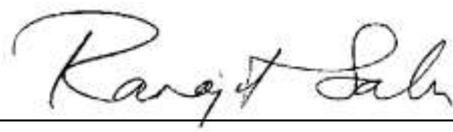
Comments on the Proposed Increase in the Minimum Emission Standard (MES) for Sulphur Dioxide (SO_2) Applicable to Coal-Fired Power Plant Stacks in South Africa

by

Dr. Ranajit (Ron) Sahu, Consultant[1]



I. Introduction

I was requested by the Centre for Environmental Rights to critically assess the Department of Environmental Affair's (DEA) proposal to modify the Minimum Emission Standard (MES) for sulphur dioxide (SO_2), effective from 1 April 2020, increasing the limit from 500 milligrams per normal cubic meter (mg/Nm^3) to 1000 mg/Nm^3. Weakening (doubling) the MES limit for SO_2 would effectively allow coal-fired boilers to emit double their previously-allowed SO_2 pollution.[2]

As I elaborate below, it is my opinion that the MES should not be doubled to 1000 mg/Nm^3, as proposed. Not only will this allow significantly more emissions and adverse harm to exposed populations, the proposal is premised upon assumptions that are false:

- that consumptive water use of the technology required to meet the lower (500 mg/Nm3) standard (flue gas desulfurization - FGD) is significant relative to its benefits;
- that the proposed alternative technology for meeting the relaxed standard of 1000 mg/Nm3 (dry sorbent injection - DSI) is significantly cheaper; and
- that there are no adverse impacts to using DSI in quantities that would be necessary to achieve SO_2 reductions of around 70% as contemplated by the relaxed standard.

The reasons for my opinion are summarised as follows:

FGD and water consumption: There is no justification for doubling the MES to the proposed higher limit based on a broad-brush (i.e., without plant by plant assessment) indictment of FGD technology, simply by presuming that it has high consumptive water needs. Consumptive water needs of FGD are not large compared to other water uses in a power station if the thermal cycle relies on water cooling. And, focusing on just the water use by FGDs while minimising or not weighing the tremendous SO_2 reductions that they can achieve – 99% or more – is misleading and

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[1] Resume provided in Attachment A.

[2] See https://www.environment.gov.za/sites/default/files/gazetted_notices/nemaqa39of2004_listofactivities_atmospheric_emissions.pdf.

unbalanced. If, in some cases, even the small additional consumptive water needs of wet FGD plants would be problematic, dry-FGD designs can provide the requisite 85% reductions needed to achieve the 500 mg/Nm^3 MES. Dry-FGDs, while not as efficient as their wet counterparts, can still easily achieve reductions in the range of 90-95%.

Impacts associated with Direct Sorbent Injection (DSI): DSI was initially developed and is mostly applied in order to remove a range of acid gases such as hydrochloric acid (HCl), hydrofluoric acid (HF). Any SO_2 reductions were an ancillary co-benefit as a result. DSI was not developed to be a primary SO_2 reduction technology as the DEA media release suggests. The DSI process results will cause an increase in Particulate Matter (PM) emissions from electro-static precipitators (ESPs); will adversely affect ESP ash handling systems; cause increases in toxic mercury emissions; and result in adverse impacts from the disposal of ESP sorbent wastes. Mitigating these dramatically raises the costs of implementing DSI.

Costs: capital costs of FGD appear to be significantly inflated. Recent, mass application of FGD, in countries such as India (presently upgrading a large fraction of its coal-fired units with FGD) show that FGD capital costs can be significantly lower, if proper procurement strategies are followed. While capital costs for DSI are indeed lower than FGD, the operating costs (including costs to mine/produce the sorbent, transport it to the coal-plant, properly condition it including reducing its size to fine power by grinding, storing it onsite without exposing it to moisture, etc.) are sizeable, especially to achieve the presumed 70% SO_2 reduction. Based on this, and coupled with mitigating the adverse DSI impacts noted in the previous paragraph, government's expectation that DSI would be a much cheaper option than FGD is not only not unsupported, but is incorrect.

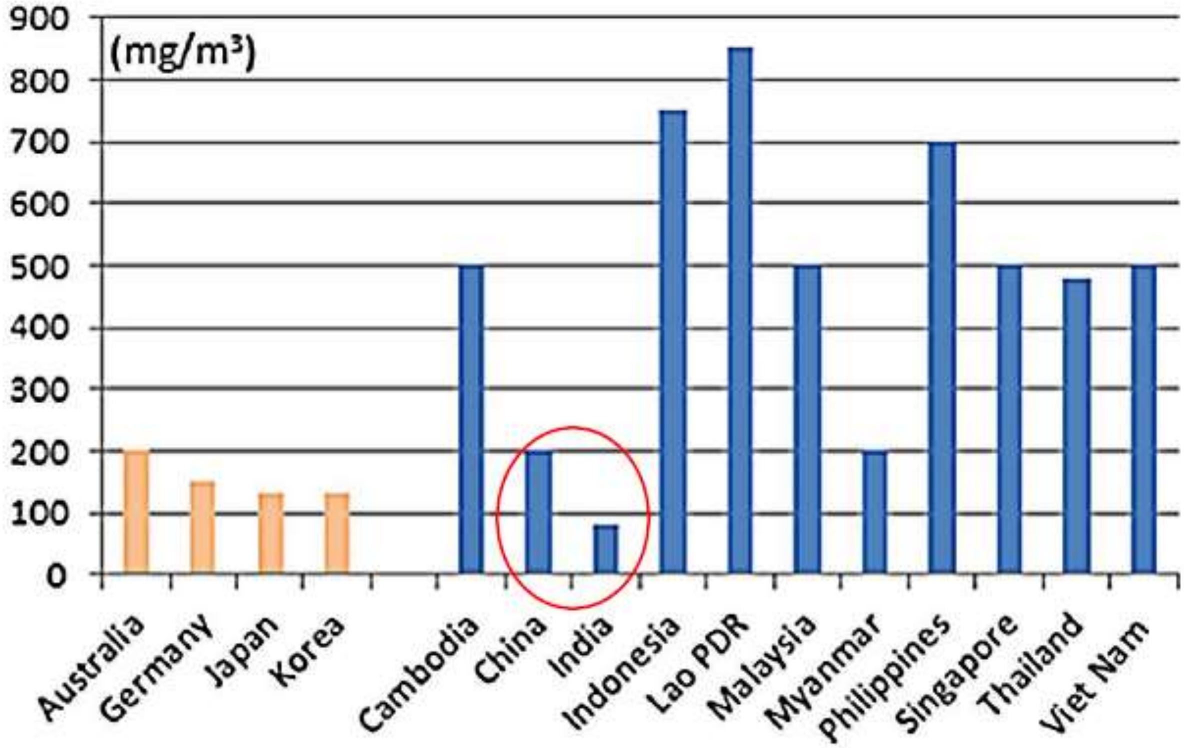
Instead, for coal-fired plants that intend to continue to operate in South Africa, I recommend that the 2020 stack MES should be reduced to levels in the range of 200 mg/Nm^3, the norm in most other jurisdictions around the world, and a level that can readily and cost-effectively be achieved by implementation of FGD.

II. The Proposed 1000 mg/Nm3 MES

The April 2015 SO_2 MES applicable to existing coal-fired power plant stacks is 3500 mg/Nm^3. This is an extraordinarily high level of allowable emissions of SO_2, a known, major air pollutant[3] and is much higher than comparable allowable levels in other countries. See the chart below which shows SO_2 limits for coal-fired plants in various countries.[4]

[3] Significant portions of South Africa's population are exposed to very high levels of SO2, including in so-called High Priority Areas (HPAs), where ambient levels of SO2 (among other pollutants, including fine particulate matter, PM2.5, which is formed in the atmosphere from SO2) are known to be greater than health-based protective levels.

[4] Motokura, M., et. al., Improving Emission Regulation for Coal-Fired Power Plants in ASEAN, ERIA Research Project Report 2016, No. 2. Available at http://www.eria.org/RPR_FY2016_02.pdf



Standards that apply in the US pursuant to application of Best Available Control Technology (BACT) can be very low, on a case-by-case basis, even for existing plants when modified. As the chart above shows, developed countries as well as China and India have standards that are 200 mg/Nm^3 or less.

South Africa's current standard of 3500 mg/Nm^3 is simply off the charts. It was set to drop to 500 mg/Nm^3 in the coming years. While still not as low as levels in most other jurisdictions (i.e., excluding Laos, Malaysia, and the Philippines) as seen in the chart above, this would have represented a reduction of approximately 85% from the 3500 mg/Nm^3 level. Compliance with the 500 mg/Nm^3 level at existing plants was expected via use of flue gas desulfurization (FGD), a widely used group[5] of technologies to reduce SO_2 emissions from existing and new coal-fired power plants. FGDs, depending on design, can reduce stack SO_2 levels by 99% or greater.

In May 2019, the South African Minister of Environmental Affairs[6] requested public comments on a proposal to modify the April 2020 500 mg/Nm^3 stack limit for existing solid-fuel combustion

See also, for example, Zhang, X., IEA Report on emission standards, available at https://www.usea.org/sites/default/files/Emission%20standards%20and%20control%20of%20PM%202.5%20from%20coal%20fired%20power%20plant%20-ccc267.pdf

[5] FGDs, generically, represent a set of technologies encompassing both wet and semi-wet or dry designs, with many variants depending on actual vendor designs.

[6] Now renamed as Department of Environment, Forestry and Fisheries

plants by increasing it to 1000 mg/Nm^3. As justification and rationale, the government's statement media statement accompanying the proposal[7] notes the following.

> "The intention of the amendment is to provide for existing plants to comply with a Sulphur dioxide (SO2) minimum emission limit of 1000mg/Nm3 instead of 500mg/Nm3. This means that existing plants would reduce emissions from the current standard of 3500mg/Nm3 to 1000mg/Nm3.
>
> This is a significant reduction and would still lead to improvements in ambient air quality as total SO2 emissions would be reduced by at least 50%. Currently, the State of Air Report over the years shows compliances with the SO2 annual ambient air quality standard but government continues to regulate it because of its contribution to secondary pollution.
>
> Achievement of the new plant standard of 500mg/Nm3 for SO2 requires the installation of limestone based wet Flue Gas Desulphurisation (FGD) which is the biggest cost driver in pollution abatement technology. This technology has the SO2 removal efficiency of over 95 percent. Although FGD is efficient, there are challenges associated with it. The typical capital cost for a 4000MW power plant is R13 billion with an additional R3 billion operating cost per annum. These costs are very high for a slow growing fossil-fuel based economy.
>
> Furthermore, FGD installation requires additional water resources and mining of new limestone as input material. South Africa's water resources are already constrained and cannot cope with the current and the growing demand from both domestic and industrial users.
>
> Limestone would have to be mined because FGD uses good quality limestone to absorb SO2 from the flue gas thus forming gypsum. The current market would not be able to absorb the gypsum that would be generated as such it would need to be disposed. The amount and quality of limestone needed is not readily available.
>
> This means that new mines would be required and mining presents additional environmental problems. In addition, good quality limestone mines are located in the Northern Cape Province which is a considerable distance from the existing major sources of SO2 and transportation would add to greenhouse gas emissions, amongst others. It should also be noted that the use of FGD technology in a plant generates additional CO2 emissions, which is a priority pollutant in the Republic.

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[7] See Minister Nomvula Mokonyane intends to amend listed activities and associated minimum standards to improve air quality in South Africa (May 23, 2019), Available at https://www.environment.gov.za/mediarelease/mokonyane_amendslegislationtoimproveairqualityinSA.

I could not find a technical analysis or technical support document providing any additional detail beyond the media statement.

> Revision of the new plant standard for the existing plants from 500mg/Nm3 to 1000mg/Nm3 opens up the scope for other technologies to be used in the abatement of SO2 pollution and would not lead to as much CO2 emissions. Dry Sorbent Injection (DSI), for example, is another type of FGD that does not require as much water. However, the SO2 removal efficiency is between 50 and 60%. Although the efficiency is low compared to wet FGD, it has lower capital costs, which are not an impediment to retrofitting existing plants."[8]

Setting aside the Orwellian media statement – i.e., touting the 'improvements" in air quality that would supposedly occur even while the proposal would allow *more* emissions of SO_2 – which is plainly impossible, much of the rationale provided above is not supported and rests on assumptions, which are either incorrect or simplistic. In this report, I address some of the Department of Environmental Affairs' flawed statements or assumptions relating to SO_2 pollution controls (i.e., FGD and dry sorbent injection, DSI) in the above rationale, and identify important concerns that the government's statements do not discuss. I understand that other specialists have addressed the increased emissions and consequent increased adverse health impacts that will result from the proposed relaxing of the already weak 500 mg/Nm^3 stack MES an even weaker 1000 mg/Nm^3 level, applicable to several of South Africa's coal-fired power stations. Thus, I have not factored into my discussion below the additional harms of weakening the existing standard.

III. FGD and Water Consumption

Although I agree with the Department of Environmental Affairs' statement that the current MES of 500 mg/Nm^3 would require the use of FGD, the government does not recognize, given the 85% reduction that would be required (i.e., from 3500 mg/Nm^3 down to 500 mg/Nm^3), that meeting the stricter standard can be achieved using not just wet FGD but also with semi-wet or dry FGD. As I discuss later, consumptive water use is not very high when using FGDs in most situations.

In any case, consumptive water use in FGDs is a very small fraction of the consumptive water used in a thermal power plant – especially those with water-based[9] thermal cooling cycles[10], including once-through and evaporative cooling technologies. The schematic below (Figure 1) shows a

[8] Media Statement, Minister of Environmental Affairs Intends to Amend Listed Activities and Associated Minimum Standards to Improve Air Quality in South Africa, 23 May 2019.

[9] Although some of the newer coal-fired units in South Africa use or are contemplating using air-cooling, most of them do not. It is my understanding that Units 5 and 6 at Grootvlei tested air-cooling and that units at Kendall are air cooled. Units at Kusile, Majuba (some units), Matimba, and Medupi are/to be air-cooled.

[10] Cooling is an essential part of the thermal cycle used by coal-fired power plants to generate electricity. The thermal cycle requires that spent steam that leaves the turbine be condensed back to water, which then travels back to the boiler to be transformed to steam, which then comes back to the turbine – hence the cycle. The spent steam condensing process only works if its heat is rejected to another media – mostly water. In once-through cooling plants, this cooling water is drawn from a river or lake, or such and rejected back to the same waterbody in a hotter state. In some plants, cooling towers are used, in which heat is rejected via evaporating a portion of the water, which then cools the rest of the water – which is recirculated. Nonetheless the evaporated water must be "made-up" from a source like a river or lake, etc.

typical 500 MW subcritical power plant and its water needs, just as an illustration.[11] This plant uses evaporative cooling using a cooling tower. As seen, most of the consumptive use (the right side in the schematic) is dominated by the cooling water evaporation, followed by boiler blowdown, etc. Moisture lost as water vapor in the stack is also significant. Water leaving with gypsum, a product that is made using FGD sludge, is a miniscule fraction of the overall consumption, since much of the FGD water is internally recycled and reused as indicated in the figure.

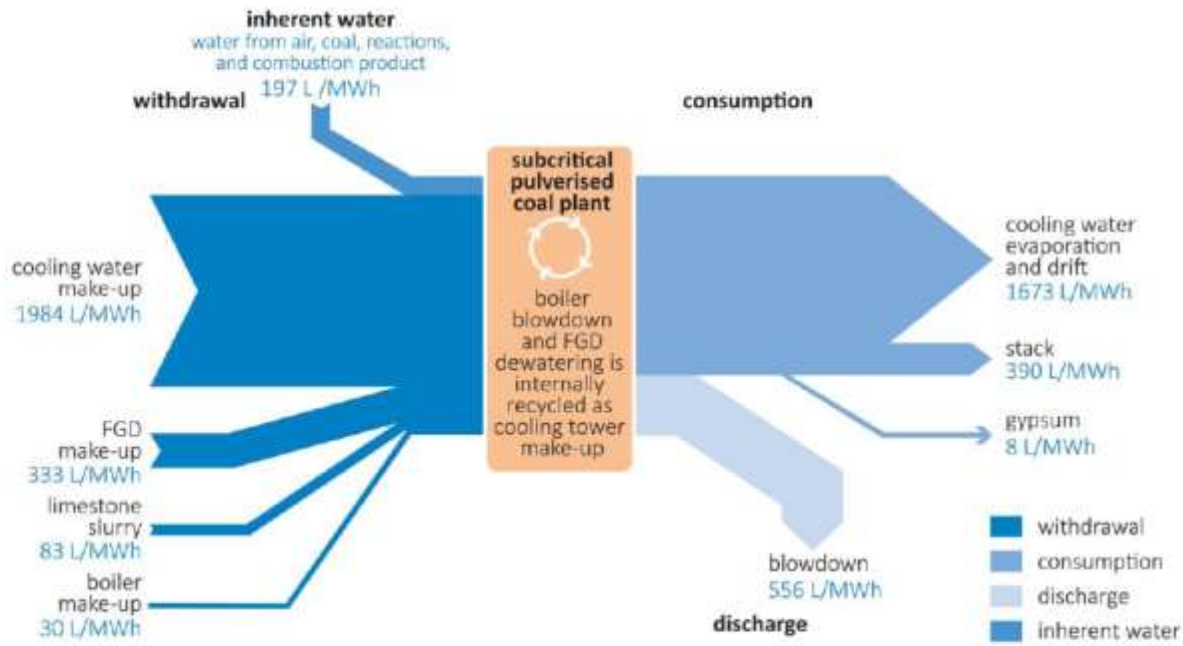

Figure 1: Water needs for a typical 500 MW subcritical coal-fired power plant

In other words, stating that water needs of FGD are large without putting it in the context of other consumptive water uses, on a plant by plant basis, is a misleadingly broad sweep. Compared to other consumptive water uses at a water-cooled thermal power plant, FGD water use is not large.

Additionally, focusing on just the water use by FGDs while minimizing or not weighing the tremendous SO_2 reductions that they can achieve – as noted earlier this can be 99% or more – i.e., much more than even the 95% level listed in the government's media statement – is misleading and unbalanced.

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[11] Carpenter, A. M., IEA report Water Consumption in Coal-Fired Power Plants, citing to others in the report. Available at https://www.usea.org/sites/default/files/Water%20conservation%20in%20coal%20fired%20power%20plants%20-%20ccc275.pdf

Lastly, as I have noted above, if in some cases the small additional consumptive water needs of wet FGD plants would be problematic, dry FGD designs can provide the requisite 85% reductions needed to achieve the 500 mg/Nm^3 MES. In dry-FGD, the slurry that contacts the exhaust gases evaporates to a dry solid powder trapping the SO_2 in the powder. Dry-FGDs, while not as efficient as their wet counterparts, can still easily achieve reductions around 95% and can achieve a limit of 200 mg/Nm^3.

While plants in water stressed areas that use air cooling are beneficial[12] and can reduce consumptive water uses dramatically, it is my opinion that the air quality and associated health benefits resulting from the very large reductions in SO_2 emissions outweigh the relatively small additional consumptive water needs of FGD. There is no justification of doubling the MES to a dangerously high level based on a broad-brush indictment of FGD relatively little consumptive water needs.

IV. Dry Sorbent Injection (DSI) and It's Impacts

As the government's statement seems to suggest, one of the motivations of the proposed relaxing of the MES seems to be based on the belief that the 1000 mg/Nm^3 standard can be achieved by using DSI instead of FGD. DSI requires the injection of one or more types of "sorbents" in dry, finely-powdered form, into the exhaust or flue gas stream leaving the boiler of a coal-fired power plant. The choice of sorbent along with the unit's exhaust configuration will dictate where the injection should occur. The two primary DSI chemistries currently being used are based on calcium or sodium-based reagents. One of the more common calcium-based sorbents is calcium hydroxide. Sodium based sorbents include naturally occurring trona (sodium sesquicarbonate)[13] or synthetically manufactured sodium bicarbonate.

For more background information on DSI, please see the first 17 pages of a technical paper authored by me and provided in Attachment B. While the paper was created for assessing DSI applicability for a US coal-fired power plant, the introductory discussion regarding DSI and its implementation details provide useful context.

I discuss DSI in this section – in particular, focusing on aspects of this technology that are problematic in their application. For example, DSI was developed initially in order to remove a range of acid gases such as hydrochloric acid (HCl), hydrofluoric acid (HF), etc. SO_2 reductions were an ancillary co-benefit as a result. Here, the government suggests the use of DSI not as a co-benefit SO_2 reduction approach but rather a primary SO_2 reduction technology. I discuss below a few of the more important negative impacts of using DSI as a SO_2-control approach that the Department of Environmental Affairs' statement above does not address. In addition, the

[12] An even more admirable idea to further reduce water needs would be to look for electricity generation without using a thermal steam cycle, such as by using renewables. In this regard, the presumption, in the government's statement that South Africa is (and, by implication, will always be) a "slow growing fossil fuel based economy) seems puzzling.

[13] It is not clear that South Africa has significant deposits of trona unlike, for example, the US. Thus, if a sodium-based sorbent is used for DSI in South Africa, it would likely be sodium bicarbonate.

government makes a meritless cost argument relative to these technologies which I will discuss at the end of this section.

IV.1 Increased Emissions of Particulate Matter

As noted in the previous discussion, DSI involves the injection of solid, powdered reagents (the "sorbent") onto which gases such as HCl, HF, and SO_2 will adsorb,[14] thus removing them from the exhaust gases. The DSI reaction process creates a powder. This, along with any unreacted or unabsorbed sorbent in the exhaust is collected in the downstream particulate matter (PM) control device. In the South African plants, this is typically an electrostatic precipitator (ESP).[15]

DSI will result in increased physical PM loading to the ESP. Very large quantities of DSI sorbents would be needed in order to reduce SO_2 emissions to the degree anticipated (i.e., from 3500 mg/Nm^3 down to 1000 mg/Nm^3 – i.e., around 70%). It is very rare that these sorts of SO_2 reduction levels are consistently achieved by DSI at all, since the main application of DSI is to reduce acid gases and not SO_2. Nonetheless, if 70% reduction of SO_2 is intended, huge quantities of DSI sorbents would be needed. And, the ESP, instead of typically collecting just fly ash from the boiler, will now, with DSI injected upstream, be required to collect fly ash and a mixture of unreacted DSI sorbents and reaction powder. The physical load on the ESP will be far in excess of what it was designed for. To maintain any reasonable level of PM performance, many ESP upgrades would be needed. The Minister's rationale does not discuss capital costs associated with such ESP upgrades, which would be far greater than the capital costs of the DSI itself.

Not only will physical loading to the ESP increase, the incoming mixture will have different chemical properties than the fly ash alone, for which the ESP was designed. This is because of the significant additional quantities of calcium and/or sodium that would be added via the DSI sorbent. This will cause adverse implications on the functioning of the ESP system. PM capture in ESPs is a complicated function of many variables, including inlet particulate loading, the electrical resistivity of the particles, the concentration of sulfuric acid mist at the inlet of the ESP, as well as the changed concentration and changed particle size distributions if DSI sorbents are injected upstream of the ESP.

The electrical resistivity, in particular, is a very important parameter and ESPs are designed anticipating a range of expected electrical resistivities in the fly ash. Basically, the electrical resistivity of a particle determines how easy or difficult it will be for the particle to be electrically charged and to hold on to the charge. Without proper electrical charging, ESPs cannot remove particles from the waste exhaust gas stream. The degree to which resistivity will change depends on a quantity of DSI sorbents used. If DSI is used, as noted above, either calcium or sodium agents will be used. In general, calcium-based sorbents will increase the resistivity of the fly ash making the ash more difficult to charge and capture while sodium sorbents decrease the resistivity of the fly ash making the ash easier to charge and collect. Sulfur compounds such as sulfur trioxide

[14] The acid gases HCl, HF, etc. are preferentially adsorbed in DSI sorbents, before SO_2 is adsorbed.

