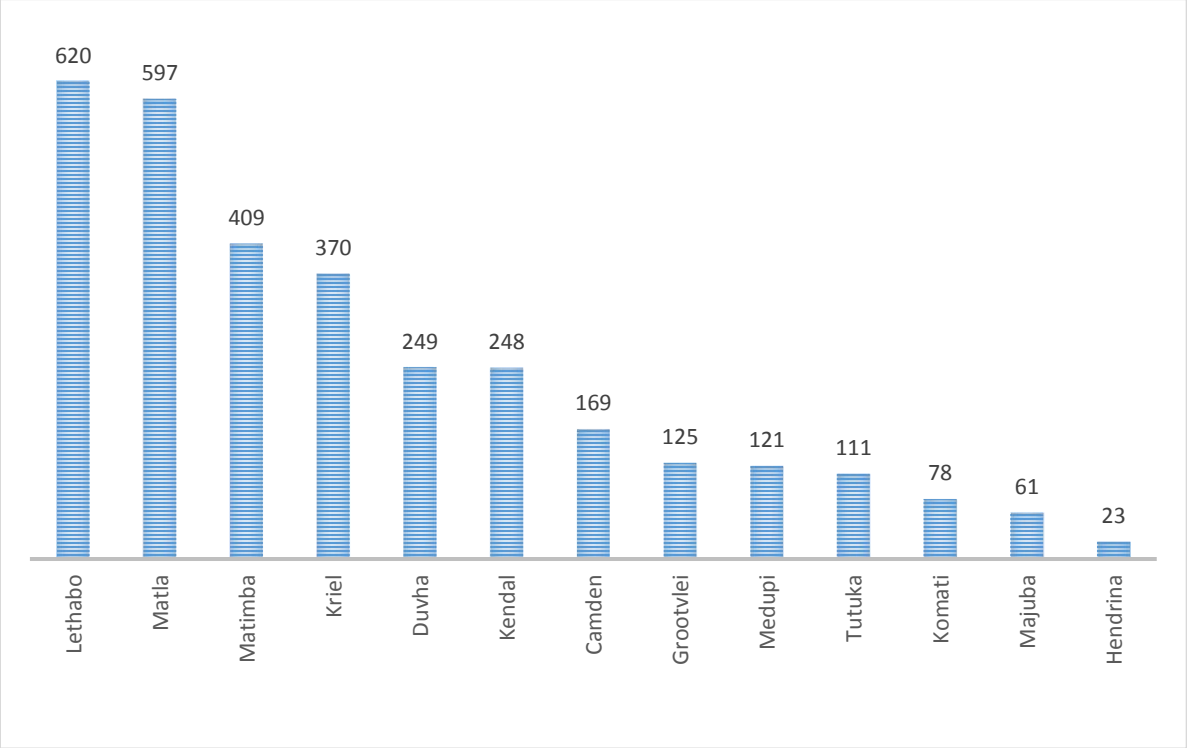

Figure 1. Number of exceedances of PM, SO2 and/or NOx AEL limits from April 2016 to December 2017. Arnot was the only plant reporting daily averages with no exceedances. Missing or excluded reports for Tutuka (10 months), Grootvlei (9 months), Majuba (1 month) and Matimba (1 month) mean actual exceedances may have been even higher.

