

Analysis of NOx Emissions for Selected Coal-Fired Units

by

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I was asked to review the recent NOx performance of selected coal-fired Electricity Generating Units (EGUs) located in areas impacting 2015 ozone moderate non-attainment areas as well as the units that are impacting the 2008 ozone non-attainment areas.

Generally, the units at issue are either equipped with Selective Catalytic Reduction (SCR) and have relatively elevated NOx levels. Or, in other cases they do not have SCR installed and, as a result, have elevated NOx emissions levels.

In all cases, I assessed NOx emissions as a 30-day average, expressed in units of pounds per million Btu heat input (lb/MMBtu).

My analysis, while presented in this report by state, followed the same general approach for the two sets of units at issue – i.e., units with SCR and those without. I therefore address the overall methodology in this section and do not then repeat that in each subsequent state-by-state analysis.

A. Assessment of NOx Emissions for Units Equipped with SCR

Generally speaking units that have SCR installed should achieve low NOx levels, especially on a 30-day rolling average basis. While the SCR catalyst does require a minimum operating temperature (MOT) in order to provide requisite NOx reductions, and while this MOT may not be met until a certain minimum load (i.e., minimum heat input or electrical power output) for a unit, the lowest heat inputs or capacity factors at which SCR can be effective can be addressed using a number of operational strategies meaning that the NOx-reduction efficiency of SCRs can be maintained at a high level for the vast majority of the time. I have addressed these operational strategies in other prior reports and include excerpted discussions of them in Appendix A. Thus, unless a unit is operated as a cyclic unit with frequent low load operation (i.e., below its SCR's capability after employing operational strategies), the 30-day average NOx emissions levels should be low, if the SCR is properly operated.

In this analysis, rather than address theoretical SCR capability of a particular unit's SCR and its performance, which would require non-public information on the design of the SCR and its catalyst along with unit operating parameters, I instead focus on the actual demonstrated NOx emissions levels achieved by the unit as reported to EPA's Clean Air Markets (or Acid Rain) database. While

¹ Resume provided in Appendix B.

this data is reported on an hourly basis, and includes the unit's heat input, power output, and NOx emissions levels, I focused my analysis on the daily and monthly reported performance. Based on past experience in these types of analysis, I considered the reported monthly NOx performance for a substantial but recent time period. Typically I reviewed monthly data from October 2017 through September 2022. This 60-month period covering 5 ozone seasons (i.e., May through October periods in 2018, 2019, 2020, 2021, and 2022) provide a representative record of the units performance under a wide range of operating time periods including periods before, during, and after the COVID 19 pandemic.

Also based on past experience, since I analyzed monthly data for a 60-month time period, I did not also need to repeat the analysis for rolling 30-day average time periods because there is little difference between 30-day rolling averages and monthly averages as long as the latter are considered for a substantial (i.e., the 5 year or 60-month period in this analysis) period, for the purposes of this analysis.

Here, the purpose was to determine the recent performance of the unit and its SCR, as reflected in the reported NOx emission rate. Importantly, it is assumed that if a unit has reported actual, low levels of NOx in this recent time period (as opposed to, for example, more distant past time periods when the SCR at the unit may have been first installed), when otherwise operating normally or in a representative manner, it can achieve that or similarly low level of NOx at other times, such as by properly or more optimally operating its existing SCR. Thus, expectations of low NOx from proper SCR operation are judged not by some theoretical standard but by the unit's own, recent, reported NOx performance.

Based on this analysis, for each unit with existing SCR, I conclude that such units have demonstrated low NOx levels (generally NOx levels of 0.07 lb/MMBtu or lower) on a monthly (i.e., 30-day average) basis in recent time periods and can therefore reasonably be required to do so in the future. The coal fired EGUs with SCRs installed that I analyzed in this report have each demonstrated that they have recently achieved and maintained significantly lower NOx emissions rates than what they often operate at, and that they can therefore consistently achieve those lower NOx rates if required to do so. Low capacity factors and MOT are not the factors that are precluding the coal fired EGUs from operating at those demonstrated, lower NOx emission rates.

B. Assessment of NOx Emissions for Units Currently Operating without SCR

There is no question that SCR is a proven NOx-reducing technology for coal-fired units, regardless of the type of coal burned. In the US fleet today there are SCR's in use at bituminous, sub-bituminous, as well as lignite coal units. Thus, the technical feasibility of installing and operating SCRs at units that do not have them is not at issue.

B.1 Cost Effectiveness of SCR On Coal Fired EGUs Generally

The widespread installation of SCRs on coal fired EGUs in the United States is indicative of the fact that SCRs are a proven cost-effective means of NOx reduction at coal fired EGUs. Over 60 percent of existing coal fired EGUs in the US over 100 MWs have SCRs, and for over 20 years all new operating coal fired EGUs have included SCRs. There can be no doubt that as an industrial sector, SCRs are reasonable to install, cost effective NOx reduction technologies.

B.2 Cost-Effectiveness of SCR

I have also conducted a second, unit specific analysis of the cost per ton of NOx reduction at selected coal fired EGUs in the US. I then compared my unit specific calculations of the cost per ton of NOx reduction at those units with the cost per ton of NOx reductions that regulatory agencies have determined to be cost effective at other coal fired EGUs in the US. SCRs would be cost effective at those units. Following long-standing practice using EPA-approved approaches, cost-effectiveness was addressed by estimating the dollars per ton of NOx reduced using SCR. The cost or numerator of the cost-effectiveness metric represents the annualized cost of the capital and operating costs of the SCR while the denominator or tons reduced represents the efficacy of the SCR.

For this analysis, I used the SCR cost-effectiveness methodology used by EPA as reflected in the Sargent and Lundy report on SCR.² This analysis considers the capital as well as the operating costs for the SCR. In conducting the analysis, I used the so-called overnight cost methodology, not including carrying costs of capital during construction. In all other aspects, the analytical methodology is highly conservative, i.e., reflects a higher than expected cost of the SCR.

Specifically, I used the following:

- (i) the EPA-assumed capital cost of over \$300/kW for the SCR. This is conservative based on past actual incurred costs for SCRs in US coal units, which have typically ranged from \$250/kW or lower;
- (ii) the post-SCR NOx level of generally around 0.03 to 0.05 lb/MMBtu, reflecting an SCR NOx reduction of less than 90%. While SCR can achieve 90% or greater NOx reduction, the efficiency does depend on the baseline or pre-SCR NOx levels, with higher efficiencies possible when baseline NOx levels are higher. Thus, while assuming a 90% reduction with SCR is appropriate with the baseline NOx is, say, 0.3 lb/MMBtu, it would not be appropriate to assume that the same 90% reduction would be possible if the baseline NOx is lower, at, say, 0.1 lb/MMBtu. I therefore adjust or assume appropriate NOx reduction efficiencies with SCR depending on the baseline NOx level for a unit;

² https://www.epa.gov/sites/default/files/2018-05/documents/attachment_5-3_scr_cost_development_methodology.pdf

(iii) for the baseline NO_x level, I used the median of the actual NO_x levels reported in the past 5 years or so;

(iv) for the unit's operations, I used a capacity factor that was the higher of the 2017-2021 median capacity factor or its more recent January-September 2022 capacity factor. This is a reasonable assumption given how COVID affected the capacity factors purely on a historical look-back basis. In most instances, this capacity factor is conservative i.e., it could be higher in the future, which would make my estimated cost-effectiveness conservative as well, meaning that the SCR would be even more cost-effective than I estimate;

(v) for annualizing the capital cost, I used EPA's standard assumptions of a 7% annual interest rate and a 30-year life of the SCR. The latter is conservative since SCR units can last longer than 30 years. Of course, the catalyst replacement or refurbishment would occur more frequently, typically every 3-5 years, depending on the unit's capacity factor;

(vi) a multi-unit capital cost discount of 15% when a plant has more than one unit. This simply reflects the procurement benefit of contracting with vendors for multiple SCRs at the same plant. In reality, this is likely conservative, since multi-unit discounts could and should be higher if proper procurement strategies are used.

Using the inputs above I obtain and report the estimated SCR cost-effectiveness values. In order to determine whether the estimated values are cost-effective or not, I compare them with policy thresholds used by EPA and various states. I note that some states such as Connecticut have deemed SCR to be cost effective when the cost-effectiveness was greater than \$ 13,635 /ton reduced, Regs. Conn. State Agencies § 22a-174-22e(h)(1)(A)(iii), and New Jersey found SCR on oil-fired boilers cost effective at up to \$18,000 per ton. NJ DEP, State Implementation Plan Revision for Infrastructure and Transport Requirements for the 70 ppb and 75 ppb 8-hour Ozone NAAQS and Negative Declaration for the Oil and Natural Gas Control Technique Guidelines 15 (May 2019), <https://dep.nj.gov/wp-content/uploads/airplanning/InfraTransportSIP2019-FinalSIP.pdf>. EPA has previously found SCRs cost effective at \$11,000 per ton. 87 Fed. Reg. 20,036, 20,081 (Apr. 6, 2022). Thus, based on my experience, EPA and states have deemed controls such as SCR to be cost-effective in the range of \$10,000 to \$15,000 per ton reduced. I note that many of these regulatory cost-effectiveness values have not been adjusted upward for inflation. Collectively, I reiterate that there is substantial conservatism built into the cost calculation that I have conducted.

B.2 Installation Schedule for SCR

In addition to cost-effectiveness, I was also asked to address the estimated time that will be needed to install SCR(s) at plants that do not have SCR at the present. EPA has previously concluded that an SCR can be installed at a coal fired EGU in as little as 21 months, while multiple SCRs at the same facility may take longer. Environmental Protection Agency, Final Report, Engineering and Economic Factors Affecting the Installation of Control Technologies for Multipollutant Strategies

(2002), EPA-600/R-02/073, available at <https://archive.epa.gov/clearskies/web/pdf/multi102902.pdf> (“It is expected that one SCR system requires about 21 months of total effort for planning, engineering, installation, and startup. Multiple SCR systems at one facility would take longer to install (e.g., approximately 35 months for seven SCRs.”). Industry estimates are even shorter. Institute Of Clean Air Companies, Typical Installation Timelines for NOx Emissions Control Technologies On Industrial Sources (December 2006), available at https://cdn.ymaws.com/www.icac.com/resource/resmgr/ICAC_NOx_Control_Installatio.pdf (48-58 weeks from commercial RFQ date). Other state air agencies have similarly relied upon a 21-month installation timeline. See Maryland Department of the Environment TECHNICAL SUPPORT DOCUMENT FOR COMAR 26.11.38 - Control of NOx Emissions from Coal-Fired Electric Generating Units available at https://mde.maryland.gov/programs/Regulations/air/Documents/TSD_Phase1_with_Appendix.pdf. I note that there are no significant long-lead items that drive longer SCR installation schedules. Further, I note that “typical” SCR schedules reflecting historical installation timelines are generally based on a business-as-usual (BAU) approach, with little incentive for faster installation.

While an exact unit specific SCR installation timeline is necessarily a unit-specific determination, it is my opinion that SCRs at specific units or plants can, as a general matter, especially with incentivized contracting approaches, be achieved in a time range of 26-36 months. This is particularly true if those units have already started consideration of SCR installation, such as for compliance with other regulatory requirements such as Regional Haze or the Cross State Air Pollution Rule.

When estimating timelines for SCR installation in the present context – i.e., recognizing that substantial ozone reductions can be obtained via precursor NOx reductions at units without SCRs – it is fair, in my opinion, to assume the following:

- (i) that the SCR installation project will prioritize time reduction in contracting and not simply follow typical or BAU approaches with regards to project planning, engineering, contracting, procurement, fabrication, installation, and commissioning, etc.;
- (ii) that some degree of prior planning or prior assessment of SCR at each unit without SCR has likely occurred in the past or is in process. In other words, it is more likely than not that any US coal unit that is currently operating without SCR has likely considered and perhaps even planned for a SCR retrofit project even though such a project has not obviously yet been implemented. This is particularly likely given EPA’s draft Cross State Air Pollution Rule, due to be finalized in March 2023, and other regulatory obligations such as EPA’s Regional Haze obligations. Thus, an SCR installation project at any unit not currently using SCR cannot reasonably be a complete surprise and will not need to be started from scratch. This presumption will also reduce installation times to the lower end of the 26-36 month range.

I now show the results of my analysis on a state-by-state basis. I note that I was not asked to address every single coal-unit in each of the states below, but selected, example, units.

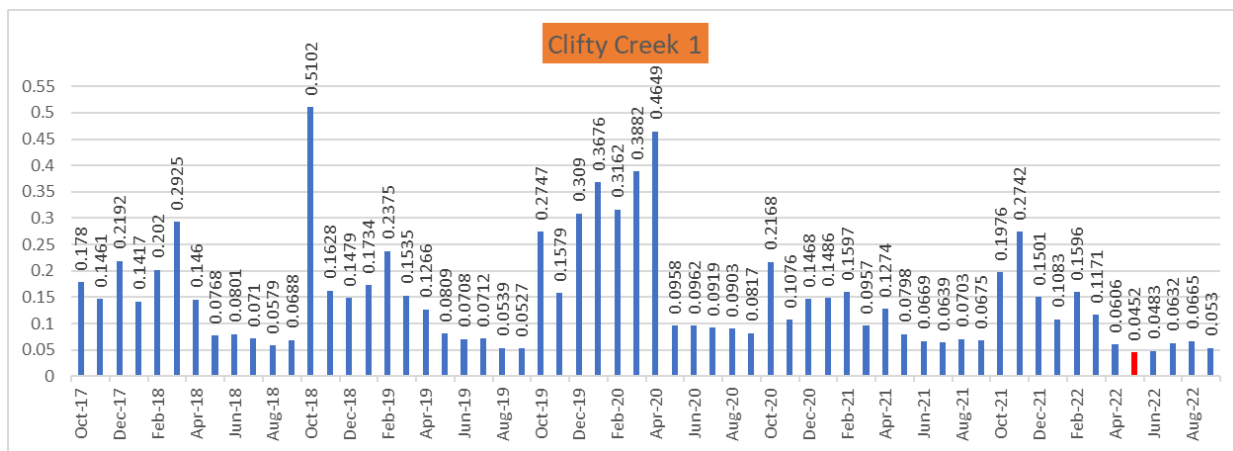
Indiana

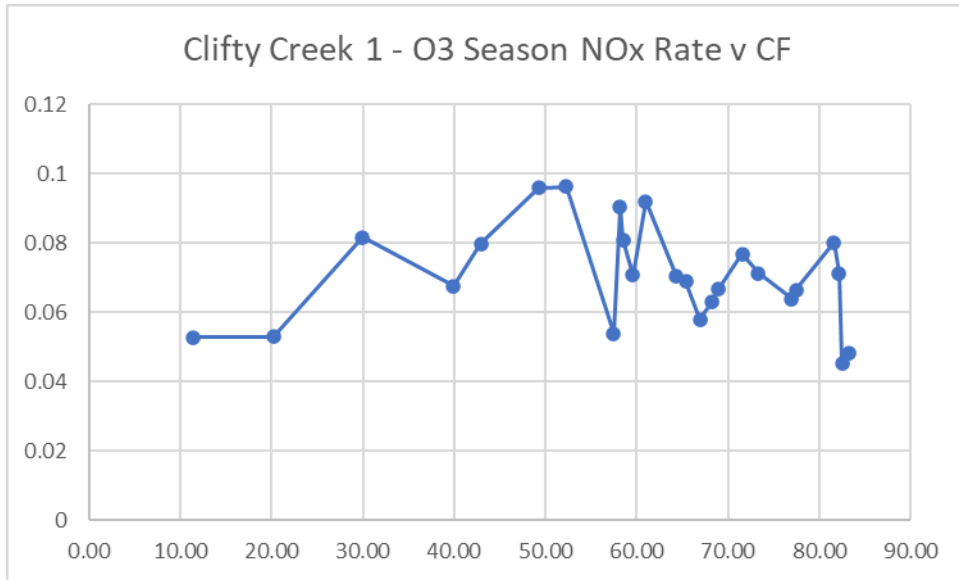
(A) Units with SCR

In Indiana, I address Clifty Creek Units 1 through 5. Each of these units is rated at around 217 MW and has an existing SCR. The table below summarizes the NO_x performance in the last three columns, in units of lb/MMBtu. While the minimum NO_x levels in the 60-month period analyzed were lower than 0.07 lb/MMBtu for each unit, the highest-month NO_x as well as the highest-month NO_x during the ozone seasons were substantially greater than 0.07 lb/MMBtu, especially for Units 4 and 5.