[15] ESPs, or more precisely dry ESPs are PM control devices which trap PM by first electrically charging PM particles as they enter the ESP, followed by collecting them on oppositely charged plates.

(which converts to sulfuric acid mist in the presence of water vapor always present in boiler exhaust gases) reduce resistivity making particles easier to charge and collect in ESPs. However, when DSI is used, the sorbents can preferentially adsorb sulfuric acid mist, removing it from the gas stream, and therefore adversely affecting PM control. While this discussion might indicate that there are benefits to using sodium-based sorbents, I will discuss other issues with sodium-based reagents below.

Both, the increased physical loading and its changed chemical composition, will have adverse impacts on the ESP's operation.[16] And, upgrading ESPs to accommodate the increased physical loading and its changes chemical composition is a significant cost. Depending on the current state of the ESP, this upgrading cost alone can range in the tens of millions of USD or hundreds of millions of SA Rand.

IV.2 Potential Ash Handling System Impacts

In addition to the ESP impacts noted above, there will be adverse impacts on the ESP's ash handling systems as well, since they will now be required to handle far greater quantities of ash as well as DSI reaction products and unreacted DSI sorbents. Thus hoppers, fans, blowers, ducts, etc. will all need to be re-evaluated and likely replaced. The capital costs for these replacements is not factored into the government's discussions.

IV.3 Adverse Impacts on Mercury Emissions

One of the more toxic byproducts of coal combustion is the emission of mercury and its compounds into the atmosphere. All coals contain mercury, in many forms, depending on the coal. Upon combustion, these mercury compounds are transformed and emitted into the atmosphere – typically as combination of elemental mercury, oxidized mercury (i.e., mercury chloride), and particulate-bound mercury. If an FGD is present, it removes substantial amounts of the oxidized mercury. DSI, however, by scavenging oxidizing agents such as chlorides, will adversely affect the formation of soluble oxidized mercury compounds and greater quantities of elemental mercury are likely to be emitted to the atmosphere.

IV.4 Adverse Impacts of Disposal of ESP Solids

As discussed in my paper in Attachment B, one of the more insidious adverse impacts of DSI use, particularly when using sodium-based sorbents, is the high leachability of toxic metals such as arsenic and selenium into groundwater, when spent DSI sorbents collected in the ESP are disposed-off in ash landfills or impoundments. These toxic metals then reach groundwater and affect all who rely on that groundwater, and can also migrate to nearby surface waters. Thus, if a power station does not have adequate mitigation to protect against contamination from its coal ash dump, the use of DSI will increase the potential risk.

[16] I should also note that I have carefully reviewed ESP performance in many South Africa coal-fired power plants, as manifested in their reported PM emissions. Based on this it is my opinion that many of the ESPs at South Africa's coal-fired power plants are old and have significant deferred maintenance, resulting in poor PM collection performance. Adding more loading to these under-performing ESPs will simply make matters worse and will result in more PM emissions.

V. Costs

The Department of Environmental Affairs' statement notes the high cost of FGD and the relatively lower capital cost of DSI. It is disingenuous, however.

First, the noted capital costs of FGD appear to be significantly inflated. Recent, mass application of FGD, in countries such as India (presently upgrading a large fraction of its coal-fired units with FGD) show that FGD capital costs can be significantly lower, if proper procurement strategies are followed.

Second, while capital costs for just DSI alone are indeed lower than capital costs of FGD, the operating costs of DSI (including costs to mine/produce the sorbent, transport it to the coal-plant, properly condition it including reducing its size to fine power by grinding, storing it onsite without exposing it to moisture, etc.) are sizeable, especially to achieve 70% SO_2 reduction. Operating costs also include disposal costs of the spent DSI/fly ash. And, as noted, significant capital costs would be needed for ESP upgrades. And, even more capital costs would need to be incurred to create proper disposal landfills in order to safely dispose of DSI (especially sodium-based) spent solids in order to avoid leaching of toxic metals into groundwater. Based on this, it is not clear that a levelized cost of DSI would be cheaper or significantly cheaper than FGD.

Based on this, it is my opinion that the government's expectation that DSI would be a much cheaper option than FGD is not only not unsupported, but is contrary to reality.

VI. Summary

Based on the foregoing, it is my opinion that the MES should not be doubled to 1000 mg/Nm^3, as proposed. Not only will this allow significantly more emissions and adverse harm to exposed populations, the proposal is premised upon assumptions that are false: that FGD consumptive water use is significant; that DSI is significantly cheaper; and that there are no adverse impacts to using DSI to achieve SO_2 reductions of around 70% as contemplated by the weaker proposed standard of 1000 mg/Nm3.

Instead, for coal-fired plants that intend to continue to operate in South Africa, I recommend that the 2020 stack MES should be reduced to levels in the range of 200 mg/Nm^3, the norm in most other jurisdictions around the world, and a level that can readily and cost-effectively be achieved by implementation of FGD. This will result in the actual improvement of air pollution in South Africa, including in the various priority areas declared in terms of South Africa's air quality legislation.

ATTACHMENT A – RESUME

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CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

Dr. Sahu has over twenty eight 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 twenty five years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty five years include various trade associations as well as individual companies such as steel mills, petroleum refineries, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including EPA, the US Dept. of Justice, several states, various agencies such as the California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

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

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

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.) public sector (such as the US Department of Justice) and public interest group clients with project management, air quality consulting, waste remediation and management consulting, as well as regulatory and engineering support consulting services.

1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.

Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.

1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.

1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.

1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.

1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

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

1984 M. S., Mechanical Engineering, Caltech, Pasadena, CA.

1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.

"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.

"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.

"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.

“Thermodynamics and Heat Transfer,” Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.

"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

"Advanced Hazardous Waste Management" University of California Extension Program, Riverside, California. 2005.

<u>Loyola Marymount University</u>

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

"Environmental Risk Assessment," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

"Hazardous Waste Remediation" Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

<u>University of Southern California</u>

"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.

<u>University of California, Los Angeles</u>

"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.

<u>International Programs</u>

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

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

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

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

PROFESSIONAL AFFILIATIONS AND HONORS

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

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

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

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

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

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

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2017.

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. (Resppondents),* 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) and Rebuttal Expert Report (Harm Phase) (May 2018) 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.

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

117. 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.

118. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

119. 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).

120. 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).

121. 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).

122. 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.

123. 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.

124. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.

125. 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.

126. 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.

127. 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.

128. 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*.

129. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coleto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

130. 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).

131. 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.

132. 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).

133. 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.

134. 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).

135. 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.

136. 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).

137. 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).

138. 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).

139. 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.

140. 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.

141. 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.

142. 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.

143. 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).

144. 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.).

145. 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).

146. 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).

147. 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.

148. 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).

149. 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).

150. 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.

151. 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.

152. 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).

153. 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).

154. 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).

155. 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).

156. 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).

157. 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).

158. 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).

159. 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).

160. 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).

161. 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.

162. 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).

163. 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).

164. 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).

165. 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.

166. 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.

167. 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).

168. 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.

169. 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.

170. 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.

171. 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.

172. 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).

173. 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).

174. 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).

175. 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.

176. 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).

177. 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.

ATTACHMENT B – Technical Paper

Technical Report

on

Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF)

by

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[1] Resume provided in Attachment A.
[2] Comparison of Sodium Bicarbonate and Trona for Multi-Pollutant Control, Yougen Kong and Stan Carpenter, Solvay Chemicals, Electric Power 2010.

1.0 Summary

This report presents background and general technical information that may be useful in assessments of the implementation of Dry Sorbent Injection (DSI) technology at coal-fired generation units for the purposes of sulfur dioxide (SO2) emission reduction. While the costs of installing, operating and maintaining a DSI system at a typical coal-fired generation unit, if feasible at all, will depend on factors that can only be properly addressed using site-specific factors, the general question of whether or not it DSI is likely to be effective at reducing SO2 emissions can be addressed in broad terms. Implementation details at particular plants and specific coal-fired boiler units will depend on numerous site-specific factors including the type of sorbent used and the specific design of the DSI system.

DSI technology was originally designed to reduce the amount of sulfur trioxide (SO3) and acid gas emissions at sources such as coal-fired boilers. Since the amount of SO2 removal achieved by DSI has always been less than other, more effective means of SO2 removal (such as via wet or dry flue gas desulfurization (FGD) systems specifically designed for sulfur dioxide removal) the technology was not previously marketed for SO2 removal, per se. However, recent regulatory drivers, such as the EPA Mercury and Air Toxics (MATS) Rule, have created renewed interest in DSI as a means of SO2 removal due to the considerably lower capital costs of DSI compared to the more conventional wet or dry FGD systems. Thus, many utilities are actively analyzing whether or not it would be feasible to install DSI, rather than FGD, at their coal-fired generation units in order to comply with stricter air emission standards. As more utilities begin to consider or implement DSI, it becomes increasingly important to understand the total costs (including capital costs, operation and maintenance costs) as well as the long-term environmental impacts of DSI.

As detailed in this report, the effectiveness of DSI technology at removing SO2 from a coal plant's air emission stream depends on many factors including sorbent type, sorbent particle size and the rate/amounts at which the sorbent is injected into the flue gas stream. The type of particulate matter controls in place at any given generation unit and the presence of other air pollutants in the flue gases will also affect the ability of a DSI system to remove SO2. Furthermore, increased SO2 removal using the most common sodium-based sorbent (trona) will result in the increase of other known air pollutants from the unit, including carbon dioxide (CO2) and possibly nitrogen oxides (NOx).

The choice of sorbent used in the DSI system will also alter the composition and properties of the boiler's solid waste streams. If a DSI system uses sodium-based sorbent, certain constituents in coal combustion waste (CCW or "coal ash"), such as arsenic, become more mobile and are more likely to leach into groundwater or adjacent surface waters, given that the vast majority of CCW disposal facilities are either unlined or do not have adequately designed liners. This increase in leachability represents not only a potential threat to water quality and public health but also additional future liabilities and operational costs for owners and operators of coal plants – costs that are presently not being factored into the conventional cost-analyses that are often used to justify technology assessments and technology selection. Since most coal plants do not already have properly designed lined coal ash impoundments located on site, they will either have to incur significant costs to construct new lined ash impoundments, retrofit existing unlined impoundments or risk discharging toxic metals into groundwater or nearby surface waters. Furthermore, the change of the coal ash's chemical composition can also render it unsuitable for use in concrete or structural fill – eliminating a potential revenue source for coal plants and further driving up the costs of DSI implementation.

We hope this report provides readers background knowledge on how DSI works and identify areas of potential concern regarding its implementation at coal-fired power plants. Although the costs and benefits of DSI vary wildly depending on design and implementation, and can only be properly addressed via site-specific analyses, this report attempts to provide information that may be useful to all stakeholders that are considering DSI as well as are likely to be affected or impacted by its use at coal-fired power plant units.

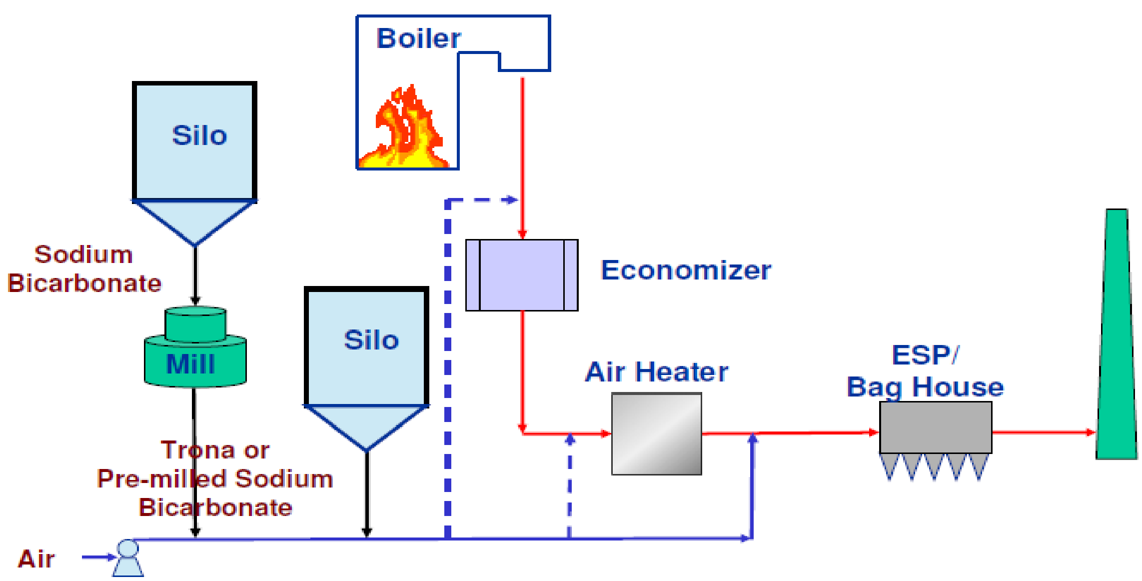
2.0 Dry Sorbent Injection

2.1 Basics and Elements of a DSI System

A Dry Sorbent Injection (DSI) system is, as the name implies, a dry process in which a sorbent is pneumatically injected either directly into a coal-fired boiler or into ducting downstream of where the coal is combusted and exhaust (flue) gas is produced. This discussion will focus on the latter, more common, implementation of DSI. The goal of the sorbent injection is to interact the sorbent with various pollutants in the flue gases (such as sulfur trioxide (SO3), various acid gases including hydrochloric acid (HCl), and sulfur dioxide (SO2), such that some fractions of these pollutants are removed from the gas stream.

Figure A,[2] below shows a simple schematic of the DSI process. We will discuss the sorbents that are used in more detail below. For now, Figure A shows that the sorbents can be injected at a number of locations, all prior to the particulate control device.

Figure A – Simple DSI Schematic



[2] Comparison of Sodium Bicarbonate and Trona for Multi-Pollutant Control, Yougen Kong and Stan Carpenter, Solvay Chemicals, Electric Power 2010.

After the appropriate chemical interactions between the pollutants in the flue gas and the sorbent, the dry waste product of reaction is removed at the (typically) existing particulate control device downstream of the injection point – which is typically either an electrostatic precipitator (ESP) or a fabric filter baghouse.

Historically, DSI was used to remove SO3 and acid gases – and these pollutants are usually present in far lower concentrations in the flue gases as compared to SO2. However, some SO2 was also invariably and unavoidably removed as well. As regulatory pressures have focused increasingly on SO2 removal, DSI vendors have increasingly targeted their systems at this pollutant. SO2 removal via DSI is the focus of this technical report.

Historically, SO2 removal was effected using various types of scrubbers, whether wet or dry. These technologies have roughly 40 years of field implementation and can routinely achieve SO2 reductions ranging from 90%+ to 99%, depending on various factors. However, they have significant capital costs.

In contrast, DSI systems have two distinct advantages that have, heretofore, propelled their acceptance as a suitable SO2 control technology. First, the capital cost of DSI systems is much lower compared to wet or dry scrubbers. Second, DSI systems take up much less physical space, which is especially important when considering retrofit or upgrades to existing units.

The expected SO2 control efficiency of DSI (and at what overall cost) is a matter of some controversy. We will explore that in more detail later in this section. However, it is rare that DSI SO2 efficiency is 90% or greater. Thus, if the SO2 efficiency requirement is 90% or greater, DSI is not likely to be an appropriate technology. For lower efficiencies, it is possible to remove SO2 via DSI but various factors including capital cost, operating costs (of which sorbent costs are a significant part), waste handling issues, etc. need to be considered before a proper decision can be made. Although several current units are using DSI in some capacity at this time, actual hard operational data are not available. Similarly it is reported that additional plants/units are considering DSI for meeting compliance needs but the extent of additional DSI adoption will not be fully clear until 2015-2016. The typical timeline for the installation and implementation of DSI, including initial assessments and permit requirements are of the order of

12-24 months. This does not include time for building a new landfill/impoundment or retrofitting an existing landfill, if that is feasible, which could significantly increase the amount of time needed to implement DSI.

2.2 Sorbents

Two primary sorbents are utilized in DSI systems: sodium sesquicarbonate, or trona, and sodium bicarbonate. Both of these, as their names suggest, are sodium based sorbents. Less frequently, a calcium based sorbent, hydrated lime, can also be used although rarely so if the goal is SO2 removal.

There are several notable differences between these materials. First, sodium bicarbonate is more effective in removing sulfur dioxide emissions than trona. Hence, less sodium bicarbonate is required for an equivalent amount of removal. But, sodium bicarbonate is more expensive than trona in the United States on a per-pound basis. Therefore these factors need to be considered in their totality before site-specific cost estimates can be made. The focus of this report, however, is Trona, since it seems to have garnered the most interest from likely DSI adopters. Trona is a naturally occurring mineral and a substantial amount of it is mined primarily from a vast formation in the Green River, WY area[3] and certain areas of California. Sodium bicarbonate, on the other hand, is a chemical compound primarily manufactured using the Solvay Process. This salt is obtained from a reaction of calcium carbonate, sodium chloride, ammonia, and carbon dioxide in water, and is more expensive than the mined trona.

Hydrated lime is not as effective as either of the sodium based sorbents so greater quantities of hydrated lime are required, making operational costs significantly greater. The reader should keep in mind that not all operational costs are properly accounted for in many situations. Thus, in actual site-specific implementation, the final economics may favor any one of these three sorbents.

[3] The largest deposit of trona in the world is in the Green River Basin in Wyoming, where seams of trona vary in depth from 600 to 3500 ft and are spread over approximately 2500 square miles. Known deposits of trona in the Green River Basin exceed 100 billion tons. Four companies currently mine trona in the Green River Basin, but only two, Solvay Chemicals and FMC market trona for SO2 control.

It should also be noted that, in addition to SO2 removal, each of these sorbents is more or less effective on other pollutants that may be of interest.

For example, trona is effective for SO2, SO3, condensable particulate matter (mostly sulfuric acid mist) and HCl. Sodium bicarbonate for is effective for SO2 and HCl. Hydrated lime is most effective for SO3, condensable PM and HCl.

2.3 Sorbent Particle Size

The effectiveness of SO2 reduction is based on many factors, including, in no particular order: sorbent mass injection rate, sorbent residence time in flue gas stream (which depends or dictates the injection location), sorbent penetration and mixing with flue gases, the type of particulate control device, flue gas temperature profile, and, finally, the sorbent particle size. Typically, the finer the sorbent particle size, the greater the sorbent surface area available for reactions. All of the other factors remaining constant, finer particle size will yield greater the SO2 removal efficiency for a given quantity of sorbent injected. Looked at another way, finer particle size requires less sorbent mass required for a specified SO2 removal efficiency.

The drawback, however, is that finer sorbent particles usually involves additional milling equipment, which, though promising reasonably quick payback, adds to initial capital cost and increases operating costs.

2.4 Reactions

The various reactions that can occur between the DSI sorbent and the pollutants in the flue gases are summarized below in Figure B.[4]

Figure B – DSI Reactions

Chemical Reactions

- **Trona Calcination**

  $$2(Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O)\,(s) + heat \rightarrow 3Na_2CO_3(s) + 5H_2O(g) + CO_2(g)$$

- **Sodium Bicarbonate Calcination**

  $$2NaHCO_3\,(s) + heat \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

- **Acid Neutralization Reactions**
  - $Na_2CO_3 + SO_2 + 1/2O_2 \rightarrow Na_2SO_4 + CO_2$
  - $Na_2CO_3 + SO_3 \rightarrow Na_2SO_4 + CO_2$
  - $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
  - $Na_2CO_3 + 2HF \rightarrow 2NaF + H_2O + CO_2$

Na_2SO_4, NaCl and NaF are collected in fly ash.

It is important to note that CO2, a greenhouse gas, is a by-product of many of these reactions when sodium-based sorbents are used in DSI. While use of hydrated lime will not create CO2 emissions during the pollution control process it should be noted that the production of hydrated lime elsewhere can create CO2 emissions as well. It should be noted that CO2 emissions can also result when limestone is used as the reagent in wet FGDs for conventional SO2 removal. Actual quantities of CO2 that can be produced as a result of SO2 removal reactions will depend on the type and quantity of reagents used as well as the quantity of SO2 removed, which, in turn, depends on the coal sulfur content and the SO2 removal efficiency via DSI or a scrubber.

[4] Comparison of Sodium Bicarbonate and Trona for Multi-Pollutant Control, Yougen Kong and Stan Carpenter, Solvay Chemicals, Electric Power 2010.

Of course, it should also be noted that the reaction products are collected in the fly-ash, which is, along with the unreacted sorbent, collected in the particulate control device downstream. Thus, the chemical and physical properties of the collected particulates from either the baghouse or the ESP change when DSI is added. Since these particulates must be disposed of, typically in existing landfills, understanding the nature of these changes is important. We will discuss this in a little more detail later.

2.5 SO2 Removal Efficiency and Factors

As noted above, SO2 removal efficiency depends on numerous factors. Briefly, these include:[5]

- sorbent injection rate or Normalized Stoichiometric Ratio (NSR);

- sorbent particle size;

- residence time of the sorbent in the flue gas stream (before capture in the PM control device);

- extent of dispersion and mixing of the sorbent and the flue gas;

- the type of PM controls device (ESP versus baghouse). A baghouse allows for longer contact time of the sorbent and the pollutant gases, given the filter cake present in the baghouse. With an ESP, there is no filter cake and hence particle size is a more important variable;

- flue gas temperature

- presence of other competing pollutants in the flue gases

[5] Dry Sorbent Injection of Sodium Sorbents for Acid Gas Mitigation, Heidi E. Davidson, Solvay Chemicals, Inc., International Biomass Expo and Conference, 2010.

In this subsection we will present some of the more important factors and their impact of the expected SO2 removal efficiency.

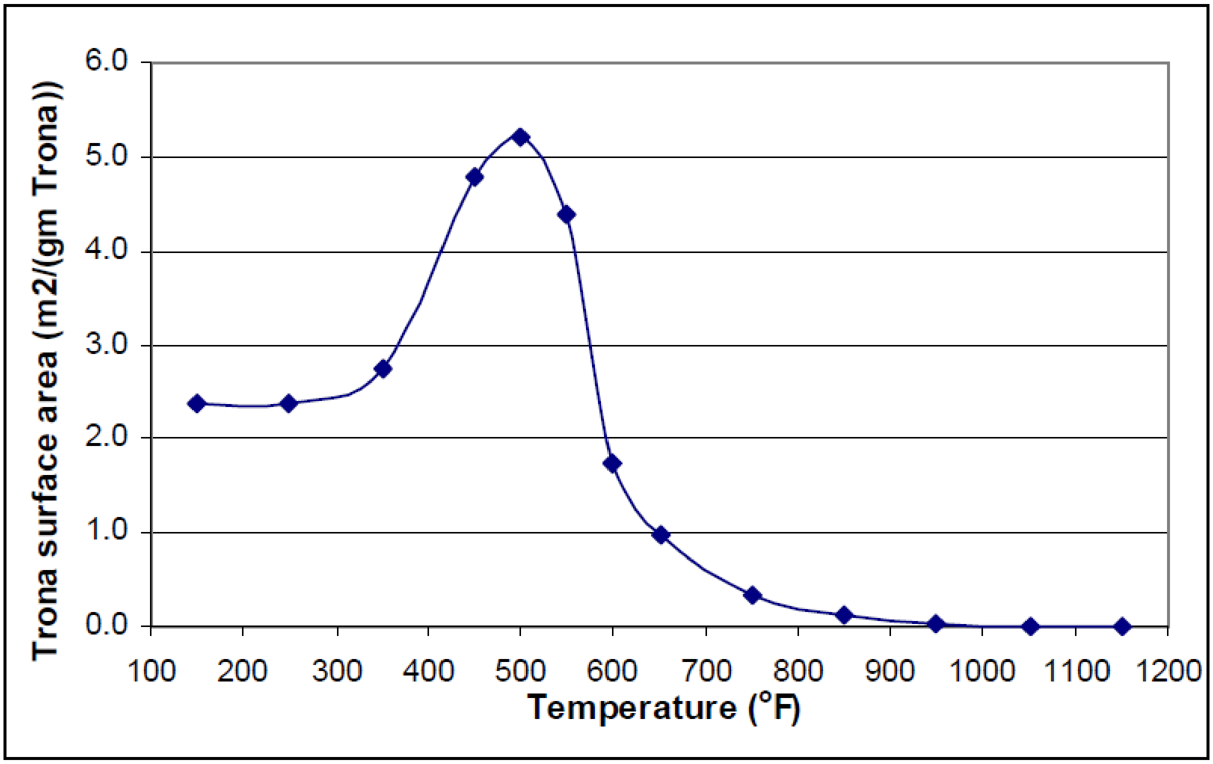
In one recent study,[6] the authors evaluated the sensitivity of SO2 removal to trona injection rate, particle size, and injection location. The predicted SO2 reduction ranged from 45-80% and was highly dependent on a parameter called the Normalized Stoichiometric Ratio (NSR)[7] and trona particle size distribution.

