Patrick Gallagher
Andrea Issod
Sierra Club
85 Second St, 2nd Floor
San Francisco, CA 94105
Telephone: (415) 977-5544
Facsimile: (415) 977-5793

Attorney and Staff of Sierra Club
(representing the Club as full-time staff according to EQC rule 6(a))

BEFORE THE ENVIRONMENTAL QUALITY COUNCIL
STATE OF WYOMING

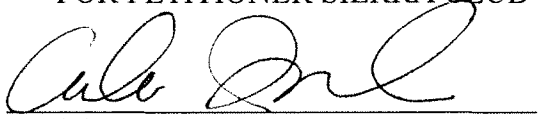
IN THE MATTER OF:	)	Docket No. 09-2801
MEDICINE BOW FUEL & POWER, LLC	)	
AIR PERMIT CT-5873	)	

INITIAL EXPERT REPORT OF RANAJIT SAHU

Sierra Club hereby submits *Ranajit Sahu's Initial Expert Report.*

Respectfully submitted this 1st day of September, 2009.

FOR PETITIONER SIERRA CLUB



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San Francisco, CA 94105
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REPORT OF RANAJIT SAHU

Qualifications

I have a Bachelor of Technology degree, with Honours (B.Tech (Hons.) from the Indian Institute of Technology (IIT), a Masters of Science (Mechanical Engineering) degree and a Doctorate in Philosophy (Ph.D), the latter two from the California Institute of Technology (Caltech). I have over eighteen years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services as well as design and specification of pollution control equipment. In that time, I have successfully managed and executed numerous projects. 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.

I have provided and continue to provide consulting services to numerous private sector, public sector and public interest group clients. My clients over the past seventeen 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 the Environmental Protection

Agency, the United States Department of Justice, California Department of Toxics Substances Control (DTSC), various municipalities, etc. I have performed projects in over 45 states, numerous local jurisdictions and internationally.

In addition to consulting, I have taught and continue to teach numerous courses in several Southern California universities including University of California Los Angeles (air pollution), University of California Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management) for the past sixteen years.

Finally, I have and continue 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. For details, please see my resume provided in Attachment A.

The following is a listing of the items provided by the rules of procedure:

1. This Report contains my opinions, conclusions and the reasons therefor; and,

2. Data or other information I used in forming my opinions are provided in footnotes throughout the Report; and,

3. A statement of my qualifications is contained in Attachment A; and,

4. A list of publications I have authored within the last ten years is shown in Attachment A; and,

5. My compensation for the preparation of this Report is $125/hour and my compensation for testimony is $150/hour; and,

6. A statement of my previous testimony within the preceding four years as an expert at trial or by deposition is contained in Attachment A.

This Report contains conclusions based on information in my possession at the time of submittal of the Report. Should additional data or other documentation become available I reserve the right to appropriately revise my analysis, calculations, and conclusions and to supplement the contents of this Report.

Introduction

Medicine Bow Fuel & Power LLC (MBFP) has proposed to build and operate an underground coal mine and an industrial gasification and liquefaction (IGL) plant near Medicine Bow in Carbon County, Wyoming.

The proposed underground coal mine, known as the Saddleback Hills Mine, will process about 8,700 tons per day (tpd) of coal. The IGL plant will use the mined coal that will be gasified to produce synthesis gas (syngas) and other products, including 18,500 barrels per day of regular gasoline, 42 tpd of sulfur and 198 MMscfd of carbon dioxide (CO2). The IGL plant will also produce about 253 MMBtu/hr of fuel gas and about 400-500 MMBtu of liquefied petroleum gas (LPG). These fuels will be used by a 400 MW electric plant that will include three combustion turbines.

According to the WDEQ Permit Analysis, the project will emit, under normal operating conditions, significant amounts of NO_x (175.9 tons per year), SO_2 (32.9 tpy), PM_{10} (195.1 tpy), CO (176.9 tpy), VOC (188.5 tpy) and HAP (24.8 tpy). Under cold startup, the flares will emit large SO2 emissions (7508.1 lb/hr from the HP flare and 3,601.2 lb/hr from the LP flare).

Issues Addressed In My Report

I have been asked by the Protestants to provide my technical and regulatory expert opinions on the following issues pertaining to this matter in this Expert Report at this time:

(i) Medicine Bow and the Wyoming Department of Environmental Quality (DEQ) did not properly consider the emissions of various pollutants, including sulfur dioxide (SO2) from normal operations of the proposed flares, as part of their potential to emit calculations. In effect, DEQ excluded emissions that will be part of the normal operations from the facility by improperly defining what is normal;

(ii) Medicine Bow and DEQ did not properly conduct the (BACT) analysis for SO2 during startup, shutdown, and malfunction time periods notwithstanding DEQ's claim that the Startup, Shutdown, and Maintenance (SSM) Plan constitutes BACT;

(iii) Medicine Bow and DEQ did not accurately estimate all of the fugitive VOC and HAP emissions that are likely to be emitted by the proposed plant; DEQ also did not properly support its contention that BACT for fugitive VOC emissions is the Leak Detection and Repair (LDAR) program proposed by Medicine Bow;

(iv) Medicine Bow and DEQ improperly classified the proposed facility as a minor source of emissions of hazardous air pollutants (HAPs), thus exempting it from applicable Maximum Achievable Control Technology (MACT) standards;

(v) Medicine Bow and DEQ failed to properly consider a regulated air pollutant, PM2.5 in their analysis;

(vi) Medicine Bow and DEQ improperly excluded emissions of fugitive particulates from the required dispersion modeling;

Medicine Bow is a Major Source of SO2 Emissions

By failing to include SO2 emissions from planned cold start, hot start and shutdown events, as well as anticipated and unavoidable malfunction events, DEQ inappropriately deemed the facility to be a non-major source of SO2 emissions. Consequently, it did not do a thorough BACT analysis for SO2 for the facility. DEQ's position, that BACT for the startup, shutdown, and malfunction (SSM) events, are the vague and unenforceable promises and guesses contained in Medicine Bow's SSM Plan, is untenable.