Plant	Unit	MW	NO _x , Min	NO _x , Max	NO _x , Max O3 Months
Clifty Creek, IN	1	217.3	0.0452	0.5102	0.0962
	2	217.3	0.0461	0.4083	0.0962
	3	217.3	0.0457	0.4489	0.0962
	4	217.3	0.0605	0.3955	0.2473
	5	217.3	0.0646	0.3874	0.1954

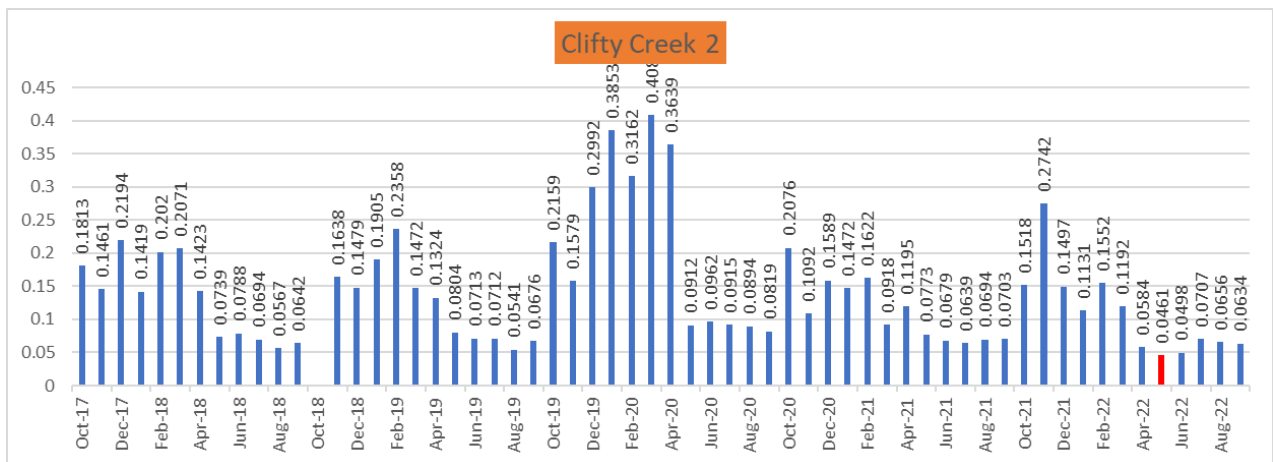
Below, I show, for each unit, two separate charts. The first chart shows the actual NO_x by month, in lb/MMBtu. The lowest month is shown in red. In the chart that follows I show the actual monthly NO_x levels (in lb/MMBtu on the vertical axis) during just the ozone season months, as a function of the monthly capacity factor (on the horizontal axis). As I noted earlier, SCR performance can potentially degrade at low capacity factors since a unit may spend operating times (within the 30-day average) below the MOT for the SCR, thus emitting NO_x that is not reduced by the SCR.



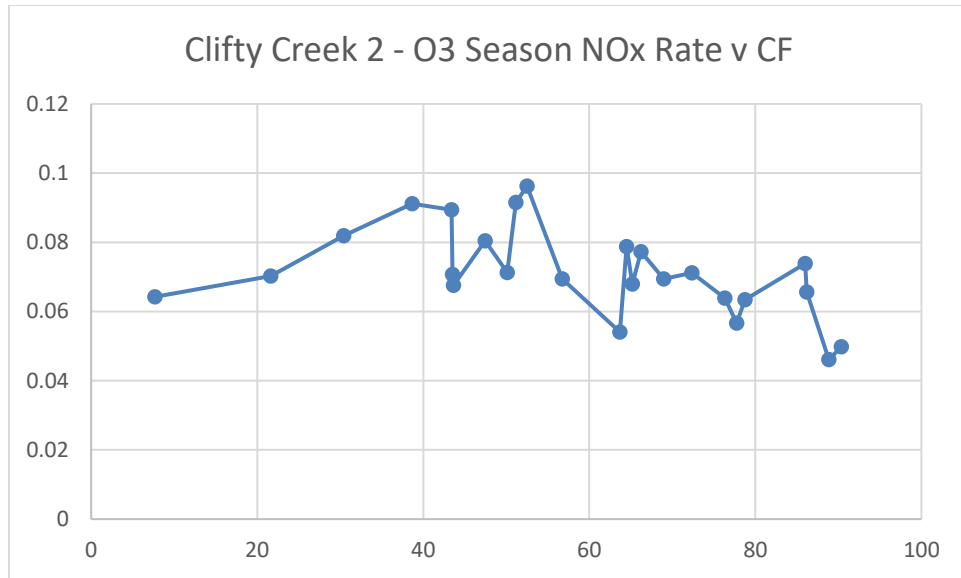


The chart above for Clifty Creek 1 shows that even at low monthly capacity factors (i.e., 10 and 20 percent), the NOx performance was below 0.07 lb/MMBtu. Collectively, the data above confirm that Clifty Creek 1's SCR can be operated such that it can meet a 30-day average NOx level of 0.07 lb/MMBtu.

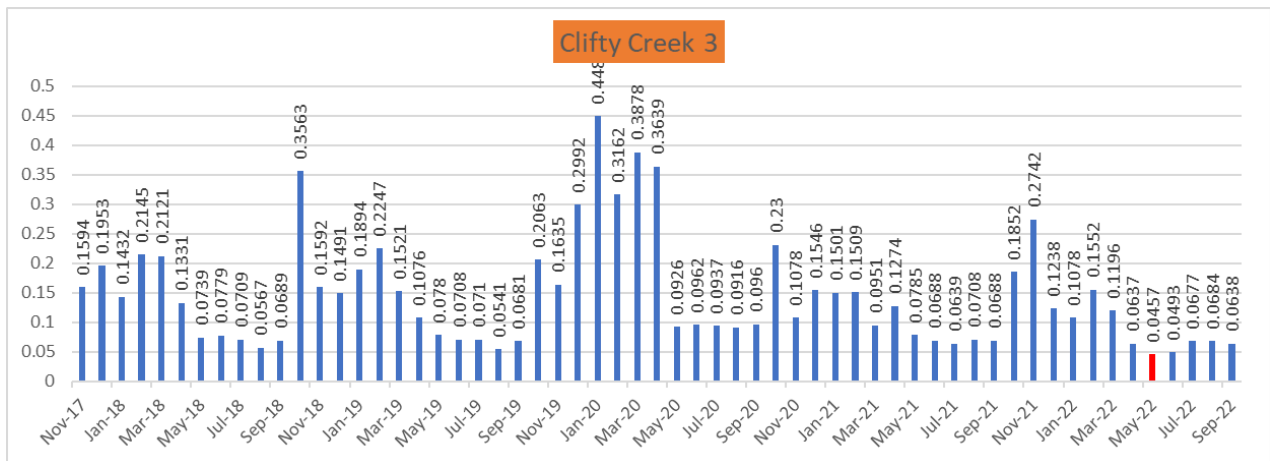
Next, I show similar charts below for Clifty Creek 2. Again, the lowest NOx month in the first chart (0.0461 lb/MMBtu) is shown in red.



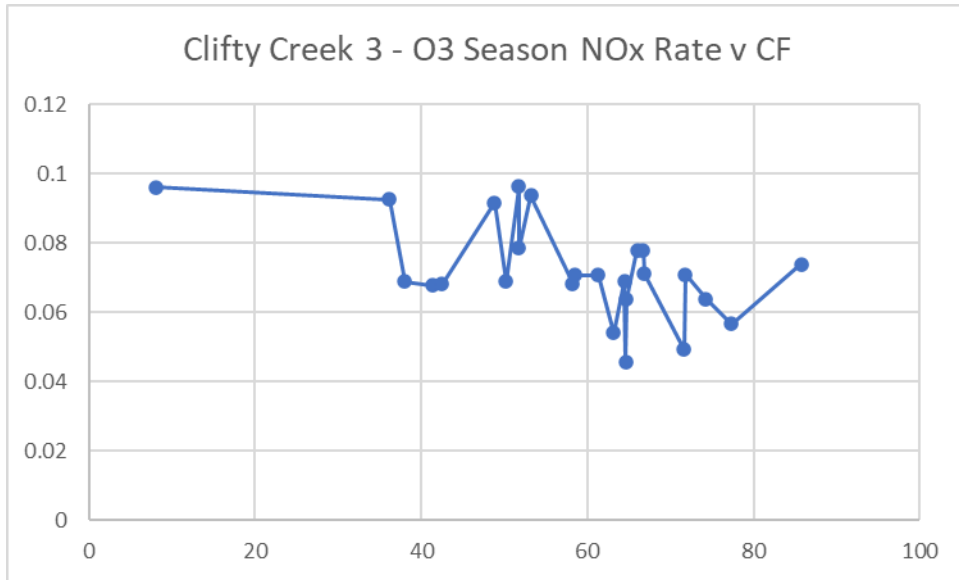
The ozone season monthly data as a function of capacity factor, shown below, also confirm that Clifty Creek 2 should be able to meet a 30-day average NOx level of 0.07 lb/MMBtu.



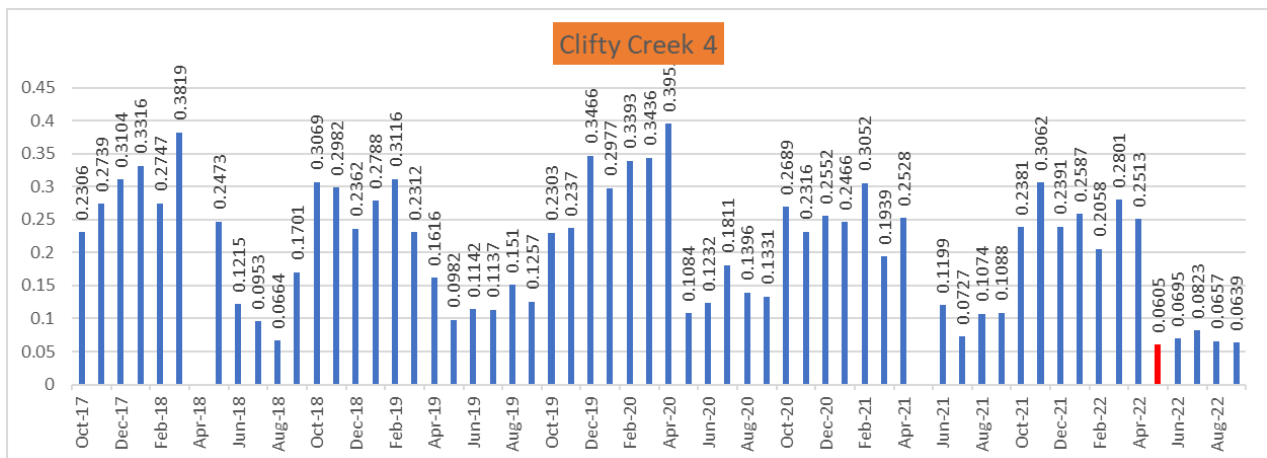
The performance charts for Clifty Creek 3, shown below, are similar to those for Clifty Creek 1 and 2 noted above.

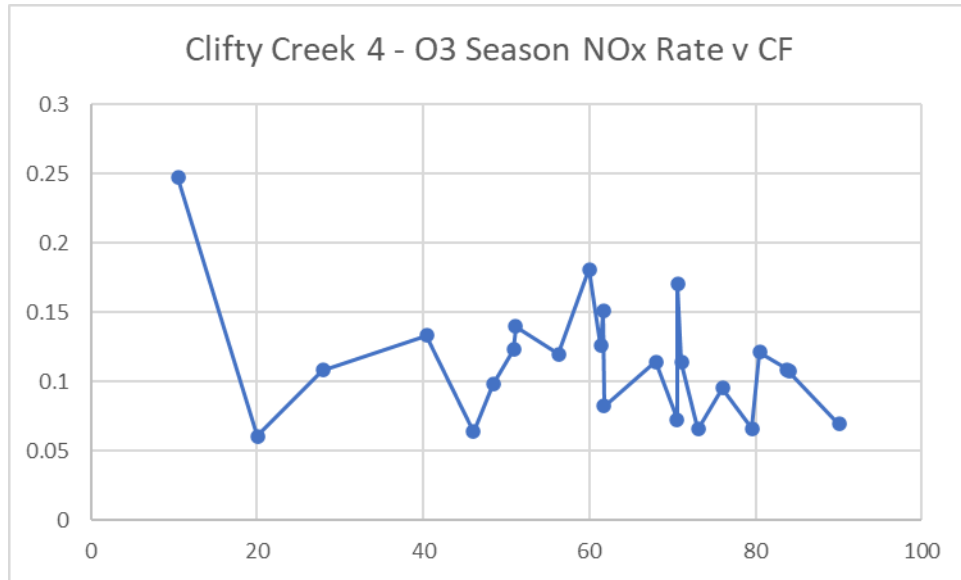


However, the NOx levels at the lowest capacity factors in the ozone season months, shown in the chart below, are not as low as for Clifty Creek Units 1 and 2. The reason for the higher NOx levels for the lowest capacity factors (as compared to Clifty Creek Units 1 and 2) was not readily ascertainable. Regardless, based on the overall NOx levels that the unit achieved, a 30-day average level of 0.07 lb/MMBtu should be achievable at this unit.

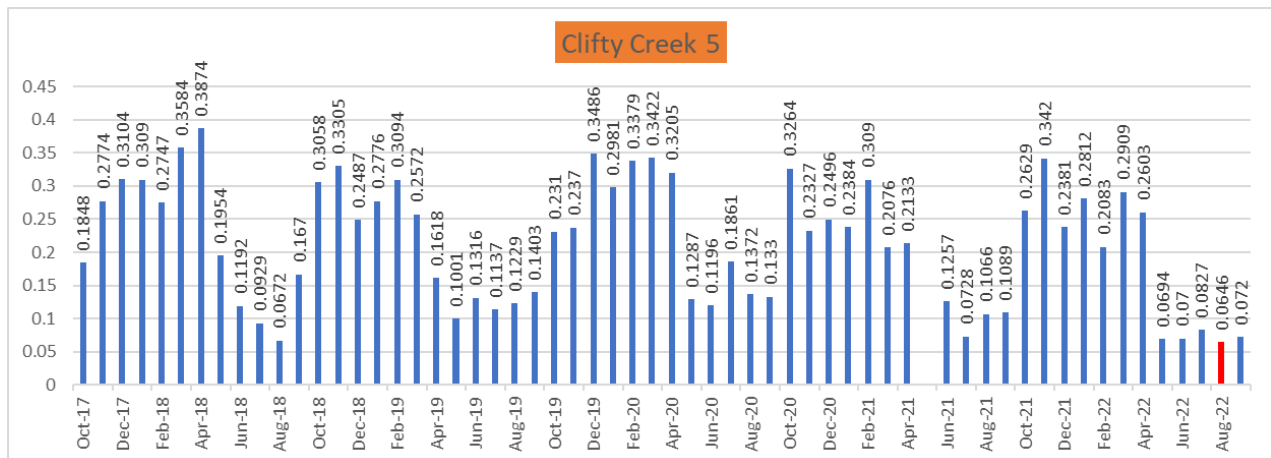


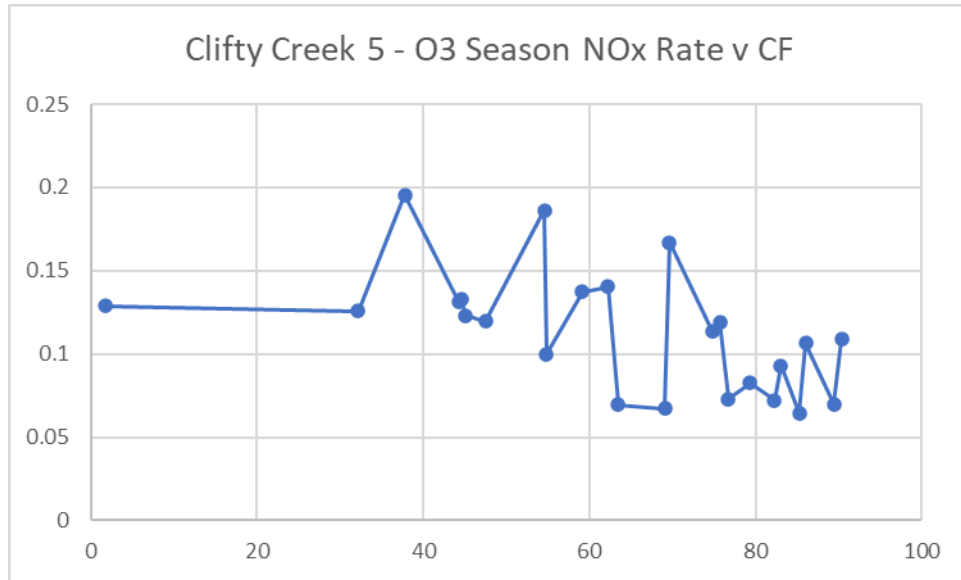
The monthly NOx and ozone season NOx as a function of capacity factor for Clifty Creek 4 are shown below. The NOx levels are higher than Units 1, 2, and 3. While there are several months, including the lowest month shown in red below, where the NOx level was below 0.07 lb/MMBtu, in general, the NOx performance for many months in the last 5 years was significantly greater than in the case of Units 1-3. Clearly, the SCR for this Unit 4 is not being operated optimally or as well as the SCRs for Units 1-3. However, the SCR's capability to reduce NOx is clearly shown by the low NOx levels achieved in several months throughout the 5-year period.





The NOx data for Clifty Creek Unit 5 are similar to that of Unit 4 above – i.e., not as good as the performance for Units 1-3.





Yet, given the performance of the SCRs at Units 1-3, it is my opinion that the SCR's for Unit 5 above (and Unit 4, prior) can be operated better and therefore realize lower levels of NOx similar to Units 1-3's demonstrated performance.

(B) Units Without SCR

The only Indiana unit without SCR that I analyzed was Unit 6 also at Clifty Creek. The summary of the cost-effectiveness for an SCR at this unit is shown in the table below. I have previously discussed the various inputs, and their general conservativeness earlier. The cost-effectiveness is estimated to be \$9,609 per ton of NOx reduced. As such SCR is cost-effective for this unit based on previous cost effectiveness determinations by regulatory agencies at other units as discussed earlier.