When a trona particle is introduced into the hot flue gas stream, upon decomposition to sodium carbonate, the surface area of the particle increases significantly. This behavior is commonly referred as the "popcorn effect". Figure C below shows the particle surface area as a function of temperature. As seen in the figure, the surface area begins to increase at approximately 300F, peaks at approximately 500F, and then decreases for increasing temperature above 500F where the internal structure of the particles begins to change. Adding trona at temperatures greater than 800F is not advisable.

[6] Cremer, M. A., et. al., Testing and Model Based Optimization of SO2 Removal With Trona in Coal Fired Utility Boilers, Paper #137.

[7] NSR represents the multiple by which sorbent must be injected as compared to the theoretical or stoichiometric amount required based on the amount of SO2 present.

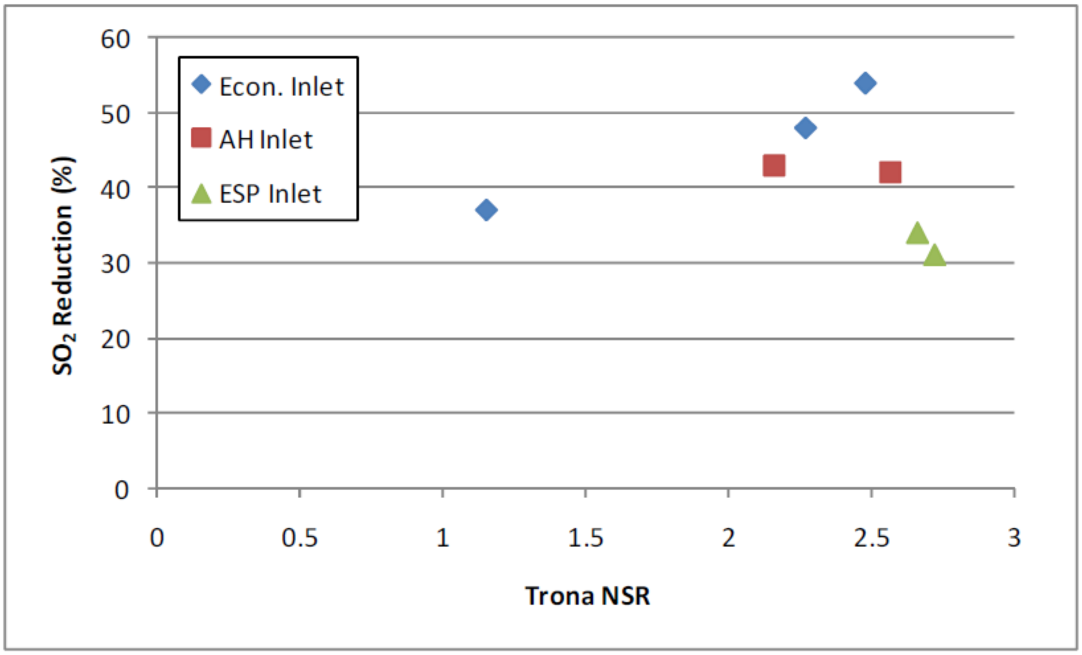
Figure C – Trona Particle Surface Area versus Temperature



Field tests have been carried out by various vendors and researchers in order to evaluate trona performance for SO2 reduction. In one set of studies the impacts of injection location were evaluated. In particular, trona was injected at the economizer inlet, the air heater inlet, and the ESP inlet. Average gas temperatures at these locations under full load conditions were reported to be 705FF, 550FF, and 230FF. These tests were primarily carried out using the as-received, unmilled Solvay T200 material (D50 = 30 μm). Figure D shows the measured SO2 reductions for these tests. The data show the best performance was achieved for trona injection at the economizer inlet and the worst performance was seen for injection at the ESP inlet. It should be noted that performance is a function of not only particle surface area discussed above but also the residence time available for the gases to mix with the injected trona, which, in turn, can depend on the flue gas flow rate, the temperature, and the geometry of the duct that transports the flue gas. Thus finding the optimal injection location is a complex function of several site-specific variables. Most of these tests were carried out for a trona NSR of approximately 2.5 (i.e., 2.5 times more trona than would be needed based on theoretical calculations).

Figure D – Effect of Injection Location on SO2 Removal Efficiency

Figure 5. Measured SO_2 reduction with unmilled trona as a function of NSR and injection location



Another set of tests focused on particle size and the effect of milling (i.e., reducing the particle size of the trona using a "mill") the trona. Two pin mills were used either in series or in parallel to supply trona to injectors or lances at the economizer inlet. When used in series, the trona was milled to a median particle size, D50, of approximately 11.6 µm. When used in parallel, the D50 was approximately 13.7 µm. Tests were carried out for NSRs ranging from approximately 1 to 3.5. These results were compared against earlier results using unmilled trona and are shown in Figure E.

Although the data are limited, the results indicate, as expected, improved SO2 reduction using the milled trona compared to the unmilled trona. As seen in the figure, measured SO2 reduction up to 74% was observed, but at a high trona injection rate (NSR of 3.5).

Figure E – Effect of Trona Particle Size and NSR on SO2 Removal Efficiency

Figure 6. Measured SO_2 reductions as a function of NSR and milling configuration.

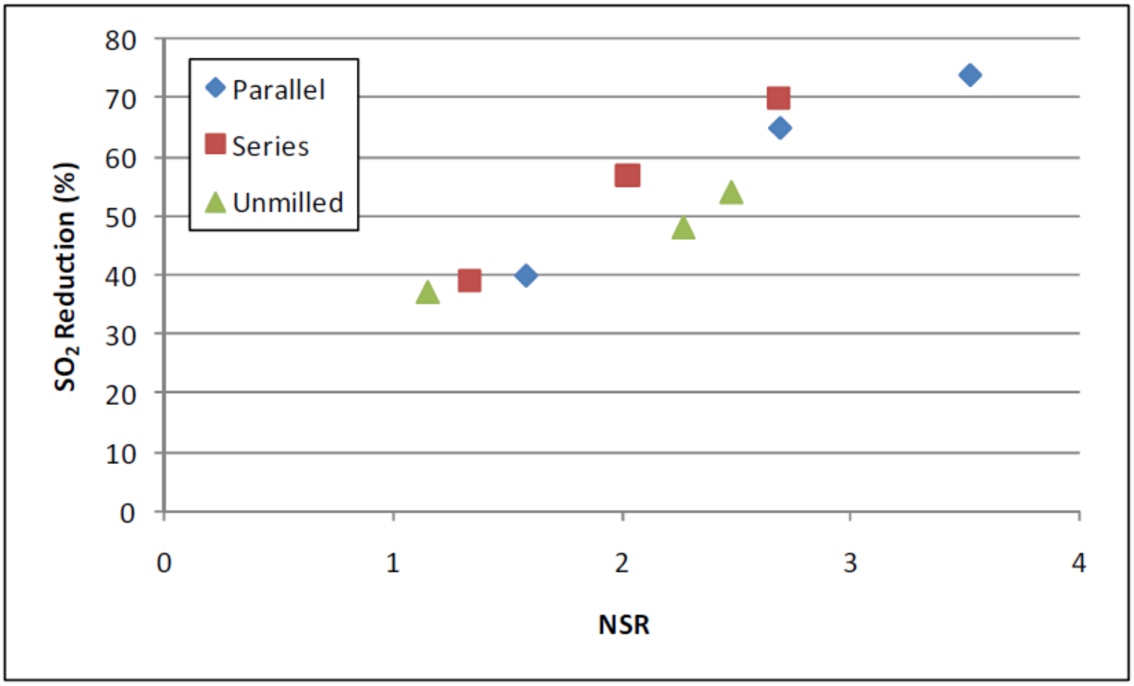
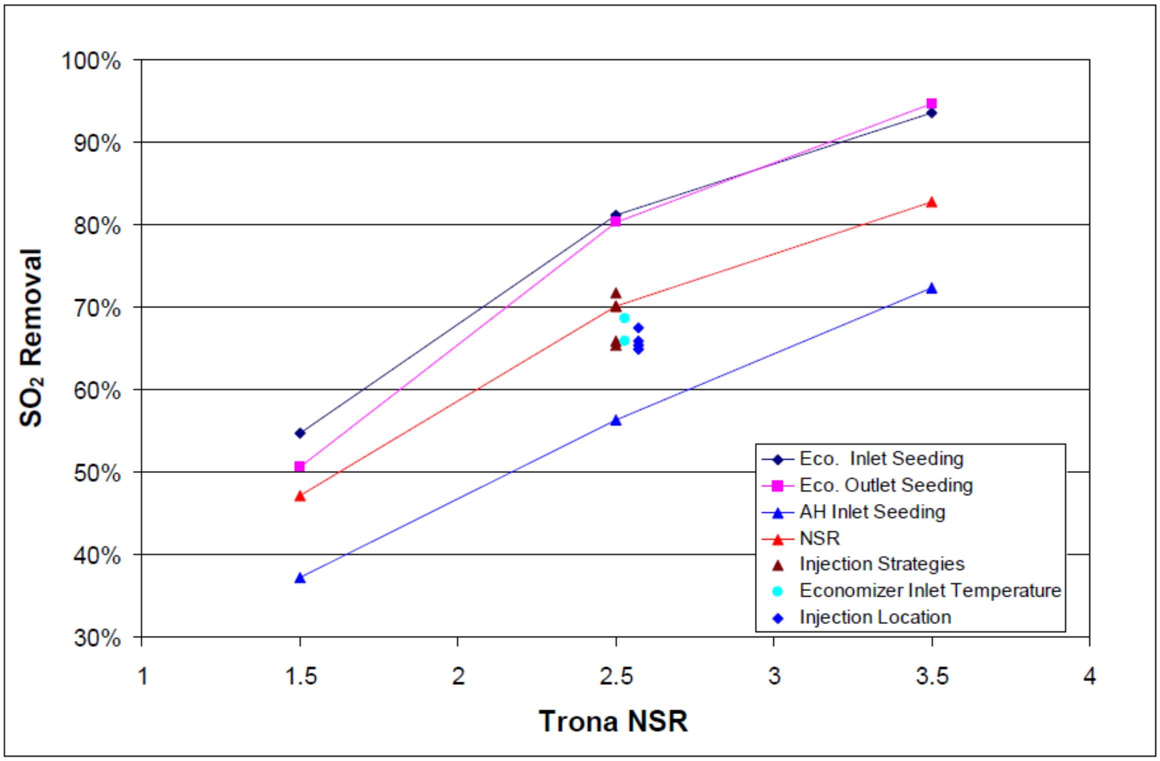


Figure F below combined the effects of various factors into one chart, showing how SO2 removal efficiency is affected by these factors. As can be seen in the figure, achieving 90% or greater SO2 removal efficiency is not generally feasible. It should also be noted that even achieving SO2 removal efficiencies of 70% or greater requires significantly greater quantities of trona injection (high NSR values). This increases the operating cost of DSI since it requires purchasing of greater quantities of trona, increased milling costs, and also higher costs of waste disposal. The effect of greater quantities of unreacted sorbents in the ash on ash properties will be discussed later.

Figure F – SO2 Removal Efficiency and Various Factors

Figure 12. Predicted impacts of injection location, trona distribution, NSR and gas temperature on SO_2 removal



2.6 DSI Challenges

While the DSI process appears relatively straightforward, is easy to understand, and is lower in capital cost as compared to the other SO2 removal options such as scrubbers, it is not without significant challenges.

As noted earlier, this report does not discuss DSI using calcium based sorbents such as hydrated lime, mainly because of its low SO2 removal efficiency (as compared with the sodium based sorbents such as trona or sodium bicarbonate), so it will not discuss myriad issues and challenges associated with calcium based sorbents.

For sodium based sorbents, the following should be noted.

- plugging and caking – historically, sodium sorbent injection systems have been beset by plugging and caking in the insides of the ducts, leading to blockages;

- dehydration – sodium sorbents can dehydrate in the conveying system, making water available for agglomeration and caking;

- thus, heat gain should be minimized in the conveying system. It is critical to use high efficiency compressors in the pneumatic systems and to properly manage the temperature of the conveying fluid since higher temperatures will increase fouling in the conveyance systems;

- increased SO2 removal with sodium may result in some NOx formation;

- ash sales may be negatively affected by sodium addition since the ash may not be suitable for applications in concrete or structural fill. Of course, loss of ash sales will affect plant economics and operation costs; and

- ash landfilling may be negatively impacted due to solubility of sodium compounds in the fly ash (i.e., Na2SO4 or Na2CO3).[8]

The last impact is significant and as yet generally unrecognized. Yet, it clearly has the potential for significantly increasing the disposal cost and/or creating significant adverse environmental impacts. Thus, some additional discussion is provided in the next subsection.

[8] Designing and Operating a Reliable DSI System, Greg Filippelli, ADA-ES, 2012

2.7 Impact on Ash Solubility

The impact of trona-based ash has been recently evaluated in industry-sponsored studies.[9] Key conclusions include the following:

- trona injection for SO2 emission control significantly changed the fly ash physical characteristics, including reduced specific surface area, and changed particle morphology and microstructure;

- trona injection for SO2 emission control significantly increased the bulk contents of sodium, sulfur, and carbonate in the fly ash, and brought great amount of soluble materials into the fly ash;

- trona injection for SO2 emission control greatly increased the fly ash solubility, pH, and leachability of anionic elements including fluoride, sulfate, chloride, and trace oxyanions of concern especially As and Se. Compared to the conventional fly ash, trona ash leached significantly more As and Se in all conditions, including varying leaching time, pH, storage time conditions. Multiple factors may contribute to the enhanced As and Se leaching from trona ash, including more alkaline pH, greater ash solubility, presence of high concentrations of competing anions (such as sulfate and carbonate), and a greater Se(VI) fraction in trona ash.

The implications are obvious. Since most plants, even including those that are able to sell some of their fly ash, dispose of the bulk of their fly ash in already existing local, unlined landfills, increased solubility of this fly ash, with trona injection, will likely increase the leachability of metals such as arsenic and selenium into groundwater below such landfills. Lining existing landfills, to the extent it can even be done, would be prohibitively expensive, even for the smaller landfills. Thus, this impact should be carefully evaluated before DSI is considered as a proper or appropriate SO2 reduction technology.

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[9] Jianmin Wang, et. al., Leaching Behavior of Coal Combustion Products and the Environmental Implication in Road Construction, A National University Transportation Center at Missouri University of Science and Technology, NUTC R214, April 2011. This work is sponsored by, among others, the Electric Power Research Institute (EPRI).

In summary, there are potentially adverse air quality as well as water quality impacts that can result from the implementation of DSI to mitigate SO2 emissions. Since the likelihood and extent of these adverse impacts will be site specific, they should be addressed during the permitting/regulatory approval stages, if this technology is evaluated/contemplated. When considering the impacts of DSI implementation on air, it is critical that any additional emissions of pollutants, such as various sizes of particulate matter from handling/processing of the sorbents and from the additional loading of sorbent on the existing particulate control devices, as well as increased emissions of greenhouse gases, such as CO2, be considered and addressed during the permitting process.

To the extent the regulatory approval process allows for a consideration of off-site environmental assessments, incremental adverse impacts from the mining, refining, transport, and storage or sorbents should also be addressed. With regards to impacts on water quality, particularly groundwater impacts, the issue of disposal of the sodium containing ash on existing landfills is paramount. This should be considered as part of the landfill permit at a site, as applicable.

3.0 The Shawnee Fossil Plant and Possible DSI Implementation

3.1 Description

Shawnee Fossil Plant is located about 10 miles northwest of Paducah, Ky., on the Ohio River. It is located approximately 13 miles downstream from the mouth of the Tennessee River. The plant consists of 10 pulverized coal-fired units, of which 9 are identical dry-bottom, wall-fired units (Units 1-9). Each of these units is rated at 175 MW. Shawnee Unit 10, which was converted to an atmospheric fluidized-bed boiler in the early 1980s and was the first such unit in the country, was idled by TVA in October 2010.[10] We will not be discussing Unit 10 further in this report.

Construction of the station was authorized in 1951. Unit 1 was placed in service in April 1953 and the last Unit 10 went into operation in October 1956. So, each unit is approximately 55 years old or more.

As far as environmental controls, Units 1 through 9 burn a blend of low-sulfur coal sourced from the Power River Basin and use low-NOx burners to reduce emissions of nitrogen oxides. None of these 9 units has any additional SO2 removal capability. Particulate matter controls at each of Units 1-9 have evolved over the years. Initially they were only equipped with mechanical dust collectors, mainly to protect the induced draft fans. In 1968, TVA initiated a program of retrofitting each unit with ESPs in order to comply with a Federal Executive Order issued in 1966. The ESPs were operational in 1973. Each unit exhausted its flue gas via a separate stack. Then, in 1974, in an effort to improve ambient air quality and reduce ground concentration of SO2 purely using dilution as the approach to pollution control, TVA built two large 800 foot tall stacks serving all ten units (5 units connected to each stack). In April 1976, the Supreme Court ruled against the tall-stack approach to "controlling" SO2 emissions. At that point, TVA decided to retrofit each unit with a baghouse. The baghouses were installed between 1978-1981. While they do not control SO2 emissions, the baghouses provided better control of particulate matter emissions from the various units. It is assumed that the old ESPs are still in place and deenergized.

[10] http://www.tva.com/sites/shawnee.htm

As noted above, initially each unit exhausted its flue in to the atmosphere via its own stack. When the baghouses were installed, the flue gas arrangement was changed. Currently, flue gases from Units 1-5 are combined and discharged to the atmosphere via a common stack and flue gases from Units 6-10 are combined and discharged to the atmosphere via a second stack.

Figure 3-A shows a general location map of the station. The Ohio River is visible at the top right hand corner of the figure.

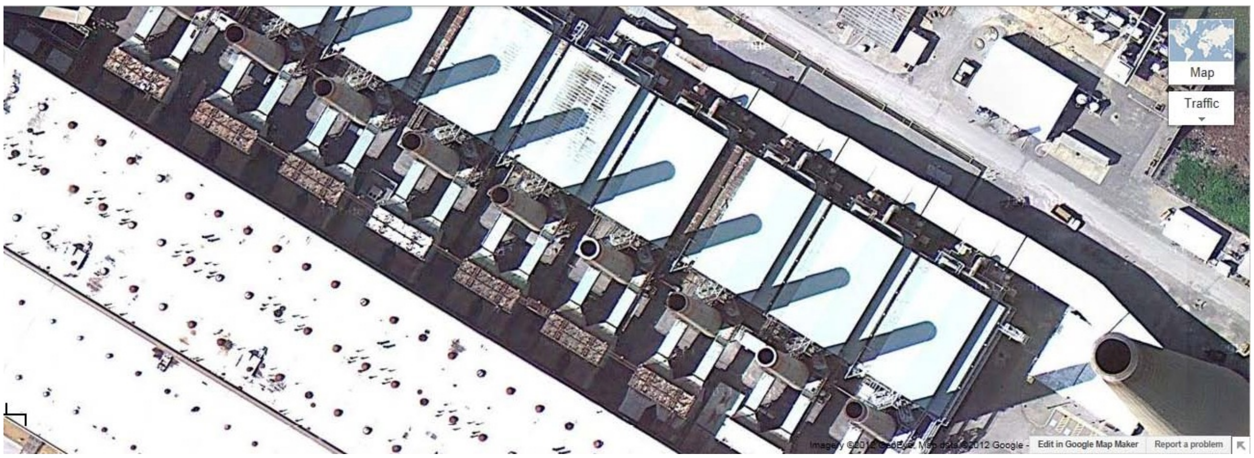
The next series of photographs below show increasing resolutions of the plant.


Swam Plant Rd
Imagery ©2012 DigitalGlobe, GeoEye

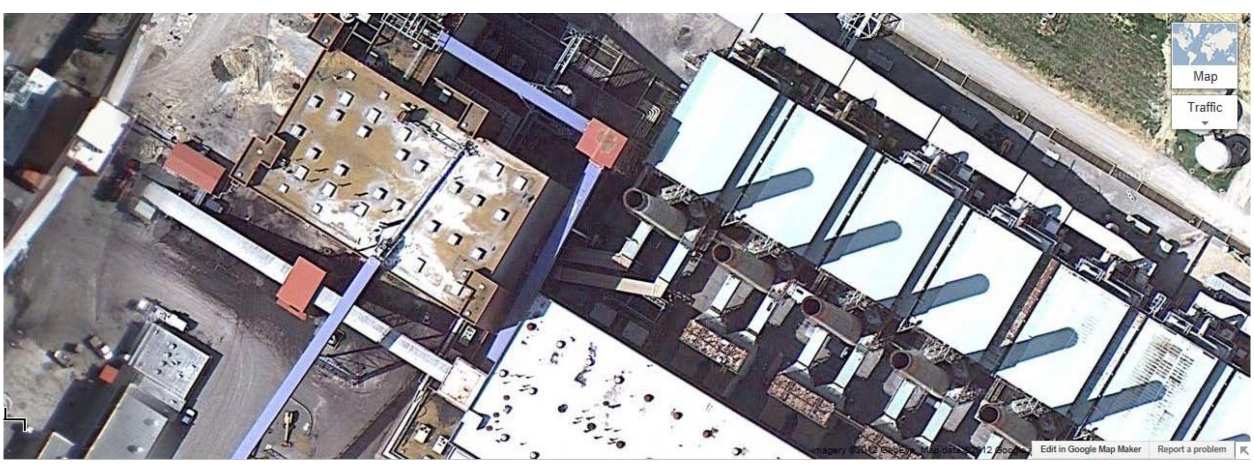

Imagery ©2012 DigitalGlobe, GeoEye, USDA Farm Service Agency, Map data ©2012 Google
Edit in Google Map Maker

The last photo above clearly shows the two current large stacks, at either end as well as shadows of the 10 existing stacks. While the boilers themselves are not seen directly since they are within the two long white buildings at the bottom of the figure, the ten, individual unit baghouses and the two common flue gas ducts are clearly visible. The units are numbered from right (Unit 1) to left (Unit 10).

