THE INSTITUTE OF CLEAN AIR COMPANIES (ICAC) DOMESTIC CONVENTIONAL POLLUTANTS DIVISION AND EMISSIONS MEASUREMENT DIVISION

Issue Brief for
United States Environmental Protection Agency
Administrator E. Scott Pruitt

THE INSTITUTE OF CLEAN AIR COMPANIES

EXECUTIVE SUMMARY

ICAC member companies have helped to clean the air over the past five decades by developing and installing reliable, cost effective control and monitoring systems that have enabled compliance with evolving environmental requirements. ICAC has achieved reductions across a broad range of pollutants, including mercury, NOx, SOx and particulate matter, as well as VOCs, acid gases and a host of other toxic air pollutants. ICAC stands ready to assist EPA in further cost-effective air pollution reduction efforts and in developing the most accurate and reliable monitoring systems for air pollutants such as ozone.

1.HISTORICAL OVERVIEW

The Institute of Clean Air Companies (ICAC) is the national non-profit trade association of companies that supply air pollution control and monitoring systems, equipment, reagents/sorbents, and services for stationary sources. ICAC has promoted the air pollution control industry and encouraged the improvement of engineering and technical standards since 1960. Our members include more than 50 companies who are leading manufacturers of equipment to control and monitor emissions of particulate matter (PM), volatile organic compounds (VOC), sulfur dioxide (SO2), nitrogen oxides (NOx), hazardous air pollutants (HAP), mercury, acid gases, and greenhouse gases (GHG). ICAC's collective technical expertise is, and will continue to be, an important resource for coal-fired boilers and other sources of air pollution.

ICAC member companies have made substantial advancements in technologies for reliable and cost-effective measurement of criteria and hazardous air pollutants, enabling timely implementation and compliance with acid rain and hazardous air pollutant regulations. These include:

- Mercury and HCl real-time monitoring in support of the utilities complying with the Mercury and Air Toxics Standards (MATS) rule as well as other industrial sources driven by NESHAP rules.
- Particulate matter (PM) real-time monitoring for compliance with the MATS rule as well as other NESHAP rules.
- Monitoring for ozone and other criteria pollutants for sources in states implementing primary national ambient air quality standards.

Furthermore, ICAC member companies have substantially advanced technology for cost-effective control of emissions from industrial and utility applications, resulting in high control efficiency of criteria and hazardous air pollutants, enabling compliance with federal, state and permitted emissions levels at costs that were lower than predicted, for a broad range of industrial applications. These technologies have enabled high levels of control:

- VOCs: typical destruction efficiencies of greater than 98% for a wide range of applications
- PM: removal greater than 95% with a wide range of technologies
- NOx: removal of greater than 95% at temperatures ranging from 300°F to 2,000°F
- SO_2: removal of greater than 90% with dry sorbent injection (DSI) of alkaline sorbents, greater than 95% with dry or wet flue gas desulfurization
- Hg: removal of greater than 90% commercially implemented with non-material impact to plant operating costs
- Acid gases: greater than 90% HCl control and greater than 95% SO_3 control demonstrated with DSI
- CO: control up to 99% efficiency at more than 1,000 power plants and industrial boilers

ICAC member companies are ready to meet the challenges ahead both in terms of improving reliability and detection limits of important species in ambient and industrial settings and in terms of lowering the cost and control effectiveness of technologies to support Clean Air Act and other standards.

The chart below provides some basic information about installed controls in the U.S.

Table 1. Quantity and Net Summer Capacity of Operable Environmental Equipment, 2004 – 2014 (EIA data; see Note[1])

	Flue Gas Desulfurization Systems		Electrostatic Precipitators		Baghouses		Select Catalytic and Non-Catalytic Reduction Systems		Activated Carbon Injection Systems		Direct Sorbent Injection Systems	
Year	Quantity	Associated Net Summer Capacity (MW)	Quantity	Associated Net Summer Capacity (MW)	Quantity	Associated Net Summer Capacity (MW)	Quantity	Associated Net Summer Capacity (MW)	Quantity	Associated Net Summer Capacity (MW)	Quantity	Associated Net Summer Capacity (MW)
2004	535	112,874	1,555	324,712	527	57,745	980	215,955	123	4,435	47	5,820
2005	539	112,372	1,542	324,511	527	57,948	1,058	235,221	128	4,693	47	6,765
2006	538	115,698	1,494	317,408	538	60,556	1,141	254,455	139	6,859	55	7,333
2007	565	129,555	1,494	317,296	555	65,587	1,176	263,382	141	7,735	56	7,407
2008	612	149,575	1,469	316,356	575	68,357	1,227	274,510	169	17,391	59	7,506
2009	652	172,829	1,454	313,902	596	73,778	1,299	296,598	227	39,546	62	8,047
2010	691	199,107	1,408	310,031	609	83,322	1,337	312,208	262	54,183	63	8,527
2011	704	209,618	1,362	306,447	632	98,422	1,385	328,228	274	59,057	72	8,783
2012	699	217,024	1,284	297,817	628	101,508	1,427	341,785	287	63,709	80	10,424
2013	674	219,019	1,205	288,633	634	104,141	1,427	347,327	259	61,085	93	12,740
2014	669	223,305	1,159	283,391	617	105,580	1,440	354,277	277	68,697	98	15,918