SUMMARY OF SCR COST-EFFECTIVENESS								
Plant	Unit	UnitSize [1]	MedianNOx [2]	SCREff	PostSCRNOx	CapFac [3]	SCR CE [4]	SCR CE w/Multi-unit Discount
Clifty Creek	6	217	0.263	80	0.053	36.4	\$ 9,609	N/A

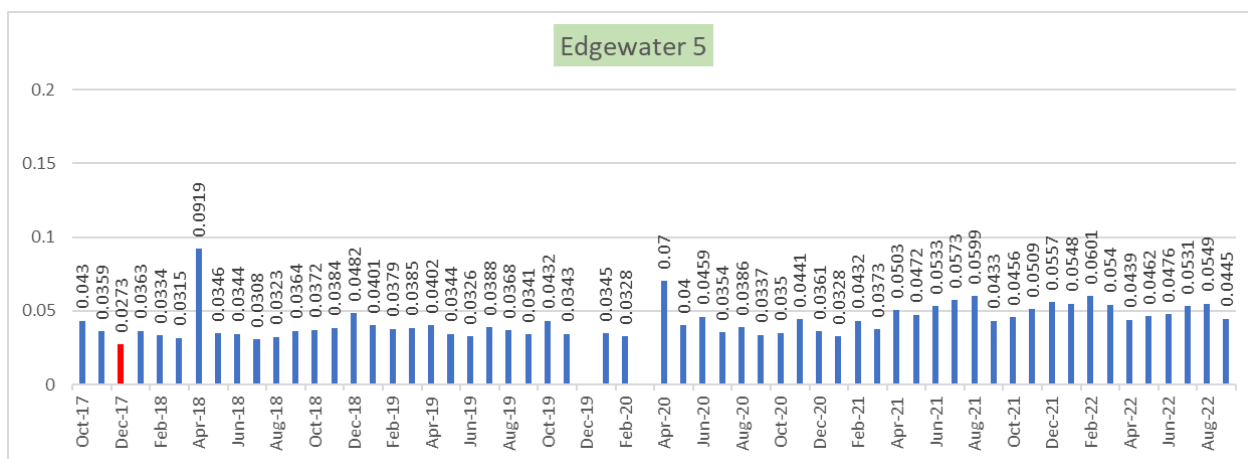
- [1] UnitSize MW
[2] MedianNOx 2018-Sep 2022 Monthly NOx (lb/MMBtu)
[3] CapFac Maximum of: Median Monthly 2017-2021 or Jan-Oct 2022
[4] SCR CE SCR Cost-Effectiveness, \$/ton

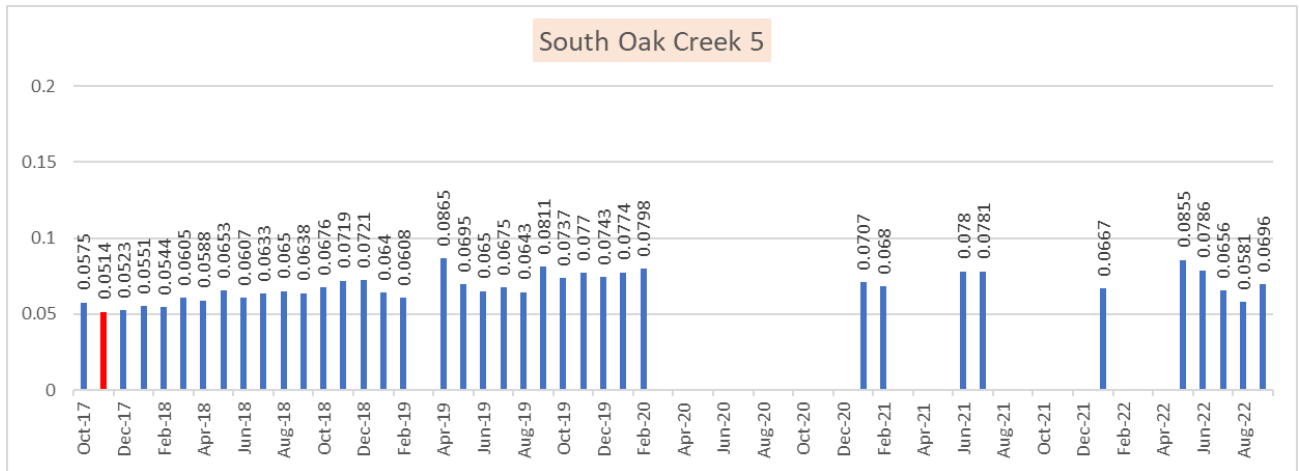
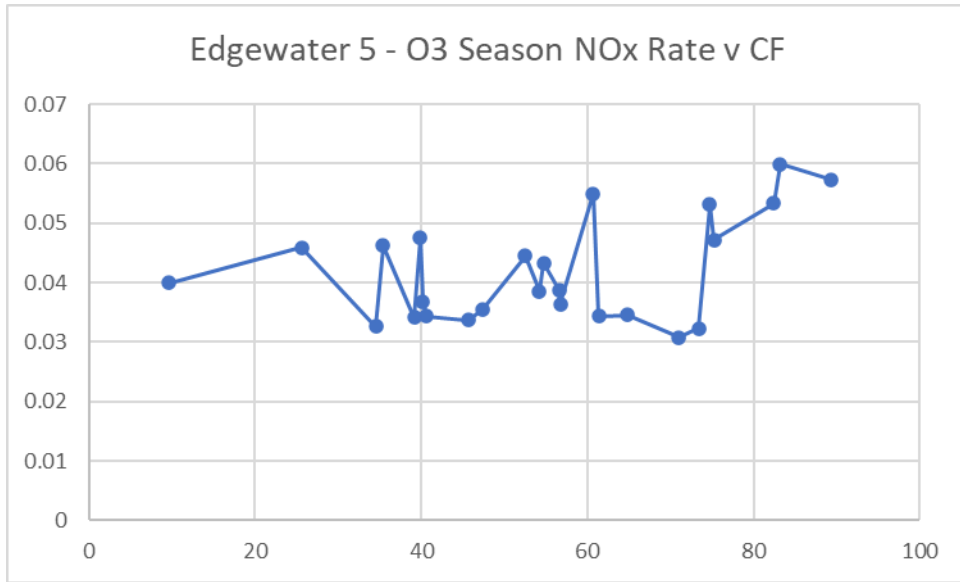
Wisconsin

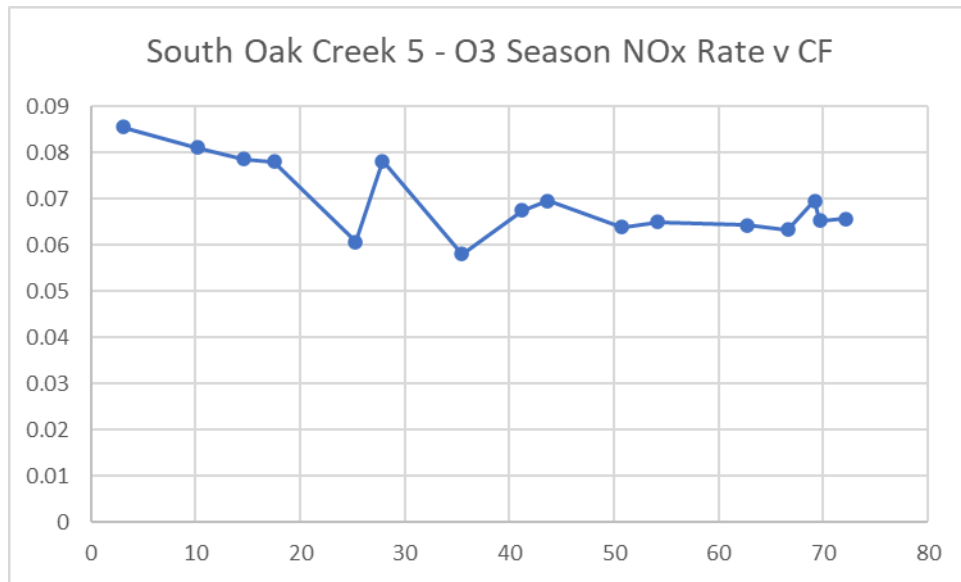
(A) Units with SCR

For Wisconsin, I address Unit 5 (approximately 380 MW) at the Edgewater plant and also Unit 5 (approximately 300 MW) at the South Oak Creek plant. Both of these units have existing SCRs. The summary of the NO_x performance for these two units is shown in the table below. Both units are being operated with good NO_x performance; however, as the NO_x level for the maximum months shown below are greater than 0.07 lb/MMBtu, there remains room for improvement in SCR operation at each unit. In addition, the highest ozone season NO_x level for the South Oak Creek Unit 5 is also greater than 0.07 lb/MMBtu.

Plant	Unit	MW	NO _x , Min	NO _x , Max	NO _x , Max O3 Months
Edgewater	5	380	0.0273	0.0919	0.0599
South Oak Creek	5	300	0.0514	0.0865	0.0855





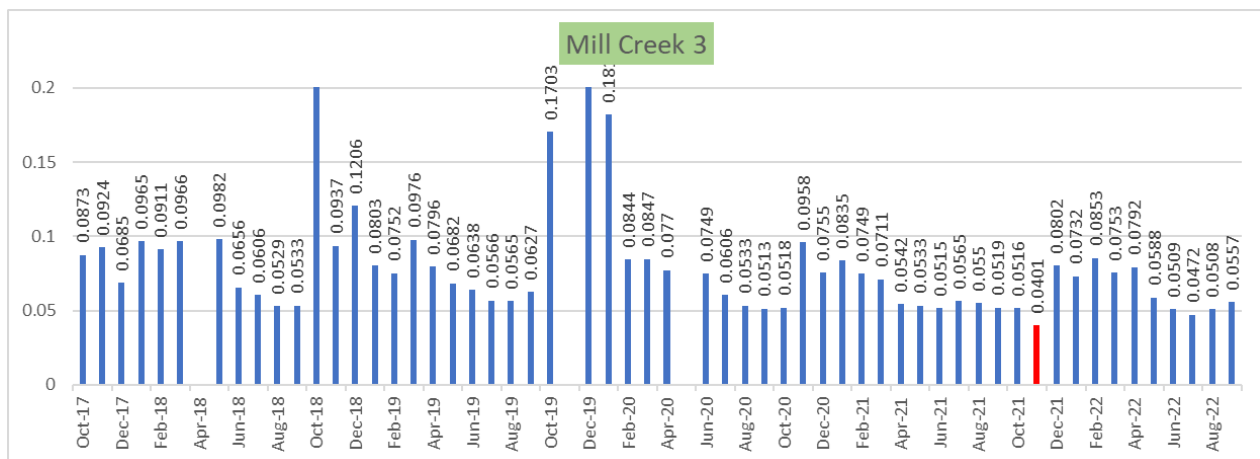


Kentucky

(A) Units with SCR

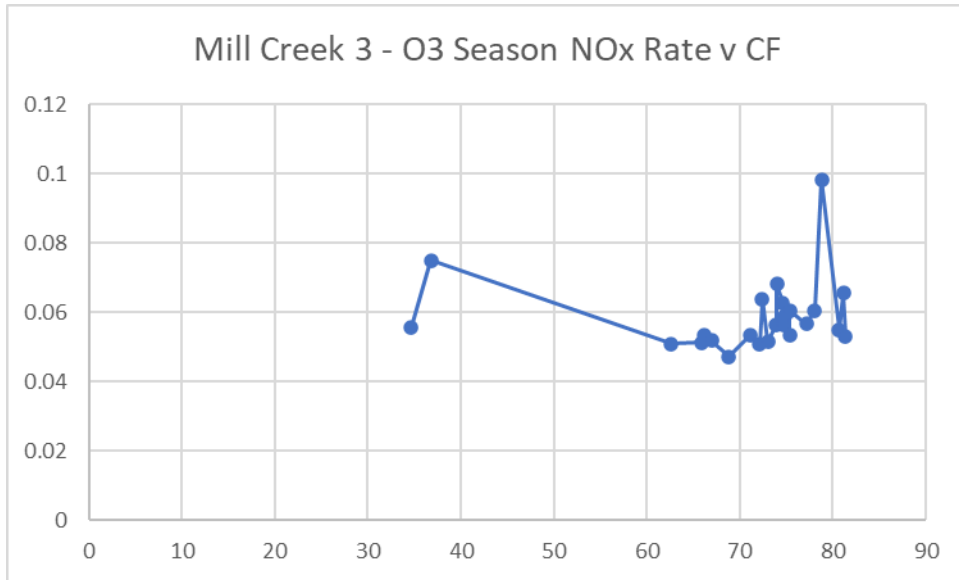
I analyzed Unit 3 (463 MW) and Unit 4 (544 MW) at the Mill Creek plant. These units have SCR installed. Each of them can clearly achieve reliably lower NO_x emission rates. They are clearly not operating their SCRs according to the SCR's NO_x reduction capacity, and it is not because of low capacity factor nor MOT issues as the charts below make clear.

Plant	Unit	MW	NO _x , Min	NO _x , Max	NO _x , Max O3 Months
Mill Creek, KY	3	463	0.0401	0.3172	0.0982
	4	544	0.0468	0.2422	0.0802

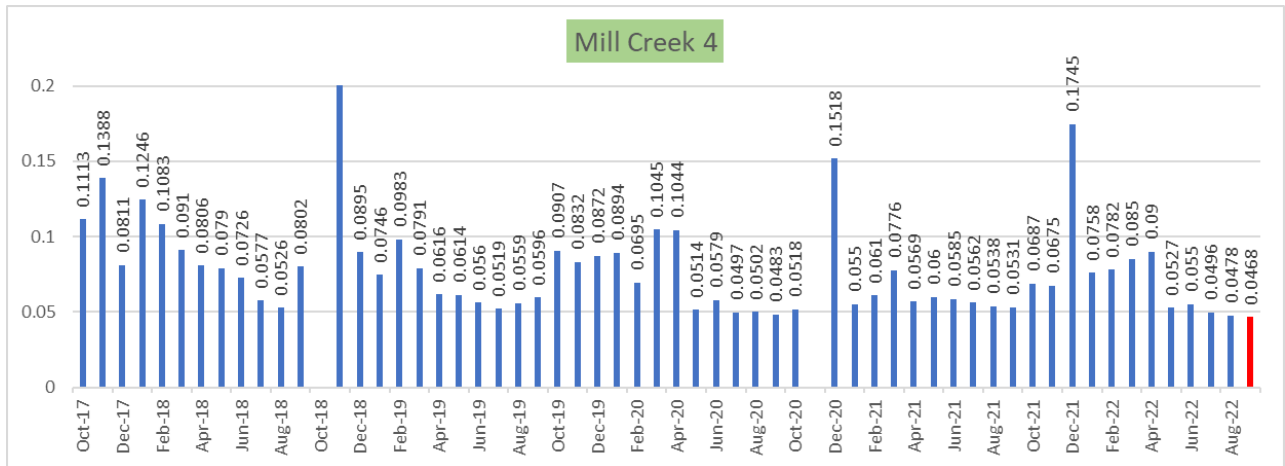


The chart above confirms that Mill Creek Unit 3 has achieved levels well below 0.07 lb/MMBtu on many months of recent operation, with a low of 0.04 lb/MMBtu, shown in red.

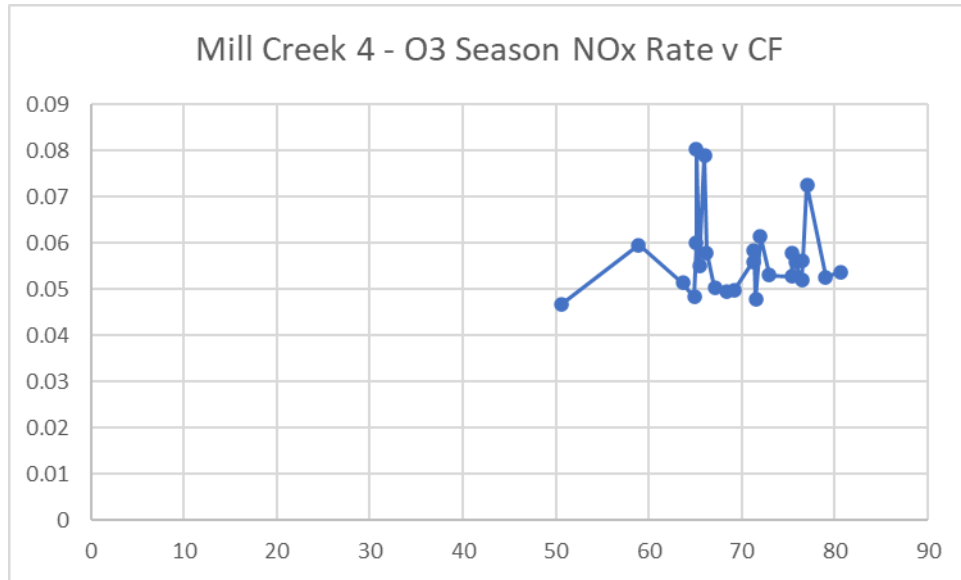
The chart below shows that Mill Creek Unit 3 has achieved less than 0.07 lb/MMBtu over a wide range of ozone-season operating capacity factors.



Similar to its sister unit, Mill Creek Unit 4 has also achieved NOx levels well below 0.07 lb/MMBtu as shown in the chart below. The low value of less than 0.047 lb/MMBtu is shown in red.



While Unit 4 has not operated at very low capacity factors during the ozone season, as shown in the chart below, it has operated below 0.07 lb/MMBtu across its range of operating capacity factors.