First, it is undisputed that the proposed plant design includes a high pressure and a lower pressure flare. The purpose of these flares is to release and combust syngas at SSM events when the downstream units cannot accommodate the syngas. Normal operation of the flares is defined as including operation in connection with SSM events. The permit application acknowledges that the flares are emission sources but only purports to include the minor emissions from the pilot flames that are on at all times. However, neither the application submitted by Medicine Bow to DEQ nor the permit issued by DEQ properly account for all of the project's air emissions, including sulfur dioxide (SO2), because they exclude emissions from actual flaring events in the facility's potential to emit.

The final permit does not include a BACT determination for sulfur dioxide emissions because SO2 emissions are estimated to be below the 40 tons/yr major source significance threshold, excluding SO2 emissions from flaring events during SSM. If flare emissions were considered, by Medicine Bow's own admission, SO2 emissions would exceed the PSD major source significance threshold.

The application and DEQ's permit application analysis estimated SO2 emissions of 256.9 tons/event from cold starts, yet did not consider these significant emissions in the facility's potential to emit. Cold starts are planned in advance,[1] and are therefore routine, predictable events associated with the normal operation of a liquid coal plant. In response to EPA's

[1] Medicine Bow acknowledges (see Answer to Interrogatory No. 2 in Response to Plaintiff's First Set of Discovery Requests to Medicine Bow, dated August 19, 2009) that cold starts will occur once every 4 years as part of the planned shutdown and subsequent re-start of the gasifiers. On an annual basis, this translates to emissions of over 64 tons/year, itself greater than the major source threshold for SO2.

comments that cold start emissions should have been considered and included, DEQ asserts that it considers cold start emissions as "…temporary in nature….and not routine as represented in the application…"[2] DEQ is incorrect. DEQ appears to erroneously conflate temporary as being the same as non-routine. The fact that cold start emissions will occur repeatedly during the life of the facility is clear, per Medicine Bow's acknowledgment that such emissions will occur at least once every four years, on a planned and forseeable basis. Just because the duration of these emissions may not be as long as the operating mode of the facility does not mean that they are not routine.[3] Emissions that are the result of a planned and forseeable event are routine. As to temporary, the duration of cold start emissions may not be very long but that does not mean that emissions during such short times are insignificant. The fact that 256.9 tons of SO2 emissions can be emitted from each cold start means that there will be significant impacts during each planned cold start.

Medicine Bow, in its application, also estimated SO2 emissions of 150.16 tpy from anticipated malfunctions and other events. Strikingly and unbelievably, DEQ flatly asserts that malfunctions will not occur at the proposed facility.[4] This is, from an engineering standpoint, an absolutely untenable position. Medicine Bow, in its admissions, notes that "…malfunctions may occasionally occur, as with any operating facility."[5]

It is my experience that EPA policy requires the inclusion of SSM emissions in calculating the potential to emit for any pollutant for a facility. For example, EPA notes in a memorandum to William O. Sullivan of the state of New Jersey, dated February 14, 2006, "…to determine PTE [Potential-to-Emit], a source must estimate its emissions based on the worst case scenario taking into account startups, shutdowns, and malfunctions…"[6]

[2] See Decision document, Item III.1
[3] Just like a periodic, short-duration visit to the dentist or to the doctor for a "routine" physical is routine, a cold start event, while brief in duration, is also routine.
[4] In its supplement to Requests for Admissions, DEQ flatly denies that malfunctions will occur.
[5] See Medicine Bow's Response to Request for Admission No. 1 in Response to Plaintiff's First Set of Discovery Requests to Medicine Bow, dated August 19, 2009
[6] EPA Memorandum from Steven Riva to William O'Sullivan, "Accounting for Emergency Generators in the Estimate of Potential to Emit," February 14, 2006.

The SSM Plan is Insufficient as BACT for Flare SSM Emissions

It is clear from the record, that neither Medicine Bow nor DEQ conducted a top-down BACT analysis for SSM emissions before concluding that the SSM Plan would suffice as BACT for the facility for SSM emissions. In doing so, DEQ entirely failed to justify its departure from setting numerical limits from the flares as part of its BACT determination. In other words, DEQ did not conduct the normal 5-step top-down BACT analysis resulting in numerical limits for emissions of various pollutants from the flares.

It is my opinion that DEQ presumed that emissions from flares cannot be monitored and that flares cannot be tested, and therefore DEQ must have concluded that it was not worthwhile to set numerical limits for flare emissions. While that may have been the case in the past, it is now possible to measure emissions from flares using techniques such as long-path infra-red techniques[7]. While these are not in common use, such techniques have been tested and are available for use.

The above notwithstanding, even if DEQ opted to not set numerical limits but rather opted for work practices as BACT from flare SSM emissions, its uncritical acceptance of the SSM Plan as BACT is not justified. Strategies to minimize emissions, consistent with the definition of BACT – permit conditions requiring specific and enforceable work practice standards, minimum loads for the gasifier during startup, permit limits on the maximum duration of startup, and the maximum number of startup events per year – were not considered by the DEQ and are not part of the permit. In a regular 5-step BACT analysis, such approaches, as well as others, would have had to be fully considered and vetted, resulting in a defensible BACT determination. It is likely that such an approach would have resulted in several directly enforceable permit conditions that would have applied during SSM events, as opposed to the perfunctory and feeble permit condition at the present requiring the SSM Plan alone, without any further detail.

[7] See, for example, http://www.clu-in.org/programs/21m2/openpath/op-ftir/

Fugitive VOC Emissions Are Improperly Estimated

Fugitive component leaks from valves, pumps, compressors, and connectors in the Medicine Bow facility are a source of VOC emissions, which also include HAPs such as methanol. The conventional estimation method for fugitive VOC emissions requires: (i) an accurate count of the number of fugitive components such as valves, connectors, pumps, sampling connections, etc.; (ii) information about the design of such components such that appropriate assumptions can be made regarding the likely emissions from each such component; (iii) selection of the proper emission factor, which in turn depends on the measurement of the level of VOC emissions near each component; and (iv) the effect of the applicable LDAR program in minimizing such emissions.