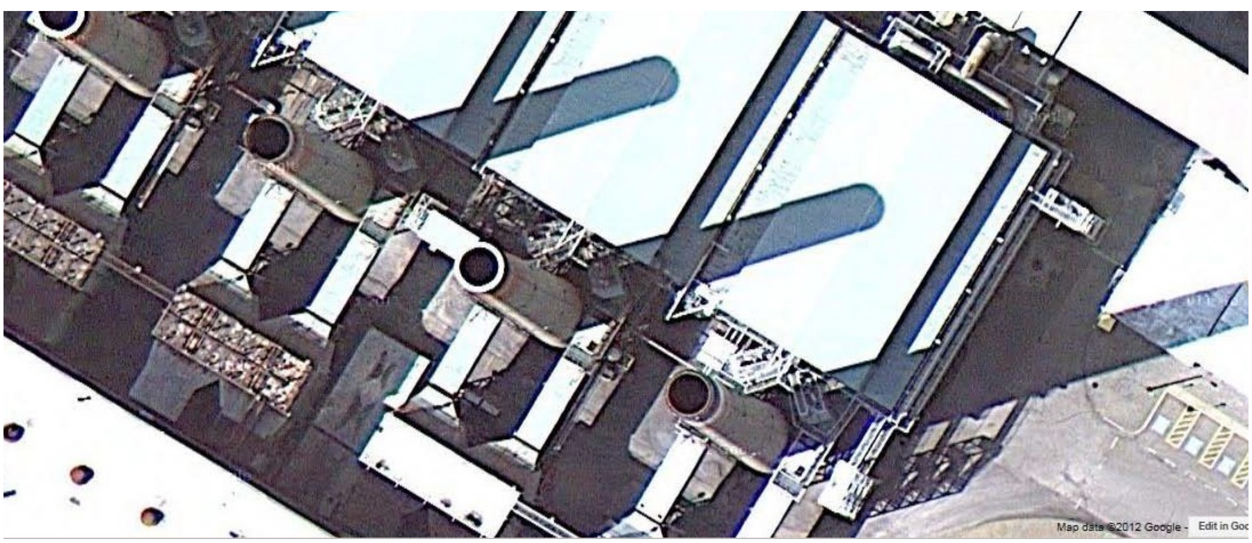
The next photo below shows a close up of the baghouses of Units 1-5, the common flue gas duct for these units and the stack. Also clearly visible are the older stacks which were left in place when the baghouses were installed. As is clearly seen, the exhaust gases from each unit emerge from the air-preheaters and are split into two parallel paths, one on either side of each old stack, before entering the respective baghouses.



Similarly, the photo below shows the close-up of Units 6-10, their respective baghouses, and the common flue gas duct, but not the stack, which is shown in the next photo. Unit 10 is located at the extreme left. Historically, Unit 10 was the test unit for the developments of various types of early scrubber designs. Facilities associated with these can be seen off to the left in the photograph.



The next series of photos shows close-ups and more detail of the duct arrangement and baghouses for Units 1 (to the extreme right) as well as partial views of adjoining Units 2 and 3.



The final set of figures, shown below, are different views of a typical baghouse for any of the Units 1-9, since these are identical.

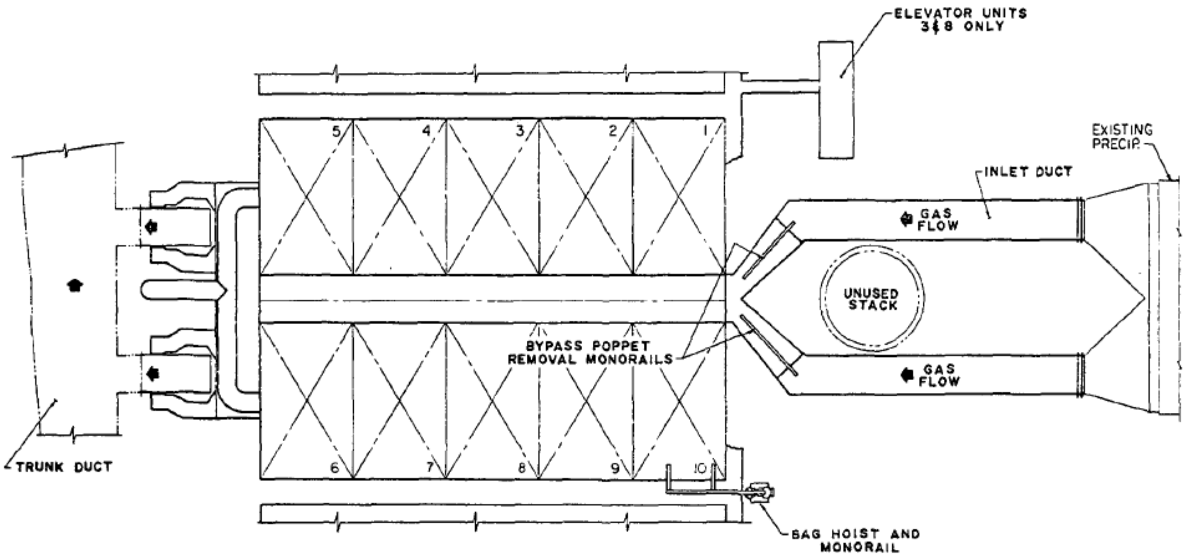


Fig. 1. Baghouse plan view.

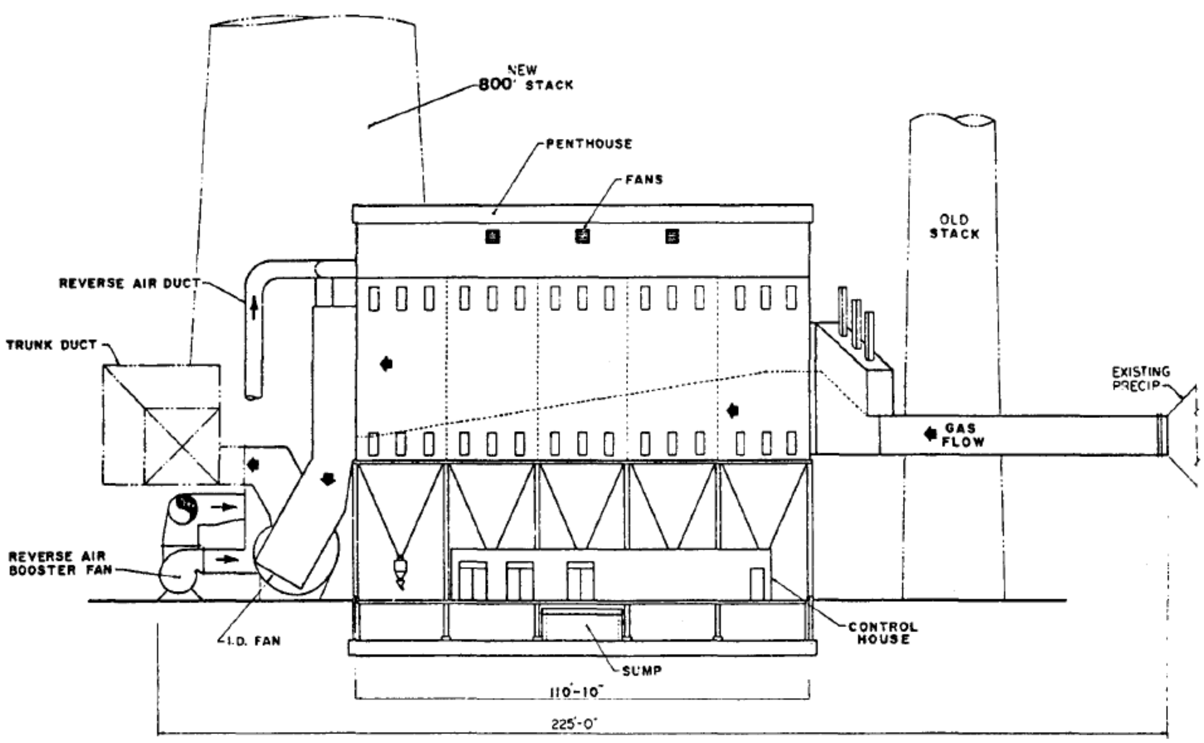


Fig. 2. Baghouse west wall elevation.

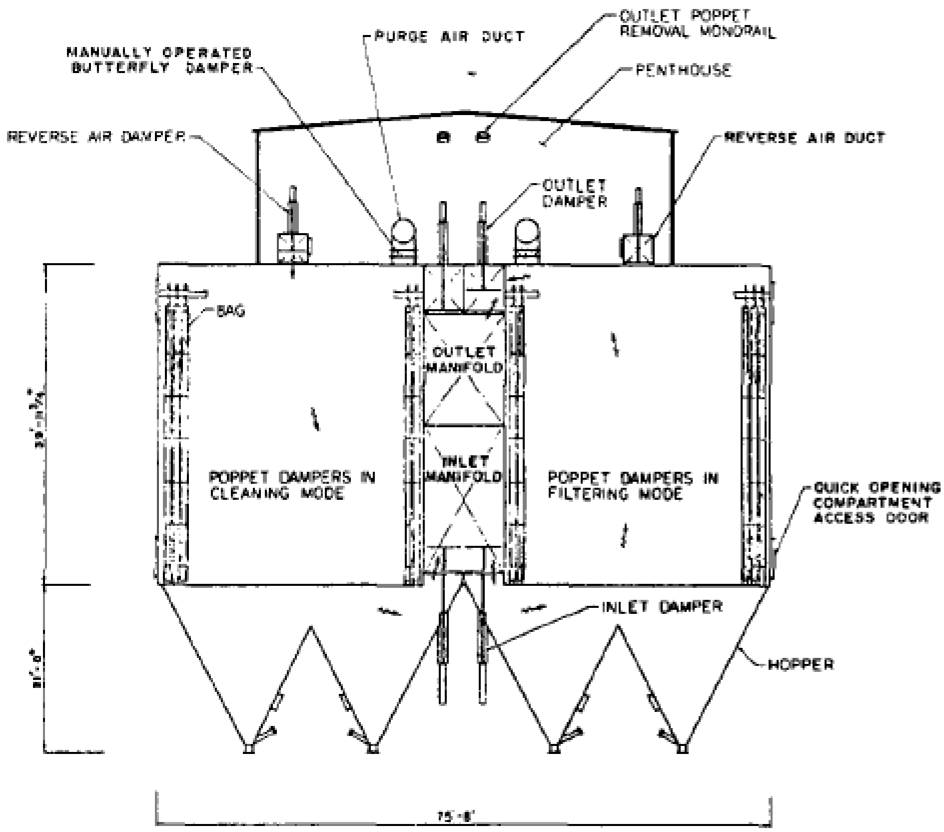


Fig. 3. Baghouse sectional view.

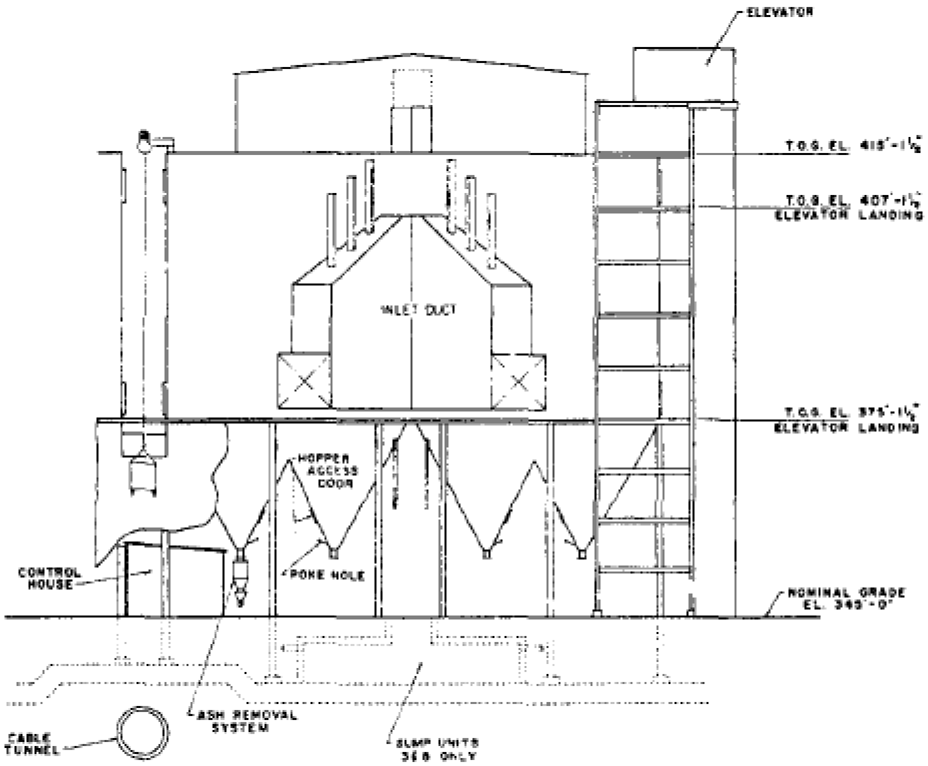


Fig. 4. Baghouse south wall elevation.

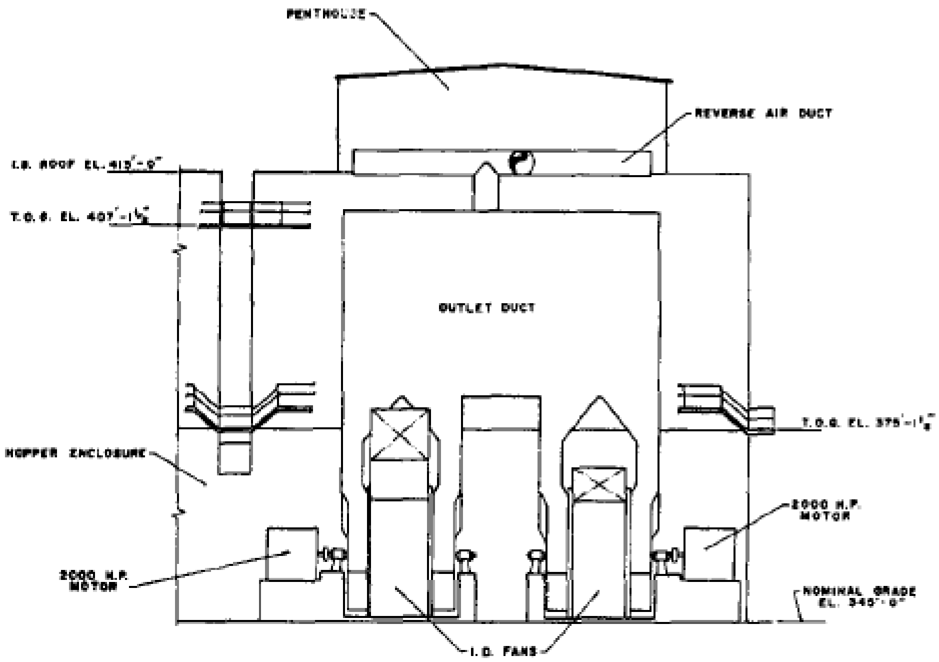


Fig. 5. Baghouse north wall elevation.

While we do have the above drawings for the baghouses, we do not have all of the operational parameters for these baghouses as they are currently operated. Nor do we have any design or operational data on the cyclones, old remnants of the ESPs (both of which provide some particulate matter control), or the air preheater. Importantly, we do not know the flu gas temperatures at specific points in the gas path.

Nonetheless, it is obvious from a conceptual standpoint that if DSI is implemented, it would likely be into the two parallel ducts that lead from each unit's air preheater to its baghouse. Any mixing would occur in the duct before capture of the particles in the baghouses.

3.2 Permit Requirements

The station is subject to a Title V permit issued by the Commonwealth of Kentucky.[11]

Focusing on SO2 and PM requirements, each of Units 1-9 is subject to the following conditions:

"2a. Pursuant to 401 KAR 61:015, Section 4 (1), particulate matter emissions shall not exceed 0.11 lb/MMBtu based on three-hour average for each unit.

b. Pursuant to 401 KAR 61:015, Section 5 (1), sulfur dioxide emissions shall not exceed 1.2 lbs/MMBtu based on a twenty-four hour average for each unit."[12]

In addition, Section J of the permit contains the Acid Rain SO2 allowance requirements for the various units as follows[13]:

2) SO_2 Allowance Allocations and NO_x Requirements for the affected units:

SO_2 Allowances: Tables 2, 3 or 4 of 40 CFR Part 73	**Year**				
	2009	2010	2011	2012	2013
Unit 1	3,643*	2,622*	2,622*	2,622*	2,622*
Unit 2	3,672*	2,702*	2,702*	2,702*	2,702*
Unit 3	3,707*	3,043*	3,043*	3,043*	3,043*
Unit 4	3,593*	3,025*	3,025*	3,025*	3,025*
Unit 5	3,825*	2,954*	2,954*	2,954*	2,954*
Unit 6	3,711*	3,242*	3,242*	3,242*	3,242*
Unit 7	3639*	3,581*	3,581*	3,581*	3,581*
Unit 8	3,570*	3,427*	3,427*	3,427*	3,427*
Unit 9	3,665*	3,672*	3,672*	3,672*	3,672*
Unit 10	4,893*	4,903*	4,903*	4,903*	4,903*

* The number of allowances allocated to Phase II affected units by the U.S. EPA may change under 40 CFR part 73. In addition, the number of allowances actually held by an affected source in a unit account may differ from the number allocated by U. S. EPA. Neither of the aforementioned conditions necessitate a revision to the unit SO_2 allowance allocations identified in this permit (See 40 CFR 72.84).

[11] Commonwealth of Kentucky, Energy and Environment Cabinet, Department for Environmental Protection, Division for Air Quality, Air Quality Permit Issued under 401 KAR 52:020, Source ID: 21-145-00006, Permit: V-09-002 R1. Issuance Date: October 22, 2009; Revision Date: February 7, 2011; Expiration Date: October 22, 2014.

[12] Ibid.

[13] In addition, the TVA has fleet wide SO2 limits set by the 2011 Consent Decree that can also affect the decision of how to retrofit units at Shawnee.

3.3 Current Emissions

Summary information from one recent stack test conducted in May 2011 was available and reviewed at the time of preparation of this report. Results indicated that the 3-run average of filterable PM emissions from combined Units 1-5 were 0.01 lb/MMBtu. Similarly, the 3-run average of filterable PM emissions from combined Units 6-9 were 0.004 lb/MMBtu. The reason for the substantially smaller emissions from combined Units 6-9 as compared to Units 1-5 is not clear since data on how each unit was operating was not available in the summary information reviewed.

SO2 emissions from each unit are monitored by CEMS and are reported to the EPA. These data, on a monthly basis, are summarized in Attachment B.

Attachment B shows that monthly-average SO2 emissions are generally around 0.7 lb/MMBtu on a 30-day average.

3.4 New Rules and Regulations

The units, if intended to be operational in the future using coal as the fuel, will need to meet the requirements of at least two recent regulations affecting SO2, PM and mercury emissions.

First, these units are subject to the electric utility Mercury and Air Toxics (MATS) rule. In the next few years, upon implementation, this rule will require either a reduction in acid gas (HCl) emissions or SO2 emissions as a surrogate for acid gases. The SO2 requirement is 0.2 lb/MMBtu, on a 30-day rolling average. In addition, either specified metal emissions limits or a filterable PM emissions limit will also need to be met. Finally, this rule requires that a mercury emissions limit will also need to be met.

In addition, emissions from the Shawnee plant cannot cause or contribute to the violation of the recently promulgated 1-hour SO2 National Ambient Air Quality Standard (NAAQS) and the PM2.5 NAAQS.

3.5 SO2 Control Efficiency Required

Based on the above, it is clear that, while the current permit limits do not pose any constraints to SO2 emissions from any of the units now, the MATS rule will impose further reductions in SO2 emissions. For these units, using current SO2 emissions levels of around 0.7 lb/MMBtu, the MATS rule requirements imply that a roughly 70% reduction in SO2 emissions will be required, assuming that the same type of coal continues to be burned in the future.

3.6 DSI Implementation Feasibility and Issues

The earlier discussion on DSI indicated that SO2 emissions could be reduced by 70%; however, in order to do so, it is likely that trona would be used as the sorbent, likely milled on site to reduce particle size, and that a relatively high NSR of around 2-3 would be needed.

Some of the key questions that need to be further investigated include:

- capability of the baghouses for Units 1-9 to handle the significantly greater expected PM load as a result of trona injection at a high NSR;

- whether the gas temperature after the air preheater is suitable for trona injection (it is likely that it is);

- based on the gas temperature, what is the ideal particle size of the trona that must be injected;

- what is the residence time of the gas in the duct length connecting the air preheater and the baghouse, and whether the residence time is sufficient to assure proper mixing needed for the 70% removal of SO2, even including the beneficial effects of the baghouses;

- design details on the current onsite active ash disposal area and ash pond;

- what is the impact of ash sales, if any from the station.

It is clear that a proper assessment of these issues and others depends on the availability of more operational and engineering data than is currently available. Only then can these feasibility/cost impact issues be more thoroughly vetted and the true cost DSI at any or all of these units be properly assessed.

ATTACHMENT A - RESUME

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

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

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

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

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

Dr. Sahu's experience includes various projects in relation to industrial waste water as well as storm water pollution compliance include obtaining appropriate permits (such as point source NPDES permits) as well development of plans, assessment of remediation technologies, development of monitoring reports, and regulatory interactions.

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

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

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.) public sector (such as the US Department of Justice) and public interest group clients with project management, air quality consulting, waste remediation and management consulting, as well as regulatory and engineering support consulting services.

1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.

Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.

1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.

1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.

1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.

1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

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

1984 M. S., Mechanical Engineering, Caltech, Pasadena, CA.

1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.

"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.

"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.

"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.

“Thermodynamics and Heat Transfer,” Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.

"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

“Advanced Hazardous Waste Management” University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

“Environmental Risk Assessment,” Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

“Hazardous Waste Remediation” Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

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

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

University of California, Los Angeles

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

International Programs

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

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

“Air Pollution Planning and Management,” IEP, UCR, Spring 1996.

“Environmental Issues and Air Pollution,” IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

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

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

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

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

PROFESSIONAL CERTIFICATIONS

EIT, California (# XE088305), 1993.

REA I, California (#07438), 2000.

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

QEP, Institute of Professional Environmental Practice, since 2000.

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

PUBLICATIONS (PARTIAL LIST)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PRESENTATIONS (PARTIAL LIST)

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

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

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

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

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

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

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

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

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

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

Annex A

Expert Litigation Support

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

(a) Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill

(b) Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.

(c) Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the US Department of Justice in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (S.D. Ohio).

(d) Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the US Department of Justice in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (S.D. Ill.).

(e) Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the US Department of Justice in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (M.D.N.C.).

(f) Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the US Department of Justice in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (S.D. Ohio).

(g) Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.

(h) Expert reports and depositions (10/31/2005 and 11/1/2005) on behalf of the US Department of Justice in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc*., 5:04-cv-00034-KSF (E.D. KY).

(i) Deposition (10/20/2005) on behalf of the US Department of Justice in connection with the Cinergy NSR Case. *United States, et* al. *v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (S.D. Ind.).

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

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

(l) Expert report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.

(m) Expert report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.

(n) Expert report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo's eight new proposed PRB-fired PC boilers located at seven TX sites.

(o) Expert testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).

(p) Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.

(q) Expert reports and deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (W.D. Pennsylvania).

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

(s) Expert reports and deposition (October 2007) on behalf of MTD Products Inc., in connection with General Power Products, LLC v MTD Products Inc., 1:06 CVA 0143 (S.D. Ohio, Western Division)

(t) Experts report and deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.

(u) Expert reports, affidavit, and deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.

(v) Affidavits (May 2010/June 2010 in the Office of Administrative Hearings))/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).

(w) Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy et al., v Duke Energy Carolinas, LLC. in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).