Based on the above, I conclude that Mill Creek Units 3 and 4 can operate their SCR and achieve monthly average NOx levels of 0.07 lb/MMBtu.

(B) Units Without SCR

For Kentucky, I analyzed Unit 1 (463 MW) and Unit 2 (544 MW) at the Mill Creek plant. The summary of the cost-effectiveness for SCR at these units is shown in the table below. I have previously discussed the various inputs, and their general conservativeness earlier. The cost-effectiveness is calculated to be \$4,148 per ton of NOx reduced for Mill Creek 1 and \$4,100 per ton of NOx reduced for Mill Creek 2. As such SCR is highly cost-effective for these units.

SUMMARY OF SCR COST-EFFECTIVENESS								
Plant	Unit	UnitSize [1]	MedianNOx [2]	SCREff	PostSCRNOx	CapFac [3]	SCR CE [4]	SCR CE w/Multi-unit Discount [5]
Mill Creek	1	356	0.280	80	0.056	68.7	\$ 4,879	\$ 4,148
Mill Creek	2	356	0.283	80	0.057	68.5	\$ 4,824	\$ 4,100

[1] UnitSize MW

[2] MedianNOx 2018-Sep 2022 Monthly NOx (lb/MMBtu)

[3] CapFac Maximum of: Median Monthly 2017-2021 or Jan-Oct 2022

[4] SCR CE SCR Cost-Effectiveness, \$/ton

[5] Multi-unit discount assumed to be 15% lower.

Missouri

(A) Units Without SCR

For Missouri I analyzed Units 1-4 at the Labadie plant. The summary of the cost-effectiveness for SCRs at these units is shown in the table below. Again, I have previously discussed the various inputs, and their general conservativeness earlier. The cost-effectiveness is calculated to be between \$11,904 and \$12,559 per ton of NO_x reduced for the four Labadie units. Again SCR is cost-effective for these units.

SUMMARY OF SCR COST-EFFECTIVENESS								
Plant	Unit	UnitSize [1]	MedianNO _x [2]	SCREff	PostSCRNO _x	CapFac [3]	SCR CE [4]	SCR CE w/Multi-unit Discount [5]
Labadie	1	574	0.092	60	0.037	82.1	\$ 14,206	\$ 12,075
Labadie	2	574	0.093	60	0.037	78.8	\$ 14,578	\$ 12,392
Labadie	3	621	0.095	60	0.038	79.1	\$ 14,005	\$ 11,904
Labadie	4	621	0.093	60	0.037	76.9	\$ 14,774	\$ 12,558

[1] UnitSize MW

[2] MedianNO_x 2018-Sep 2022 Monthly NO_x (lb/MMBtu)

[3] CapFac Maximum of: Median Monthly 2017-2021 or Jan-Oct 2022

[4] SCR CE SCR Cost-Effectiveness, \$/ton

[5] Multi-unit discount assumed to be 15% lower.

Colorado

(A) Units Without SCR

For Colorado I analyzed Units 1 at the Rawhide plant. The summary of the cost-effectiveness for SCRs at this unit is shown in the table below. Again, I have previously discussed the various inputs, and their general conservativeness earlier. The cost-effectiveness is calculated to be \$11,114 per ton of NO_x reduced. Therefore, SCR is cost-effective for this unit.

SUMMARY OF SCR COST-EFFECTIVENESS								
Plant	Unit	UnitSize [1]	MedianNO _x [2]	SCREff	PostSCRNO _x	CapFac [3]	SCR CE [4]	SCR CE w/Multi-unit Discount
Rawhide	1	294	0.118	70	0.035	82.3	\$ 11,114	N/A

[1] UnitSize MW

[2] MedianNO_x 2018-Sep 2022 Monthly NO_x (lb/MMBtu)

[3] CapFac Maximum of: Median Monthly 2017-2021 or Jan-Oct 2022

[4] SCR CE SCR Cost-Effectiveness, \$/ton

Texas

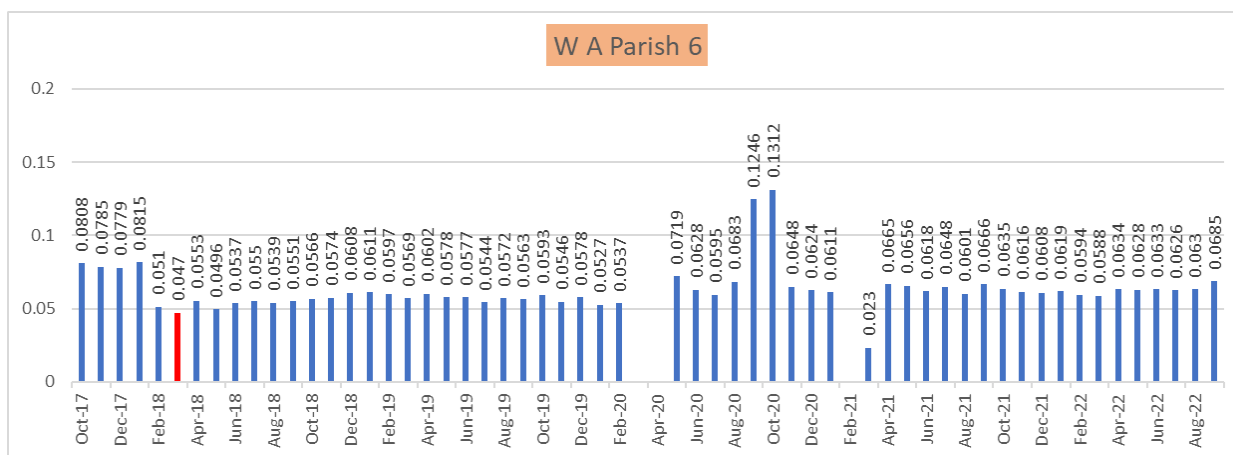
(A) Units with SCR

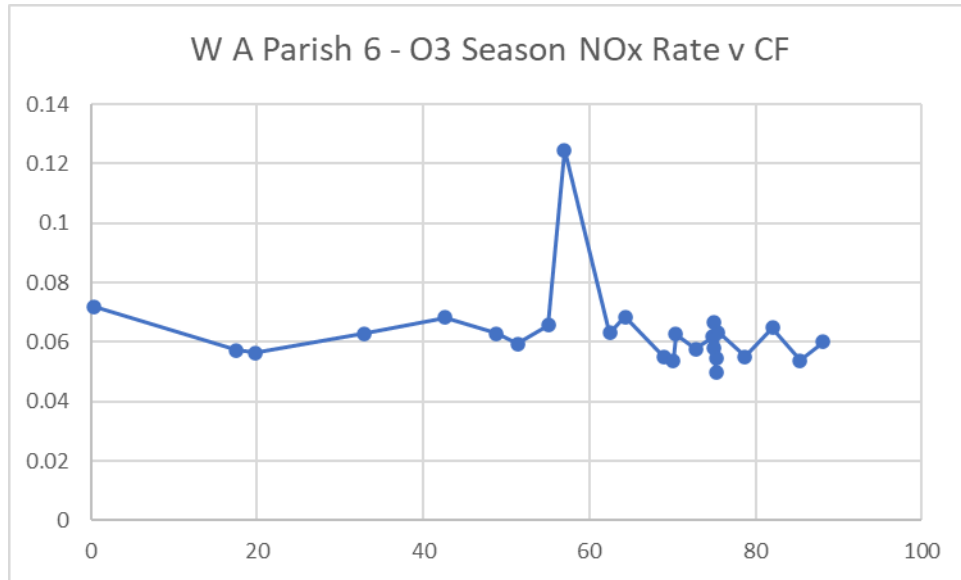
For units that have SCR already installed, I assessed Unit 6 (734 MW), Unit 7 (615 MW), and Unit 8 (654 MW) at the W. A. Parish plant. Each of them can clearly achieve reliably lower NOx emission rates. They are not operating their SCRs according to the SCR's NOx reduction capacity, and it is not because of low capacity factor nor MOT issues as the summary table below and the respective Unit-specific charts that follow clearly demonstrate.

Plant	Unit	MW	NOx, Min	NOx, Max	NOx, Max O3 Months
W A Parish, TX	6	734	0.047	0.1312	0.1246
	7	615	0.04	0.0976	0.0731
	8	654	0.0388	0.0846	0.0522

Note the minimum monthly NOx levels achieved by each of the three W A Parish units above – i.e., less than 0.05 lb/MMBtu.

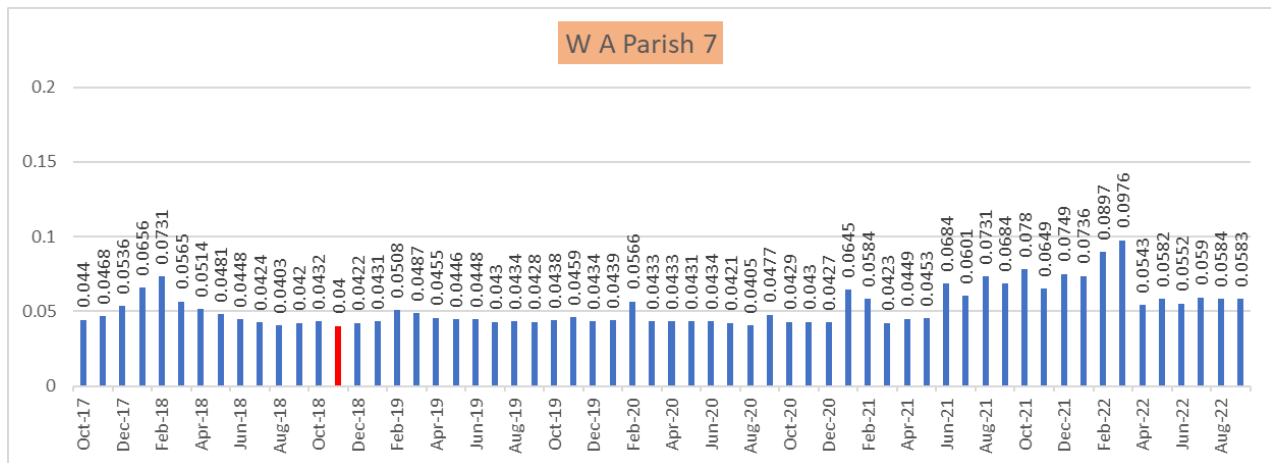
The monthly NOx chart for the last 60 months for Unit 6 is shown below, following by the NOx versus ozone season capacity factor chart for this unit .



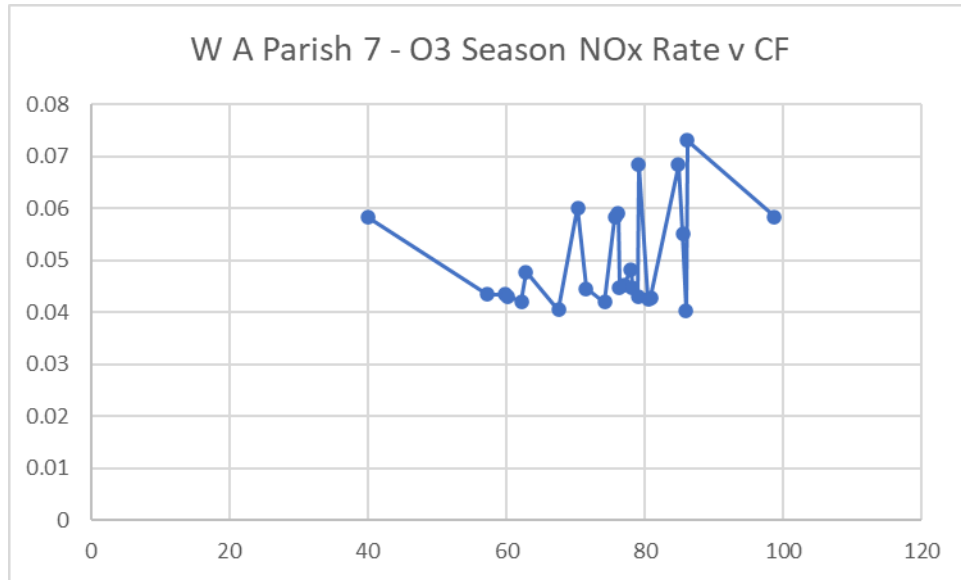


Both of the charts above confirm that Parish Unit 6 can achieve less than 0.07 lb/MMBtu monthly average NOx levels.

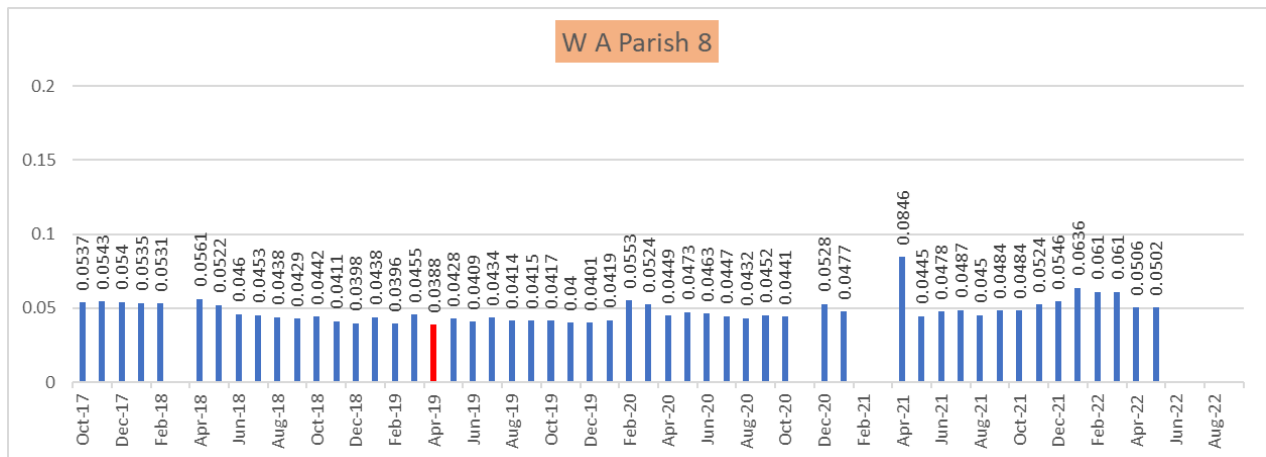
I reach a similar conclusion for Parish Unit 7 by reviewing its operating data as summarized in the two charts below. Monthly NOx levels have generally been less than 0.05 lb/MMBtu, with just a few months exceeding 0.07 lb/MMBtu in the last 60 months.



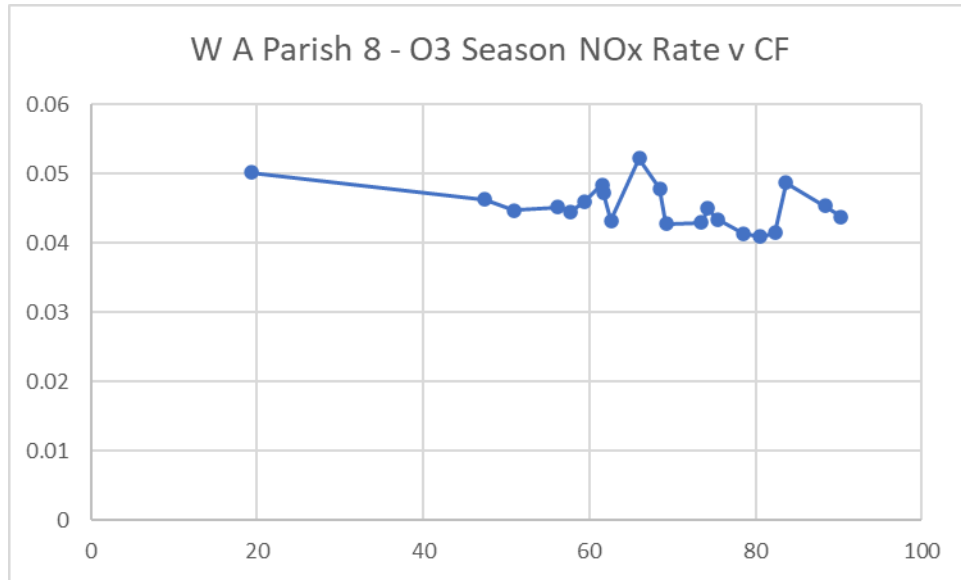
The chart below confirms that Unit 7 generally operates at a high ozone-season capacity factor and has no difficulty meeting monthly NOx levels of 0.07 lb/MMBtu.



The demonstrated NOx performance of Parish Unit 8 is also like that of Unit 7 above. Over the last 60 months the unit has generally maintained NOx levels of less than 0.05 lb/MMBtu. I note that the unit has not operated recently due to a fire in the unit in the summer of 2022.



When operating in the ozone season, the capacity factors and NOx levels for Unit 8 are shown below. As the chart clearly shows the unit has met and can therefore meet NOx levels of less than 0.07 lb/MMBtu across its operating monthly capacity factor range.



I therefore conclude that W A Parish Units 6, 7, and 8 can achieve monthly-average NOx levels less than 0.07 lb/MMBtu with little additional effort.

(A) Units without SCR

In addition to the three W A Parish units with existing SCRs that I address above, I also estimated the cost-effectiveness for a dozen Texas coal-fired units that currently operate without SCR.