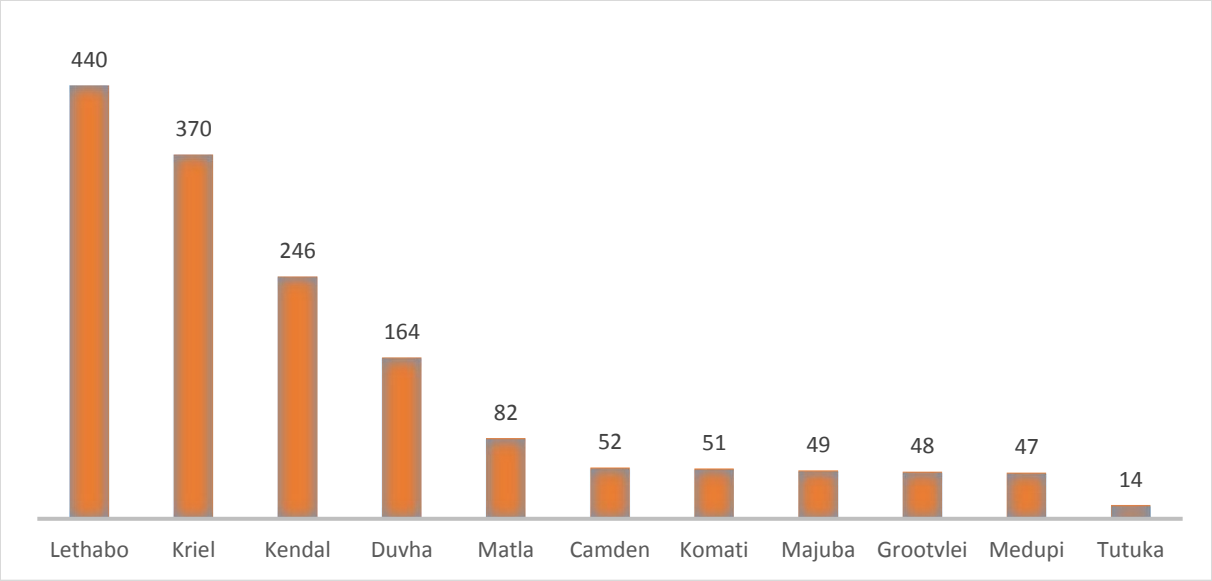

Figure 2. Number of PM AEL limit exceedances from April 2016 to December 2017. Stations reporting daily averages with no PM limit exceedances included Arnot, Hendrina and Matimba.