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

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

(z) Expert Report on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone's proposed Unit 3 in Texas (February 2009).

(aa) Expert Report and deposition on behalf of MTD Products, Inc., in the matter of Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al. (June 2009, July 2009).

(bb) Expert Report on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper's proposed Pee Dee plant in South Carolina (August 2009).

(cc) Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.

(dd) Expert Report (August 2009) and Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

(ee) Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coleto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (October 2009).

(ff) Expert Report, Rebuttal Report (September 2009) and Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

(gg) Expert Report (December 2009), Rebuttal reports (May 2010 and June 2010) and depositions (June 2010) on behalf of the US Department of Justice in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

(hh) Prefiled testimony (October 2009) and Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

(ii) Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).

(jj) Written Direct Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions,* No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

(kk) Expert report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.

(ll) Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the US EPA and US Department of Justice in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (US District Court for the Eastern District of Michigan).

(mm) Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.

(nn) Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).

(oo) Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

(pp) Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

(qq) Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of Public Service Company of New Mexico (PNM)'s Mercury Report for the San Juan Generating Station, CIVIL NO. 1:02-CV-0552 BB/ATC (ACE). US District Court for the District of New Mexico.

(rr) Comment Report (October 2010) on the Draft Permit Issued by the Kansas DHE to Sunflower Electric for Holcomb Unit 2. Prepared on behalf of the Sierra Club and Earthjustice.

(ss) Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

(tt) Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

(uu) Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (US District Court for the Eastern District of Texas, Texarkana Division).

(vv) Comment Report (December 2010) on the Pennsylvania Department of Environmental Protection (PADEP)'s Proposal to grant Plan Approval for the Wellington Green Energy Resource Recovery Facility on behalf of the Chesapeake Bay Foundation, Group Against Smog and Pollution (GASP), National Park Conservation Association (NPCA), and the Sierra Club.

(ww) Written Expert Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

(xx) Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.

(yy) Expert Report (March 2011), Rebuttal Expert Report (Jue 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (US District Court for the District of Colorado).

(zz) Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority,* Civil Action No. 4:11-cv-00791 (US District Court for the Southern District of Texas, Houston Division).

(aaa) Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

(bbb) Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

(ccc) Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.,* Civil Action No. A-08-CA-648-LY (US District Court for the Western District of Texas, Austin Division).

(ddd) Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.,* Case No. 3:10-cv-747 (TJM/DEP) (US District Court for the Northern District of New York).

(eee) Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association,* Case No. 11-417-MJP (US District Court for the Western District of Washington).

(fff) Expert Report (March 2012) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (US District Court for the Southern District of Texas, Houston Division).

(ggg) Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency,* Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).

(hhh) Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plan) (Supreme Court of the State of Kansas).

(iii) Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality,* Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).

(jjj) Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.,* Civil Action No. 07-CV-5298 (JKG) (US District Court for the Eastern District of Pennsylvania).

(kkk) Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project

(lll) Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.

(mmm) Expert report (August 2012) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.

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

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

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

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

(ppp) In February 2003, provided expert witness testimony on regulatory framework and emissions calculation methodology issues on behalf of the US Department of Justice in the Ohio Edison NSR Case in the US District Court for the Southern District of Ohio.

(qqq) In June 2003, provided expert witness testimony on regulatory framework, emissions calculation methodology, and emissions calculations on behalf of the US Department of Justice in the Illinois Power NSR Case in the US District Court for the Southern District of Illinois.

(rrr) In August 2006, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Western Greenbrier) on behalf of the Appalachian Center for the Economy and the Environment in West Virginia.

(sss) In May 2007, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Thompson River Cogeneration) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) before the Montana Board of Environmental Review.

(ttt) In October 2007, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Sevier Power Plant) on behalf of the Sierra Club before the Utah Air Quality Board.

(uuu) In August 2008, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Big Stone Unit II) on behalf of the Sierra Club and Clean Water before the South Dakota Board of Minerals and the Environment.

(vvv) In February 2009, provided expert witness testimony regarding power plant emissions and BACT issues on a permit challenge (Santee Cooper Pee Dee units) on behalf of the Sierra Club and the Southern Environmental Law Center before the South Carolina Board of Health and Environmental Control.

(www) In February 2009, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (NRG Limestone Unit 3) on behalf of the Sierra Club and the Environmental Integrity Project before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

(xxx) In November 2009, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (Las Brisas Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

(yyy) In February 2010, provided expert witness testimony regarding power plant emissions, BACT issues and MACT issues on a permit challenge (White Stallion Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

(zzz) In September 2010 provided oral trial testimony on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (W.D. Pennsylvania).

(aaaa) Oral Direct and Rebuttal Expert Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

(bbbb) Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions,* No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

(cccc) Oral Testimony (October 2010) regarding mercury and total PM/PM10 emissions and other issues on a remanded permit challenge (Las Brisas Energy Center) on behalf of the Environmental Defense Fund before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

(dddd) Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

(eeee) Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

(ffff) Deposition (December 2010) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

(gggg) Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).

(hhhh) Oral Expert Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

(iiii) Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (US District Court for the District of Colorado).

(jjjj) Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of

Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

(kkkk) Oral Testimony at Hearing (March 2012) on behalf of the US Department of Justice in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

(llll) Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

ATTACHMENT B

SUMMARY OF EPA AIR MARKET PROGRAM DATA
2006-2011 EMISSIONS DATA FOR SHAWNEE FOSSIL PLANT

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	1	CSSH15	2006	1	308.0	0.752	149.3	0.365	84011.2	2090	818824	744	80406	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	2	305.0	0.743	150.2	0.366	84301.7	2086	821653	672	80833	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	3	363.0	0.782	176.6	0.380	95228.3	2057	928151	744	92604	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	4	337.7	0.725	184.3	0.396	95589.1	2059	931669	720	92868	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	5	343.1	0.753	164.0	0.360	93469.9	2090	911014	744	89444	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	6	319.7	0.730	161.4	0.369	89830.6	2103	875540	720	85431	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	7	347.2	0.737	181.1	0.384	96735.4	2120	942838	744	91256	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	8	343.7	0.727	183.4	0.388	96948.6	2085	944918	744	93000	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	9	316.2	0.733	161.5	0.375	88477.4	2037	862355	720	86888	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	10	327.6	0.742	170.2	0.386	90592.1	1975	882963	744	91762	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	11	308.1	0.722	162.8	0.382	87534.0	2001	853157	720	87504	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2006	12	323.2	0.772	160.7	0.384	85854.1	1964	836783	744	87445	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	1	309.7	0.746	158.5	0.382	85220.6	1959	830609	744	87015	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	2	287.6	0.742	144.2	0.372	79555.0	1969	775390	644	80805	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	3	337.0	0.710	172.8	0.364	97457.8	2015	949880	744	96753	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	4	300.5	0.721	149.4	0.358	85545.0	2000	833771	672	85538	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	5	327.6	0.728	145.6	0.324	92288.8	2059	899501	744	89654	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	6	319.7	0.722	163.2	0.369	90871.9	2086	885690	720	87133	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	7	356.1	0.758	179.0	0.381	96435.2	2063	939913	744	93505	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	8	368.9	0.771	205.6	0.430	98193.7	2076	957053	744	94598	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	9	300.0	0.713	158.8	0.377	86361.8	2107	841735	680	81973	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	10	332.6	0.715	173.6	0.373	95522.4	2062	931016	744	92647	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	11	320.0	0.736	165.0	0.380	89199.0	2012	869386	720	88684	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2007	12	331.3	0.745	172.1	0.387	91182.7	2000	888719	744	91191	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	1	350.0	0.778	189.2	0.421	92280.2	1965	899420	744	93931	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	2	324.4	0.804	175.7	0.435	82795.7	1944	806977	696	85200	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	3	350.8	0.791	187.2	0.422	91038.1	1964	887312	744	92725	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	4	336.9	0.747	205.7	0.456	92940.7	2018	901846	720	92119	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	5	335.4	0.757	198.7	0.448	91343.7	2007	886351	744	91042	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	6	267.0	0.718	146.4	0.393	76681.5	2048	744073	720	74902	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	7	304.3	0.733	158.0	0.381	85566.4	2116	830289	744	80864	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	8	307.7	0.761	169.4	0.419	83317.7	2056	808471	744	81046	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	9	280.9	0.721	161.4	0.414	80277.3	2026	778965	720	79246	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	10	310.2	0.749	175.4	0.424	85365.8	2004	828342	744	85179	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	11	336.4	0.801	184.8	0.440	86555.2	1976	839886	720	87587	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2008	12	320.5	0.844	153.5	0.404	78254.1	1982	759336	739	78948	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	1	185.3	0.737	88.0	0.350	51795.9	2023	502599	519	51211	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	2								0		DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	3	224.3	0.668	101.8	0.303	69195.2	2078	671431	586	66609	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	4	283.6	0.688	161.8	0.392	84960.8	2045	824411	720	83102	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	5	262.9	0.685	140.6	0.366	79095.7	2048	767500	744	77246	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	6	256.6	0.682	140.7	0.374	77590.4	2060	752894	720	75341	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	7	291.9	0.753	161.1	0.416	79842.7	2050	774750	744	77886	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	8	262.2	0.756	138.6	0.400	71495.5	2090	693753	695	68403	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	9	183.5	0.729	97.7	0.388	51875.8	2126	503377	447	48808	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	10	286.2	0.720	149.4	0.376	81894.6	2051	794661	744	79874	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	11	218.2	0.658	111.4	0.336	68347.3	2073	663202	720	65935	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2009	12	269.1	0.637	145.7	0.344	87147.5	2023	845632	744	86170	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	1	227.4	0.664	122.0	0.356	70610.9	2024	685171	679	69783	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	2	263.6	0.680	140.3	0.362	79924.5	1999	775543	672	79963	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	3	255.2	0.632	144.5	0.358	83265.3	2001	807963	744	83244	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	4	223.2	0.616	130.3	0.360	74700.2	2008	724848	720	74401	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	5	260.0	0.662	143.7	0.366	80981.3	1994	785801	744	81207	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	6	257.1	0.695	142.8	0.386	76201.1	2081	739415	720	73231	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	7	254.0	0.704	150.3	0.417	74378.6	2096	721735	744	70988	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	8	217.3	0.689	135.9	0.431	64962.1	2093	630357	674	62080	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	9	244.4	0.684	156.6	0.439	73587.2	2054	714051	720	71642	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	10	232.5	0.671	136.9	0.396	71356.6	1996	692403	743	71503	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	11	96.9	0.706	51.5	0.375	28298.4	1978	274592	312	28606	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2010	12	349.6	0.765	216.1	0.473	94164.4	1921	913721	744	98044	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	1	342.9	0.737	202.9	0.436	95844.5	1956	930026	744	98005	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	2	271.6	0.701	160.9	0.415	79828.1	1979	774607	672	80691	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	3	270.8	0.626	172.9	0.400	89184.8	2023	865401	744	88187	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	4	259.8	0.601	168.4	0.389	89173.2	2069	865291	720	86215	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	5	258.3	0.603	169.2	0.395	88343.0	2073	857230	744	85219	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	6	249.3	0.598	142.4	0.342	85902.5	2068	833551	720	83094	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	7	281.8	0.646	177.3	0.407	89854.6	2060	871899	744	87245	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	8	286.4	0.681	175.9	0.418	86739.9	2045	841678	744	84846	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	9	253.5	0.663	149.6	0.391	78780.8	2034	764447	720	77454	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	10	280.1	0.688	159.8	0.392	83911.6	1972	814229	744	85118	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	11	259.1	0.680	143.2	0.376	78587.1	2030	762570	720	77421	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2011	12	108.9	0.676	56.1	0.348	33218.4	1987	322333	312	33440	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	1	142.9	0.642	82.6	0.371	45853.9	1970	444941	434	46552	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	2								0		DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	3	109.7	0.697	59.4	0.377	32476.5	1998	315135	295	32505	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	4	194.8	0.794	121.5	0.495	50541.6	1904	490429	435	53101	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	5	314.4	0.797	176.3	0.447	81306.9	1924	788958	744	84499	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	6	260.7	0.743	120.6	0.344	72351.4	2024	702058	692	71506	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	7	286.9	0.779	124.9	0.339	76571.6	2046	736493	744	74844	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	8	266.0	0.707	127.9	0.340	78273.1	2042	752859	744	76660	DB-WF		LNB	Baghouse
KY	Shawnee	1	CSSH15	2012	9	258.7	0.737	110.3	0.314	72987.4	2036	702019	720	71689	DB-WF		LNB	Baghouse
							0.717											

Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
2	CSSH15	2006	1	318.5	0.752	154.3	0.364	86913.2	2090	847109	744	83190	DB-WF		LNB	Baghouse
2	CSSH15	2006	2	294.2	0.743	144.9	0.366	81306.3	2086	792457	672	77958	DB-WF		LNB	Baghouse
2	CSSH15	2006	3	355.1	0.784	172.5	0.381	92972.4	2056	906163	744	90436	DB-WF		LNB	Baghouse
2	CSSH15	2006	4	335.4	0.725	183.1	0.396	94924.8	2058	925195	720	92231	DB-WF		LNB	Baghouse
2	CSSH15	2006	5	348.5	0.754	166.5	0.360	94892.9	2090	924883	744	90800	DB-WF		LNB	Baghouse
2	CSSH15	2006	6	324.0	0.730	163.7	0.369	91033.5	2103	887265	720	86564	DB-WF		LNB	Baghouse
2	CSSH15	2006	7	347.9	0.737	181.3	0.384	96919.2	2120	944630	744	91417	DB-WF		LNB	Baghouse
2	CSSH15	2006	8	348.7	0.727	186.1	0.388	98356.6	2085	958641	744	94359	DB-WF		LNB	Baghouse
2	CSSH15	2006	9	274.4	0.728	138.9	0.369	77291.0	2044	753326	641	75642	DB-WF		LNB	Baghouse
2	CSSH15	2006	10	314.2	0.742	163.1	0.385	86881.2	1975	846795	744	87999	DB-WF		LNB	Baghouse
2	CSSH15	2006	11	315.5	0.722	166.6	0.381	89651.9	2001	873799	720	89608	DB-WF		LNB	Baghouse
2	CSSH15	2006	12	316.0	0.772	157.3	0.384	83955.5	1964	818279	744	85512	DB-WF		LNB	Baghouse
2	CSSH15	2007	1	312.0	0.746	159.7	0.382	85821.8	1959	836468	744	87630	DB-WF		LNB	Baghouse
2	CSSH15	2007	2	308.3	0.742	154.8	0.373	85240.2	1971	830800	658	86489	DB-WF		LNB	Baghouse
2	CSSH15	2007	3	337.7	0.710	173.0	0.364	97582.7	2015	951098	744	96876	DB-WF		LNB	Baghouse
2	CSSH15	2007	4	329.1	0.720	164.3	0.360	93772.1	2001	913956	720	93733	DB-WF		LNB	Baghouse
2	CSSH15	2007	5	330.5	0.728	147.0	0.324	93097.4	2059	907381	744	90435	DB-WF		LNB	Baghouse
2	CSSH15	2007	6	303.8	0.722	155.1	0.368	86391.6	2086	842022	720	82849	DB-WF		LNB	Baghouse
2	CSSH15	2007	7	359.2	0.758	180.5	0.381	97179.3	2063	947166	744	94234	DB-WF		LNB	Baghouse
2	CSSH15	2007	8	364.2	0.771	203.4	0.431	96866.2	2075	944114	744	93373	DB-WF		LNB	Baghouse
2	CSSH15	2007	9	308.9	0.714	162.9	0.376	88791.2	2108	865413	682	84242	DB-WF		LNB	Baghouse
2	CSSH15	2007	10	339.0	0.715	176.8	0.373	97345.2	2062	948783	744	94432	DB-WF		LNB	Baghouse
2	CSSH15	2007	11	331.2	0.736	170.7	0.379	92328.0	2012	899883	720	91785	DB-WF		LNB	Baghouse
2	CSSH15	2007	12	320.4	0.745	166.4	0.387	88230.1	2000	859941	730	88231	DB-WF		LNB	Baghouse
2	CSSH15	2008	1	359.7	0.779	193.7	0.420	94715.5	1965	923155	733	96422	DB-WF		LNB	Baghouse
2	CSSH15	2008	2	350.9	0.803	189.8	0.435	89641.8	1944	873704	696	92219	DB-WF		LNB	Baghouse
2	CSSH15	2008	3	372.6	0.791	198.5	0.422	96611.4	1964	941633	744	98364	DB-WF		LNB	Baghouse
2	CSSH15	2008	4	345.5	0.748	210.3	0.455	95218.0	2018	923944	720	94385	DB-WF		LNB	Baghouse
2	CSSH15	2008	5	345.7	0.757	204.9	0.449	94150.6	2006	913587	744	93852	DB-WF		LNB	Baghouse
2	CSSH15	2008	6	283.3	0.717	156.3	0.396	81412.9	2046	789984	720	79568	DB-WF		LNB	Baghouse
2	CSSH15	2008	7	320.5	0.733	166.7	0.381	90113.6	2115	874412	744	85200	DB-WF		LNB	Baghouse
2	CSSH15	2008	8	320.4	0.762	176.8	0.420	86702.4	2056	841314	744	84361	DB-WF		LNB	Baghouse
2	CSSH15	2008	9	302.0	0.722	173.9	0.416	86250.6	2025	836927	720	85183	DB-WF		LNB	Baghouse
2	CSSH15	2008	10	278.9	0.751	157.1	0.423	76554.9	2004	742848	639	76409	DB-WF		LNB	Baghouse
2	CSSH15	2008	11	355.1	0.801	195.2	0.440	91347.9	1977	886392	720	92434	DB-WF		LNB	Baghouse
2	CSSH15	2008	12	296.9	0.848	143.1	0.409	72182.5	1979	700420	696	72945	DB-WF		LNB	Baghouse
2	CSSH15	2009	1	244.8	0.740	117.0	0.353	68218.7	2016	661957	646	67674	DB-WF		LNB	Baghouse
2	CSSH15	2009	2	215.2	0.698	108.0	0.350	63571.1	2038	616858	596	62392	DB-WF		LNB	Baghouse
2	CSSH15	2009	3	254.8	0.675	115.4	0.306	77832.5	2121	755241	709	73396	DB-WF		LNB	Baghouse
2	CSSH15	2009	4	242.9	0.690	136.9	0.389	72576.2	2046	704237	663	70941	DB-WF		LNB	Baghouse
2	CSSH15	2009	5	245.8	0.685	131.5	0.366	74001.9	2049	718072	744	72240	DB-WF		LNB	Baghouse
2	CSSH15	2009	6	235.1	0.682	129.0	0.374	71105.0	2061	689963	720	69016	DB-WF		LNB	Baghouse
2	CSSH15	2009	7	274.6	0.754	150.9	0.414	75108.1	2052	728808	744	73219	DB-WF		LNB	Baghouse
2	CSSH15	2009	8	280.0	0.758	147.5	0.399	76166.5	2092	739078	744	72830	DB-WF		LNB	Baghouse
2	CSSH15	2009	9	292.3	0.750	153.1	0.393	80312.3	2113	779310	720	76008	DB-WF		LNB	Baghouse
2	CSSH15	2009	10	171.5	0.735	89.9	0.385	48118.6	2055	466916	468	46829	DB-WF		LNB	Baghouse
2	CSSH15	2009	11	82.1	0.655	42.1	0.336	25839.0	2046	250727	292	25263	DB-WF		LNB	Baghouse
2	CSSH15	2009	12	238.2	0.640	129.7	0.349	76730.5	2018	744551	669	76049	DB-WF		LNB	Baghouse
2	CSSH15	2010	1	245.7	0.664	131.5	0.355	76331.8	2030	740683	744	75204	DB-WF		LNB	Baghouse
2	CSSH15	2010	2	260.0	0.680	138.6	0.363	78794.9	1999	764582	672	78849	DB-WF		LNB	Baghouse
2	CSSH15	2010	3	266.8	0.632	151.0	0.358	86976.9	2000	843979	744	86973	DB-WF		LNB	Baghouse
2	CSSH15	2010	4	247.3	0.616	144.7	0.360	82771.7	2007	803170	720	82475	DB-WF		LNB	Baghouse
2	CSSH15	2010	5	273.6	0.662	151.6	0.366	85241.6	1994	827141	744	85497	DB-WF		LNB	Baghouse
2	CSSH15	2010	6	297.3	0.696	166.2	0.389	88068.9	2079	854574	720	84717	DB-WF		LNB	Baghouse
2	CSSH15	2010	7	327.9	0.704	195.3	0.419	96060.2	2095	932123	744	91723	DB-WF		LNB	Baghouse
2	CSSH15	2010	8	289.8	0.691	183.0	0.436	86484.5	2089	839200	744	82786	DB-WF		LNB	Baghouse
2	CSSH15	2010	9	285.8	0.685	184.3	0.441	86057.7	2053	835057	720	83853	DB-WF		LNB	Baghouse
2	CSSH15	2010	10	275.5	0.673	163.2	0.399	84409.7	1993	819063	744	84691	DB-WF		LNB	Baghouse
2	CSSH15	2010	11	281.0	0.691	160.1	0.394	83873.2	1970	813859	720	85166	DB-WF		LNB	Baghouse
2	CSSH15	2010	12	341.4	0.765	210.6	0.472	91985.7	1921	892580	744	95788	DB-WF		LNB	Baghouse
2	CSSH15	2011	1	321.7	0.737	190.8	0.437	89962.2	1956	872947	744	92007	DB-WF		LNB	Baghouse
2	CSSH15	2011	2	254.9	0.702	151.5	0.417	74820.6	1978	726017	672	75646	DB-WF		LNB	Baghouse
2	CSSH15	2011	3	238.9	0.626	152.4	0.399	78660.7	2024	763280	744	77738	DB-WF		LNB	Baghouse
2	CSSH15	2011	4	249.2	0.600	161.4	0.389	85552.2	2069	830154	720	82689	DB-WF		LNB	Baghouse
2	CSSH15	2011	5	249.1	0.603	163.0	0.395	85072.6	2073	825495	744	82073	DB-WF		LNB	Baghouse
2	CSSH15	2011	6	240.5	0.598	137.5	0.342	82893.4	2067	804352	720	80187	DB-WF		LNB	Baghouse
2	CSSH15	2011	7	274.4	0.647	172.9	0.407	87477.8	2060	848836	744	84946	DB-WF		LNB	Baghouse
2	CSSH15	2011	8	286.0	0.681	175.7	0.418	86534.1	2045	839681	744	84648	DB-WF		LNB	Baghouse
2	CSSH15	2011	9	249.2	0.663	147.2	0.392	77432.7	2035	751366	720	76099	DB-WF		LNB	Baghouse
2	CSSH15	2011	10	278.0	0.687	159.4	0.394	83448.1	1971	809732	744	84682	DB-WF		LNB	Baghouse
2	CSSH15	2011	11	192.6	0.661	107.7	0.370	60031.9	2029	582520	543	59173	DB-WF		LNB	Baghouse
2	CSSH15	2011	12	264.7	0.652	156.9	0.387	83691.9	2004	812101	744	83522	DB-WF		LNB	Baghouse
2	CSSH15	2012	1	236.8	0.651	136.4	0.375	74976.8	2009	727535	744	74636	DB-WF		LNB	Baghouse
2	CSSH15	2012	2	262.6	0.664	155.4	0.393	81503.7	2037	790870	696	80014	DB-WF		LNB	Baghouse
2	CSSH15	2012	3	268.6	0.702	142.9	0.374	78824.9	2019	764876	744	78071	DB-WF		LNB	Baghouse
2	CSSH15	2012	4	313.6	0.785	209.7	0.525	82322.2	1929	798813	720	85367	DB-WF		LNB	Baghouse
2	CSSH15	2012	5	308.1	0.797	173.0	0.448	79696.0	1924	773327	744	82829	DB-WF		LNB	Baghouse
2	CSSH15	2012	6	271.2	0.738	126.0	0.343	75745.5	2026	734993	720	74779	DB-WF		LNB	Baghouse
2	CSSH15	2012	7	288.6	0.778	125.6	0.339	77073.4	2048	741319	744	75281	DB-WF		LNB	Baghouse
2	CSSH15	2012	8	152.1	0.724	72.8	0.347	43663.9	2031	419975	413	43003	DB-WF		LNB	Baghouse
2	CSSH15	2012	9	257.3	0.735	110.2	0.315	72793.9	2037	700158	720	71485	DB-WF		LNB	Baghouse

Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
3	CSSH15	2006	1	331.8	0.752	160.5	0.364	90505.9	2090	882125	744	86590	DB-WF		LNB	Baghouse
3	CSSH15	2006	2	310.6	0.743	153.1	0.366	85839.2	2086	836638	672	82292	DB-WF		LNB	Baghouse
3	CSSH15	2006	3	364.2	0.781	177.2	0.380	95737.7	2057	933116	744	93072	DB-WF		LNB	Baghouse
3	CSSH15	2006	4	340.2	0.726	185.4	0.396	96180.9	2058	937437	720	93476	DB-WF		LNB	Baghouse
3	CSSH15	2006	5	356.7	0.754	170.2	0.360	97064.6	2091	946050	744	92853	DB-WF		LNB	Baghouse
3	CSSH15	2006	6	339.8	0.730	171.6	0.369	95524.1	2104	931033	720	90801	DB-WF		LNB	Baghouse
3	CSSH15	2006	7	359.2	0.737	186.9	0.383	100070.0	2121	975339	744	94358	DB-WF		LNB	Baghouse
3	CSSH15	2006	8	355.4	0.727	190.0	0.389	100321.2	2084	977789	744	96269	DB-WF		LNB	Baghouse
3	CSSH15	2006	9	312.0	0.732	160.0	0.375	87436.6	2038	852210	720	85816	DB-WF		LNB	Baghouse
3	CSSH15	2006	10	327.2	0.742	170.0	0.385	90505.6	1975	882120	744	91665	DB-WF		LNB	Baghouse
3	CSSH15	2006	11	315.7	0.722	166.9	0.382	89742.3	2001	874680	720	89717	DB-WF		LNB	Baghouse
3	CSSH15	2006	12	329.3	0.772	163.8	0.384	87485.8	1964	852687	744	89090	DB-WF		LNB	Baghouse
3	CSSH15	2007	1	323.4	0.746	165.5	0.382	89003.7	1960	867481	744	90835	DB-WF		LNB	Baghouse
3	CSSH15	2007	2	278.0	0.742	139.9	0.373	76889.7	1967	749413	591	78182	DB-WF		LNB	Baghouse
3	CSSH15	2007	3	342.6	0.710	175.4	0.364	98962.5	2015	964546	744	98247	DB-WF		LNB	Baghouse
3	CSSH15	2007	4	330.4	0.720	164.9	0.359	94138.5	2001	917528	720	94094	DB-WF		LNB	Baghouse
3	CSSH15	2007	5	312.9	0.728	139.1	0.323	88225.4	2066	859896	744	85424	DB-WF		LNB	Baghouse
3	CSSH15	2007	6	321.1	0.721	163.7	0.368	91380.6	2088	890647	720	87541	DB-WF		LNB	Baghouse
3	CSSH15	2007	7	363.0	0.758	182.3	0.381	98239.0	2063	957493	744	95241	DB-WF		LNB	Baghouse
3	CSSH15	2007	8	364.1	0.771	203.4	0.431	96907.3	2075	944514	744	93388	DB-WF		LNB	Baghouse
3	CSSH15	2007	9	324.9	0.713	171.2	0.376	93447.7	2109	910798	720	88625	DB-WF		LNB	Baghouse
3	CSSH15	2007	10	340.6	0.715	177.7	0.373	97804.3	2062	953257	744	94872	DB-WF		LNB	Baghouse
3	CSSH15	2007	11	339.1	0.736	174.8	0.379	94514.0	2012	921189	720	93970	DB-WF		LNB	Baghouse
3	CSSH15	2007	12	343.7	0.745	178.5	0.387	94633.1	2000	922349	744	94628	DB-WF		LNB	Baghouse
3	CSSH15	2008	1	360.4	0.778	194.7	0.420	95034.1	1965	926261	744	96723	DB-WF		LNB	Baghouse
3	CSSH15	2008	2	334.4	0.803	181.2	0.435	85422.4	1944	832579	696	87890	DB-WF		LNB	Baghouse
3	CSSH15	2008	3	361.4	0.791	192.9	0.422	93780.7	1964	914044	744	95482	DB-WF		LNB	Baghouse
3	CSSH15	2008	4	338.4	0.748	206.3	0.456	93305.6	2018	905386	720	92487	DB-WF		LNB	Baghouse
3	CSSH15	2008	5	352.5	0.757	209.2	0.449	96019.4	2006	931721	744	95719	DB-WF		LNB	Baghouse
3	CSSH15	2008	6	304.5	0.717	167.3	0.394	87536.2	2048	849401	720	85479	DB-WF		LNB	Baghouse
3	CSSH15	2008	7	329.5	0.731	170.9	0.379	92854.9	2120	901012	744	87597	DB-WF		LNB	Baghouse
3	CSSH15	2008	8	336.4	0.759	185.1	0.418	91359.6	2061	886505	744	88658	DB-WF		LNB	Baghouse
3	CSSH15	2008	9	322.6	0.721	184.9	0.414	92178.2	2027	894444	720	90958	DB-WF		LNB	Baghouse
3	CSSH15	2008	10	66.9	0.764	38.3	0.437	18047.8	1994	175127	170	18100	DB-WF		LNB	Baghouse
3	CSSH15	2008	11	336.9	0.802	185.5	0.441	86636.9	1976	840679	695	87710	DB-WF		LNB	Baghouse
3	CSSH15	2008	12	360.2	0.841	173.3	0.405	88282.4	1983	856645	744	89023	DB-WF		LNB	Baghouse
3	CSSH15	2009	1	261.3	0.739	125.0	0.354	72892.7	2020	707312	646	72172	DB-WF		LNB	Baghouse
3	CSSH15	2009	2	217.4	0.699	109.1	0.351	64126.5	2038	622247	597	62935	DB-WF		LNB	Baghouse
3	CSSH15	2009	3	256.9	0.671	118.3	0.309	78936.3	2118	765953	648	74529	DB-WF		LNB	Baghouse
3	CSSH15	2009	4	278.1	0.688	158.7	0.393	83309.1	2046	808384	720	81444	DB-WF		LNB	Baghouse
3	CSSH15	2009	5	266.9	0.685	143.1	0.367	80324.9	2049	779428	744	78407	DB-WF		LNB	Baghouse
3	CSSH15	2009	6	239.5	0.682	131.9	0.375	72406.4	2060	702591	720	70296	DB-WF		LNB	Baghouse
3	CSSH15	2009	7	293.7	0.755	162.3	0.417	80151.5	2050	777746	744	78205	DB-WF		LNB	Baghouse
3	CSSH15	2009	8	305.1	0.757	161.3	0.400	83100.3	2092	806359	744	79440	DB-WF		LNB	Baghouse
3	CSSH15	2009	9	288.4	0.751	151.1	0.393	79177.9	2112	768303	720	74994	DB-WF		LNB	Baghouse
3	CSSH15	2009	10	296.6	0.720	155.0	0.376	84876.5	2050	823595	744	82792	DB-WF		LNB	Baghouse
3	CSSH15	2009	11	231.6	0.658	118.4	0.336	72550.1	2074	703985	720	69948	DB-WF		LNB	Baghouse
3	CSSH15	2009	12	264.3	0.636	143.1	0.344	85666.8	2025	831265	744	84608	DB-WF		LNB	Baghouse
3	CSSH15	2010	1	246.9	0.663	132.0	0.355	76720.6	2031	744456	744	75537	DB-WF		LNB	Baghouse
3	CSSH15	2010	2	250.7	0.679	133.5	0.362	76092.9	2000	738363	672	76075	DB-WF		LNB	Baghouse
3	CSSH15	2010	3	263.3	0.632	149.0	0.358	85843.9	2001	832984	744	85802	DB-WF		LNB	Baghouse
3	CSSH15	2010	4	240.5	0.615	140.7	0.360	80587.0	2009	781970	720	80230	DB-WF		LNB	Baghouse
3	CSSH15	2010	5	258.3	0.662	142.8	0.366	80400.6	1995	780166	744	80602	DB-WF		LNB	Baghouse
3	CSSH15	2010	6	263.7	0.697	147.4	0.390	77949.8	2080	756383	720	74938	DB-WF		LNB	Baghouse
3	CSSH15	2010	7	299.5	0.704	177.9	0.418	87747.5	2095	851460	744	83786	DB-WF		LNB	Baghouse
3	CSSH15	2010	8	291.4	0.691	184.5	0.438	86901.7	2089	843248	744	83204	DB-WF		LNB	Baghouse
3	CSSH15	2010	9	258.1	0.685	166.7	0.443	77614.8	2052	753132	720	75648	DB-WF		LNB	Baghouse
3	CSSH15	2010	10	250.9	0.672	149.1	0.399	76934.7	1993	746530	744	77186	DB-WF		LNB	Baghouse
3	CSSH15	2010	11	267.7	0.691	152.3	0.393	79821.3	1970	774543	720	81017	DB-WF		LNB	Baghouse
3	CSSH15	2010	12	330.3	0.765	204.4	0.473	88999.8	1921	863606	744	92658	DB-WF		LNB	Baghouse
3	CSSH15	2011	1	302.0	0.741	178.6	0.438	83956.3	1954	814669	744	85913	DB-WF		LNB	Baghouse
3	CSSH15	2011	2	240.8	0.699	143.3	0.416	71013.0	1980	689071	672	71731	DB-WF		LNB	Baghouse
3	CSSH15	2011	3	252.5	0.626	161.2	0.400	83134.8	2024	806695	744	82162	DB-WF		LNB	Baghouse
3	CSSH15	2011	4	248.8	0.600	161.4	0.389	85409.5	2069	828770	720	82549	DB-WF		LNB	Baghouse
3	CSSH15	2011	5	204.2	0.602	133.1	0.392	69906.1	2079	678329	612	67238	DB-WF		LNB	Baghouse
3	CSSH15	2011	6	217.5	0.599	124.3	0.342	74881.8	2069	726612	720	72400	DB-WF		LNB	Baghouse
3	CSSH15	2011	7	245.3	0.642	157.3	0.412	78701.8	2060	763679	658	76396	DB-WF		LNB	Baghouse
3	CSSH15	2011	8	253.4	0.679	157.6	0.422	76924.2	2042	746430	683	75340	DB-WF		LNB	Baghouse
3	CSSH15	2011	9	248.3	0.664	147.2	0.394	77088.9	2033	748030	720	75826	DB-WF		LNB	Baghouse
3	CSSH15	2011	10	260.4	0.688	150.2	0.397	77961.2	1970	756490	744	79139	DB-WF		LNB	Baghouse
3	CSSH15	2011	11	246.5	0.677	137.2	0.377	75000.7	2028	727768	720	73965	DB-WF		LNB	Baghouse
3	CSSH15	2011	12	244.1	0.652	144.7	0.386	77210.6	2006	749210	744	76982	DB-WF		LNB	Baghouse
3	CSSH15	2012	1	238.7	0.651	137.8	0.376	75551.5	2009	733112	744	75230	DB-WF		LNB	Baghouse
3	CSSH15	2012	2	140.5	0.675	83.0	0.399	42907.7	2064	416355	380	41580	DB-WF		LNB	Baghouse
3	CSSH15	2012	3	56.2	0.715	32.1	0.409	16199.9	2004	157196	158	16170	DB-WF		LNB	Baghouse
3	CSSH15	2012	4	300.7	0.785	202.7	0.529	78948.9	1927	766079	716	81957	DB-WF		LNB	Baghouse
3	CSSH15	2012	5	306.8	0.797	172.4	0.448	79384.1	1926	770300	744	82443	DB-WF		LNB	Baghouse
3	CSSH15	2012	6	269.4	0.739	125.2	0.344	75097.5	2025	728705	720	74176	DB-WF		LNB	Baghouse
3	CSSH15	2012	7	286.9	0.779	125.1	0.340	76581.8	2047	736591	744	74841	DB-WF		LNB	Baghouse
3	CSSH15	2012	8	262.2	0.707	126.0	0.340	77129.6	2043	741860	744	75518	DB-WF		LNB	Baghouse
3	CSSH15	2012	9	253.5	0.736	108.5	0.315	71671.7	2036	689364	720	70407	DB-WF		LNB	Baghouse

0.716

Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
4	CSSH15	2006	1	323.7	0.752	156.9	0.364	88352.2	2089	861134	744	84604	DB-WF		LNB	Baghouse
4	CSSH15	2006	2	304.2	0.742	149.9	0.366	84113.6	2086	819819	672	80658	DB-WF		LNB	Baghouse
4	CSSH15	2006	3	361.9	0.781	175.9	0.380	95039.7	2057	926313	744	92401	DB-WF		LNB	Baghouse
4	CSSH15	2006	4	341.3	0.725	186.1	0.395	96554.1	2058	941075	720	93814	DB-WF		LNB	Baghouse
4	CSSH15	2006	5	352.1	0.753	168.1	0.360	95909.0	2091	934786	744	91750	DB-WF		LNB	Baghouse
4	CSSH15	2006	6	337.6	0.730	170.5	0.369	94906.9	2104	925017	720	90216	DB-WF		LNB	Baghouse
4	CSSH15	2006	7	355.8	0.736	185.0	0.383	99146.7	2121	966340	744	93469	DB-WF		LNB	Baghouse
4	CSSH15	2006	8	133.8	0.754	66.9	0.377	36427.4	2121	355043	273	34350	DB-WF		LNB	Baghouse
4	CSSH15	2006	9	276.4	0.736	139.7	0.372	77047.5	2033	750952	620	75807	DB-WF		LNB	Baghouse
4	CSSH15	2006	10	329.5	0.742	171.2	0.385	91142.3	1974	888325	744	92320	DB-WF		LNB	Baghouse
4	CSSH15	2006	11	271.7	0.726	141.5	0.378	76844.2	2002	748968	634	76755	DB-WF		LNB	Baghouse
4	CSSH15	2006	12	304.8	0.772	151.6	0.384	81009.8	1963	789569	744	82527	DB-WF		LNB	Baghouse
4	CSSH15	2007	1	308.0	0.746	157.4	0.381	84737.3	1959	825899	744	86529	DB-WF		LNB	Baghouse
4	CSSH15	2007	2	290.0	0.742	145.7	0.373	80216.7	1967	781839	618	81562	DB-WF		LNB	Baghouse
4	CSSH15	2007	3	341.0	0.710	174.6	0.364	98551.6	2015	960542	744	97835	DB-WF		LNB	Baghouse
4	CSSH15	2007	4	330.4	0.720	164.9	0.359	94114.9	2001	917298	720	94077	DB-WF		LNB	Baghouse
4	CSSH15	2007	5	325.2	0.728	144.4	0.323	91620.5	2059	892987	744	88992	DB-WF		LNB	Baghouse
4	CSSH15	2007	6	307.2	0.722	156.7	0.368	87319.3	2086	851065	720	83708	DB-WF		LNB	Baghouse
4	CSSH15	2007	7	347.0	0.758	174.4	0.381	93933.3	2063	915528	744	91081	DB-WF		LNB	Baghouse
4	CSSH15	2007	8	363.6	0.771	202.9	0.430	96826.9	2076	943731	744	93269	DB-WF		LNB	Baghouse
4	CSSH15	2007	9	292.5	0.711	154.3	0.375	84375.0	2109	822370	652	80026	DB-WF		LNB	Baghouse
4	CSSH15	2007	10	321.0	0.714	167.5	0.373	92209.3	2062	898725	744	89416	DB-WF		LNB	Baghouse
4	CSSH15	2007	11	294.0	0.736	151.1	0.378	81916.2	2012	798403	720	81443	DB-WF		LNB	Baghouse
4	CSSH15	2007	12	322.8	0.745	167.8	0.387	88923.7	2000	866701	744	88944	DB-WF		LNB	Baghouse
4	CSSH15	2008	1	282.7	0.775	152.1	0.417	74899.2	1969	730013	598	76075	DB-WF		LNB	Baghouse
4	CSSH15	2008	2								0		DB-WF		LNB	Baghouse
4	CSSH15	2008	3	303.2	0.787	161.6	0.419	79062.9	1965	770596	607	80467	DB-WF		LNB	Baghouse
4	CSSH15	2008	4	326.5	0.743	201.0	0.457	90574.7	2018	878888	720	89768	DB-WF		LNB	Baghouse
4	CSSH15	2008	5	378.0	0.757	224.3	0.449	102932.2	2007	998800	744	102586	DB-WF		LNB	Baghouse
4	CSSH15	2008	6	315.4	0.717	174.0	0.395	90726.0	2047	880353	720	88655	DB-WF		LNB	Baghouse
4	CSSH15	2008	7	338.7	0.733	176.2	0.382	95186.6	2115	923638	744	90001	DB-WF		LNB	Baghouse
4	CSSH15	2008	8	338.8	0.761	187.7	0.422	91743.5	2057	890230	744	89196	DB-WF		LNB	Baghouse
4	CSSH15	2008	9	311.2	0.721	180.0	0.417	88954.0	2025	863160	720	87863	DB-WF		LNB	Baghouse
4	CSSH15	2008	10	347.4	0.749	197.1	0.425	95639.3	2005	928029	744	95422	DB-WF		LNB	Baghouse
4	CSSH15	2008	11	244.6	0.800	133.9	0.438	62998.7	1981	611306	486	63612	DB-WF		LNB	Baghouse
4	CSSH15	2008	12	381.8	0.843	184.1	0.407	93354.3	1981	905859	744	94239	DB-WF		LNB	Baghouse
4	CSSH15	2009	1	280.2	0.740	134.9	0.356	78060.1	2011	757453	699	77628	DB-WF		LNB	Baghouse
4	CSSH15	2009	2	269.9	0.698	136.9	0.354	79707.1	2039	773433	672	78175	DB-WF		LNB	Baghouse
4	CSSH15	2009	3	55.2	0.685	26.4	0.328	16606.4	2190	161140	119	15168	DB-WF		LNB	Baghouse
4	CSSH15	2009	4	127.5	0.684	74.1	0.397	38440.2	2047	373001	328	37563	DB-WF		LNB	Baghouse
4	CSSH15	2009	5	61.8	0.686	33.3	0.370	18555.1	2069	180048	191	17933	DB-WF		LNB	Baghouse
4	CSSH15	2009	6	267.7	0.683	147.0	0.375	80764.5	2058	783693	699	78501	DB-WF		LNB	Baghouse
4	CSSH15	2009	7	311.9	0.753	173.1	0.418	85365.8	2049	828343	744	83312	DB-WF		LNB	Baghouse
4	CSSH15	2009	8	302.4	0.757	160.2	0.401	82293.7	2090	798533	744	78753	DB-WF		LNB	Baghouse
4	CSSH15	2009	9	295.6	0.749	155.3	0.393	81371.5	2113	789588	720	77002	DB-WF		LNB	Baghouse
4	CSSH15	2009	10	300.4	0.720	157.0	0.376	85981.0	2050	834313	744	83891	DB-WF		LNB	Baghouse
4	CSSH15	2009	11	224.0	0.658	114.5	0.336	70143.9	2071	680636	720	67723	DB-WF		LNB	Baghouse
4	CSSH15	2009	12	271.1	0.637	147.1	0.345	87743.2	2023	851412	744	86767	DB-WF		LNB	Baghouse
4	CSSH15	2010	1	253.3	0.663	135.4	0.355	78711.8	2030	763778	744	77533	DB-WF		LNB	Baghouse
4	CSSH15	2010	2	273.6	0.680	145.8	0.362	82964.0	1999	805037	672	83003	DB-WF		LNB	Baghouse
4	CSSH15	2010	3	263.9	0.632	149.5	0.358	86061.5	2001	835096	744	86024	DB-WF		LNB	Baghouse
4	CSSH15	2010	4	208.1	0.614	122.1	0.360	69863.3	2009	677914	720	69565	DB-WF		LNB	Baghouse
4	CSSH15	2010	5	243.7	0.662	135.2	0.367	75850.1	1995	736011	744	76045	DB-WF		LNB	Baghouse
4	CSSH15	2010	6	284.4	0.696	158.7	0.389	84205.2	2081	817082	720	80912	DB-WF		LNB	Baghouse
4	CSSH15	2010	7	321.5	0.704	191.8	0.420	94091.4	2094	913018	744	89859	DB-WF		LNB	Baghouse
4	CSSH15	2010	8	296.1	0.692	187.7	0.439	88186.1	2088	855711	744	84461	DB-WF		LNB	Baghouse
4	CSSH15	2010	9	280.0	0.685	181.1	0.443	84309.8	2051	818097	720	82214	DB-WF		LNB	Baghouse
4	CSSH15	2010	10	265.7	0.673	157.5	0.399	81408.3	1993	789938	744	81693	DB-WF		LNB	Baghouse
4	CSSH15	2010	11	272.4	0.691	155.0	0.393	81260.9	1971	788512	720	82474	DB-WF		LNB	Baghouse
4	CSSH15	2010	12	349.0	0.765	215.8	0.473	94023.4	1921	912353	744	97876	DB-WF		LNB	Baghouse
4	CSSH15	2011	1	325.8	0.738	193.5	0.438	90973.0	1955	882756	744	93072	DB-WF		LNB	Baghouse
4	CSSH15	2011	2	278.6	0.701	165.9	0.418	81856.2	1977	794287	672	82789	DB-WF		LNB	Baghouse
4	CSSH15	2011	3	267.7	0.626	171.1	0.400	88206.7	2023	855909	744	87212	DB-WF		LNB	Baghouse
4	CSSH15	2011	4	267.2	0.600	173.5	0.390	91746.4	2069	890260	720	88696	DB-WF		LNB	Baghouse
4	CSSH15	2011	5	262.1	0.602	171.8	0.395	89671.4	2074	870119	744	86489	DB-WF		LNB	Baghouse
4	CSSH15	2011	6	241.3	0.598	138.0	0.342	83149.0	2067	806832	720	80454	DB-WF		LNB	Baghouse
4	CSSH15	2011	7	266.7	0.646	168.7	0.409	85045.5	2059	825234	744	82591	DB-WF		LNB	Baghouse
4	CSSH15	2011	8	219.6	0.674	137.7	0.422	67182.3	2044	651902	573	65748	DB-WF		LNB	Baghouse
4	CSSH15	2011	9	252.4	0.663	149.7	0.393	78409.9	2031	760848	720	77210	DB-WF		LNB	Baghouse
4	CSSH15	2011	10	268.4	0.689	154.3	0.396	80334.0	1970	779515	744	81569	DB-WF		LNB	Baghouse
4	CSSH15	2011	11	242.0	0.678	134.3	0.376	73602.3	2030	714199	720	72526	DB-WF		LNB	Baghouse
4	CSSH15	2011	12	112.7	0.676	58.1	0.348	34375.4	1987	333560	310	34605	DB-WF		LNB	Baghouse
4	CSSH15	2012	1	131.6	0.643	75.6	0.369	42194.4	1970	409432	404	42828	DB-WF		LNB	Baghouse
4	CSSH15	2012	2	0.0	0.548	0.0	0.548	0.4	2089	4	0	0	DB-WF		LNB	Baghouse
4	CSSH15	2012	3	111.1	0.704	60.7	0.384	32550.5	1989	315853	296	32728	DB-WF		LNB	Baghouse
4	CSSH15	2012	4	324.4	0.784	218.8	0.529	85334.3	1928	828040	720	88537	DB-WF		LNB	Baghouse
4	CSSH15	2012	5	324.6	0.797	182.5	0.448	83898.2	1924	814102	744	87200	DB-WF		LNB	Baghouse
4	CSSH15	2012	6	271.3	0.739	127.2	0.346	75677.7	2020	734335	716	74941	DB-WF		LNB	Baghouse
4	CSSH15	2012	7	308.3	0.779	134.9	0.341	82292.1	2044	791515	744	80524	DB-WF		LNB	Baghouse
4	CSSH15	2012	8	284.4	0.708	137.2	0.341	83579.5	2040	803898	744	81934	DB-WF		LNB	Baghouse
4	CSSH15	2012	9	268.2	0.735	115.0	0.315	75831.0	2035	729369	720	74523	DB-WF		LNB	Baghouse