I analyzed Unit 1 at JK Spruce (556 MW); Unit 1 (893 MW) and Unit 2 (957 MW) at Limestone; Unit 1 (793 MW), Unit 2 (793 MW), and Unit 3 (793 MW) at Martin Lake; Unit 1 (615 MW), Unit 2 (615 MW), and Unit 3 (460 MW) at Sam Seymour/Fayette; Units 1 and 2 at Tolk (568 MW each); and Unit 1 (416MW) at San Miguel. The summary of the cost-effectiveness for SCRs at each of these units is shown in the table below. Again, I have previously discussed the various inputs, and their general conservativeness earlier. The cost-effectiveness for every unit except Tolk 1 and 2 is calculated to be below \$9,000 per ton of NOx reduced, with a very modest multi-unit discount on the SCR capital cost (15%) as noted prior. As such SCR is very cost-effective for these units. The cost-effectiveness for Tolk Units 1 and 2 are each below \$12,000, indicating that SCRs are also cost effective at the two Tolk units as well, when compared to previous cost effectiveness decisions by regulatory agencies at other plants.

SUMMARY OF SCR COST-EFFECTIVENESS								
Plant	Unit	UnitSize [1]	MedianNOx [2]	SCREff	PostSCRNOx	CapFac [3]	SCR CE [4]	SCR CE w/Multi-unit Discount [5]
J K Spruce	1	556	0.146	70	0.044	69.5	\$ 9,255	
Limestone	1	893	0.152	70	0.045	55.1	\$ 10,501	\$ 8,926
Limestone	2	957	0.168	70	0.050	63	\$ 8,411	\$ 7,149
Martin Lake	1	793	0.151	70	0.045	62.6	\$ 9,538	\$ 8,108
Martin Lake	2	793	0.152	70	0.046	60.1	\$ 9,838	\$ 8,362
Martin Lake	3	793	0.144	70	0.043	66	\$ 9,618	\$ 8,175
Sam Seymour	1	615	0.125	70	0.037	74.5	\$ 10,158	\$ 8,634
Sam Seymour	2	615	0.114	70	0.034	76.6	\$ 10,573	\$ 8,987
Sam Seymour	3	460	0.126	70	0.038	86.8	\$ 8,927	\$ 7,588
Tolk	1	568	0.161	80	0.032	35.6	\$ 14,029	\$ 11,925
Tolk	2	568	0.156	80	0.031	36.8	\$ 13,903	\$ 11,818
San Miguel	1	410	0.156	70	0.047	76.8	\$ 8,273	

[1] UnitSize MW

[2] MedianNOx 2018-Sep 2022 Monthly NOx (lb/MMBtu)

[3] CapFac Maximum of: Median Monthly 2017-2021 or Jan-Oct 2022

[4] SCR CE SCR Cost-Effectiveness, \$/ton

[5] Multi-unit discount assumed to be 15% lower.

Appendix A³

Excerpts Addressing SCR Performance to Obtain Low NO_x Levels

³ Appendix A contains excerpts of a prior report I have authored. The entire report is available at <https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0668-0758>

F. Strategies to Achieve Better SCR Performance and Lower NO_x Levels

As noted earlier, an SCR, using specially formulated catalysts and relying on good mixing of the reducing agent (ammonia) and the exhaust gas containing NO_x, prior to the introduction into the SCR itself, achieves high levels of NO_x reduction as long as inlet gas temperatures are high enough for maintaining high catalyst activity and by avoiding damage to the catalysts such as by blocking the catalyst pores and/or chemically deactivating the catalyst.

As such since the heart of the NO_x reduction occurs at the catalyst, the SCR itself (i.e., the mechanical housing) and its age is of less significance, as long as it is maintained with some care.

It should be noted that all catalyst activity deteriorates over time due to inevitable degradation, especially for those catalyst layers that first see the incoming gas. In addition, the presence of pollutants such as sulfur compounds can adversely affect catalyst activity because reactions of such compounds and the ammonia reagent can cause a range of salts to form and deposit on the catalyst surfaces, which then inhibit NO_x reduction.

Thus maintaining SCR activity requires an anticipation of likely deterioration mechanisms and accounting for them during operation. This includes factors such as proper catalyst management (i.e., rotating catalysts such that front layers are replaced by rear layers and/or sent to be rejuvenated or replaced) using actual activity data; managing and maintain high inlet gas temperatures above the so-called catalyst minimum operating temperature (MOT) while the load in the unit varies; and cycling the unit such that any deposition of ammonium salts can be reversed at higher gas temperatures.

There are myriad such strategies, with likely optimal combinations that can only be determined on a unit-specific analysis because of variabilities include coal type, type and age of the boiler, geometries and temperature profiles, and location of the SCR in the exhaust gas path, among some of the variables. While attempts were made, using vendor contacts, to ascertain which specific strategy/strategies may have been used at the units of interest in this analysis (i.e., those for which data were analyzed earlier) specific information was not forthcoming due to confidentiality reasons.

Thus, this section provides a general discussion of approaches that can be used to maintain good SCR catalyst performance with age and changing unit operation – i.e., with more cycling than baseload operations, at lower capacity factors.

F1. Catalyst Management

After design, which is not discussed in this report, proper catalyst management is essential for maintaining high levels of catalyst performance over time. Since catalyst deterioration over time is inevitable, it needs to be monitored and managed. The following figures are drawn from a major SCR catalyst vendor and illustrate the factors and concepts in catalyst management.

Figure 1 – SCR Catalyst Management Overview

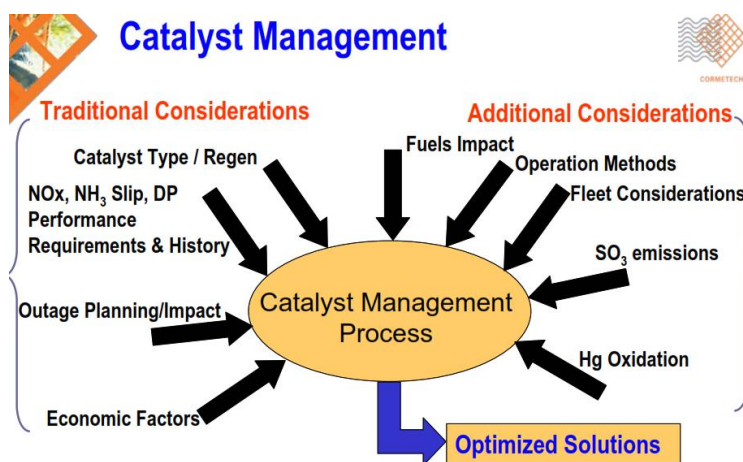
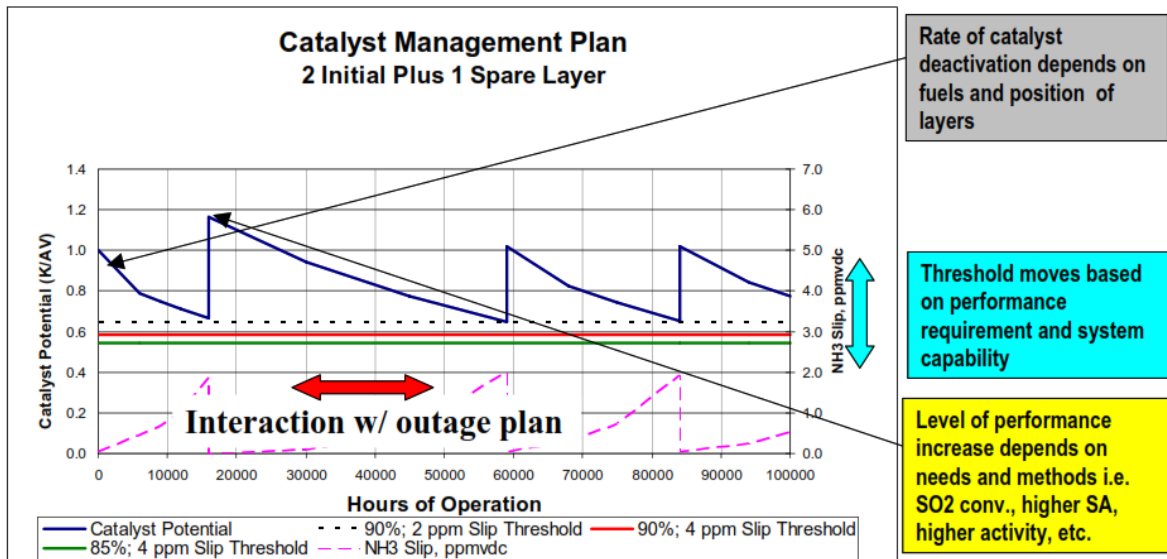


Figure 1 shows the many factors that are considered in properly managing catalyst activity to make sure it is maintained at a high level. Important technical factors that affect this include catalyst type (noted above), the quantity of catalyst (not noted above), the arrangements of the catalyst layers in the SCR along the gas path and the type of screens located ahead of the catalyst to ensure that the catalyst is not impacted by particulate matter (i.e., ash from the boiler) to the extent possible.⁷

Figure 2 below shows a conceptual catalyst management plan where the SCR contains space for three layers of catalyst along the gas path. The simple idea is that as the lead layer's performance deteriorates over time (the blue saw-tooth profile in the upper panel), it is replaced with catalyst from the other layers, and then either cleaned and regenerated or replaced with new catalyst.

⁷ SCRs can be located in the so-called "high-dust" configuration in which the catalyst is placed prior to particulate matter controls such that the gas temperature is in the proper range for good catalyst operation. Dust management in this configuration is a critical factor in catalyst life and activity.

Figure 2 – Catalyst Management Plan Example



Of course catalyst management is useless without proper monitoring of the catalyst activity. Figures 3 and 4 below illustrate some basic concepts.

Figure 3 – Catalyst Testing

- Catalyst testing & sampling methodology
 - Full elements / plates from each layer
 - Molar ratio 1 vs. design MR
 - SO₂ conversion
 - Appropriate aging of samples
 - Qualification of regeneration process
- AIG Tuning/Distribution Measurement
 - Potential for AIG and mixing optimization

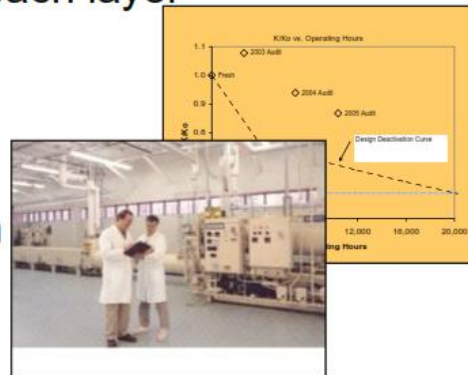
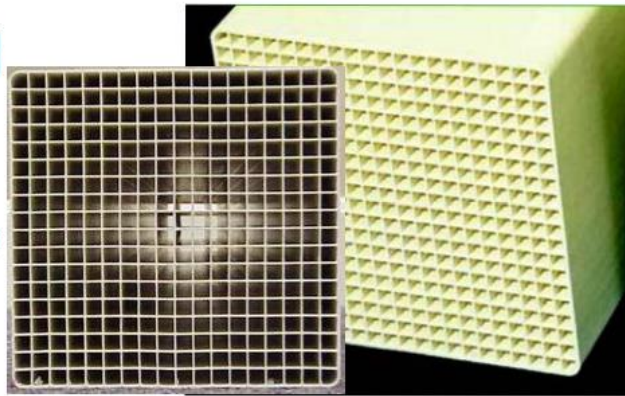


Figure 4 – Catalyst Inspection

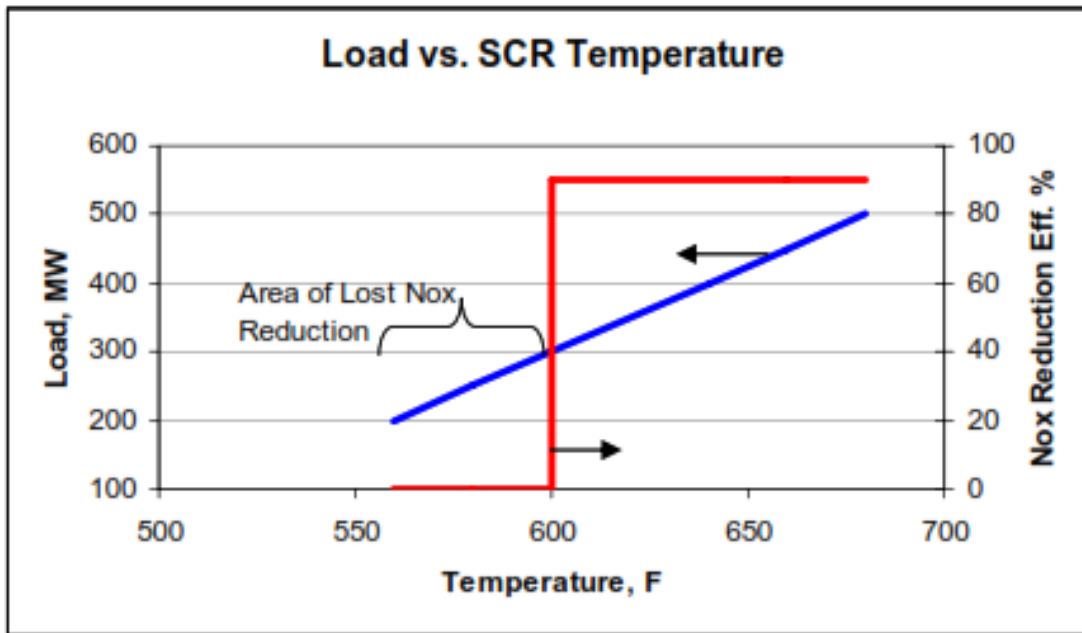
- Catalyst and system inspections
 - LPA mitigation considerations
 - Screen, perforated plate, or aerodynamic design
- Catalyst type and pitch selection
 - Experience
 - Qualification process



F2. Catalyst Performance and Inlet Temperature

Like all catalysts, SCR catalysts require a minimum operating temperature (MOT) below which they have little activity – and therefore little NO_x reduction. Therefore, it is important that catalysts with the lowest possible MOTs are selected (or substituted when older catalyst layers are replaced per the catalyst management discussion prior) and then temperatures above the MOT are maintained under the widest range of loads. This is shown conceptually in Figure 5 below. The MOT is assumed to be 600 F – and therefore there is 90% NO_x reduction above that temperature and no reduction below that as shown in the red curve. The blue curve shows a unit's gas temperature at SCR inlet as a function of load. Thus, in this example, the SCR would not provide any NO_x reduction below a unit load of 300 MW. If the red curve is shifted to the left – i.e., to lower temperatures - more NO_x reduction can occur at lower loads, allowing for load cycling to lower loads. Conversely, if the blue curve is shifted to the right by increasing inlet temperature at lower loads, again more NO_x reduction can occur at those lower loads.

Figure 5 – Unit Load and SCR Performance



An example of implementation of the strategy of lowering MOT is shown below in Figure 6 for Gibson Unit 1, a sister unit to Gibson Unit 2, whose NO_x performance was previously reviewed.

Figure 6 – MOT reduction at Gibson Unit 1

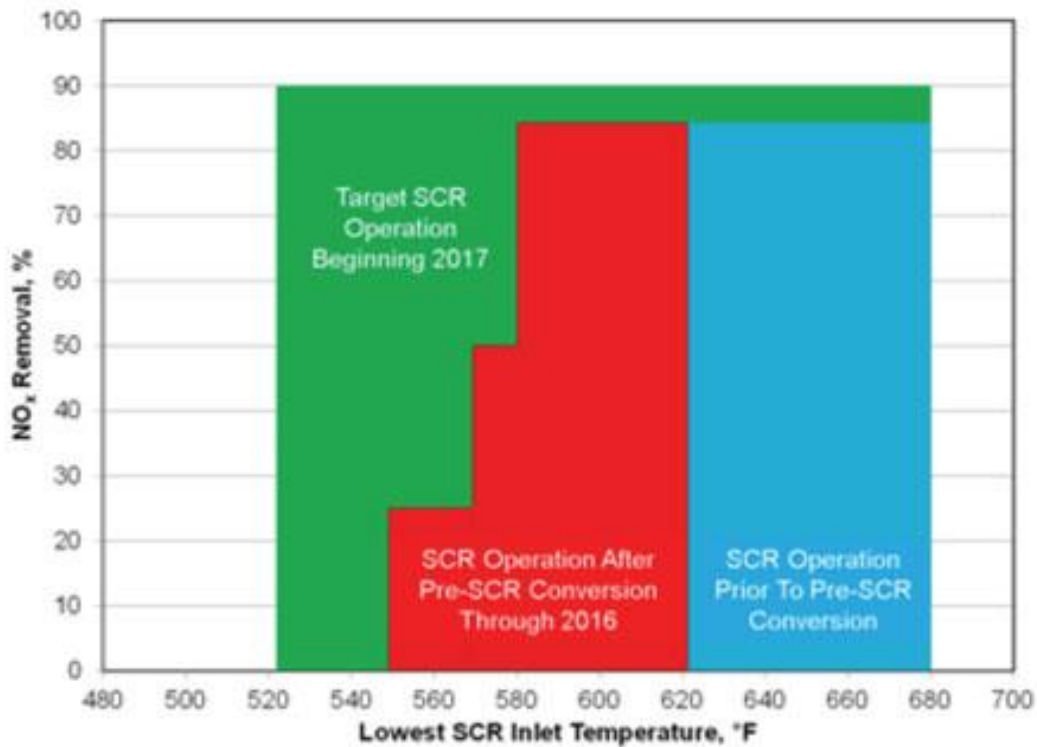
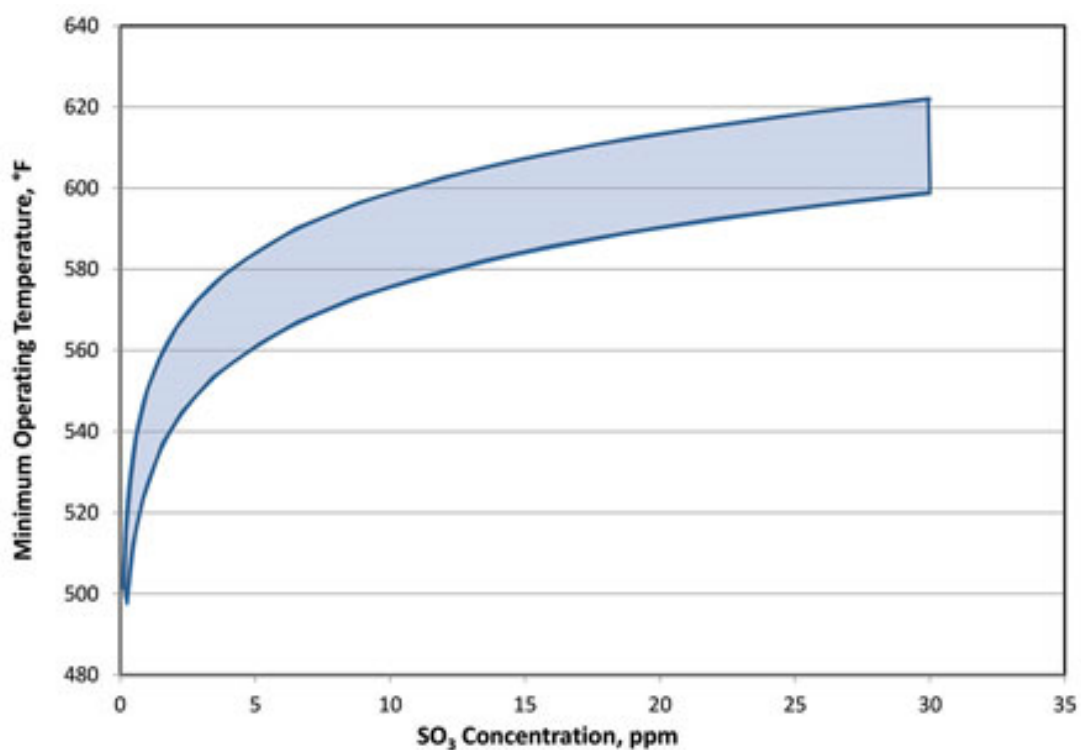