[1] Note: 'Associated Net Summer Capacity' is defined as the net summer capacity of the generators that are associated with the operation of this environmental equipment. In some cases, respondents have reported equipment late. Counts and capacity may have changed from prior publications of this table because of late reporting. Data for 2005 and earlier are based primarily on Form EIA-767 data. In 2006, the Form EIA-767 was suspended. Data for 2007 and later are based primarily on Form EIA-860 data. All data for 2006 are inferred based on submissions from subsequent years. Beginning in 2013 environmental data was collected at a more detailed level, which increases its accuracy and, in some cases, reduces the equipment counts.

2. MERCURY CONTROL: A SUCCESS STORY

Mercury control is successful and very cost-effective today for coal-fired processes (including power plants) as a result of decades of technology development work that was driven by confidence in national-level mercury control regulation. Operating costs under all of MATS (including mercury controls) have dropped to a range of less than $1.00/MW-hr (averaging $0.50/MW-hr) for coal-fired power plants.[2]

2.1 WHY MERCURY FROM COAL?

The common knowledge that mercury is a persistent neurotoxin (as exemplified in fish advisories nationally) and EPA's and states' multiple efforts at regulation of mercury has reinforced that this was a pressing problem. For example, as described in the opening statement of Mercury Control from Coal Combustion by the UN Global Mercury Partnership[3]:

> "*Burning of coal is the largest single anthropogenic source of mercury air emissions, having more than tripled since 1970. Coal burning for power generation is increasing alongside economic growth. The releases from power plants and industrial boilers represent today roughly a quarter of mercury releases to atmosphere. Household burning of coal is also a significant source of mercury emissions and a human health hazard.*
> *Although coal contains only small concentrations of mercury, it is burnt in very large volumes. Up to 95% of mercury releases from power plants can be reduced. This can be achieved by improving coal and plant performance, and optimizing control systems for other pollutants.*"

Mercury pollution can lead to contaminated fish, which when eaten can lead to a variety of dangerous health effects. The sensitivity of vulnerable populations such as pregnant women and children, as well as subsistence fishermen, to exposure has led EPA and numerous states to issue a number of advisories and to provide other information regarding the dangers posed by mercury in contaminated fish.[4]

In order to address this pressing need, control technologies available for meeting mercury and other limits under the MATS rule have been developed over many

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[2] Staudt, J.E., "Update of the Cost of Compliance with MATS – Ongoing Cost of Controls," White Paper by Andover Technology Partners, May 2017.
[3] Sloss, Lesley and Peter Nelson. "Mercury Control from Coal Combustion." *UN Environment.* United Nations, n.d. Web. 25 July 2017 <http://www.unep.org/chemicalsandwaste/global-mercury-partnership/mercury-control-coal-combustion>.
[4] "Guidelines for Eating Fish That Contain Mercury." *EPA.* Environmental Protection Agency, 19 Jan. 2017. Web. 11 Aug. 2017. <https://www.epa.gov/mercury/guidelines-eating-fish-contain-mercury>.

years and summarized by others, as in the reports "Assessment of Technology Options Available to Achieve Reductions of Hazardous Air Pollutants"[5] and "Control Technologies to Reduce Conventional and Hazardous Air Pollutants from Coal-Fired Power Plants."[6]

2.2 TECHNOLOGY INVESTMENT AND DEVELOPMENT

Development for technology and demonstrations was funded by the EPA, the Department of Energy, the Electric Power Research Institute (EPRI), and by suppliers of sorbents, equipment providers, measurement suppliers, and by numerous utility sources. The evaluation, development, and commercialization of mercury control technologies began soon after the passing of the Clean Air Act Amendments.

From the period of 1990 to 1997, the DOE Mercury Measurement and Controls Program evolved from studies of Hazardous Air Pollutants performed in that time. These studies were performed on several power plants around the United States. The major finding concluded that mercury was not well controlled using the installed air pollution control devices. DOE ran these studies in collaboration and joint funding with EPRI, the University of North Dakota Energy and Environmental Research Center (UNDEERC) and numerous utility companies, including Southern Company, Ohio Power, Illinois Power Minnesota Power and many others.