By its own admission, Medicine Bow does not have and could not have provided an accurate count of fugitive components. Although Medicine Bow notes that it has provided "…the best available estimate of components…"[8] and that "…the final component count will be available when the plant is about to be commissioned…"[9] it has not provided any supporting detail as to how it came up with its count of fugitive components. No engineering design drawings, which would allow for the verification of Medicine Bow's component counts, were provided. Thus, DEQ could not possibly have verified any of the component counts. Nor was the public able to review such counts or to even compare and contrast such counts with those from other comparable facilities that are currently operating. As such this fundamental input to the fugitive VOC calculations was unverifiable. Compounding its error, DEQ has not made the counts enforceable in the permit.

Second, no engineering design details for any of the components are found in the record. Without this data and detail, it is impossible to determine whether the average emission factors that Medicine Bow has used in estimating emissions, are even appropriate.

[8] Permittee's Response to Appeal, Paragraph 49, June 3, 2009

[9] Medicine Bow's Response to Interrogatory No. 7, Response to Plaintiff's First Set of Discovery Requests to Medicine Bow, August 19, 2009.

Third, the emission factors used by Medicine Bow, as noted in its very own calculations, are taken from a 1995 EPA document, which is now over 14 years old.[10] The emission factors were derived from surveys conducted at various chemical plants and refineries in the late 1980s and early 1990s. Subsequently, EPA audits have shown that actual emissions from fugitive sources can be significantly greater than previously believed.[11]

Fourth, since little detail relating to the LDAR program has been provided in the record, it is impossible to ascertain if the control efficiencies assumed by Medicine Bow, as a result of application of the LDAR program, are meaningful or real. Clearly DEQ could not have verified any of these assumptions. DEQ's review in this regard amounts to little more than rubber-stamping what it was provided by Medicine Bow.

Considered together, Medicine Bow's estimates for fugitive VOC emissions are unverifiable, use 1995 emission factors that have been shown to underestimate fugitive emissions, and more likely than not, underestimate the emissions of VOCs, including HAPs.

[10] Protocol for Equipment Leak Emission Estimates, EPA-453/R-95-017, November 1995. Contrary to Medicine Bow's assertions as noted in paragraph 49 of the Permittee's Response to Appeal, dated June 3, 2009, that the final emission calculations were based on EPA's Protocol for Equipment Leak Emission Estimates, updated in May 2008, no such updated document was ever produced. All of Medicine Bow's calculations use the 1995 version of the document.

[11] EPA Enforcement Alert, Volume 2, Number 9, October 1999. EPA 300-N-99-014.

BACT for Fugitive Emissions is Inappropriately Determined

By their own admissions, Medicine Bow and the DEQ assert that BACT for fugitive VOC emissions is the Leak Detection and Repair (LDAR) program proposed by Medicine Bow.[12] Specifically, this LDAR program is "…based on a leak detection level of 500 ppm for valves and connectors and a leak detection level of 2000 ppm for pumps."[13] Medicine Bow notes also that "[T]he DEQ reviewed these levels and found them to be similar to the requirements of Subpart VVa of 40 CFR Part 60 and NESHAPS. NESHAP thresholds are considered to be representative of maximum achievable control technology, and typically require greater control than BACT. Based on the proposed monitoring levels meeting NSPS/NESHAP thresholds the Division determined the proposed LDAR program to be representative of BACT for fugitive emissions."[14] DEQ also stated that "…LDAR levels which were determined to represent BACT for VOCs from fugitive equipment leaks….are consistent with levels established in NSPS and NESHAP."[15]

First, I note that neither Medicine Bow nor DEQ conducted the preferred and reliable top-down 5-step BACT analysis before arriving at its BACT determination. DEQ also failed to explain why they did not follow this approach.

Second, as I noted earlier, it is undisputed that DEQ concluded that the proposed LDAR program was BACT because it was "similar to" or "consistent with" the requirements in the applicable New Source Performance Standards (NSPS) and NESHAP.[16] However, just because the LDAR program is similar to NSPS and NESHAP does not mean that is BACT. In fact, BACT can be no less stringent than the applicable NSPS or NESHAP. This follows directly from the definition of BACT and numerous EPA guidance documents, some of which are discussed below. The BACT definition[17] in the Federal regulations states that:

[12] See DEQ Response to Request No. 3 in which DEQ states that "Medicine Bow proposed an LDAR program as BACT and DEQ determined BACT."
[13] See Answer to Interrogatory No. 3, Respondent DEQ's Responses to Petitioner's First Set of Discovery Requests, dated August 19, 2009
[14] Ibid.
[15] See Decision document, Item IV.5.
[16] NESHAP regulations are found in 40 CFR Part 61 for various source categories.
[17] See 40 CFR 52.21(b)(12).

> "***In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR Parts 60 and 61***"

Similar provisions also apply in the in the Wyoming regulations.

This requirement which effectively sets the applicable NSPS (40 CFR Part 60) or NESHAP (40 CFR Part 61) standard as the "floor" for any BACT determination is also reflected in numerous EPA guidance on BACT. Examples are discussed below.