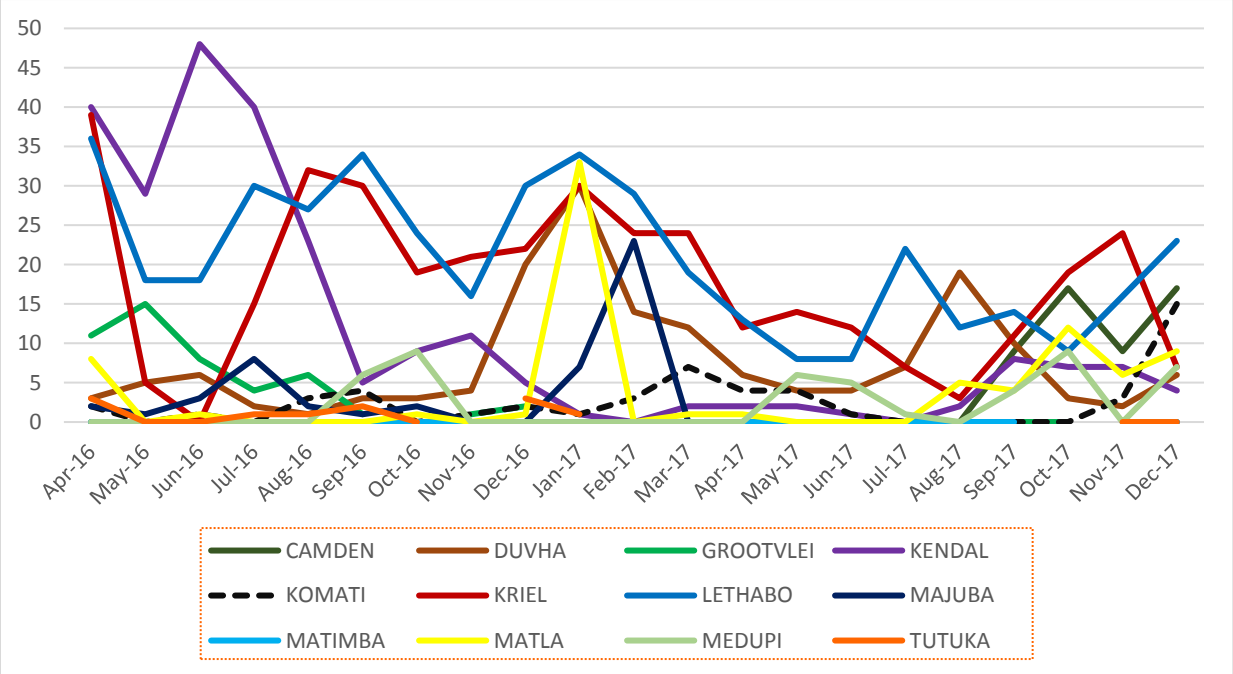

Figure 3. Exceedances of PM AEL limits by plant by month, April to December 2017. Many plants reported chronic PM limit exceedances for several consecutive months, particularly Kendal, Lethabo, Kriel, and Duvha.

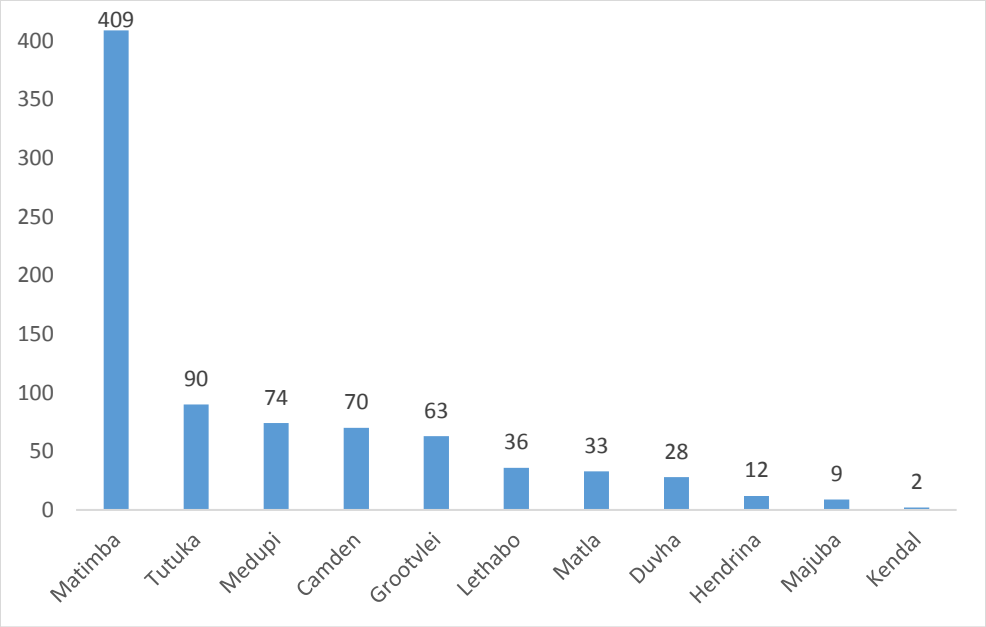

Figure 4. Number of SO2 AEL limit exceedances from April 2016 to March 2017. Stations that reported daily averages with no exceedances of SO2 included Arnot, Komati and Kriel.