0.713

Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
5	CSSH15	2006	1	313.8	0.751	152.2	0.364	85738.3	2090	835657	744	82052	DB-WF		LNB	Baghouse
5	CSSH15	2006	2	304.0	0.742	150.0	0.366	84033.4	2086	819037	672	80574	DB-WF		LNB	Baghouse
5	CSSH15	2006	3	357.8	0.782	174.1	0.380	93913.1	2057	915332	744	91328	DB-WF		LNB	Baghouse
5	CSSH15	2006	4	331.9	0.725	181.2	0.396	93897.0	2059	915177	720	91224	DB-WF		LNB	Baghouse
5	CSSH15	2006	5	332.7	0.756	158.7	0.360	90313.6	2090	880251	739	86405	DB-WF		LNB	Baghouse
5	CSSH15	2006	6	295.8	0.729	150.0	0.370	83294.7	2104	811838	635	79186	DB-WF		LNB	Baghouse
5	CSSH15	2006	7	351.2	0.736	182.9	0.383	97861.2	2121	953812	744	92297	DB-WF		LNB	Baghouse
5	CSSH15	2006	8	352.3	0.727	188.1	0.388	99404.0	2085	968850	744	95360	DB-WF		LNB	Baghouse
5	CSSH15	2006	9	325.8	0.734	166.7	0.375	91138.9	2037	888296	720	89497	DB-WF		LNB	Baghouse
5	CSSH15	2006	10	332.3	0.742	172.6	0.385	91905.9	1975	895768	744	93076	DB-WF		LNB	Baghouse
5	CSSH15	2006	11	312.9	0.722	165.4	0.382	88905.6	2001	866526	720	88876	DB-WF		LNB	Baghouse
5	CSSH15	2006	12	320.7	0.772	159.5	0.384	85211.2	1963	830517	744	86797	DB-WF		LNB	Baghouse
5	CSSH15	2007	1	312.4	0.745	159.9	0.382	85987.8	1959	838086	744	87786	DB-WF		LNB	Baghouse
5	CSSH15	2007	2	292.5	0.742	146.7	0.372	80844.9	1968	787962	635	82142	DB-WF		LNB	Baghouse
5	CSSH15	2007	3	333.9	0.710	170.9	0.364	96465.6	2015	940210	744	95762	DB-WF		LNB	Baghouse
5	CSSH15	2007	4	328.5	0.720	164.0	0.360	93570.8	2001	911994	720	93528	DB-WF		LNB	Baghouse
5	CSSH15	2007	5	329.8	0.728	146.4	0.323	92908.2	2060	905537	744	90223	DB-WF		LNB	Baghouse
5	CSSH15	2007	6	270.8	0.727	136.9	0.367	76455.5	2085	745178	664	73328	DB-WF		LNB	Baghouse
5	CSSH15	2007	7	361.7	0.758	181.9	0.381	97913.6	2063	954322	744	94944	DB-WF		LNB	Baghouse
5	CSSH15	2007	8	374.2	0.770	208.6	0.430	99673.2	2076	971472	744	96015	DB-WF		LNB	Baghouse
5	CSSH15	2007	9	332.9	0.713	175.5	0.376	95761.6	2108	933351	720	90856	DB-WF		LNB	Baghouse
5	CSSH15	2007	10	331.0	0.714	173.0	0.373	95101.1	2061	926910	744	92274	DB-WF		LNB	Baghouse
5	CSSH15	2007	11	331.7	0.736	171.1	0.380	92475.2	2012	901317	720	91937	DB-WF		LNB	Baghouse
5	CSSH15	2007	12	337.1	0.745	175.2	0.387	92830.1	2000	904776	744	92846	DB-WF		LNB	Baghouse
5	CSSH15	2008	1	365.5	0.778	197.2	0.420	96351.1	1965	939097	744	98056	DB-WF		LNB	Baghouse
5	CSSH15	2008	2	340.9	0.803	184.6	0.435	87138.0	1944	849300	696	89650	DB-WF		LNB	Baghouse
5	CSSH15	2008	3	83.1	0.810	44.3	0.432	21054.0	1958	205205	168	21504	DB-WF		LNB	Baghouse
5	CSSH15	2008	4	332.2	0.745	204.5	0.459	91860.5	2018	891365	699	91063	DB-WF		LNB	Baghouse
5	CSSH15	2008	5	353.4	0.757	210.4	0.450	96273.8	2006	934190	744	95975	DB-WF		LNB	Baghouse
5	CSSH15	2008	6	308.1	0.717	170.3	0.396	88530.1	2046	859046	720	86539	DB-WF		LNB	Baghouse
5	CSSH15	2008	7	345.6	0.734	179.7	0.381	97104.1	2115	942245	744	91831	DB-WF		LNB	Baghouse
5	CSSH15	2008	8	337.4	0.761	186.4	0.421	91339.0	2057	886305	744	88816	DB-WF		LNB	Baghouse
5	CSSH15	2008	9	286.0	0.721	165.4	0.417	81800.0	2028	793741	672	80654	DB-WF		LNB	Baghouse
5	CSSH15	2008	10	338.8	0.749	192.0	0.424	93304.0	2005	905369	744	93089	DB-WF		LNB	Baghouse
5	CSSH15	2008	11	353.6	0.802	194.2	0.440	90856.6	1975	881625	720	91997	DB-WF		LNB	Baghouse
5	CSSH15	2008	12	360.6	0.843	173.6	0.406	88212.0	1982	855962	744	89008	DB-WF		LNB	Baghouse
5	CSSH15	2009	1	294.3	0.742	140.5	0.355	81703.3	2011	792804	744	81271	DB-WF		LNB	Baghouse
5	CSSH15	2009	2	272.0	0.699	137.8	0.354	80247.2	2038	778674	672	78743	DB-WF		LNB	Baghouse
5	CSSH15	2009	3	305.0	0.672	140.2	0.309	93566.0	2107	907910	744	88815	DB-WF		LNB	Baghouse
5	CSSH15	2009	4	270.1	0.688	154.6	0.394	80908.2	2044	785087	696	79160	DB-WF		LNB	Baghouse
5	CSSH15	2009	5	269.0	0.685	143.9	0.366	80948.0	2049	785474	744	79008	DB-WF		LNB	Baghouse
5	CSSH15	2009	6	264.4	0.682	145.0	0.374	79949.6	2061	775786	720	77585	DB-WF		LNB	Baghouse
5	CSSH15	2009	7	304.0	0.754	168.0	0.416	83157.5	2050	806916	744	81126	DB-WF		LNB	Baghouse
5	CSSH15	2009	8	300.0	0.757	158.7	0.401	81645.7	2090	792245	744	78136	DB-WF		LNB	Baghouse
5	CSSH15	2009	9	264.3	0.751	138.0	0.392	72498.9	2114	703493	720	68576	DB-WF		LNB	Baghouse
5	CSSH15	2009	10	282.2	0.721	147.3	0.376	80681.1	2050	782885	744	78700	DB-WF		LNB	Baghouse
5	CSSH15	2009	11	222.0	0.658	113.5	0.336	69544.8	2071	674824	720	67149	DB-WF		LNB	Baghouse
5	CSSH15	2009	12	274.2	0.637	148.6	0.346	88637.8	2022	860093	744	87693	DB-WF		LNB	Baghouse
5	CSSH15	2010	1	253.3	0.663	135.5	0.355	78696.7	2030	763631	744	77549	DB-WF		LNB	Baghouse
5	CSSH15	2010	2	274.3	0.680	146.1	0.362	83200.7	1999	807333	672	83239	DB-WF		LNB	Baghouse
5	CSSH15	2010	3	273.5	0.632	154.9	0.358	89163.3	2000	865195	744	89145	DB-WF		LNB	Baghouse
5	CSSH15	2010	4	248.6	0.616	145.4	0.360	83210.0	2007	807423	720	82924	DB-WF		LNB	Baghouse
5	CSSH15	2010	5	283.5	0.661	156.6	0.365	88394.9	1995	857739	744	88624	DB-WF		LNB	Baghouse
5	CSSH15	2010	6	282.4	0.695	156.9	0.386	83708.8	2081	812265	720	80456	DB-WF		LNB	Baghouse
5	CSSH15	2010	7	25.7	0.673	15.6	0.409	7876.7	2086	76432	84	7551	DB-WF		LNB	Baghouse
5	CSSH15	2010	8	307.7	0.691	196.7	0.442	91769.2	2085	890480	718	88008	DB-WF		LNB	Baghouse
5	CSSH15	2010	9	291.3	0.685	188.3	0.442	87710.5	2053	851095	720	85463	DB-WF		LNB	Baghouse
5	CSSH15	2010	10	288.6	0.672	171.2	0.398	88578.6	1995	859515	744	88818	DB-WF		LNB	Baghouse
5	CSSH15	2010	11	304.5	0.692	173.2	0.393	90741.0	1970	880501	720	92100	DB-WF		LNB	Baghouse
5	CSSH15	2010	12	349.8	0.764	216.4	0.473	94322.6	1921	915256	744	98198	DB-WF		LNB	Baghouse
5	CSSH15	2011	1	330.9	0.737	196.3	0.437	92602.7	1956	898570	744	94703	DB-WF		LNB	Baghouse
5	CSSH15	2011	2	270.3	0.700	161.5	0.418	79574.1	1980	772142	651	80363	DB-WF		LNB	Baghouse
5	CSSH15	2011	3	260.9	0.620	169.1	0.402	86734.7	2029	841625	693	85484	DB-WF		LNB	Baghouse
5	CSSH15	2011	4	280.3	0.600	181.5	0.388	96292.3	2071	934371	720	93009	DB-WF		LNB	Baghouse
5	CSSH15	2011	5	249.5	0.603	164.3	0.397	85341.0	2077	828100	645	82188	DB-WF		LNB	Baghouse
5	CSSH15	2011	6								0		DB-WF		LNB	Baghouse
5	CSSH15	2011	7	265.6	0.654	169.1	0.416	83704.5	2060	812221	625	81254	DB-WF		LNB	Baghouse
5	CSSH15	2011	8	314.8	0.680	193.9	0.419	95425.3	2044	925957	744	93368	DB-WF		LNB	Baghouse
5	CSSH15	2011	9	261.3	0.663	155.3	0.394	81198.5	2033	787908	720	79891	DB-WF		LNB	Baghouse
5	CSSH15	2011	10	283.5	0.688	163.5	0.397	84882.6	1970	823652	744	86174	DB-WF		LNB	Baghouse
5	CSSH15	2011	11	284.4	0.678	158.0	0.377	86411.1	2029	838489	720	85178	DB-WF		LNB	Baghouse
5	CSSH15	2011	12	292.0	0.652	172.6	0.386	92283.1	2005	895465	744	92052	DB-WF		LNB	Baghouse
5	CSSH15	2012	1	261.7	0.651	151.9	0.378	82813.1	2005	803575	744	82616	DB-WF		LNB	Baghouse
5	CSSH15	2012	2	279.1	0.664	166.1	0.395	86609.8	2036	840418	696	85069	DB-WF		LNB	Baghouse
5	CSSH15	2012	3	300.6	0.703	159.8	0.373	88199.5	2019	855841	744	87380	DB-WF		LNB	Baghouse
5	CSSH15	2012	4	334.9	0.785	223.7	0.524	87969.7	1931	853612	720	91136	DB-WF		LNB	Baghouse
5	CSSH15	2012	5	300.2	0.799	170.3	0.453	77457.9	1920	751609	663	80686	DB-WF		LNB	Baghouse
5	CSSH15	2012	6	291.5	0.740	135.8	0.345	81187.4	2024	787797	720	80237	DB-WF		LNB	Baghouse
5	CSSH15	2012	7	315.8	0.779	138.1	0.341	84314.0	2044	810961	744	82496	DB-WF		LNB	Baghouse
5	CSSH15	2012	8	182.6	0.721	88.6	0.350	52647.6	2029	506382	469	51903	DB-WF		LNB	Baghouse
5	CSSH15	2012	9	270.6	0.736	115.9	0.315	76429.6	2036	735127	720	75085	DB-WF		LNB	Baghouse

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	6	CSSH60	2006	1	306.5	0.700	143.1	0.327	89791.4	2187	875160	744	82113	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	2	292.0	0.700	136.8	0.328	85550.3	2124	833821	672	80574	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	3	332.4	0.732	157.4	0.347	93189.4	2109	908279	744	88384	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	4	320.6	0.684	163.5	0.349	96198.2	2079	937601	720	92536	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	5	327.7	0.712	154.2	0.335	94467.2	2062	920732	744	91613	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	6	300.3	0.694	151.0	0.349	88798.5	2035	865481	720	87277	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	7	331.3	0.691	178.0	0.371	98376.8	2095	958836	744	93915	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	8	340.9	0.740	172.5	0.374	94543.7	1969	921481	744	96010	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	9	309.1	0.761	142.9	0.352	83339.2	1902	812272	720	87619	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	10	325.3	0.744	160.9	0.368	89667.4	2005	873951	744	89451	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	11	317.1	0.713	157.8	0.355	91224.4	2089	889125	720	87352	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2006	12	328.1	0.748	143.2	0.326	90077.5	2120	877944	744	84985	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	1	298.2	0.710	139.2	0.331	86230.3	2131	840448	744	80935	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	2	286.0	0.744	141.3	0.368	78836.4	2095	768382	622	75255	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	3	344.0	0.714	166.9	0.347	98805.0	2167	963012	744	91202	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	4	350.0	0.746	171.2	0.365	96239.5	2196	938007	720	87641	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	5	334.2	0.683	167.7	0.343	100410.9	2334	978666	744	86039	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	6	313.5	0.675	163.3	0.351	95348.3	2244	929317	720	84996	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	7	355.9	0.701	190.6	0.375	104154.6	2284	1015155	744	91217	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	8	395.5	0.729	226.7	0.418	111264.7	2327	1084451	744	95612	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	9	82.5	0.694	42.2	0.355	24362.0	2297	237447	166	21213	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	10	80.9	0.709	42.1	0.369	23413.4	2051	228198	198	22828	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	11	337.3	0.714	177.8	0.376	96927.7	2068	944711	720	93755	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2007	12	333.2	0.710	169.5	0.361	96235.7	2082	937965	744	92459	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	1	340.9	0.753	172.3	0.381	92909.5	1933	905534	744	96141	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	2	315.6	0.776	155.2	0.382	83431.7	1954	813168	696	85416	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	3	334.5	0.783	167.5	0.392	87612.0	1902	853923	744	92147	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	4	350.6	0.759	199.4	0.432	95225.2	1952	923500	720	97587	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	5	344.8	0.760	172.2	0.379	93647.7	1877	907552	744	99759	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	6	292.3	0.718	143.0	0.351	84013.8	1953	814237	720	86030	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	7	300.4	0.677	160.4	0.361	91648.7	2042	888177	744	89754	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	8	299.6	0.710	155.1	0.368	87070.7	1977	843714	744	88103	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	9	284.7	0.683	149.2	0.358	86049.5	2027	834094	720	84918	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	10	307.6	0.728	147.2	0.348	87164.5	1969	844772	744	88558	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	11	344.9	0.789	161.9	0.370	90254.3	1945	874871	720	92808	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2008	12	339.6	0.832	133.1	0.326	84234.2	1944	816622	744	86675	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	1	274.0	0.735	115.8	0.310	76931.6	1977	745892	744	77833	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	2	234.3	0.725	99.0	0.306	66735.4	1919	646789	634	69557	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	3	79.4	0.661	34.0	0.283	24758.7	2140	240245	255	23140	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	4	217.3	0.673	78.6	0.243	66598.6	2005	645458	720	66420	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	5	244.2	0.673	103.5	0.285	74916.3	1991	725940	744	75258	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	6	269.1	0.674	115.8	0.290	82444.2	2043	799116	720	80715	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	7	317.1	0.747	150.3	0.354	87566.2	2101	849493	744	83359	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	8	288.2	0.767	125.2	0.333	77499.9	2057	751447	744	75364	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	9	287.7	0.758	126.0	0.332	78283.3	2087	758945	719	75031	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	10	304.3	0.749	143.4	0.353	83695.0	2069	812114	744	80919	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	11	235.3	0.660	115.6	0.324	73537.3	2130	713567	720	69057	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2009	12	260.8	0.615	135.3	0.319	87408.6	2042	847640	744	85627	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	1	241.4	0.654	120.9	0.328	76131.6	2013	737931	677	75623	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	2	274.6	0.659	143.8	0.345	85998.2	2056	834071	672	83644	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	3	288.5	0.607	170.9	0.360	97901.4	2131	949980	744	91893	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	4	213.4	0.605	112.4	0.319	72695.1	2119	705396	588	68600	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	5	292.5	0.637	141.1	0.307	94731.3	2102	919222	744	90153	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	6	302.6	0.703	147.0	0.341	88775.7	2111	861352	720	84121	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	7	191.6	0.700	113.5	0.415	56463.3	2030	547234	470	55642	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	8	315.4	0.681	176.2	0.380	95539.5	2129	926800	744	89754	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	9	290.1	0.690	171.4	0.408	86679.0	2086	841084	720	83115	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	10	177.1	0.658	100.8	0.375	55447.7	2145	538034	469	51688	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	11	29.8	0.694	12.4	0.288	8860.0	2095	85973	102	8459	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2010	12	369.7	0.765	185.9	0.385	99581.4	1984	966287	744	100407	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	1	349.5	0.757	164.4	0.356	95143.2	1969	923216	744	96639	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	2	280.8	0.695	129.0	0.319	83265.9	2015	807968	672	82638	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	3	277.8	0.602	145.3	0.315	95089.7	2130	922700	744	89275	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	4	284.8	0.601	151.0	0.319	97678.4	2137	947819	720	91399	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	5	288.9	0.599	165.3	0.343	99364.7	2143	964182	744	92750	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	6	273.2	0.591	150.8	0.326	95335.1	2196	925076	720	86834	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	7	315.4	0.639	174.3	0.353	101746.4	2191	987294	744	92856	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	8	309.0	0.670	167.3	0.363	95031.9	2151	922141	744	88354	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	9	274.3	0.661	137.1	0.330	85574.8	2149	830370	720	79653	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	10	278.8	0.674	139.6	0.337	85305.0	2092	827755	744	81544	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	11	183.7	0.657	96.6	0.346	57647.0	2067	559374	481	55791	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2011	12								0		DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	1	158.5	0.627	79.0	0.313	52067.2	2080	505234	438	50072	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	2	54.1	0.650	26.8	0.322	17141.5	2043	166331	140	16779	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	3	299.5	0.696	132.3	0.308	88693.5	2096	860635	744	84641	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	4	348.0	0.773	177.8	0.395	92800.4	2066	900486	720	89829	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	5	334.5	0.773	155.0	0.358	89143.3	2114	864999	744	84334	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	6	283.2	0.727	125.2	0.321	80255.0	2217	778751	719	72390	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	7	317.2	0.768	139.1	0.337	85894.7	2209	826163	744	77771	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	8	271.7	0.675	130.6	0.324	83683.5	2174	804895	744	77001	DB-WF		LNB	Baghouse
KY	Shawnee	6	CSSH60	2012	9	263.7	0.720	116.6	0.318	76119.8	2159	732143	720	70510	DB-WF		LNB	Baghouse
							0.702											