In a December 22, 1978 memo,[18] Mr. Barber of EPA states:

> "***As indicated in separate guidance for making case-by-case BACT determinations, the utility is also required to demonstrate that the proposed controls are not less stringent than the applicable NSPS***"

In a later 1979 memo to all Deputy Regional Administrators, Mr. Barber, then-Director of OAQPS, also reiterated earlier guidance when he wrote:

> "***(BACT) which is defined on a case-by-case basis and can be no less stringent than the applicable NSPS***"[19]

In a 1979 guidance on determining BACT under PSD,[20] Mr. David Hawkins, then Assistant Administrator at EPA wrote:

> "***The BACT decision is to take into account energy, environmental, and economic impacts and other costs associated with application of alternative control systems. This case-by-case approach allows adoption of improvements in emission control technology to become widespread more rapidly than would occur through the uniform Federal new source or hazardous emission standards. In setting the NSPS, for example, emission limits are selected which can reasonably be met by all new or modified sources in an industrial category, even though some individual sources are capable of lower emissions. Additionally, because of resource limitations in EPA, revision of new source standards must lag somewhat behind the evolution of new or improved technology. Accordingly, new or modified facilities in some source categories may be capable of achieving lower emission levels that NSPS without substantial economic impacts. The case-

[18] See December 22, 1978 memo from Mr. Barber to others at EPA. Available at http://www.epa.gov/region07/programs/artd/air/nsr/nsrmemos/coalfire.pdf
[19] See January 10, 1979 memo from Mr. Barber.
[20] See January 4, 1979 Guidance for Determining BACT Under PSD 8.8, by David G. Hawkins, available at http://www.epa.gov/ttn/nsr/psd1/p8_8.html

> by-case BACT approach provides a mechanism for determining and applying the best technology in each individual situation. Hence, NSPS and NESHAPS are Federal guidelines for BACT determinations and establish minimum acceptable control requirements for a BACT determination***"

Echoing the same theme Mr. Gary McCutchen, then Chief of EPA's New Source Section within OAQPS, specifically addressed this BACT and NSPS relationship:

> "***The NSPS are established after long and careful consideration of a standard that can be reasonably achieved by (sic) new source anywhere in the nation. This means that even a very recent NSPS does not represent the best technology available***The NSPS is the least common denominator and must be met***The BACT requirement, on the other hand, is the greatest degree of emissions control that can be achieved at a specific source and accounts for site specific variables on a case-by-case basis***[21]

Finally, in EPA's 1990 Draft[22] NSR/PSD guidance, the following discussion makes clear that the NSPS is indeed the floor for any BACT determination:

> "***An NSPS simply defines the minimal level of control to be considered in the BACT analysis. The fact that a more stringent technology was not selected for a NSPS (or that a pollutant is not regulated by an NSPS) does not exclude that control alternative or technology as a BACT candidate. When developing a list of possible BACT alternatives, the only reason for comparing control options to an NSPS is to determine whether the control option would result in an emissions level less stringent than the NSPS. If so, the option is unacceptable***"[23]

In view of all of the above, to conclude, as DEQ has done that just because the LDAR program is similar to the NSPS, it must therefore be BACT, is just erroneous.

Instead, DEQ should have conducted a full top-down BACT analysis for fugitive VOC emissions. Options such as leakless (not leaking at 2000 ppm) pumps and valve designs as well as other levels of LDAR controls (i.e., more stringent than the 500 ppm/2000 ppm proposed)

[21] See memo from Mr. McCutchen to Mr. Richard E. Grusnick, January 28, 2987.

[22] Although this guidance is denoted as Draft, nonetheless it has been and continues to be widely used by air quality professionals both within the EPA (such as permit writers) and others for PSD analysis. Numerous Court decisions and EPA Administrative decisions has also referred to and/or relied on this Draft guidance as being authoritative with regards to PSD.

[23] See page B.12 of EPA's Draft New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting" (EPA OAQPS, October 1990).

should have been considered in such a BACT analysis. Problems resulting from poor design and implementation of LDAR programs and means of mitigating them in order to make the program effective should also have been considered.[24] For example, enhanced LDAR in many parts of the country aims to control valve fugitive losses to less than 200 ppm, which is considerably smaller than the 500 ppm, assumed as BACT by DEQ.[25]

[24] See Leak Detection and Repair, A Best Practices Guide, EPA, available at http://www.epa.gov/compliance/resources/publications/assistance/ldarguide.pdf. See also the MARAMA Model Rule for Enhanced LDAR available at http://www.marama.org/Projects/021907_ModelRule_EquipmentLeaks.pdf.
[25] Ibid.

The Facility is Not a Minor Source of HAP Emissions

Major source of hazardous air pollutant (HAP) emissions are those that have the potential to emit any of the regulated HAPs over 10 tons/year or the combination of all regulated HAPs over 25 tons/year.[26] Numerous regulated VOC HAPs, such as methanol, benzene, and others will be emitted from the facility including those from combustion sources such as the flares and from fugitive emission sources such as the numerous valves, flanges, connectors, pumps, compressors, sampling connections, and the like.

Medicine Bow and DEQ entirely failed to account for VOC/HAP emissions from the flares during SSM events.

First, consistent with its approach relating to SO2 emissions from flares discussed earlier, Medicine Bow and DEQ did not estimate emissions of HAPs from the high pressure and the low pressure flares during SSM events. I presume that their failure to provide such estimates may stem from their assumption that VOC/HAPs may be fully oxidized and consumed in flares. However that would be an error.

Flares are simply not a VOC/HAP emissions control device, although some incidental VOC/HAP destruction can occur in flares. The reason for this is simple. VOC/HAP destruction via combustion, which is what occurs in flares, requires three conditions to be met: high temperature, significant turbulence such that the molecule to be destroyed is able to recirculate in the high temperature zone, and as a result, greater than minimum residence times. For every VOC/HAP compound, there is a relationship between the temperature and the residence time at that temperature, and the destruction efficiency. In the present instance, no engineering detail has been provided by Medicine Bow as to the design of the flares; specifically how any residence time will be achieved during flare combustion and how the design will assure that the minimum required residence time will be achieved. Thus, assumptions presumably made by Medicine Bow as to VOC destruction efficiency in the flare are wholly unsupported and could not have been reviewed by the DEQ and the public. The net result of this is that the calculated VOC/HAP

[26] 40 CFR 63.41

emissions are underestimated (i) by not including the VOC/HAP emissions from the flares during SSM events; and (ii) by likely over-estimating the destruction efficiency of the flares.