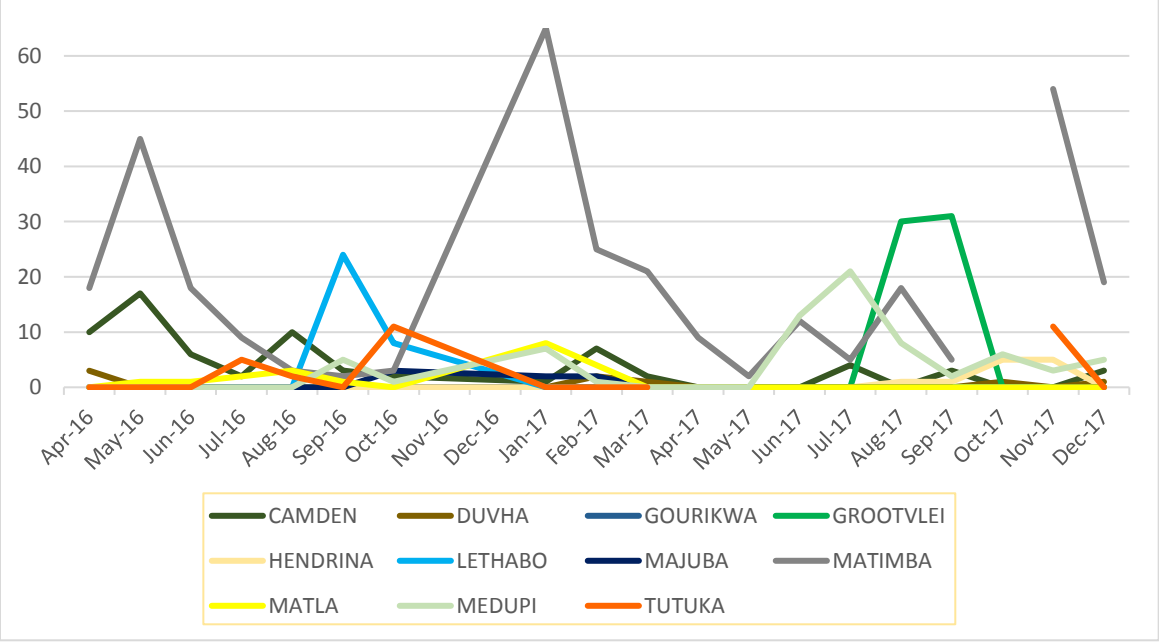

Figure 5. Exceedances of SO2 AEL limits by plant by month, April to December 2017. Many plants have chronic SO2 limit exceedances many months in a row, particularly Matimba, Matla and Camden.

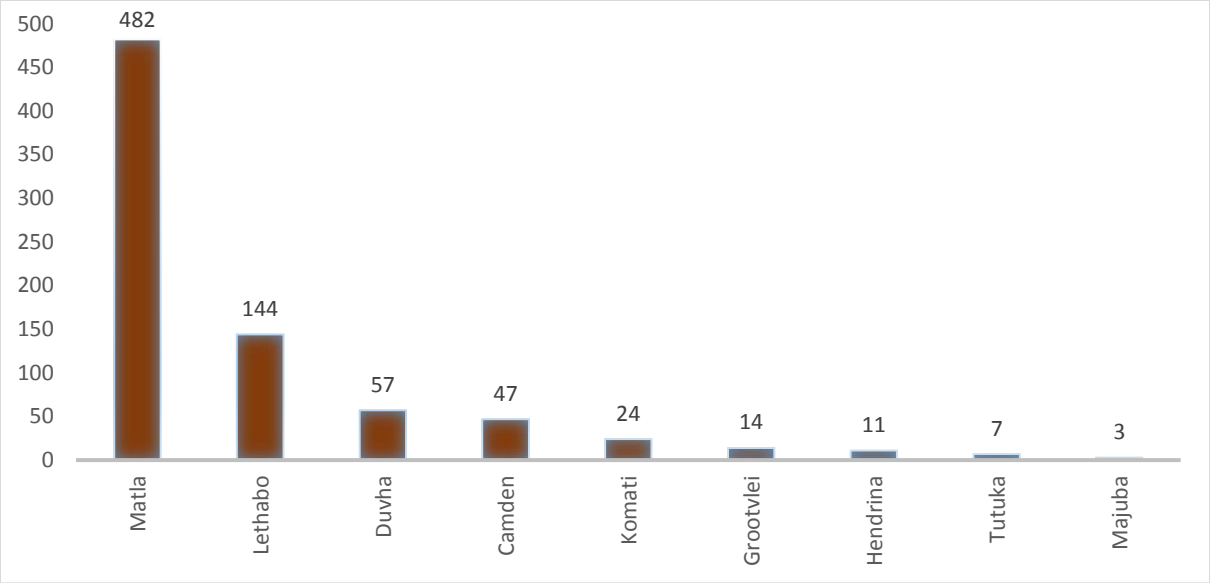

Figure 6. Number of NOx AEL limit exceedances from April 2016 to December 2017. Stations that reported daily averages with no exceedances of NOx included Arnot, Kendal, Kriel, Matimba and Medupi.