In 2000, DOE/NETL (National Energy Technology Laboratory) began a comprehensive test program of the most promising mercury control technologies at coal fired utilities around the country. This test program was completed in three distinct phases, moving from pilot-scale testing to full-scale testing, and eventually, into driving additional control efficiency at less cost to the utility. Overall, DOE/NETL co-funded over 40 full-scale mercury tests at utility sites with various air pollution control devices burning a variety of coal types. Additionally, several lab and pilot-scale test programs were funded to further the understanding and technology development. These programs were jointly funded by industry, technology developers, including many ICAC members, the government and EPRI.

Reliable measurement of mercury emissions proved to be difficult early in the testing programs. Since the 1990s development work was conducted on the sorbent trap measurement method, a lower-cost method in comparison with more cumbersome, manual wet chemistry methods such as the Ontario Hydro method and EPA Method 29, a multi-metals measurement method. In addition, developers invested significantly in continuous mercury measurement technology in conjunction with these testing programs and independently. Between 2004 and

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[5] Lipinski, George, P.E., Jean Leonard, and Carl Richardson, PhD. *Assessment of Technology Options Available to Achieve Reductions of Hazardous Air Pollutants.* Austin: URS Corporation, 2011. Web. 6 July 2017 <http://www.lexissecuritiesmosaic.com/gateway/FedReg/file_4-8-11-URSTechnologyReport.pdf>.

[6] Staudt, James E., PhD. *Control Technologies to Reduce Conventional and Hazardous Air Pollutants from Coal-Fired Power Plants.* Boston: NESCAUM, 2011. Web. 6 July 2017 <www.nescaum.org/documents/coal-control-technology-nescaum-report-20110330.pdf>.

2006, DOE and UNDEERC jointly sponsored a $3,000,000 program to further develop the measurement of mercury emissions. ICAC members also contributed significantly to the development and documentation of EPA Method 324, which eventually was adapted and adopted as the current sorbent trap mercury measurement methods 30A and 30B.

2.3 INVESTMENT, COMMERCIALIZATION AND PRESENT-DAY IMPLEMENTATION

MATS[7] established a clear market need for mercury control equipment, chemicals, and supporting measurements. ICAC member companies responded to this market need, having invested in technology development specific to coal-fired power plants and other dilute, mercury-containing gas streams over many years, transferring applicability from sources such as municipal solid waste combustion gases. ICAC members worked to develop technologies that worked under a wide range of mercury concentrations and chloride contents.

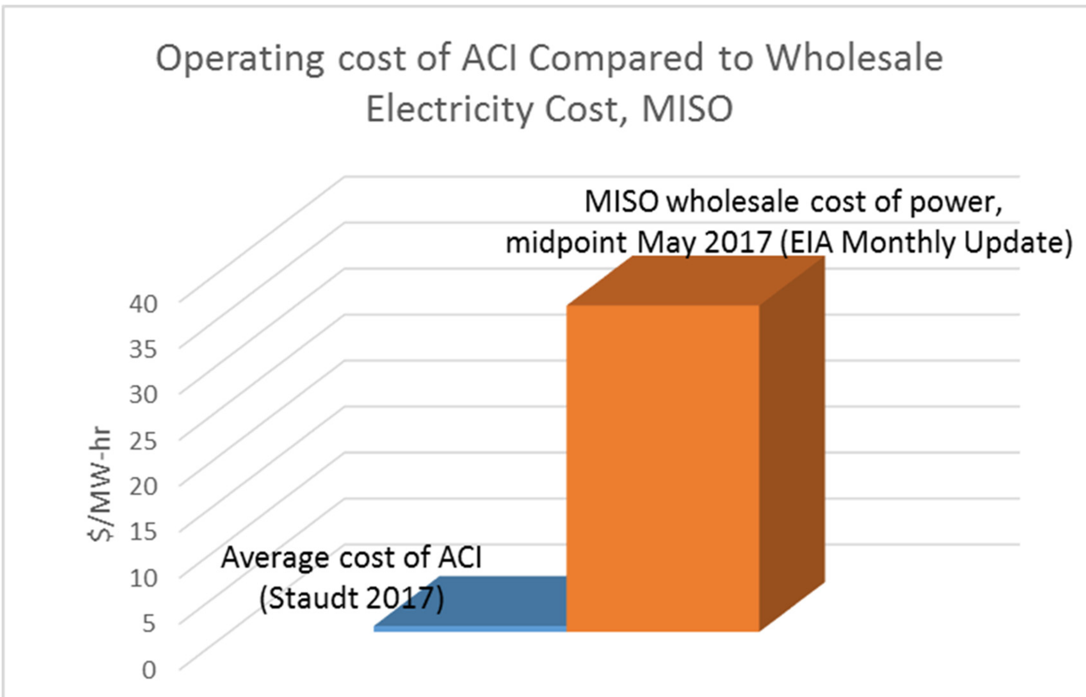
When it came time to fully commercialize and scale up the equipment and chemical supplies that MATS rule compliance demanded, the air pollution control industry invested in new production facilities here in the U.S. to provide the equipment, measurements, and activated carbon and other reagents and sorbents needed to address the new demand. ICAC members also continued to evolve other technical solutions including fuel blending and existing control optimization, non-carbon sorbents, improvements to carbon-based sorbents, wet and dry scrubber additives, and oxidizing coal additives. Having multiple options in place, as well as a robust industry of suppliers that drive innovation through internal research and development, dramatically reduces the costs of compliance for end users over time.