Figure 6 shows how the SCR inlet temperature, which was 550 – 620 F after SCR conversion through 2016, has been reduced to 520 F beginning 2017 – allowing for lower loads where higher levels of NO_x can be reduced. The figure also shows that the SCR catalyst itself after 2017 provides higher NO_x reduction (to 90%) compared to the earlier catalyst (85%).

One of the strategies to obtain lower MOT is to reduce the SO₃ that can be formed in the exhaust gases as discussed in the next section. If lower SO₃ levels can be maintained, the MOT can be lowered. A generic relationship between MOT and SO₃ concentrations is shown in Figure 7 below.

Figure 7 – Relationship between MOT and SO₃ Concentration



It has been reported that Duke Energy has obtained MOTs as low as 500 F at Gibson station by lowering SO₃ in the inlet gas using sorbent injection.⁸

Regarding the blue curve in Figure 5, additional strategies have been used to maintain high inlet gas temperatures (i.e., above MOT) under a range of loads. As noted in the literature,⁹ one option

⁸ <https://www.power-eng.com/coal/boilers/scr-performance/#gref>
Power Engineering, SCR Performance March 2017

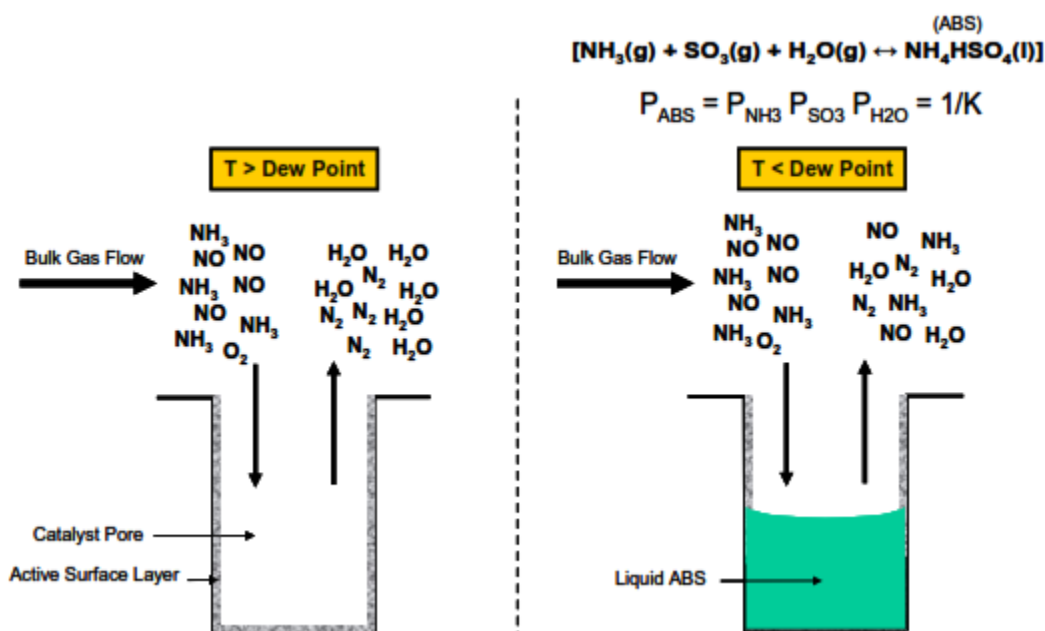
⁹ <https://www.powermag.com/scr-reheat-burners-keep-nox-in-spec-at-low-loads/>
Power, March 1, 2015

is to install gas-side economizer bypass ductwork to divert a portion of the hot flue gas that would normally enter the economizer and send it directly to the inlet of the SCR. In other instances, direct reheating of the exhaust gases using so-called SCR reheat burners can increase the gas temperature to the SCR. These are installed in the ductwork.

F3. Reduction of SCR Catalyst Activity Due to Ammonium Salts

As noted briefly earlier, sulfur compounds in the exhaust gases can oxidize to SO₃ and then combine with ammonia to form several salts which can deposit in catalyst pores and therefore not allow NO_x reduction in those areas of the catalyst. The concept is shown in Figure 8 below.

Figure 8 – Ammonium Salt Formation and Deposition



This salt formation is reversible however, allowing the catalyst activity to be regained. Simply increasing the gas temperature by increasing the unit load can reverse this phenomenon. Thus unit cycling to high capacity factors, which occurs normally in many cycling units, can mitigate this temporary loss of activity.

In some cases ensuring that the least amount of ammonia is used (and properly mixed and distributed across the catalyst layer) will minimize the ammonia slip and lead to the least amount of salt formation, if very low sulfur compounds are present. On the other hand, some amount of ammonia slip may be beneficial to NO_x reduction if significant levels of sulfur compounds are present and if the resulting SO₃ can be reduced to avoid salt formation when the SO₃ reacts with ammonia. SO₃ removal upstream of the air heater, and ideally upstream of the SCR reactor itself,

by injecting sorbents¹⁰ (often used for MACT acid gas compliance) can be an important strategy at both high- and low-loads. For higher-load operation, the goal is to reduce SO₃ to very low levels prior to the SCR or even earlier at the air heater inlet. This relieves the constraint on ammonia slip because there is not enough SO₃ available to form appreciable amounts of salts. With the ammonia slip constraint relaxed, modest increases in ammonia slip are possible, which allows the NOx reduction efficiency to be increased. This illustrates the unit-specific nature of optimization.

F4. Upgraded Instrumentation and Automation

Maintaining proper process conditions, especially during cycling conditions, requires instrumentation and control systems that can react quickly to load changes, measure critical parameters such as inlet NOx concentrations, inlet gas temperatures, inlet SO₃ conditions, etc. and many other parameters and appropriately adjust inputs such as ammonia injection, using feedback loops. The role of upgrading instrumentation is therefore critical in achieving optimum SCR performance. Over time improvements in sensors, measurement software, optimization software, and the like, make it imperative that the instrumentation and controls that are installed in SCRs that are aging should be evaluated and upgraded in order to enable more current hardware and software to allow for greater control of key variables such as temperatures, in-line NOx and ammonia measurements, and the spatial distribution of these parameters in the SCR inlet duct.

A recent article discusses this in the context of Brandon Shores, whose strong NOx performance was noted earlier.¹¹

Conclusion

There are numerous strategies that can be used to operate SCRs optimally at cycling units, including during low load operations.

¹⁰ Of course using coal with lower sulfur levels, such as PRB coals will reduce SO₃ emissions all other parameters being the same.

¹¹ <http://www.emersonautomationexperts.com/papers/Optimization-of-Emissions-Reduction-Equipment-SCR.pdf>

Appendix B
Copy of Resume

RANAJIT (RON) SAHU, PH.D, CEM (NEVADA)

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

Dr. Sahu has over thirty two 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 thirty years of project management experience and has successfully managed and executed hundreds of 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 three decades include various trade associations as well as individual companies such as steel mills, petroleum refineries, chemical plants, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, land development companies, and various entities in the public sector including EPA, the US Dept. of Justice, several states (including New York, New Jersey, Connecticut, Kansas, Oregon, New Mexico, Pennsylvania, and others), various agencies such as the California DTSC, and various cities and municipalities. Dr. Sahu has executed projects in all 50 US states, numerous local jurisdictions and internationally.

In addition to consulting, for approximately two decades, Dr. Sahu taught numerous courses in several Southern California universities as adjunct faculty, including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management). He 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 and engineering 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, environmental

consulting, project management, 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, CA.
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.
- 1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department.
- 1989-1990 Kinetics Technology International, Corp. **Development Engineer**. Involved in thermal engineering R&D and project work related to low-NO_x ceramic radiant burners, fired heater NO_x 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, California Institute of Technology (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 beginning 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 beginning 1998.

"Hazardous Waste Remediation" Loyola Marymount University, Dept. of Civil Engineering. Various years beginning 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.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-mid-1990s.

Air and Waste Management Association, West Coast Section, 1989-mid-2000s.

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, 2000 - 2021.

CEM, State of Nevada (#EM-1699).

PUBLICATIONS (PARTIAL LIST)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PRESENTATIONS (PARTIAL LIST)

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

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

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

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

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

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

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

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

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

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

Annex A

Expert Litigation Support

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

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

B. Matters for which Dr. Sahu has provided affidavits and expert reports include:

2. 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.
3. 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 United States in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).
4. Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the United States in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).
5. Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the United States in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (Middle District of North Carolina).
6. Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the United States 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 (Southern District of Ohio).
7. Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.
8. Expert Report and Deposition (10/31/2005 and 11/1/2005) on behalf of the United States in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc.*, 5:04-cv-00034-KSF (Eastern District of Kentucky).
9. Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.
10. Expert Report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.
11. 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.
12. 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.
13. 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.

14. Expert Testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).
15. Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.
16. Expert Report 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 (Western District of Pennsylvania).
17. Expert Reports and Pre-filed Testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.
18. Expert Report 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 (Southern District of Ohio, Western Division) .
19. Expert 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.
20. 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.
21. Affidavits (May 2010/June 2010 in the Office of Administrative Hearings)/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).
22. Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).
23. Declaration (August 2008) on behalf of the Sierra Club in the matter of Dominion Wise County plant MACT.us
24. Expert Report (June 2008) on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis.
25. Expert Report (February 2009) 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.
26. Expert Report (June 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*
27. Expert Report (August 2009) 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).
28. Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.
29. Expert Report (August 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

30. Expert Report and Rebuttal Report (September 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.
31. Expert Report (December 2009) and Rebuttal reports (May 2010 and June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).
32. Pre-filed Testimony (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
33. Pre-filed Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.
34. Expert Report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.
35. Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the United States in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (Eastern District of Michigan).
36. Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.
37. Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (District of Colorado).
38. Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
39. Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
40. Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, November 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. Public Service Company of New Mexico* (PNM), Civil No. 1:02-CV-0552 BB/ATC (ACE) (District of New Mexico).
41. Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
42. Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
43. Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant*

Generation Company LLC, Case No. 5:10-cv-00156-DF-CMC (Eastern District of Texas, Texarkana Division).

44. Pre-Filed Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
45. Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.
46. Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).
47. Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority*, Civil Action No. 4:11-cv-00791 (Southern District of Texas, Houston Division).
48. Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
49. Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).
50. Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.*, Civil Action No. A-08-CA-648-LY (Western District of Texas, Austin Division).
51. Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.*, Case No. 3:10-cv-747 (TJM/DEP) (Northern District of New York).
52. Declaration (October 2011) on behalf of the Plaintiffs in the matter of *American Nurses Association et. al. (Plaintiffs), v. US EPA (Defendant)*, Case No. 1:08-cv-02198-RMC (US District Court for the District of Columbia).
53. Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association*, Case No. 11-417-MJP (Western District of Washington).
54. Expert Report (March 2012) and Supplemental Expert Report (November 2013) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.*, Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).
55. Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency*, Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).
56. Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plant) (Supreme Court of the State of Kansas).

57. Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality*, Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).
58. Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) on behalf of the states of New Jersey and Connecticut in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.*, Civil Action No. 07-CV-5298 (JKG) (Eastern District of Pennsylvania).
59. Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project.
60. Expert Report (August 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.
61. Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.
62. Expert Report (October 2012) on behalf of the Appellants (Robert Concilus and Leah Humes) in the matter of Robert Concilus and Leah Humes v. Commonwealth of Pennsylvania Department of Environmental Protection and Crawford Renewable Energy, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2011-167-R.
63. Expert Report (October 2012), Supplemental Expert Report (January 2013), and Affidavit (June 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.
64. Pre-filed Testimony (October 2012) on behalf of No-Sag in the matter of the North Springfield Sustainable Energy Project before the State of Vermont, Public Service Board.
65. Pre-filed Testimony (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.
66. Expert Report (February 2013) on behalf of Petitioners in the matter of Credence Crematory, Cause No. 12-A-J-4538 before the Indiana Office of Environmental Adjudication.
67. Expert Report (April 2013), Rebuttal report (July 2013), and Declarations (October 2013, November 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
68. Declaration (April 2013) on behalf of Petitioners in the matter of *Sierra Club, et al., (Petitioners) v. Environmental Protection Agency et al. (Respondents)*, Case No., 13-1112, (Court of Appeals, District of Columbia Circuit).
69. Expert Report (May 2013) and Rebuttal Expert Report (July 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).
70. Declaration (August 2013) on behalf of A. J. Acosta Company, Inc., in the matter of *A. J. Acosta Company, Inc., v. County of San Bernardino*, Case No. CIVSS803651.
71. Comments (October 2013) on behalf of the Washington Environmental Council and the Sierra Club in the matter of the Washington State Oil Refinery RACT (for Greenhouse Gases), submitted to the Washington State Department of Ecology, the Northwest Clean Air Agency, and the Puget Sound Clean Air Agency.

72. Statement (November 2013) on behalf of various Environmental Organizations in the matter of the Boswell Energy Center (BEC) Unit 4 Environmental Retrofit Project, to the Minnesota Public Utilities Commission, Docket No. E-015/M-12-920.
73. Expert Report (December 2013) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
74. Expert Testimony (December 2013) on behalf of the Sierra Club in the matter of Public Service Company of New Hampshire Merrimack Station Scrubber Project and Cost Recovery, Docket No. DE 11-250, to the State of New Hampshire Public Utilities Commission.
75. Expert Report (January 2014) on behalf of Baja, Inc., in *Baja, Inc., v. Automotive Testing and Development Services, Inc. et. al*, Civil Action No. 8:13-CV-02057-GRA (District of South Carolina, Anderson/Greenwood Division).
76. Declaration (March 2014) on behalf of the Center for International Environmental Law, Chesapeake Climate Action Network, Friends of the Earth, Pacific Environment, and the Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. the Export-Import Bank (Ex-Im Bank) of the United States*, Civil Action No. 13-1820 RC (District Court for the District of Columbia).
77. Declaration (April 2014) on behalf of Respondent-Intervenors in the matter of *Mexichem Specialty Resins Inc., et al., (Petitioners) v Environmental Protection Agency et al.*, Case No., 12-1260 (and Consolidated Case Nos. 12-1263, 12-1265, 12-1266, and 12-1267), (Court of Appeals, District of Columbia Circuit).
78. Direct Prefiled Testimony (June 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17319 (Michigan Public Service Commission).
79. Expert Report (June 2014) on behalf of ECM Biofilms in the matter of the US Federal Trade Commission (FTC) v. ECM Biofilms (FTC Docket #9358).
80. Direct Prefiled Testimony (August 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of Consumers Energy Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17317 (Michigan Public Service Commission).
81. Declaration (July 2014) on behalf of Public Health Intervenors in the matter of *EME Homer City Generation v. US EPA* (Case No. 11-1302 and consolidated cases) relating to the lifting of the stay entered by the Court on December 30, 2011 (US Court of Appeals for the District of Columbia).
82. Expert Report (September 2014), Rebuttal Expert Report (December 2014) and Supplemental Expert Report (March 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and PacifiCorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).
83. Expert Report (November 2014) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).
84. *Declaration (January 2015) relating to Startup/Shutdown in the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.*
85. Pre-filed Direct Testimony (March 2015), Supplemental Testimony (May 2015), and Surrebuttal Testimony (December 2015) on behalf of Friends of the Columbia Gorge in the matter of the Application for a Site Certificate for the Troutdale Energy Center before the Oregon Energy Facility Siting Council.