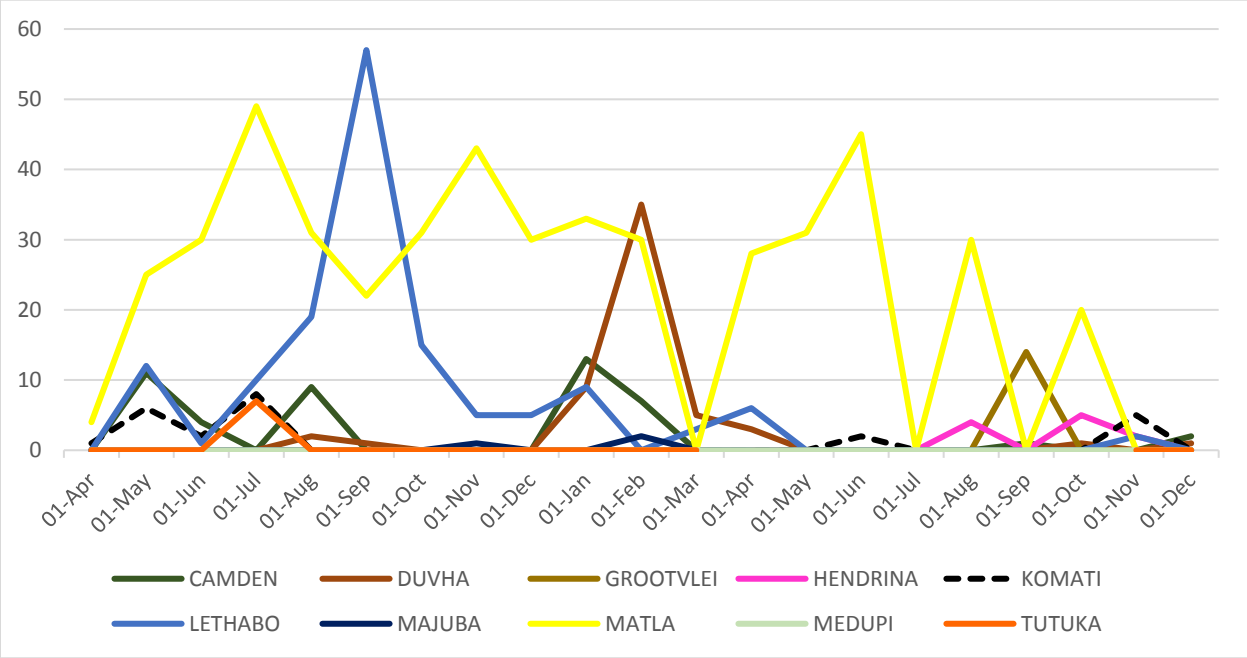

Figure 7. Exceedances of NOx AEL limits by plant by month, April to December 2017. Many plants have chronic NOx limit exceedances, particularly Matla, Lethabo, and Duvha.

Findings

First, I note that coal-fired power plants, especially those not equipped with the full suite of modern air pollution controls[1] (which is true of the Eskom plants I have analyzed) are among the highest emitters of SO2, NOx, and PM from all industrial sources, as confirmed in the Highveld Priority Area Air Quality Management Plan (HPA AQMP) and the draft Mid-Term Review of the HPA AQMP reports.