Despite the above, Medicine Bow's initial application showed that its HAP potential to emit was greater than 10 tons/year for individual HAPs (e.g., methanol) and was greater than 25 tons/year for all HAPs.[27] At some point, Medicine Bow revised its HAP calculations such that the total HAP potential emissions were, conveniently, 24.8 tons/year or slightly below the 25 tons per year major source threshold. However, even in this calculation, the HAP with the single highest potential emissions was methanol, with emissions at 10.3 tons/year, making the facility a major source of HAPs anyway.[28] It should be kept in mind that all of the reasons discussed previously relating to likely inaccurate fugitive VOC emissions also apply in this case. Medicine Bow revised its calculations yet again, stating that it had changed the design of 8 of its 30 sampling connections to a different (closed loop) design thereby reducing the facility methanol potential to emit to 9.2 tons/year and the total HAP emissions to 23.6 tons/year[29] – making it a minor source and thereby avoiding having to prepare and comply with case-by-case Maximum Achievable Control Technology (MACT) standards.

There are numerous assumptions, all of them unsupported that Medicine Bow relies on to arrive at its methanol HAP potential to emit of 9.2 tons/year. Among them are:

- no support such as drawings or engineering piping and instrumentation diagrams for its count of fugitive emission components that are at the heart of its methanol emissions from these components; thus, one is simply left with an assertion by Medicine Bow as to the counts;

- no support relating to any design information for any of the components, including the 8 replacement closed-loop sampling connections. This is essential so that the applicability of the

[27] See Table 1.2 of Medicine Bow's Amended PSD Permit Application, dated December 31, 2007. The page containing Table 1.2 shows a revision date of May 12, 2008. I note that the summation of the annual HAP emissions in Table 1.2 appears to be incorrect. Using the data provided in the table, the sum of all HAPs exceeds 30 tons/year.
[28] See Decision document, Item II.14
[29] See Decision document, Item II.14

emissions factors to these designs can be assessed, which DEQ clearly did not do. I will note here that even though 8 out of the 30 sampling connections have been switched to closed loop type, even these designs will typically involve the addition of other components such as additional valves and flanges – however, these additional valves and flanges do not appear to have been accounted for in Medicine Bow's revised calculations.

- no support for the assumptions relating to the chemical composition of the process streams that have been used in the calculations;

- no support for the emission factors themselves, given their age and given the known low biases for estimating fugitive emissions, as discussed in the VOC section earlier;

- no support for the LDAR control efficiency assumed by Medicine Bow because details of the LDAR program (which affect the efficiency calculation) are simply not known at this time; and

- omission of HAP emissions including possibly methanol emissions from flaring events associated with SSM.

Because of the conditional nature of the calculation and all of the assumptions listed above that have to be relied upon by Medicine Bow in arriving at its potential to emit of 9.2 tons/year, Medicine Bow simply cannot claim any robustness in this result. In other words, minor changes in one or several of the assumptions above can increase the methanol potential to emit to over 10 tons/year.

Since the methanol potential to emit relies on numerous assumptions, it is logical to assume that DEQ would insist on the verifiability and enforceability of each of these assumptions in order to assure that the potential to emit, in fact, is 9.2 tons/year. Yet, the permit is notably silent on this. Other than a requirement to verify the counts of components after construction, there is no requirement to verify the chemical composition, no basis to verify the design, no requirement to assess the applicability of the emission factors used, and no requirement to verify the LDAR

control efficiency used. Thus, DEQ seems to have relied on a self-verifying approach. Given the close (i.e., less than 10%) value of the methanol potential to emit to the major source threshold, it is difficult to find a basis for DEQ's faith that the facility will be a minor source.

At best, given all of the assumptions, and if every one of these assumptions is made an enforceable permit condition subject to verification, recordkeeping, testing, and reporting, Medicine Bow can claim to be a synthetic minor source – i.e., minor only as a result of meeting these numerous assumptions. To assert, without verifying these assumptions, as Medicine Bow has done and as DEQ has accepted, that it is somehow a true minor source with a robust potential to emit well below the major source thresholds of 10/25 tons/year, is simply erroneous.[30]

[30] See Permittee's Response to Appeal, paragraph 31, page 12.

Failure to Consider $PM_{2.5}$

There is no question that $PM_{2.5}$ is a regulated air pollutant with its own National Ambient Air Quality Standards (NAAQS).[31] As such Medicine Bow and DEQ cannot dispute this. It is also likely that the proposed plant would be a major source of $PM_{2.5}$ emissions,[32] thus requiring BACT for $PM_{2.5}$.

Yet despite the fact that the proposed plant would be a major source of $PM_{2.5}$, a regulated NSR pollutant, the entire record starting from the permit application by Medicine Bow and through the issuance of the draft permit by the DEQ does not contain a BACT-determined emission limitation or any other design, equipment, work practice or operational standard for $PM_{2.5}$; DEQ simply did not evaluate BACT for reducing $PM_{2.5}$ emissions. Nor did it require any modeling for $PM_{2.5}$ or any of the other aspects of $PM_{2.5}$ regulation as required for a major source of this pollutant.

DEQ's justification for its omission is its reliance on what is typically known as EPA's Surrogate Policy for $PM_{2.5}$ – namely that PM_{10} can be considered to be a surrogate for $PM_{2.5}$, which I will briefly describe later. DEQ explains its position in this regard in its Decision document.[33] In its Decision document, DEQ also notes that it has approval for implementation of the Surrogate Policy as a result of its approval of its Interstate Transport of pollution SIP dated July 7, 2008. I cannot comment on EPA's erroneous approval of such a SIP in this Report. I will note however, that: (a) DEQ's analysis of $PM_{2.5}$ is technically flawed; and (b) that EPA's position on $PM_{2.5}$ has been clarified recently, as will be discussed shortly. As to (a), DEQ notes that PM_{10} includes $PM_{2.5}$. This is true on a mass basis. However, DEQ is wrong to then conclude that therefore there is no need for any separate consideration of $PM_{2.5}$ at all. In fact, if that were true, it begs the question of why EPA has recognized $PM_{2.5}$ as a separate pollutant, distinct from PM_{10}, with

[31] http://www.epa.gov/air/criteria.html

[32] Table 1.1 of Medicine Bow's permit application, dated May 12, 2008 shows that its own estimate of PM10 emissions is 196 tons/year. DEQ's application analysis of June 19, 2008 (Tables III, VI) shows 195 tons/year. Over 120 tons/year of these emissions are from the combustion turbines alone. The majority of these PM10 emissions would be in the PM2.5 range. Since the major source threshold for PM2.5 is potential emissions is 10 tons/year, it is more than likely that the proposed facility would be a major source for PM2.5 emissions. See New Source Review for $PM_{2.5,}$ David Campbell, EPA Region 3.