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	7	CSSH60	2006	1	308.5	0.700	144.1	0.327	90385.1	2187	880946	744	82667	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	2	289.3	0.702	135.1	0.328	84567.9	2122	824246	672	79712	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	3	339.2	0.733	160.5	0.347	94994.0	2107	925868	744	90160	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	4	317.7	0.684	161.5	0.348	95290.7	2079	928757	720	91669	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	5	322.5	0.712	151.6	0.335	92911.2	2062	905567	744	90121	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	6	305.2	0.693	153.4	0.348	90373.4	2034	880831	720	88880	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	7	323.9	0.691	173.5	0.370	96144.1	2094	937074	744	91829	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	8	329.2	0.740	166.5	0.374	91253.3	1967	889410	744	92804	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	9	300.0	0.761	138.4	0.351	80845.4	1903	787966	720	84974	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	10	311.3	0.744	154.5	0.369	85881.1	2006	837047	744	85608	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	11	329.4	0.713	164.1	0.355	94852.5	2088	924486	720	90848	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2006	12	334.3	0.748	146.1	0.327	91734.4	2119	894094	744	86563	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	1	312.3	0.709	145.7	0.331	90360.3	2129	880703	738	84891	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	2	322.8	0.746	160.1	0.370	88826.6	2094	865752	664	84858	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	3	343.9	0.715	166.9	0.347	98718.6	2166	962169	728	91153	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	4	352.6	0.745	172.6	0.365	97075.3	2196	946153	720	88393	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	5	351.1	0.684	175.5	0.342	105335.9	2333	1026668	744	90319	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	6	316.4	0.675	164.8	0.351	96223.4	2245	937847	720	85734	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	7	367.6	0.702	196.5	0.375	107487.2	2284	1047637	744	94135	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	8	395.9	0.730	225.8	0.416	111296.4	2328	1084759	744	95632	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	9	323.2	0.660	166.6	0.340	100525.0	2344	979773	670	85778	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	10	358.8	0.712	175.4	0.348	103430.1	2142	1008088	744	96594	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	11	342.0	0.714	179.8	0.376	98218.1	2068	957289	720	94975	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2007	12	351.0	0.710	178.5	0.361	101454.4	2082	988829	744	97458	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	1	341.3	0.754	172.5	0.381	92886.1	1932	905305	744	96155	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	2	335.0	0.776	165.2	0.383	88606.8	1953	863607	696	90754	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	3	370.7	0.782	185.7	0.392	97235.9	1901	947723	744	102274	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	4	349.6	0.760	198.8	0.432	94905.1	1953	920403	720	97212	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	5	333.3	0.760	166.2	0.379	90457.4	1877	876642	744	96367	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	6	291.9	0.718	142.4	0.350	83891.3	1953	813051	720	85922	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	7	284.0	0.677	151.0	0.360	86578.8	2043	839042	744	84772	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	8	291.5	0.711	150.3	0.366	84633.9	1975	820107	738	85693	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	9	290.9	0.683	152.0	0.357	87864.1	2027	851683	720	86675	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	10	323.0	0.728	154.4	0.348	91509.6	1969	886885	744	92948	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	11	349.2	0.789	163.9	0.370	91298.7	1946	884994	720	93851	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2008	12	291.1	0.843	115.2	0.333	71276.9	1928	690932	659	73937	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	1	218.9	0.733	94.0	0.315	61585.4	1969	597060	705	62543	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	2	237.6	0.725	100.1	0.306	67626.4	1918	655398	672	70530	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	3	258.6	0.677	106.1	0.278	78732.0	2062	763595	672	76355	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	4	250.2	0.675	90.4	0.244	76530.1	2007	741734	720	76265	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	5	243.8	0.673	103.2	0.285	74782.7	1991	724642	744	75113	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	6	259.4	0.674	111.6	0.290	79465.0	2043	770245	720	77777	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	7	310.9	0.747	147.1	0.353	85842.9	2102	832774	744	81670	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	8	265.7	0.765	116.0	0.334	71646.9	2055	694628	672	69722	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	9								0		DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	10	59.7	0.742	27.8	0.346	16583.1	2031	160914	145	16329	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	11	212.9	0.655	104.9	0.323	67009.7	2122	650225	667	63167	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2009	12	267.5	0.617	137.8	0.318	89445.2	2041	867414	744	87634	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	1	247.6	0.654	123.0	0.325	78159.8	2017	757564	744	77499	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	2	268.5	0.659	140.3	0.344	84013.4	2055	814818	672	81762	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	3	275.8	0.608	163.7	0.361	93528.5	2130	907548	744	87832	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	4	247.7	0.609	129.1	0.317	83896.3	2123	814085	720	79046	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	5	267.6	0.636	129.1	0.307	86742.7	2101	841704	744	82566	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	6	294.6	0.702	142.7	0.340	86518.5	2112	839452	720	81912	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	7	319.4	0.699	173.8	0.380	94309.1	2051	913895	744	91971	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	8	309.5	0.680	173.1	0.380	93853.9	2107	910443	744	89099	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	9	290.7	0.689	171.3	0.406	87001.7	2072	844215	720	83982	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	10	279.7	0.661	153.6	0.363	87148.4	2134	845641	744	81673	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	11	303.6	0.679	141.8	0.317	92223.9	2078	894888	720	88763	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2010	12	335.0	0.769	171.2	0.393	89773.3	1976	871114	744	90852	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	1	344.6	0.756	162.2	0.356	93891.6	1971	911072	744	95286	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	2	271.8	0.695	125.1	0.320	80589.0	2017	781992	672	79927	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	3	267.0	0.601	140.1	0.316	91495.0	2134	887819	744	85740	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	4	262.7	0.601	139.0	0.318	90089.2	2137	874178	720	84299	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	5	277.5	0.600	159.0	0.344	95352.2	2144	925246	744	88940	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	6	262.8	0.591	144.3	0.324	91704.3	2200	889845	720	83368	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	7	285.0	0.640	157.2	0.353	91862.6	2193	891387	744	83761	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	8	294.0	0.670	158.5	0.361	90447.2	2154	877654	744	83980	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	9	264.0	0.661	131.6	0.330	82312.4	2151	798714	720	76526	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	10	274.1	0.673	137.1	0.337	83912.1	2089	814240	744	80336	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	11	184.5	0.663	94.2	0.339	57340.0	2065	556396	533	55546	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2011	12	243.1	0.646	112.0	0.298	77534.0	2045	752347	744	75838	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	1	252.0	0.642	116.0	0.295	80949.4	2087	785493	744	77559	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	2	216.5	0.670	91.9	0.284	66647.3	2060	646703	574	64721	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	3	257.9	0.701	112.3	0.305	75834.3	2097	735858	668	72330	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	4	347.7	0.774	178.2	0.396	92652.4	2065	899049	720	89757	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	5	337.1	0.773	156.0	0.358	89847.6	2115	871833	744	84973	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	6	279.7	0.727	123.5	0.321	79276.7	2215	769258	720	71582	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	7	313.2	0.768	136.9	0.336	84853.1	2210	816146	744	76777	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	8	278.1	0.675	133.4	0.324	85624.6	2173	823565	744	78794	DB-WF		LNB	Baghouse
KY	Shawnee	7	CSSH60	2012	9	267.6	0.720	118.3	0.318	77307.4	2159	743567	720	71630	DB-WF		LNB	Baghouse
							0.701											

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	8	CSSH60	2006	1	311.5	0.700	145.4	0.327	91280.5	2187	889673	744	83463	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	2	245.9	0.710	113.4	0.328	71044.9	2123	692445	572	66927	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	3	0.4	0.659	0.2	0.323	125.7	2131	1225	113	118	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	4	195.9	0.686	98.2	0.344	58630.9	2077	571452	441	56448	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	5	339.3	0.712	159.6	0.335	97737.9	2062	952610	744	94819	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	6	314.0	0.693	157.7	0.348	92959.1	2033	906033	720	91429	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	7	333.9	0.691	178.9	0.370	99116.0	2094	966040	744	94680	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	8	341.9	0.740	172.8	0.374	94805.1	1967	924027	744	96381	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	9	317.9	0.762	146.5	0.351	85639.7	1903	834694	720	90000	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	10	339.9	0.743	167.9	0.367	93827.1	2003	914495	744	93702	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	11	333.7	0.713	166.2	0.355	96092.7	2088	936574	720	92052	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2006	12	347.1	0.748	151.9	0.327	95268.3	2119	928536	744	89897	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	1	317.2	0.709	148.1	0.331	91808.4	2128	894816	725	86299	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	2	317.6	0.744	157.3	0.369	87558.4	2093	853390	646	83662	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	3	346.8	0.715	167.6	0.346	99493.5	2165	969723	708	91930	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	4	372.5	0.746	181.9	0.364	102463.1	2196	998666	720	93301	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	5	351.5	0.684	175.8	0.342	105417.6	2333	1027464	744	90376	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	6	322.0	0.676	167.6	0.352	97802.2	2243	953235	720	87221	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	7	348.5	0.701	184.9	0.372	101973.4	2276	993896	712	89603	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	8	392.0	0.730	223.4	0.416	110123.4	2326	1073327	740	94678	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	9	279.3	0.666	143.7	0.343	86012.2	2322	838328	580	74080	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	10	351.2	0.712	171.7	0.348	101217.9	2141	986527	744	94534	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	11	335.6	0.714	176.6	0.376	96430.1	2067	939861	720	93289	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2007	12	338.6	0.710	172.2	0.361	97782.9	2083	953045	744	93907	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	1	343.7	0.754	173.6	0.381	93578.9	1933	912058	744	96836	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	2	327.5	0.777	161.2	0.383	86480.2	1953	842880	696	88540	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	3	353.4	0.782	177.2	0.392	92742.8	1902	903931	744	97547	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	4	340.5	0.760	193.5	0.432	92349.3	1953	895622	720	94573	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	5	334.1	0.760	166.7	0.379	90740.4	1877	879382	744	96662	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	6	294.3	0.718	143.7	0.351	84584.7	1952	819769	720	86646	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	7	289.0	0.677	153.9	0.361	88083.3	2042	853625	744	86253	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	8	303.0	0.712	156.3	0.367	87895.6	1976	851717	738	88960	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	9	286.7	0.683	149.7	0.356	86663.6	2026	840036	720	85551	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	10	305.7	0.729	146.3	0.349	86537.9	1968	838701	744	87959	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	11	342.1	0.789	160.7	0.370	89506.2	1946	867620	720	92010	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2008	12	345.8	0.833	135.5	0.326	85640.6	1942	830256	744	88185	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	1	254.8	0.736	107.5	0.310	71437.7	1978	692644	744	72223	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	2	238.2	0.723	100.1	0.304	68011.0	1918	659128	672	70922	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	3	283.1	0.678	114.3	0.274	86086.6	2062	834933	744	83487	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	4	186.3	0.675	70.7	0.256	56919.5	2026	551838	499	56200	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	5	246.3	0.673	104.2	0.284	75591.2	1991	732478	744	75918	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	6	260.4	0.673	112.1	0.290	79793.8	2045	773433	720	78051	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	7	310.6	0.746	146.7	0.352	85813.4	2102	832483	744	81636	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	8	304.8	0.767	131.8	0.332	81982.6	2054	794900	744	79827	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	9	294.9	0.758	128.5	0.330	80244.0	2087	777959	720	76915	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	10	189.1	0.745	87.7	0.346	52309.7	2071	507547	483	50511	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	11	217.6	0.659	106.8	0.324	68020.8	2126	660037	720	63984	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2009	12	232.3	0.615	120.1	0.318	77933.2	2042	755749	744	76340	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	1	235.8	0.654	116.5	0.323	74374.8	2020	720866	744	73623	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	2	91.6	0.688	43.2	0.324	27456.7	1986	266188	227	27653	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	3	0.0	0.670	0.0	0.335	1.2	2071	12	1	1	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	4	0.0	0.000	0.0	0.000	0.2	2186	1	0	0	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	5	234.5	0.629	114.1	0.306	76849.5	2097	745705	626	73307	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	6	280.1	0.700	135.9	0.340	82511.7	2114	800584	719	78054	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	7	201.6	0.705	105.0	0.367	59047.3	2040	572225	552	57880	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	8	76.6	0.693	40.3	0.365	22783.5	2138	221077	221	21317	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	9	301.0	0.689	177.5	0.407	90011.3	2085	873418	720	86331	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	10	293.9	0.662	161.2	0.363	91498.3	2133	887850	744	85789	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	11	319.0	0.679	149.0	0.317	96845.3	2078	939732	720	93208	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2010	12	315.0	0.771	161.7	0.396	84205.8	1971	817088	640	85452	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	1	355.5	0.757	167.4	0.356	96835.0	1972	939632	744	98220	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	2	270.3	0.695	124.7	0.320	80198.3	2016	778202	672	79553	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	3	278.1	0.602	145.8	0.315	95274.0	2134	924489	744	89297	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	4	110.0	0.601	57.0	0.311	37734.8	2148	366158	310	35143	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	5	190.0	0.604	111.9	0.356	64842.4	2139	629196	478	60630	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	6	274.5	0.591	151.3	0.326	95755.5	2195	929155	720	87245	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	7	316.6	0.638	175.2	0.353	102201.5	2192	991710	744	93262	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	8	311.6	0.672	168.4	0.363	95557.7	2149	927244	744	88923	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	9	273.9	0.661	137.1	0.331	85401.3	2147	828686	720	79554	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	10	293.7	0.674	147.0	0.337	89865.7	2088	872011	744	86085	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	11	272.1	0.678	132.7	0.330	82778.1	2062	803234	720	80307	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2011	12	263.4	0.648	120.3	0.296	83856.4	2043	813696	744	82109	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	1	177.2	0.628	88.7	0.314	58171.5	2084	564468	503	55827	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	2	123.0	0.650	59.3	0.313	38982.2	2065	378261	329	37757	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	3	322.2	0.698	140.7	0.305	95136.3	2097	923153	744	90751	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	4	356.2	0.773	181.8	0.395	94972.1	2066	921559	720	91939	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	5	346.2	0.773	160.9	0.359	92287.2	2112	895505	744	87400	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	6	292.4	0.727	129.1	0.321	82897.5	2216	804393	716	74807	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	7	316.9	0.769	138.3	0.335	85744.1	2210	824716	744	77589	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	8	157.0	0.693	75.2	0.332	47101.6	2182	453039	415	43165	DB-WF		LNB	Baghouse
KY	Shawnee	8	CSSH60	2012	9	229.1	0.713	101.4	0.316	66783.8	2161	642348	611	61812	DB-WF		LNB	Baghouse

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	9	CSSH60	2006	1	312.0	0.700	145.8	0.327	91426.7	2187	891099	744	83597	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	2	283.4	0.699	132.8	0.328	83161.3	2123	810537	672	78327	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	3	334.9	0.732	158.5	0.346	93849.1	2108	914709	744	89035	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	4	305.3	0.685	155.4	0.349	91449.5	2080	891317	720	87937	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	5	280.6	0.717	129.8	0.332	80257.2	2048	782234	678	78385	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	6	314.4	0.692	158.1	0.348	93159.5	2033	907986	720	91647	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	7	325.8	0.691	174.5	0.370	96721.6	2095	942703	744	92355	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	8	335.4	0.740	169.7	0.374	92976.2	1968	906202	744	94512	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	9	313.2	0.761	144.7	0.351	84462.2	1902	823217	720	88815	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	10	336.2	0.744	166.3	0.368	92762.9	2004	904121	744	92565	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	11	305.2	0.713	151.7	0.354	87880.5	2084	856533	682	84319	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2006	12	123.0	0.735	58.4	0.349	34316.3	2100	334464	270	32687	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	1	112.8	0.717	49.6	0.315	32288.9	2127	314706	303	30367	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	2	0.3	0.626	0.2	0.317	109.5		1067	6		DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	3	337.4	0.713	163.8	0.346	97129.7	2167	946681	693	89660	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	4	359.8	0.750	175.8	0.366	98466.3	2194	959709	683	89776	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	5	350.9	0.684	175.7	0.342	105264.7	2333	1025973	744	90246	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	6	329.9	0.675	171.5	0.351	100325.2	2245	977825	720	89387	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	7	364.0	0.701	194.5	0.375	106540.7	2284	1038412	744	93297	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	8	403.8	0.730	230.2	0.416	113548.5	2328	1106710	744	97535	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	9	345.5	0.653	180.2	0.340	108613.1	2364	1058605	720	91900	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	10	314.7	0.717	151.2	0.345	90040.5	2150	877587	682	83747	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	11	321.1	0.714	168.9	0.376	92239.5	2058	899017	719	89619	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2007	12	330.5	0.710	168.2	0.361	95514.2	2081	930933	744	91778	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	1	340.5	0.753	171.8	0.380	92720.6	1933	903693	744	95947	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	2	317.0	0.778	156.0	0.383	83631.4	1953	815114	696	85630	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	3	354.4	0.783	177.6	0.392	92946.5	1901	905916	744	97769	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	4	324.6	0.760	184.4	0.432	88105.3	1953	854467	720	90243	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	5	338.7	0.760	168.5	0.378	91935.5	1877	890959	744	97951	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	6	289.6	0.718	141.6	0.351	83268.9	1952	807015	720	85327	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	7	296.7	0.677	158.0	0.361	90428.3	2041	876350	744	88606	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	8	283.7	0.711	147.0	0.368	82397.7	1976	798440	744	83405	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	9	280.3	0.683	146.6	0.357	84681.7	2027	820847	720	83565	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	10	316.4	0.729	151.1	0.348	89539.6	1968	867793	744	90989	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	11	352.0	0.789	165.1	0.370	92074.7	1946	892515	720	94614	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2008	12	341.4	0.830	133.7	0.325	84797.0	1944	822078	744	87252	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	1	271.3	0.735	114.6	0.310	76155.2	1975	738357	744	77131	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	2	241.3	0.724	101.7	0.305	68788.3	1918	666659	672	71735	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	3	277.1	0.678	112.1	0.275	84230.2	2062	816923	744	81715	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	4	244.1	0.675	87.4	0.242	74571.0	2003	722704	720	74472	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	5	237.3	0.673	100.2	0.284	72783.9	1991	705276	744	73109	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	6	231.9	0.673	99.8	0.290	71067.0	2042	688856	720	69606	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	7	250.5	0.743	116.7	0.346	69534.0	2101	674532	670	66202	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	8	287.0	0.768	124.1	0.332	77133.7	2051	747863	744	75224	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	9	287.0	0.758	125.1	0.330	78135.5	2087	757514	720	74892	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	10	191.9	0.748	89.2	0.348	52856.0	2055	512853	486	51451	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	11	225.7	0.659	110.7	0.323	70558.7	2123	684664	720	66460	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2009	12	262.4	0.617	135.5	0.319	87761.9	2042	851087	744	85970	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	1	240.5	0.655	118.9	0.324	75809.5	2019	734779	744	75084	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	2	250.9	0.659	130.5	0.343	78499.3	2055	761328	672	76387	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	3	251.6	0.606	148.0	0.356	85585.4	2131	830473	697	80306	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	4	255.9	0.611	133.0	0.318	86291.1	2124	837323	720	81268	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	5	272.6	0.637	131.2	0.307	88179.4	2101	855646	744	83923	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	6	277.8	0.702	134.7	0.340	81538.8	2112	791134	720	77220	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	7	261.9	0.699	142.5	0.380	77318.6	2044	749262	744	75661	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	8	270.8	0.680	151.4	0.380	82065.2	2109	796078	744	77809	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	9	271.9	0.689	159.7	0.405	81293.2	2074	788822	720	78391	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	10	30.6	0.678	15.9	0.351	9306.3	2087	90304	97	8919	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	11	271.9	0.679	126.3	0.315	82545.3	2078	800973	714	79464	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2010	12	301.0	0.763	148.2	0.376	81319.8	1988	789086	697	81800	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	1	326.5	0.755	154.1	0.356	89197.5	1968	865523	733	90636	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	2	257.9	0.695	118.4	0.319	76444.3	2016	741774	672	75843	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	3	248.1	0.602	129.5	0.314	84913.5	2130	823957	739	79714	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	4	264.4	0.601	140.1	0.319	90654.4	2138	879662	720	84821	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	5	266.5	0.599	152.2	0.342	91710.3	2143	889907	744	85595	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	6	239.9	0.591	131.8	0.325	83682.5	2197	812005	710	76184	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	7	283.1	0.639	156.3	0.353	91340.7	2192	886323	744	83345	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	8	281.1	0.671	151.6	0.362	86292.9	2151	837342	744	80243	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	9	236.3	0.660	117.9	0.329	73764.6	2152	715770	720	68568	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	10	173.6	0.672	89.1	0.345	53226.6	2095	516484	476	50805	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	11	246.9	0.676	120.8	0.331	75286.6	2062	730540	720	73029	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2011	12	105.6	0.682	43.2	0.279	31889.2	2025	309437	308	31499	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	1	238.0	0.643	109.0	0.294	76321.2	2081	740583	706	73349	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	2	251.0	0.666	109.1	0.290	77644.2	2055	753410	696	75552	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	3	281.1	0.699	122.6	0.305	82868.7	2095	804115	744	79097	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	4	299.0	0.772	153.6	0.397	79792.6	2064	774264	720	77313	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	5	235.1	0.772	108.0	0.355	62763.1	2118	609019	569	59280	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	6	262.3	0.726	116.2	0.322	74458.1	2213	722501	719	67305	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	7	307.7	0.769	134.3	0.336	83179.6	2208	800049	744	75345	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	8	269.2	0.675	129.0	0.324	82900.4	2174	797362	744	76269	DB-WF		LNB	Baghouse
KY	Shawnee	9	CSSH60	2012	9	256.7	0.722	112.8	0.317	73976.7	2159	711531	720	68530	DB-WF		LNB	Baghouse
							0.701											

ST	Plant	Unit	AS	YR	MO	SO2 (tons)	SO2 Rate	NOx (tons)	NOx Rate	CO2 (tons)	CO2 Rate	HI (MMBtu)	OT	GLoad (MWh)	Unit Type	SO2 Control	NOx Control	PM Control
KY	Shawnee	10	CSSH60	2006	1	169.6	0.472		0.000	73781.6	2427	719116	555	60796	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	2	188.9	0.387		0.000	100240.2	2409	977011	672	83230	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	3	124.4	0.283		0.000	90123.1	2463	878394	658	73196	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	4	89.8	0.373	85.4	0.354	49435.5	2435	481833	333	40602	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	5	117.4	0.455	87.4	0.338	52985.9	2479	516433	383	42747	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	6	239.3	0.447	185.9	0.348	109736.8	2501	1069557	720	87769	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	7	168.2	0.399	153.3	0.364	86561.1	2566	843689	600	67462	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	8	183.0	0.340	201.0	0.374	110353.6	2495	1075569	744	88464	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	9	106.6	0.212	176.6	0.351	103127.5	2546	1005139	720	81003	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	10	69.8	0.347	71.7	0.356	41344.1	2209	402974	361	37428	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	11	111.4	0.372	104.3	0.348	61457.9	1748	599008	569	70312	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2006	12	112.9	0.281	131.3	0.326	82551.2	1807	804595	744	91360	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	1	149.7	0.396	124.9	0.330	77659.7	1951	756926	714	79619	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	2	80.6	0.390	76.7	0.371	42413.7	2046	413393	361	41458	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	3								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	4								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	5	115.5	0.426	90.6	0.334	55692.1	1403	542812	700	79406	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	6	162.7	0.468	121.0	0.348	71263.9	1553	694589	720	91781	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	7	88.1	0.368	89.7	0.375	49111.8	1464	478668	531	67109	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	8	177.0	0.494	148.6	0.415	73475.7	1462	716135	744	100504	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	9	127.6	0.386	112.4	0.340	67829.4	1452	661105	720	93429	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	10	168.8	0.430	137.5	0.350	80589.8	1830	785469	694	88071	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	11	185.6	0.406	170.5	0.373	93878.9	2039	915001	689	92062	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2007	12	159.1	0.372	154.1	0.360	87835.2	1969	856098	720	89236	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	1	202.7	0.380	202.1	0.379	109324.4	2208	1065613	744	99005	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	2	134.0	0.281	181.2	0.380	97800.9	2242	953249	696	87253	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	3	200.7	0.491	160.6	0.393	83776.7	2383	816523	701	70319	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	4	103.4	0.465	92.5	0.416	45628.4	2290	444717	387	39856	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	5	255.5	0.501	193.2	0.379	104579.7	2357	1019303	744	88743	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	6	203.0	0.454	155.9	0.349	91653.6	2420	893301	720	75732	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	7	269.2	0.541	178.5	0.358	102161.1	2438	995727	744	83814	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	8	265.9	0.515	187.0	0.362	105869.5	2573	1031893	744	82296	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	9	204.9	0.509	138.2	0.343	82572.9	2595	804796	633	63638	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	10	222.5	0.472	163.4	0.347	96637.9	2290	941885	744	84397	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	11	166.8	0.403	153.0	0.369	84985.3	2089	828317	720	81355	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2008	12	52.3	0.158	111.4	0.336	68149.0	2081	664225	626	65497	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	1	132.8	0.509	64.5	0.247	53595.2	2276	522371	512	47103	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	2	128.9	0.355	129.8	0.357	74623.1	2314	727327	672	64507	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	3	33.6	0.251	38.0	0.283	27521.3	2337	268234	223	23550	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	4	132.6	0.389	81.8	0.240	70038.8	2312	682646	574	60585	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	5	168.6	0.372	107.2	0.237	93014.2	2337	906577	744	79586	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	6	115.1	0.309	100.2	0.269	76378.3	2334	744442	636	65443	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	7	39.0	0.434	18.4	0.205	18444.8	2384	179771	237	15472	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	8	86.6	0.317	72.2	0.265	55968.1	2114	545493	502	52950	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	9	82.1	0.356	40.1	0.174	47307.3	2171	461085	472	43572	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	10	0.8	0.073	2.9	0.272	2213.4	2048	21577	21	2161	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	11								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2009	12	88.1	0.387	62.4	0.274	46705.7	2027	455224	476	46087	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	1	82.1	0.218	133.7	0.355	77217.2	1957	752606	744	78908	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	2	19.1	0.118	69.8	0.430	33304.1	1982	324598	375	33598	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	3	1.8	1.783	0.3	0.323	210.1		2048	19	0	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	4								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	5								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	6	6.8	0.205	14.6	0.438	6859.2	3601	66857	199	3810	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	7	293.9	0.719	69.2	0.169	83916.0	2258	817894	744	74321	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	8	48.4	0.565	23.2	0.271	17578.4	2406	171329	213	14611	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	9								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	10	0.0	0.201	0.0	0.012	34.8		339	18	0	CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	11								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2010	12								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	1								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	2								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	3								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	4								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	5								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	6								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	7								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	8								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	9								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	10								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	11								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2011	12								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	1								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	2								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	3								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	4								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	5								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	6								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	7								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	8								0		CFB	Other	Other	Baghouse
KY	Shawnee	10	CSSH60	2012	9								0		CFB	Other	Other	Baghouse
							0.408											