Activated carbon, for example, which is the dominant chemical used for control of mercury from coal-fired flue gases, has several ICAC-member domestic suppliers. Collectively they invested at least $750 million in manufacturing and logistics facilities and opened two new coal mines (in Texas and Louisiana) to supply the raw material for activated carbon production. States like Louisiana, Texas, Oklahoma, Mississippi, Wyoming, Kentucky, Virginia, West Virginia, Ohio and Pennsylvania all benefit from well-paying jobs at ICAC member company facilities and in related industries like coal mining, which is important for both energy use and as a source of consumable product. The benefits to the local and state economies from these operating facilities and mines, as well as the transportation and distribution of products, are significant. In addition, the activated carbon industry has continued to invest in research and development, improving the products available and reducing

[7] Prior to MATS, ICAC members invested substantial amounts of resources in technology aimed at meeting the requirements of the Clean Air Mercury Rule, only to have that rule overturned. Work done to ensure compliance with MATS could face a similar outcome, which ICAC believes should be avoided through a path that provides long-term regulatory certainty.

the costs of compliance. The cost reductions and improvements in technology have had the material benefit of enabling coal-fired power generators to operate their plants with flexibility and cleaner emissions while keeping costs of compliance low. Further information regarding costs, which vary depending on the technology, can be found in reference 2, which is also attached to this document as Attachment B. Figure 1 below shows the average operating cost of ACI in comparison with the midpoint of wholesale electricity pricing in MISO from May 2017.

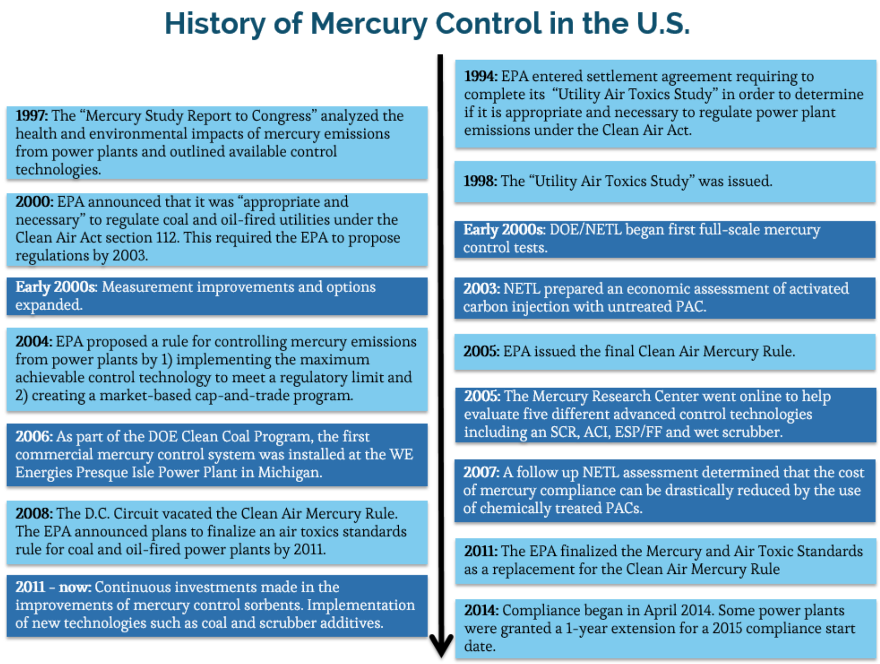
Figure 1. Average operating cost of ACI compared to wholesale electricity pricing in MISO



Activated carbon injection is one of several technologies used to control mercury from coal-fired power plants. Alternatives have continued to evolve as well, with suppliers optimizing their chemicals and controls. The availability of ICAC-supported technologies for mercury control allows ever-improving mercury compliance options. These technologies support clean coal power generation.