[33] See Decision Document, Permit Application AP-5873, Item II.19, page 5, March 4, 2009.

its own NAAQS, etc. The fact is that just because the mass of $PM_{2.5}$ is subsumed within the mass of PM_{10}, does not mean that they are equivalent. The emissions characteristics from different sources, the means of their control, and their dispersion characteristics are or can be different. Thus, DEQ's justification for not considering or requiring Medicine Bow to consider $PM_{2.5}$ is simply wrong.

(a) DEQ Should Not Rely on Surrogate Policy

DEQ relies on certain memoranda issued by EPA to support the contention that it is not required to address $PM_{2.5}$ as a PSD pollutant.[34] This older and conditional EPA guidance indicated that sources would be allowed to use implementation of a PM_{10} program as a surrogate for meeting $PM_{2.5}$ NSR requirements. The purpose of that guidance was to provide time for the development of necessary tools to calculate the emissions of $PM_{2.5}$ and related precursors, adequate modeling techniques to project ambient impacts, and $PM_{2.5}$ monitoring sites.[35] In the 12 years since the guidance was written, EPA has resolved almost all of these technical issues, as discussed below. Impracticalities referenced in the guidance as the basis for using PM_{10} as a surrogate (modeling, emission calculations and estimates, etc.) have been largely resolved, as evidenced by EPA's proposal in 2007.[36] EPA has recognized, in other instances that EPA's April 5, 2005 policy guidance memo "…does not bind State and local governments…"[37]

(b) There Are No Longer Any Technical Impediments to Conducting a BACT Analysis for $PM_{2.5}$ or for Setting a $PM_{2.5}$ Emission Limit

In the Page $PM_{2.5}$ Memo, EPA explained that the Seitz Memo "identified significant technical difficulties with implementing PSD for $PM_{2.5}$ because of limitations in ambient monitoring and

[34] Preliminary Determination at 13-14 (citing Memorandum from John S. Seitz, Director, EPA Office of Air Quality Planning & Standards, Interim Implementation of New Source Review Requirements for PM2.5 (Oct. 23, 1997) (the "Seitz Memo"); Memorandum from Stephen D. Page, Director, Implementation of New Source Review Requirements in PM2.5 Nonattainment Areas (April 5, 2005) (the "Page PM2.5 Memo").
[35] Proposed Rule To Implement the Fine Particle National Ambient Air Quality Standards, 70 Fed. Reg. 65984, 66043 (Nov. 1, 2005).
[36] See 72 FR 54112, September 21, 2007. EPA also noted in 70 FR 66043 that the "practical difficulties" identified in the Seitz memo "have been resolved in most respects."
[37] See EPA Comments on the proposed Pee Dee power plant in South Carolina.

modeling capabilities."[38] As EPA affirmed in its recently issued implementation rule for $PM_{2.5}$, in the decade since EPA issued the Seitz Memo, concerns about monitoring and modeling $PM_{2.5}$ have been largely resolved. $PM_{2.5}$ monitoring stations have been in operation for many years; measurement methods are in place; and adequate modeling techniques have been developed.

With regard to measurement methods at the source, which are of concern in the BACT context, EPA has now issued Other Test Method 27 (OTM-27) for filterable $PM_{2.5}$. While this is not yet a promulgated test method, it is based on Method 201A, a well-established test method that has been formally adopted by EPA.[39] Further, Method 202 is in regular use to measure condensable PM. EPA is now preparing to release a modified version of this method to improve its accuracy and repeatability (which will be available well before Medicine Bow starts operating). EPA is also developing a test method capable of measuring both filterable and condensable particulate. The draft of this method, known as the "dilution sampling method," is available on the EPA website as Other Test Method 28 (OTM-28).[40]

In short, there are reliable, field-tested methods available right now to measure $PM_{2.5}$ at the source and even better methods are already available in draft form (and likely to become final before the Medicine Bow plant begins operation). Medicine Bow and DEQ can no longer justify use of the surrogate policy on the grounds that there are no accurate measurement techniques for $PM_{2.5}$.

I should note that methods to quantify $PM_{2.5}$ emissions from combustion sources such as turbine exhaust and from fugitive sources such as piles, material handling, etc. have long been available. EPA's emission factor compilation document AP-42 contains approaches to size classify PM emissions into various size classes as emitted from different control devices.[41] Of course, the applicant is free to use similar data from equipment vendors in order to improve the accuracy of

[38] Memorandum from Stephen D. Page, Director, Implementation of New Source Review Requirements in PM2.5 Nonattainment Areas 4 (April 5, 2005) (the "Page PM2.5 Memo") at 4.
[39] 72 Fed. Reg. at 20653 ("we believe that further validation of this method is unwarranted since the technology and procedures are based upon the same as evaluated for promulgated Method 201A").
[40] EPA website: www.epa.gov/ttn/emc/ctm.html.
[41] See, for example, AP-42 Section 1.1, Table 1.1-6 and Figure 1.1-1. Available at www.epa.gov/ttn.

the emissions estimates. Similarly, AP-42 also contains approaches to quantifying emissions of $PM_{2.5}$ from fugitive sources as well.[42]