86. Brief of Amici Curiae Experts in Air Pollution Control and Air Quality Regulation in Support of the Respondents, On Writs of Certiorari to the US Court of Appeals for the District of Columbia, No. 14-46, 47, 48. *Michigan et. al., (Petitioners) v. EPA et. al., Utility Air Regulatory Group (Petitioners) v. EPA et. al., National Mining Association et. al., (Petitioner) v. EPA et. al.*, (Supreme Court of the United States).
87. Expert Report (March 2015) and Rebuttal Expert Report (January 2016) on behalf of Plaintiffs in the matter of *Conservation Law Foundation v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).
88. Declaration (April 2015) relating to various Technical Corrections for the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.
89. Direct Prefiled Testimony (May 2015) on behalf of the Michigan Environmental Council, the Natural Resources Defense Council, and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Increase its Rates, Amend its Rate Schedules and Rules Governing the Distribution and Supply of Electric Energy and for Miscellaneous Accounting Authority, Case No. U-17767 (Michigan Public Service Commission).
90. Expert Report (July 2015) and Rebuttal Expert Report (July 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).
91. Declaration (August 2015, Docket No. 1570376) in support of “Opposition of Respondent-Intervenors American Lung Association, et. al., to Tri-State Generation’s Emergency Motion;” Declaration (September 2015, Docket No. 1574820) in support of “Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors for Remand Without Vacatur;” Declaration (October 2015) in support of “Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors to State and Certain Industry Petitioners’ Motion to Govern, *White Stallion Energy Center, LLC v. US EPA*, Case No. 12-1100 (US Court of Appeals for the District of Columbia).
92. Declaration (September 2015) in support of the Draft Title V Permit for Dickerson Generating Station (Proposed Permit No 24-031-0019) on behalf of the Environmental Integrity Project.
93. Expert Report (Liability Phase) (December 2015) and Rebuttal Expert Report (February 2016) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., Environmental Law and Policy Center, and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
94. Declaration (December 2015) in support of the Petition to Object to the Title V Permit for Morgantown Generating Station (Proposed Permit No 24-017-0014) on behalf of the Environmental Integrity Project.
95. Expert Report (November 2015) on behalf of Appellants in the matter of *Sierra Club, et al. v. Craig W. Butler, Director of Ohio Environmental Protection Agency et al.*, ERAC Case No. 14-256814.
96. Affidavit (January 2016) on behalf of Bridgewatch Detroit in the matter of *Bridgewatch Detroit v. Waterfront Petroleum Terminal Co., and Waterfront Terminal Holdings, LLC.*, in the Circuit Court for the County of Wayne, State of Michigan.
97. Expert Report (February 2016) and Rebuttal Expert Report (July 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

98. Direct Testimony (May 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.
99. Declaration (June 2016) relating to deficiencies in air quality analysis for the proposed Millenium Bulk Terminal, Port of Longview, Washington.
100. Declaration (December 2016) relating to EPA's refusal to set limits on PM emissions from coal-fired power plants that reflect pollution reductions achievable with fabric filters on behalf of Environmental Integrity Project, Clean Air Council, Chesapeake Climate Action Network, Downwinders at Risk represented by Earthjustice in the matter of *ARIPPA v EPA*, Case No. 15-1180. (D.C. Circuit Court of Appeals).
101. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
102. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Backus Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
103. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Drakulic Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
104. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Deutsch Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
105. Affidavit (February 2017) pertaining to deficiencies water discharge compliance issues at the Wood River Refinery in the matter of *People of the State of Illinois (Plaintiff) v. Phillips 66 Company, ConocoPhillips Company, WRB Refining LP (Defendants)*, Case No. 16-CH-656, (Circuit Court for the Third Judicial Circuit, Madison County, Illinois).
106. Expert Report (March 2017) on behalf of the Plaintiff pertaining to non-degradation analysis for waste water discharges from a power plant in the matter of *Sierra Club (Plaintiff) v. Pennsylvania Department of Environmental Protection (PADEP) and Lackawanna Energy Center*, Docket No. 2016-047-L (consolidated), (Pennsylvania Environmental Hearing Board).
107. Expert Report (March 2017) on behalf of the Plaintiff pertaining to air emissions from the Heritage incinerator in East Liverpool, Ohio in the matter of *Save our County (Plaintiff) v. Heritage Thermal Services, Inc. (Defendant)*, Case No. 4:16-CV-1544-BYP, (US District Court for the Northern District of Ohio, Eastern Division).
108. Rebuttal Expert Report (June 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight (Plaintiffs) v Coyote Creek Mining Company LLC (Defendant)*, Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).
109. Expert Affidavit (August 2017) and Penalty/Remedy Expert Affidavit (October 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant,)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).
110. Expert Report (August 2017) on behalf of Appellant in the matter of *Patricia Ann Troiano (Appellant) v. Upper Burrell Township Zoning Hearing Board (Appellee)*, Court of Common Pleas of Westmoreland County, Pennsylvania, Civil Division.
111. Expert Report (October 2017), Supplemental Expert Report (October 2017), and Rebuttal Expert Report (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

112. Declaration (December 2017) on behalf of the Environmental Integrity Project in the matter of permit issuance for ATI Flat Rolled Products Holdings, Breckenridge, PA to the Allegheny County Health Department.
113. Expert Report (Harm Phase) (January 2018), Rebuttal Expert Report (Harm Phase) (May 2018) and Supplemental Expert Report (Harm Phase) (April 2019) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
114. Declaration (February 2018) on behalf of the Chesapeake Bay Foundation, et. al., in the matter of the Section 126 Petition filed by the state of Maryland in *State of Maryland v. Pruitt (Defendant)*, Civil Action No. JKB-17-2939 (Consolidated with No. JKB-17-2873) (US District Court for the District of Maryland).
115. Direct Pre-filed Testimony (March 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of *NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC*, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).
116. Expert Affidavit (April 2018) and Second Expert Affidavit (May 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.
117. Direct Pre-filed Testimony and Affidavit (December 2018) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).
118. Expert Report (February 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.
119. Declaration (March 2019) on behalf of Earthjustice in the matter of comments on the renewal of the Title V Federal Operating Permit for Valero Houston refinery.
120. Expert Report (March 2019) on behalf of Plaintiffs for Class Certification in the matter of *Resendez et al v Precision Castparts Corporation* in the Circuit Court for the State of Oregon, County of Multnomah, Case No. 16cv16164.
121. Expert Report (June 2019), Affidavit (July 2019) and Rebuttal Expert Report (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellants) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.
122. Affidavit/Expert Report (August 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.
123. Expert Report (October 2019) relating to the appeal of air permit (Plan Approval) on behalf of Appellants in the matter of *Clean Air Council and Environmental Integrity Project (Appellants) v. Commonwealth of Pennsylvania Department of Environmental Protection and Sunoco Partners Marketing and Terminals L.P.*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-057-L.
124. Expert Report (December 2019), Affidavit (March 2020), Supplemental Expert Report (July 2020), and Declaration (February 2021) on behalf of Earthjustice in the matter of *Objection to the*

- Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation, Dale, Indiana, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.*
125. Affidavit (December 2019) on behalf of Plaintiff-Intervenor (Surfrider Foundation) in the matter of *United States and the State of Indiana (Plaintiffs), Surfrider Foundation (Plaintiff-Intervenor), and City of Chicago (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2:18-cv-00127 (US District Court for the Northern District of Indiana, Hammond Division).
 126. Declarations (January 2020, February 2020, May 2020, July 2020, and August 2020) and Pre-filed Testimony (April 2021) in support of Petitioner's Motion for Stay of PSCAA NOC Order of Approval No. 11386 in the matter of the *Puyallup Tribe of Indians v. Puget Sound Clean Air Agency (PSCAA) and Puget Sound Energy (PSE)*, before the State of Washington Pollution Control Hearings Board, PCHB No. P19-088.
 127. Expert Report (April 2020) on behalf of the plaintiff in the matter of Orion Engineered Carbons, GmbH (Plaintiff) vs. Evonik Operations, GmbH (formerly Evonik Degussa GmbH) (Respondent), before the German Arbitration Institute, Case No. DIS-SV-2019-00216.
 128. Expert Independent Evaluation Report (June 2020) for *PacifiCorp's Decommissioning Costs Study Reports dated January 15, 2020 and March 13, 2020 relating to the closures of the Hunter, Huntington, Dave Johnston, Jim Bridger, Naughton, Wyodak, Hayden, and Colstrip (Units 3&4) plants*, prepared for the Oregon Public Utility Commission (Oregon PUC).
 129. Direct Pre-filed Testimony (July 2020) on behalf of the Sierra Club in the matter of *the Application of the Ohio State University for a certificate of Environmental Compatibility and Public Need to Construct a Combined Heat and Power Facility in Franklin County, Ohio*, before the Ohio Power Siting Board, Case No. 19-1641-EL-BGN.
 130. Expert Report (August 2020) and Rebuttal Expert Report (September 2020) on behalf of WildEarth Guardians (petitioners) in the matter of *the Appeals of the Air Quality Permit No. 7482-M1 Issued to 3 Bear Delaware Operating – NM LLC (EIB No. 20-21(A) and Registrations Nos. 8729, 8730, and 8733 under General Construction Permit for Oil and Gas Facilities (EIB No. 20-33 (A)*, before the State of New Mexico, Environmental Improvement Board.
 131. Expert Report (July 2020) on the *Initial Economic Impact Analysis (EIA) for A Proposal To Regulate NOx Emissions from Natural Gas Fired Rich-Burn Natural Gas Reciprocating Internal Combustion Engines (RICE) Greater Than 100 Horsepower* prepared on behalf of Earthjustice and the National Parks Conservation Association in the matter of Regulation Number 7, Alternate Rules before the Colorado Air Quality Control Commission.
 132. Expert Report (August 2020) and Supplemental Expert Report (February 2021) on the Potential Remedies to Avoid Adverse Thermal Impacts from the Merrimack Station on behalf of Plaintiffs in the matter of *Sierra Club Inc. and the Conservation Law Foundation (Plaintiffs) v. Granite Shore Power, LLC et. al., (Defendants)*, Civil Action No. 19-cv-216-JL (US District Court for the District of New Hampshire.)
 133. Expert Report (August 2020) and Supplemental Expert Report (December 2020) on behalf of Plaintiffs in the matter of *PennEnvironment Inc., and Clean Air Council (Plaintiffs) and Allegheny County Health Department (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2-19-cv-00484-MJH (US District Court for the Western District of Pennsylvania.)
 134. Pre-filed Direct Testimony (October 2020) and Sur-rebuttal Testimony (November 2020) on behalf of petitioners (Ten Persons Group, including citizens, the Town of Braintree, the Town of Hingham, and the City of Quincy) in the matter of Algonquin Gas Transmission LLC, Weymouth MA, No. X266786 Air Quality Plan Approval, before the Commonwealth of Massachusetts, Department of Environmental Protection, the Office of Appeals and Dispute Resolution, OADR Docket Nos. 2019-008, 2019-009, 2019010, 2019-011, 2019-012 and 2019-013.

135. Expert Report (November 2020) on behalf of Protect PT in the matter of *Protect PT v. Commonwealth of Pennsylvania Department of Environmental Protection and Apex Energy (PA) LLC*, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2018-080-R (consolidated with 2019-101-R)(the “Drakulic Appeal”).
136. Expert Report (December 2020) on behalf of Plaintiffs in the matter of *Sierra Club Inc. (Plaintiff) v. GenOn Power Midwest LP (Defendants)*, Civil Action No. 2-19-cv-01284-WSS (US District Court for the Western District of Pennsylvania.)
137. Pre-filed Testimony (January 2021) on behalf of the Plaintiffs (Shrimpers and Fishermen of the Rio Grande Valley represented by Texas RioGrande Legal Aid, Inc.) in the matter of the Appeal of Texas Commission on Environmental Quality (TCEQ) Permit Nos. 147681, PSDTX1522, GHGPSDTX172 for the Jupiter Brownsville Heavy Condensate Upgrader Facility, Cameron County, before the Texas State Office of Administrative Hearings, SOAH Docket No. 582-21-0111, TCEQ Docket No. 2020-1080-AIR.
138. Expert Reports (March 2021 and May 2021) regarding the Aries Newark LLC Sludge Processing Facility, Application No. CPB 20-74, Central Planning Board, City of Newark, New Jersey.
139. Expert Report (April 2021) for *Charles Johnson Jr. (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:20-CV-01329 (Related to 12-968 BELO in MDL No. 2179). (US District Court for the Eastern District of Louisiana, New Orleans Division).
140. Expert Report (April 2021) for *Floyd Ruffin (Plaintiff), v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:20-cv-00334-CJB-JCW (US District Court for the Eastern District of Louisiana, New Orleans Division).
141. Expert Report (April 2021) and Sur-Rebuttal Report (June 2021) on behalf of the Plaintiffs in the matter of *Modern Holdings, LLC, et al. (Plaintiffs) v. Corning Inc., et al. (Defendants)*, Civil Action No. 5:13-cv-00405-GFVT, (US District Court for the Eastern District of Kentucky, Central Division at Lexington).
142. Expert Report (May 2021) for *Clifford Osmer (Plaintiff) v. BP Exploration and Production Inc., et. al., (Defendants)* related to No. 18-CV-12557 (US District Court for the Eastern District of Louisiana).
143. Expert Report (May 2021) and Rebuttal Expert Report (January 2022) for *James Noel (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 1:19-CV-00694-JB-MU-C (US District Court for the Southern District of Alabama, Southern Division).
144. Expert Report (June 2021) and Declarations (May 2021 and June 2021) on behalf of Plaintiffs in the matter of *Sierra Club (Plaintiff) v. Woodville Pellets, LLC (Defendant)*, Civil Action No. 9:20-cv-00178-MJT (US District Court for the Eastern District of Texas, Lufkin Division.)
145. Expert Witness Disclosure (June 2021) on behalf of the Plaintiffs in the matter of *Jay Burdick, et. al., (Plaintiffs) v. Tanoga Inc. (d/b/a Taconic) (Defendant)*, Index No. 253835, (State of New York Supreme Court, County of Rensselaer).
146. Expert Report (June 2021) on behalf of Appellants in the matter of *PennEnvironment and Earthworks (Appellants) v. Commonwealth of Pennsylvania Department of Environmental Protection (Appellee) and MarkWest Liberty Midstream and resource, LLC (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2020-002-R.
147. Expert Report (June 2021) for *Antonia Saavedra-Vargas (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:18-CV-11461 (US District Court for the Eastern District of Louisiana, New Orleans Division).
148. Affidavit (June 2021) for Lourdes Rubi in the matter of *Lourdes Rubi (Plaintiff) v. BP Exploration and Production Inc., et. al., (Defendants)*, related to 12-968 BELO in MDL No. 2179 (US District Court for the Eastern District of Louisiana, New Orleans Division).

149. Expert Report (June 2021) for *Wallace Smith (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:19-CV-12880 (US District Court for the Eastern District of Louisiana, New Orleans Division).
150. Declaration (July 2021) on behalf of Plaintiffs in the matter of *Stephanie Mackey and Nick Migliore, on behalf of themselves and all others similarly situated (Plaintiffs) v. Chemtool Inc. and Lubrizol Corporation (Defendants)*, Case No. 2021-L-0000165, State of Illinois, Circuit Court of the 17th Judicial Circuit, Winnebago County.
151. Declaration (July 2021, August 2021) on behalf of Petitioners in the matter of the Petition for a Hearing on the Merits Regarding Air Quality Permit No. 3340-RMD issued to New Mexico Terminal Services, LLC by *Mountain View Neighborhood Association et. al., (Petitioners) v. City of Albuquerque Environmental Health Department*, AQCB Petition No. 2020-1 before the Albuquerque-Bernalillo County Air Quality Control Board.
152. Expert Disclosure (September 2021) on behalf of the Plaintiffs in the matter of *State of New York, Town of Hempstead, Town of Brookhaven, Incorporated Village of Garden City and Long Island Power Authority et. al., (Plaintiffs) v. Covanta Hempstead Company et. al., (Defendants)*, Index No. 7549/2013 before the Supreme Court of the State of New York, County of Nassau.
153. Expert Report (October 2021) for *John A. Battiste (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 1:21-CV-00118 (US District Court for the Southern District of Alabama, Mobile Division)
154. Declaration/Expert Report (October 2021) for *Charles K. Grasley et. al., (Plaintiffs) v. Chemtool Incorporated (Defendant)*, Case No. 2021-L-0000162 (State of Illinois, In the Circuit Court of the 17th Judicial Circuit, Winnebago County).
155. Declaration (October 2021) and Expert Report (November 2021) on behalf of the Plaintiffs in the matter of Toll Brothers, Inc., and Porter Ranch Development Company (Plaintiffs) v. Sempra Energy, Southern California Gas Company et. al., (Defendants), Southern California [Aliso Canyon] Gas Leak Cases, JCCP No.: 4861, Lead Case No.: BC674622, Superior Court of the State of California for the County of Los Angeles.
156. Expert Report (November 2021) and Declaration (September 2022) on behalf of Plaintiffs in Re: Deepwater Horizon BELO Cases, Case No. 3:19cv963-MCR-GRJ (US District Court for the Northern District of Florida, Pensacola Division).
157. Declaration (November 2021) for the *United States of America and the State of Kansas, Department of Health and Environment (Plaintiffs) v. Coffeyville Resources Refining & Marketing, LLC (Defendant)*, Civ. No. 6:04-cv-01064-JAR-KGG (US District Court for the District of Kansas).
158. Expert Report/Affidavit (December 2021) on behalf of the City of Detroit in the matter of Marathon Petroleum Company (Claimant) v. City of Detroit Building Safety Engineering and Environmental Department, BSEED Case No. MCR 2018-2525, DAH Appeal No. 21-SWA-01, before the State of Michigan, City of Detroit Department of Appeals and Hearings.
159. Expert Report (December 2021) for *John Pabst (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 21-CV-00290 (US District Court for the Eastern District of Louisiana).
160. Expert Report (December 2021) for *Audrey Annette Tillery-Perdue individually and as person representative of the estate of Eddie Lewis Perdue (Plaintiff) v. BP Exploration and Production Inc., et. al., (Defendant)*, Civil Action No. 5:19-cv-00052-MCR-GRJ (US District Court for the Northern District of Florida, Pensacola Division).
161. Expert Report (February 2022) for *Richard Dufour (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 19-cv-00591 (US District Court for the Southern District of Mississippi).