As is clear from my analysis, all of the Eskom coal plants for which I was able to analyze data, except for Arnot, self-report significant numbers of exceedances for at least one pollutant. Because the applicable limits in the AELs are quite lax compared to those recommended by the World Health Organization, World Bank Group, or those adopted by China, for example[2], having any exceedances of the AEL limits is very troubling. Even perfect compliance with AEL limits allows for discharges of pollution at unhealthy levels. Exceedances are even more troubling since most of these plants are located in area that is already significantly impaired from an air pollution standpoint (e.g., those in the Mpumalanga HPA). There was a high frequency of exceedances of certain pollutants at certain plants. Examples include:

- Lethabo and Duvha had PM exceedances in 100% of reported months (21/21).
- Kriel had PM exceedances in 95% of reported months (20/21). It is also worth noting that Kriel's AEL limit for PM is higher than the 2015 Minimum Emission Standard (MES). I discuss MES further below.
- Kendal had PM exceedances in 90% of reported months (19/21), with up to 48 exceedances in a single month (June 2016).
- Matimba had SO2 exceedances in 100% reported months (20/20), with up to 65 exceedances in a single month (January 2017).
- Medupi had SO2 exceedances in 81% of reported months (17/21).
- Camden had SO2 exceedances in 62% reported months (13/21).
- Matla had NOx exceedances in 76% of reported months (16/21), with up to 45 exceedances in a single month (June 2017). Matla's AEL limit for NOx is also higher than the 2015 MES. Lethabo had NOx exceedances in 57% of reported months (12/21), with up to 57 exceedances in a month (April 2017.)

[1] Best available technologies to reduce air pollution from coal plants include wet flue gas desulphurization, low NOx burners, selective catalytic reduction, fabric filters, and mercury-specific controls.

[2] World Health Organization (2005), https://www.who.int/airpollution/publications/aqg2005/en/; (WHO guidelines for PM10 are 50 mg/Nm3 (24 hr 99th percentile); SO2: 20 mg/Nm3 (24 hr); NOx 200 mg/Nm3 (1 hr)). World Bank/IFC, Environmental, Health, and Safety Guidelines for Thermal Power Plants, Table 6 (May 31, 2017), https://www.ifc.org/wps/wcm/connect/9a362534-bd1b-4f3a-9b42-a870e9b208a8/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES. (Table 6 notes that for coal burning power plants over 600 MWth in degraded airsheds, the World Bank recommends limiting PM emissions to 25 mg/Nm3, SO2 to 200 mg/Nm3, and NOx to 200 mg/Nm3; China's relevant standards as of January 2017 were 30 mg/Nm3 for PM, and 50-200 mg/Nm3 for SO2.)

Many plants with frequent exceedances have AEL limits that are higher than the 2015 Minimum Emission Standards (100 mg/Nm3 for PM, 3500 mg/Nm3 for SO2, and 1100 mg/Nm3 for NOx). For example:

- Matla's PM limit of 125 mg/Nm3 was exceeded 82 times over the 21 month study period. Its NOx limit of 1200 mg/Nm3 was exceeded 482 times.
- Kriel's PM limit of 125 mg/Nm3 was exceeded 370 times.
- Tutuka's PM limit of 350 mg/Nm3 was exceeded 14 times.
- Majuba's NOx limit of 1500 was exceeded 3 times.
- Hendrina's NOx limit of 1200 was exceeded 11 times.
- Grootveli's PM limit of 350 mg/Nm3 (in 2016) and 200 mg/Nm3 (in 2017) was exceeded 48 times. Its SO2 limit of 4000 mg/Nm3 was exceeded 63 times. Its NOx limit of 1700 mg/Nm3 was exceeded 14 times.
- Camden's NOx limit of 1300 was exceeded 47 times.

Second, in addition to the number of exceedances that I report here, I can state qualitatively that many of these reported exceedances were significantly greater than the applicable AELs. For example, PM exceedances reached at least 500 mg/Nm3 at Duvha and Lethabo, 600 mg/Nm3 at Kriel, and 1500 mg/Nm3 at Grootvlei. At Grootvlei, 77% of the PM exceedances reached at least 400 mg/Nm3. At Kriel, 47% of PM exceedances were over 200 mg/Nm3.

While that is evident in a simple review of the hardcopy reports, I did not conduct a quantitative analysis of the levels of exceedances because the data underlying the graphic reports was not made publicly available. As I recommend below, electronic reporting of the underlying data would provide a clear ability to conduct such an analysis. This is one of the major shortcomings of the current hardcopy reporting in addition to others noted below.