(c) DEQ Cannot Assume That BACT for PM_{10} is BACT for $PM_{2.5}$

DEQ cannot assume that BACT for PM_{10} is BACT for $PM_{2.5}$. Instead, because the effectiveness of controls varies with respect to particulate size, it is necessary to address PM_{10} and $PM_{2.5}$ separately. In fact, control technologies for PM_{10} often do not provide for effective control of $PM_{2.5}$. As EPA has acknowledged, $PM_{2.5}$ and PM_{10} "are generally associated with distinctly different source types and formation processes."[43] EPA has also recognized that "[i]n contrast to PM[10], EPA anticipates that achieving the NAAQS for PM[2.5] will generally require States to evaluate different sources for controls, to consider controls of one or more precursors in addition to direct PM emissions, and to adopt different control strategies."[44]

For example, while a fabric filter may be, in general, the most appropriate generic control device for both of these pollutants, the degree of control of each, for a given type of filter material, will be very different. Thus, the choice of fabric (which is not discussed as part of the record) is important. DEQ does not distinguish between membrane bags (which operate via surface filtration mechanisms) and the standard cloth bags (which operate via volume filtration), both of which can be used in fabric filters. Simply noting that "…the selected control technology for particulate matter emissions from the boilers (fabric filtration) is also effective for $PM_{2.5}$…." as DEQ has done, does not mean that what has been specified for PM10 BACT (were it even to be correct) is BACT for $PM_{2.5}$.

[42] See, for example, AP-42 Section 13.2-4. Also available at www.epa.giv/ttn.
[43] Proposed Rule To Implement the Fine Particle National Ambient Air Quality Standards, 71 Fed. Reg. 65,984, 65,992 (November 1, 2005).
[44] 72 Fed. Reg. 20586, 20589.

(d) Other States and Regions and Regulated Entities Consider $PM_{2.5}$ Separately

Other states and EPA regions have moved beyond the outdated surrogate policy and now require full consideration of $PM_{2.5}$, including emission limits, BACT, modeling, and compliance demonstrations.

The state of Montana, in the Highwood case, explicitly required the applicant, not only to quantify but also to prepare a separate PM2.5 BACT analysis.[45] Connecticut's policies[46] note that "…a demonstration of compliance with the PM_{10} NAAQS will no longer serve as a surrogate for compliance with the $PM_{2.5}$ NAAQS. Instead, NSR permit applicants must consider $PM_{2.5}$ as a criteria pollutant and address it in preparing an application." Clearly, states like Montana and Connecticut saw no technical impediments to considering $PM_{2.5}$ as a pollutant in its own right, instead of relying on outdated guidance from the EPA.

EPA regional offices are now disavowing the surrogate policy. In a recent letter to the Kansas DHE, EPA Region VII, in connection with the proposed new Sunflower project, notes that "[W]e recommend that part of the analysis include an evaluation of $PM_{2.5}$ emissions instead of relying on PM_{10} emissions as a surrogate."[47]

More tellingly, in a more recent and extensive exposition,[48] and directly applicable to this matter, EPA's Administrator has noted that significant technical justification needs to be provided before it can be assumed that PM_{10} is a proper surrogate for $PM_{2.5}$. Where such justification is not provided, an agency cannot simply assume that surrogacy exists. As EPA notes, "[W]hen EPA issued the PM_{10} Surrogate Policy in 1997, the Agency did not identify criteria to be applied before the policy could be used for satisfying the $PM_{2.5}$ requirements. However, courts have

[45] See Highwood Generating Station Circulating Fluidized Bed Boiler BACT Analysis for Emissions of Particulate Matter with Aerodynamic Diameter Equal to or Less Than 2.5 Microns ($PM_{2.5}$), prepared for Southern Montana Electric Generation and Transmission Cooperative, September 26, 2008.
[46] See CTDEP Interim PM2.5 New Source Review Modeling Policies and Procedures, dated 8/21/07.
[47] See letter from EPA Region VII (Mr. William W. Rice) to Mr. Roderick L. Bremby, Kansas Department of Health and Environment, dated July 1, 2009.
[48] See EPA Administrators Order in the matter of Louisville Gas and Electric Company, Petition No., IV-2008-3, relating to the Trimble County Title V/PSD Air Permit issued by the Kentucky Division for Air Quality, dated August 12, 2009.

issued a number of opinions that are properly read as limiting the use of PM_{10} as a surrogate for meeting the PSD requirements for $PM_{2.5}$. Applicants and state permitting authorities seeking to rely on the PM_{10} Surrogate Policy should consider these opinions in determining whether PM_{10} serves as an adequate surrogate for meeting the $PM_{2.5}$ requirements in the case of the specific permit application at issue." EPA notes further that, "…[E]PA believes that the overarching legal principle …..is that a surrogate may be used only after it has been shown to be reasonable (such as where the surrogate is a reasonable proxy for the pollutant or has a predictable correlation to the pollutant…". Just like in the Trimble case, DEQ did not provide any technical justification for why PM_{10} should be the surrogate for $PM_{2.5}$. Without this, DEQ has no technical basis to automatically assume the adequacy of PM_{10} as a surrogate.

In addition to all of the above examples, even permit applicants from other utilities have begun to include $PM_{2.5}$ in their applications. A recent example is the proposed White Stallion CFB plant in Texas.

In view of the above, the position of DEQ and its explanation that PM_{10} and $PM_{2.5}$ are not two different types of pollutants is misleading. As noted above, if that were the case, there would not be any need for separate NAAQS for PM_{10} and $PM_{2.5}$. In fact, the dispersion characteristics, the exposure characteristics, the chemical compositions, and the toxicological impacts of PM10 and PM2.5 are quite different.

Based on all of these shortcomings, I conclude that DEQ has committed significant technical errors and that its simplistic application of the surrogate policy (which EPA itself has recognized is now no longer needed) with regards to $PM_{2.5}$ is in error.

Failure To Include Fugitive Particulate Emissions In Dispersion Modeling

It is my understanding that Medicine Bow did not include fugitive emissions of particulate matter (from sources such as haul roads, coal handling, coal storage and the like) in its dispersion modeling.