162. Expert Report (February 2022) and Rebuttal Expert Report (June 2022, in preparation) for *Kamuda (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010475 (Circuit Court of Cook County, Illinois).
163. Expert Report (February 2022) in the matter of the *Appeal Petition for Hearing on Air Quality Permit No. 8585 on behalf of Earth Care New Mexico et. al., (Petitioners) v. New Mexico Environment Department and Associated Asphalt and Materials, LLC (Applicant)*, No. EIB 21-48 before the State of New Mexico Environmental Improvement Board.
164. Expert Report (March 2022) and Affidavit (June 2022) in the matter of Clean Air Council et. al., (Appellants) v. Commonwealth of Pennsylvania, Department of Environmental Protection (Appellee) and Renovo Energy Center (Permittee) EHB Docket No. 2021-055-R before the Commonwealth of Pennsylvania Environmental Hearing Board.
165. Declaration (March 2022) in the matter of Max Midstream Texas LLC Air Quality Permit No. 162941 for the Seahawk Crude Condensate Terminal in Calhoun County Texas, TCEQ Docket No. 2022-0157-AIR, before the Texas Commission on Environmental Quality.
166. Expert Pre-filed Testimony (April 2022) in the matter of Application of TPC Group LLC for New State and PSD Air Quality Permits (various), TCEQ Docket No. 2021-1422-AIR, SOAH Docket No. 582-22-0799, Before the Texas State Office of Administrative Hearings.
167. Expert Report (April 2022) and Rebuttal Report (August 2022) for *Teresa Fornek (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010744 (Circuit Court of Cook County, Illinois.)
168. Rule 26 Disclosure (May 2022) in the matter of the *Water Works and Sewer Board of the City of Gadsden (Plaintiff) v. 3M Company, et. al., (Defendants)*, Civil Action No.: 31 CV-2016-900676.00 (Circuit County of Etowah County, Alabama)
169. Expert Report (June 2022) for *Heather Schumacher (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-011939 (Circuit Court of Cook County, Illinois.)
170. Expert Report (June 2022), Rebuttal Reports (August 2022, September 2022) for Plaintiffs in *Phylliss Grayson et. al. (Plaintiffs), v Lockheed Martin Corporation (Defendant)*, Case No. 6:20-cv-01770. (US District Court for the Middle District of Florida – Orlando Division.)
171. Expert Affidavit (July 2022) for Center for Environmental Rights in connection with the 2019 South Africa Integrated Resource Plan in *African Climate Alliance et. al. v. The Minister of Mineral Resources and Energy et. al.*, in the High Court of South Africa, Gauteng Division, Pretoria.
172. Expert Affidavit (July 2022) for Center for Environmental Rights in connection with the Limpopo Mine (Lephalale Coal Mines Ltd.) in *Earthlife Africa v. The Minister of Forestry, Fisheries and Environment et. al.*, in the High Court of South Africa, Gauteng Division, Pretoria, Case No. 9149/2022.
173. Pre-filed Testimony (July 2022) and Rebuttal Testimony (September 2020) on behalf of the Puyallup Tribe of Indians in the matter of *Washington Utilities and Transportation Commission (Complainant) v. Puget Sound Energy (Respondent)* before the Washington Utilities and Transportation Commission, Docket UE-220066 and UG-220067 (Consolidated).
174. Expert Affidavit (October 2022) for *Concerned Citizens of Cook County GA (Petitioner) v. Georgia Department of Natural Resources (Respondent) and Spectrum Energy Georgia, LLC (Respondent Intervenor)* before the Office of State Administrative Hearings, State of Georgia, Docket No: 2303405-OSAH-BNR-AQ-37-Barnes.

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

175. 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.
176. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.
177. Trial Testimony (February 2003) on behalf of the United States in the Ohio Edison NSR Cases, *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).
178. Trial Testimony (June 2003) on behalf of the United States in the Illinois Power NSR Case, *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).
179. Deposition (10/20/2005) on behalf of the United States in connection with the Cinergy NSR Case. *United States, et al. v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (Southern District of Indiana).
180. Oral Testimony (August 2006) on behalf of the Appalachian Center for the Economy and the Environment re. the Western Greenbrier plant, WV before the West Virginia DEP.
181. Oral Testimony (May 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) re. the Thompson River Cogeneration plant before the Montana Board of Environmental Review.
182. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.
183. Oral Testimony (August 2008) on behalf of the Sierra Club and Clean Water re. Big Stone Unit II before the South Dakota Board of Minerals and the Environment.
184. Oral Testimony (February 2009) on behalf of the Sierra Club and the Southern Environmental Law Center re. Santee Cooper Pee Dee units before the South Carolina Board of Health and Environmental Control.
185. Oral Testimony (February 2009) on behalf of the Sierra Club and the Environmental Integrity Project re. NRG Limestone Unit 3 before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
186. Deposition (July 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*
187. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coletto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
188. Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
189. Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.
190. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).
191. Oral Testimony (November 2009) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
192. Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

193. Oral Testimony (February 2010) on behalf of the Environmental Defense Fund re. the White Stallion Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
194. Deposition (June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).
195. Trial Testimony (September 2010) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (Western District of Pennsylvania).
196. Oral Direct and Rebuttal Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
197. Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.
198. Oral Testimony (October 2010) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
199. Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.
200. Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.
201. Deposition (December 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
202. Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)’s Cherokee power plant. No. 09-cv-1862 (D. Colo.).
203. Oral Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
204. Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).
205. Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
206. Oral Testimony at Hearing (March 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
207. Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost

Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

208. Oral Testimony at Hearing (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.
209. Deposition (March 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.
210. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
211. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).
212. Deposition (February 2014) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
213. Trial Testimony (February 2014) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.*, Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).
214. Trial Testimony (February 2014) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
215. Deposition (June 2014) and Trial (August 2014) on behalf of ECM Biofilms in the matter of the *US Federal Trade Commission (FTC) v. ECM Biofilms* (FTC Docket #9358).
216. Deposition (February 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and PacifiCorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).
217. Oral Testimony at Hearing (April 2015) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).
218. Deposition (August 2015) on behalf of Plaintiff in the matter of *Conservation Law Foundation (Plaintiff) v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).
219. Testimony at Hearing (August 2015) on behalf of the Sierra Club in the matter of *Amendments to 35 Illinois Administrative Code Parts 214, 217, and 225* before the Illinois Pollution Control Board, R15-21.
220. Deposition (May 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

221. Trial Testimony (October 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).
222. Deposition (April 2016) on behalf of the Plaintiffs in *UNatural Resources Defense Council, Respiratory Health Association, and Sierra Club (Plaintiffs) v. Illinois Power Resources LLC and Illinois Power Resources Generation LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (Central District of Illinois, Peoria Division).
223. Trial Testimony at Hearing (July 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.
224. Trial Testimony (December 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.
225. Trial Testimony (July-August 2016) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
226. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
227. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Backus Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
228. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Drakulic Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
229. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Deutsch Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
230. Deposition Testimony (July 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight v Coyote Creek Mining Company LLC (Defendant)* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).
231. Deposition Testimony (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).
232. Deposition Testimony (December 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).
233. Deposition Testimony (January 2018) in the matter of National Parks Conservation Association (NPCA) v. State of Washington Department of Ecology and British Petroleum (BP) before the Washington Pollution Control Hearing Board, Case No. 17-055.
234. Trial Testimony (January 2018) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).
235. Trial Testimony (April 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).

236. Deposition (June 2018) (harm Phase) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
237. Trial Testimony (July 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.
238. Deposition (January 2019) and Trial Testimony (January 2019) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).
239. Deposition (February 2019) and Trial Testimony (March 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.
240. Deposition (June 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.
241. Deposition (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellants) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.
242. Deposition (December 2019) on behalf of the Plaintiffs in the matter of David Kovac, individually and on behalf of wrongful death class of Irene Kovac v. BP Corporation North America Inc., Circuit Court of Jackson County, Missouri (Independence), Case No. 1816-CV12417.
243. Deposition (February 2020, virtual) and testimony at Hearing (August 2020, virtual) on behalf of Earthjustice in the matter of *Objection to the Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation, Dale, Indiana*, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.
244. Hearing (July 14-15, 2020, virtual) on behalf of the Sierra Club in the matter of *the Application of the Ohio State University for a certificate of Environmental Compatibility and Public Need to Construct a Combined Heat and Power Facility in Franklin County, Ohio*, before the Ohio Power Siting Board, Case No. 19-1641-EL-BGN.
245. Hearing (September 2020, virtual) on behalf of WildEarth Guardians (petitioners) in the matter of *the Appeals of the Air Quality Permit No. 7482-M1 Issued to 3 Bear Delaware Operating – NM LLC (EIB No. 20-21(A) and Registrations Nos. 8729, 8730, and 8733 under General Construction Permit for Oil and Gas Facilities (EIB No. 20-33 (A))*, before the State of New Mexico, Environmental Improvement Board.
246. Deposition (December 2020, March 4-5, 2021, all virtual) and Hearing (April 2021, virtual) in support of Petitioner’s Motion for Stay of PSCAA NOC Order of Approval No. 11386 in the matter of the *Puyallup Tribe of Indians v. Puget Sound Clean Air Agency (PSCAA) and Puget Sound Energy (PSE)*, before the State of Washington Pollution Control Hearings Board, PCHB No. P19-088.
247. Hearing (September 2020, virtual) on the *Initial Economic Impact Analysis (EIA) for A Proposal To Regulate NOx Emissions from Natural Gas Fired Rich-Burn Natural Gas Reciprocating*

- Internal Combustion Engines (RICE) Greater Than 100 Horsepower* prepared on behalf of Earthjustice and the National Parks Conservation Association in the matter of Regulation Number 7, Alternate Rules before the Colorado Air Quality Control Commission.
248. Deposition (December 2020, virtual and Hearing February 2021, virtual) on behalf of the Plaintiffs (Shrimpers and Fishermen of the Rio Grande Valley represented by Texas RioGrande Legal Aid, Inc.) in the matter of the Appeal of Texas Commission on Environmental Quality (TCEQ) Permit Nos. 147681, PSDTX1522, GHGPSDTX172 for the Jupiter Brownsville Heavy Condensate Upgrader Facility, Cameron County, before the Texas State Office of Administrative Hearings, SOAH Docket No. 582-21-0111, TCEQ Docket No. 2020-1080-AIR.
 249. Deposition (January 2021, virtual) on behalf of Plaintiffs in the matter of *PennEnvironment Inc., and Clean Air Council (Plaintiffs) and Allegheny County Health Department (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2-19-cv-00484-MJH (US District Court for the Western District of Pennsylvania.)
 250. Deposition (February 2021, virtual) on behalf of Plaintiffs in the matter of *Sierra Club Inc. (Plaintiff) v. GenOn Power Midwest LP (Defendants)*, Civil Action No. 2-19-cv-01284-WSS (US District Court for the Western District of Pennsylvania.)
 251. Deposition (April 2021, virtual) on the Potential Remedies to Avoid Adverse Thermal Impacts from the Merrimack Station on behalf of Plaintiffs in the matter of *Sierra Club Inc. and the Conservation Law Foundation (Plaintiffs) v. Granite Shore Power, LLC et. al., (Defendants)*, Civil Action No. 19-cv-216-JL (US District Court for the District of New Hampshire.)
 252. Deposition (June 2021, virtual) on behalf of Plaintiffs in the matter of *Sierra Club (Plaintiff) v. Woodville Pellets, LLC (Defendant)*, Civil Action No. 9:20-cv-00178-MJT (US District Court for the Eastern District of Texas, Lufkin Division).
 253. Deposition (June 2021, virtual) on behalf of the Plaintiffs in the matter of *Modern Holdings, LLC, et al. (Plaintiffs) v. Corning Inc., et al. (Defendants)*, Civil Action No. 5:13-cv-00405-GFVT, (US District Court for the Eastern District of Kentucky, Central Division at Lexington).
 254. Testimony (June 2021, virtual) regarding the Aries Newark LLC Sludge Processing Facility, Application No. CPB 20-74, (Central Planning Board, City of Newark, New Jersey).
 255. Testimony at Hearing (October 2021) on behalf of Evraz Rocky Mountain Steel in the matter of Colorado's Proposed Revisions to Regulation 22, the Greenhouse Gas Emissions and Energy Management for the Manufacturing Sector in Colorado (GEMM Rule), before the Colorado Air Quality Control Commission.
 256. Deposition (November 2021) for *Charles Johnson Jr. (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 2:20-CV-01329 (Related to 12-968 BELO in MDL No. 2179). (US District Court for the Eastern District of Louisiana).
 257. Testimony at Hearing (November 2021) on behalf of *National Parks Conservation Association, et. al.*, in the matter of the Proposed Revisions to Colorado's Regional Haze State Implementation Plan (SIP) and Colorado Regulation 23, before the Colorado Air Quality Control Commission.
 258. Deposition (December 2021) on behalf of Plaintiffs in Re: Deepwater Horizon BELO Cases, Case No. 3:19cv963-MCR-GRJ (US District Court for the Northern District of Florida, Pensacola Division).
 259. Deposition (December 2021) for *James Noel (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 1:19-CV-00694-JB-MU-C (US District Court for the Southern District of Alabama, Southern Division).
 260. Testimony at Hearing (February 2022, virtual) in the matter of the *Appeal Petition for Hearing on Air Quality Permit No. 8585 on behalf of Earth Care New Mexico et. al., (Petitioners) v. New Mexico Environment Department and Associated Asphalt and Materials, LLC (Applicant)*, No. EIB 21-48 before the State of New Mexico Environmental Improvement Board.

261. Deposition (March 2022) and Rebuttal Deposition (July 2022) for *Kamuda (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010475 (Circuit Court of Cook County, Illinois.)
262. Deposition (April 2022, virtual) in the matter of Application of TPC Group LLC for New State and PSD Air Quality Permits (various), TCEQ Docket No. 2021-1422-AIR, SOAH Docket No. 582-22-0799, Before the Texas State Office of Administrative Hearings.
263. Deposition (May 2022, virtual) in the matter of the *Water Works and Sewer Board of the City of Gadsden (Plaintiff) v. 3M Company, et. al., (Defendants)*, Civil Action No.: 31 CV-2016-900676.00 (Circuit County of Etowah County, Alabama)
264. Deposition (June 2022 and September 2022, both virtual) for *Teresa Fornek (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010744 (Circuit Court of Cook County, Illinois.)
265. Deposition (June 2022, virtual) on behalf of the Plaintiffs in the matter of Toll Brothers, Inc., and Porter Ranch Development Company (Plaintiffs) v. Sempra Energy, Southern California Gas Company et. al., (Defendants), Southern California [Aliso Canyon] Gas Leak Cases, JCCP No.: 4861, Lead Case No.: BC674622, Superior Court of the State of California for the County of Los Angeles.
266. Deposition (July 2022) for *Richard Dufour (Plaintiff) v. BP Exploration and Production Inc., et. al. (Defendant)*, Civil Action No. 19-cv-00591 (US District Court for the Southern District of Mississippi).
267. Trial (August 2022) on behalf of the Plaintiffs in the matter of *Modern Holdings, LLC, et al. (Plaintiffs) v. Phillips (Defendants)*, Civil Action No. 5:13-cv-00405-GFVT, (US District Court for the Eastern District of Kentucky, Central Division at Lexington).
268. Trial (August 2022, in person) for *Susan Kamuda (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010475 (Circuit Court of Cook County, Illinois).
269. Deposition (September 2022, virtual) for *Heather Schumacher (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010744 (Circuit Court of Cook County, Illinois.)
270. Deposition (September 2022) on behalf of Plaintiffs in *Phylliss Grayson et. al. (Plaintiffs), v Lockheed Martin Corporation (Defendant)*, Case No. 6:20-cv-01770. (US District Court for the Middle District of Florida – Orlando Division.)
271. Hearing (October 2022) on behalf of the Puyallup Tribe of Indians in the matter of *Washington Utilities and Transportation Commission (Complainant) v. Puget Sound Energy (Respondent)* before the Washington Utilities and Transportation Commission, Docket UE-220066 and UG-220067 (Consolidated).
272. Deposition (September 2022) for *Teresa Fornek (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010475 (Circuit Court of Cook County, Illinois).
273. Trial (October 2022, in person) for *Teresa Fornek (Plaintiff) v. Sterigenics U.S., LLC, et. al., (Defendant)*, Case No. 2018-L-010475 (Circuit Court of Cook County, Illinois).