Third, many of the exceedances are frequent at particular plants as opposed to being sporadic, indicating that the underlying causes of such exceedances are not being addressed by Eskom. To the extent that the purpose of exceedance reporting is to identify the causes of such exceedances, and enable actions to mitigate underlying causes, I do not see evidence of such analysis or actions by the operators. Again, as noted, it is imperative that every effort should be made to eliminate to the greatest extent possible any exceedances in heavily populated areas already impaired by air pollution.

Finally, in one particular aspect, the data that I have presented may be deceptive – specifically for the plants that have reported relatively fewer exceedances. The monthly reports do not contain information to clearly identify if the reason for relatively few exceedances is that the plant in question was operating well below capacity or with some units offline during the month. I have recommended below that future monthly reports also provide plant and unit energy production and operating data. This would enable identification of the better-managed plants, normalizing for capacity and energy production factors.

Recommendations for Reporting

My analysis of plant emissions exceedances was severely limited by inconsistent, incomplete and unclear reporting. When faced with uncertainty, I gave the benefit of the doubt to Eskom, and so my calculations underrepresent the extent of AEL exceedances. More accurate and comprehensive reporting would significantly enhance government enforcement of AELs and public scrutiny of power plant compliance. To that end, I have the following recommendations:

1. The data should be reported and made available to the public electronically (i.e., in Excel, ASCII or similar format). Using hardcopy reports are not necessary in our time. If needed at all, they should be provided in addition to electronic data. Not only are many of the hardcopy reports difficult to read, they pose an unnecessary hurdle to understanding the ongoing compliance problems at these power plants.

2. In addition to the emissions data, reporting should also include daily energy production data (i.e., MWhr) as well as daily average load levels (i.e., MW). This would provide the ability and context to evaluate the emissions data; and to be able to normalize the emissions data against capacity and energy production. This too should be provided electronically.

3. Emissions as well as energy and capacity data noted above should be provided on a *per unit* basis and not on a *per stack* basis, as is done in many of the current reports. This would provide insight into unit-level emissions performance, where pollutants are actually generated.

4. To the extent that the emissions data are affected by non-normal operating periods – such as startup or shutdown events; or periods that meet Section 30 criteria – these should be clearly and separately noted in the electronic data – including any applicable time windows where such exemptions may apply.

5. To the extent that any of the data are affected by performance issues with the monitoring equipment – i.e., CEMS malfunctions – those should be separately noted in the electronic data files.

6. As noted earlier, the significance of reporting both raw and final emission data is not clear. Any adjustments to raw data that are made by the power plant operator to obtain the final data should be clearly explained and noted in the electronic report. Deviations between raw and final data should be clearly explained.

7. If hardcopy reports are still needed, the format should be standardized. Currently, the types of information reported, the manner in which they are reported, and the degree to which the reported data are properly reviewed – vary between plants. I recommend that the format for each report be made standard including what information should be reported on a mandatory basis (daily emissions, energy, capacity, CEMS malfunction periods, periods of startup and shutdown, Section 30 periods, etc. as noted earlier) or voluntary basis (coal input data, heat input data, etc.). The format for hardcopy reporting (colored bar graphs for each day per pollutant, clearly legible, separate graphs for each pollutant, etc.) should be specified.

8. Reports with graphs that are clearly erroneous (such as the Tutuka graphs that are copied from previous reports with the month names changed, or the Grootvlei graphs with SO2 emissions over 300,000 mg/Nm3 and NOx emissions over 200,000 mg/Nm3) should have been corrected before finalization and publication. It is worrisome that plant operators and regulators in charge of reviewing these monthly reports appear to be neglecting to review reports or require corrective actions for blatant and consistent problems in both reporting and AEL exceedances themselves.

Attachment A

Vitae

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

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EXPERIENCE SUMMARY

Dr. Sahu has over 30 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 for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; 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 25 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.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty five years include various trade associations as well as individual companies such as steel mills, petroleum refineries, cement manufacturers, 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, several states, various agencies such as the California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

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.