It is my experience that such emissions are to be included as part of dispersion modeling and are routinely so included. In fact, I am aware of such emissions being included for another facility (the Dry Fork Generating Station) during its permitting by the DEQ itself.[49]

In addition, examples of other facilities for which such emissions have been included as part of their dispersion modeling include:

- Highwood Generating Station, Great Falls, Montana;[50]

- Ely Energy Center, Ely, Nevada;[51]

- White Pine Energy Station, Ely, Nevada;[52]

- Plant Washington, Sandersville, Georgia;[53]

- Longleaf Energy Station, Hilton, Georgia;[54]

- Hyperion Energy Center, Union County, South Dakota;[55]

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[49] Dry Fork Generating Station, Gillette, Wyoming, Basin Electric Power Cooperative. DEIS prepared in August 2007 (PM10 modeling on page 4-26). Available at: http://www.usda.gov/rus/water/ees/pdf/Basin_DF_DEIS/Basin%20Dry%20Fork%20DEI S%20Ch4-7%200907.pdf

[50] Highwood Generating Station, Great Falls, Montana[50], Southern Montana Electric Cooperative Inc. Final EIS prepared in January 2007. Available at http://www.deq.mt.gov/eis/HighwoodGeneratingStation/VolI/H%20-%20FEIS%20Vol.%20I%20-%20Chapter%204_Environmental%20Consequences.pdf

[51] Ely Energy Center, Ely, Nevada. Sierra Pacific Resources. Appendix 9 – Air Quality Impact Analysis prepared in October 2007. Available at http://ndep.nv.gov/bapc/download/ely/A9.pdf

[52] White Pine Energy Station, Ely, Nevada. White Pine Energy Associates/LS Power. Appendix 8 – Environmental Evaluation and Dispersion Modeling Files prepared in December 2006. Available at http://ndep.nv.gov/bapc/download/ls/app8.pdf

[53] Plant Washington, Sandersville, Georgia Power4Georgia, LLC. PSD Permit Application prepared in January 2008. Available at: http://www.air.dnr.state.ga.us/airpermit/downloads/permits/psd/dockets/plantwashington/facilitydocs/30300051app.pdf

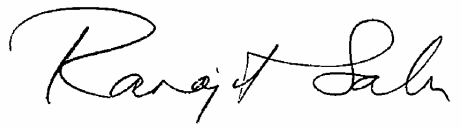
[54] Longleaf Energy Station, Hilton, Georgia. LS Power. PSD Permit Application prepared in November 2004. Available at:http://www.air.dnr.state.ga.us/airpermit/downloads/permits/psd/dockets/longleaf/facilitydocs/Longleaf_PSD_Applic.pdf

[55] Hyperion Energy Center, Union County, South Dakota. Hyperion Refining LLC. PSD Permit Application prepared in December 2007. Available at:http://www.hyperionec.com/files/HEC_SD_PSD_App.pdf

- Kentucky NewGas, Central City, Kentucky;[56]

- Advanced Supercritical Pulverized Coal (ASCPC) Project, Essexville, Michigan[57];

- Virginia City Hybrid Energy Center, Wise County, Virginia[58].



Dated: August 31, 2009

Dr. Ranajit Sahu
311 North Story Place
Alhambra, CA 91801
Ph: (626) 382 0001

[56] Kentucky NewGas, Central City, Kentucky. Kentucky SynGas, LLC. Air Permit Application – Volume 2 Air Modeling Report prepared in December 2008.
[57] Advanced Supercritical Pulverized Coal (ASCPC) Project, Essexville, Michigan. Consumers Energy. PSD Permit Application – Section 6 Ambient Impact Analysis. prepared in October 2007. Available at: http://www.deq.state.mi.us/aps/downloads/permits/CFPP/2007/341-07/Section%206%20-%20Ambient%20Impact%20Analysis.pdf
[58] Virginia City Hybrid Energy Center, Wise County, Virginia. Virginia Dominion Power. PSD Permit Application Volume II Class II Air Quality Modeling. Prepared in February 2007 and updated in August 2007.

Attachment A

Resume for Ranajit Sahu

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

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

311 North Story Place
Alhambra, CA 91801
Phone: 626-382-0001
e-mail (preferred): sahuron@earthlink.net

EXPERIENCE SUMMARY

Dr. Sahu has over eighteen 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 eighteen 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 seventeen 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.

In addition to consulting, Dr. Sahu has taught and continues to teach 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 and at USC (air pollution) and Cal State 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.

"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 10/07/2009.

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 Puchase 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.

Annex A

Expert Litigation Support

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) 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).

(h) 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.).

(i) Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.

(j) Expert report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.

(k) 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.

(l) 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.

(m) 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.

(n) 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).

(o) Expert reports and pre-filed testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.

(p) 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)

(q) 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.

(r) 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.

(s) Affidavit/Declaration and Expert Report on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6, under construction in North Carolina.

(t) Dominion Wise County MACT Declaration (August 2008)

(u) Expert Report on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis (June 13, 2008).

(v) 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).

(w) 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).

(x) 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).

(y) Expert Report 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). (August 2009).

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

(z) In February, 2002, provided expert witness testimony on emissions data on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

(aa) 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.

(bb) 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.

(cc) 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.

(dd) 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.

(ee) 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.

(ff) 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.

(gg) 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.

(hh) 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.

CERTIFICATE OF SERVICE

I hereby certify that I have served a true and correct copy of the foregoing *Initial Expert Report of Ranajit Sahu* via electronic mail on this the 1st day of September, 2009 to the following:

John Corra
Director, DEQ
jcorra@wyo.gov

Nancy Vehr
Sr. Asst. Attorney General
nvehr@state.wy.us

Jude Rolfes
Medicine Bow Fuel & Power
jrolfes@dkrwaf.com

Mary Throne
Hickey & Evans
mthrone@hickeyevans.com

Hickey & Evans
bhayward@hickeyevans.com

John A. Coppede
Hickey & Evans
jcoppede@hickeyevans.com

Andrea Issod
Sierra Club