A recent U.S. Energy Information Administration (EIA) report indicates that a significant number of electric power plants have invested in equipment as a response to the EPA's MATS rule. With the initial MATS compliance date of April 2015 coupled with the one-year compliance extension granted to many utilities, the EIA report indicates that between January 2015 and April 2016, approximately 87GW of coal-fired plants installed pollution control equipment. Some plants, totaling 2.3 GW, received another one-year extension allowing them until April 2017 to comply.

Figure 2. Summary of Regulatory and Technology Progress in Mercury Control



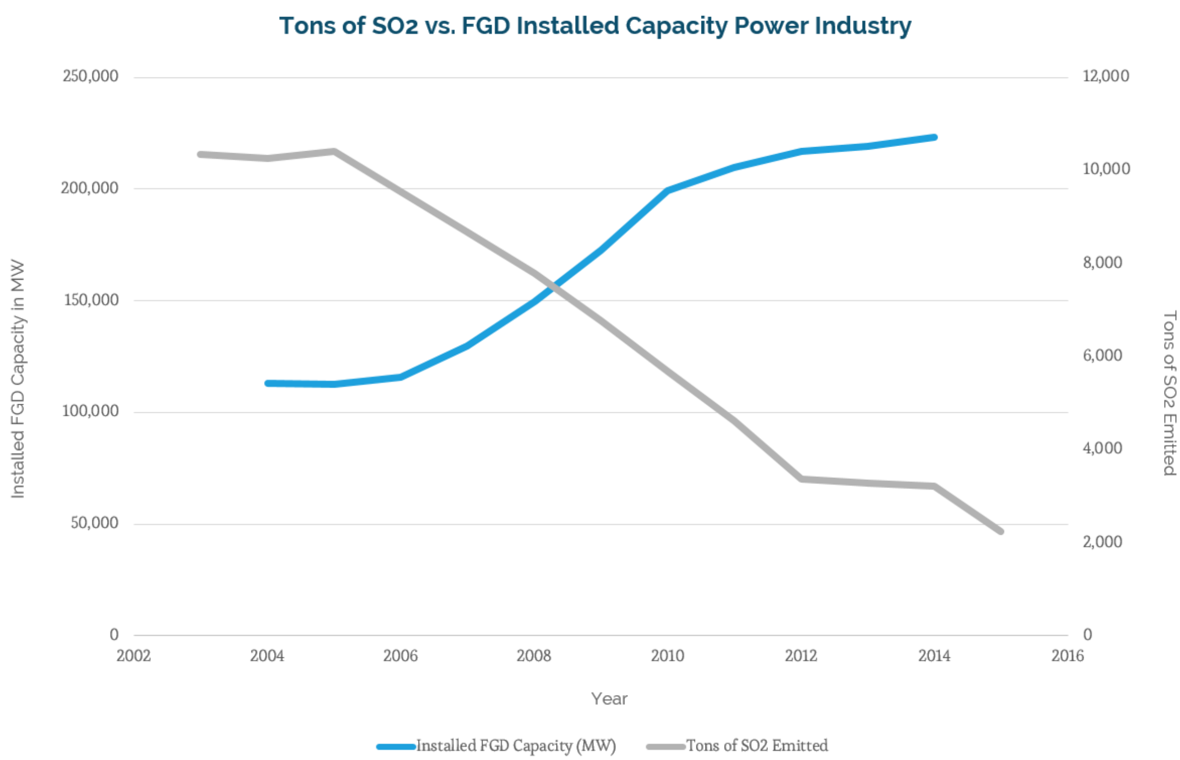
3 . ACID GAS

Acid gas removal for high sulfur coal units is predominantly handled by wet or dry Flue Gas Desulfurization (FGD) technology, which is quite expensive, costing as much as a billion dollars in capital costs for a single facility. By 2010, most units burning high sulfur coal had installed wet FGD. Attention since then has been on units burning blends of lower sulfur western coals such as Powder River Basin (PRB) coal. Many PRB units have been able to treat their acid gases with Dry Sorbent Injection (DSI) systems that typically can be installed at much lower capital costs (under $20 million).

DSI technology injects into the flue gas stream either calcium-based products such as hydrated lime, or sodium based products such as trona or sodium bicarbonate (baking soda). With DSI technology, smaller units that could not afford wet FGD or units that expect a limited life that could not justify a high capital cost system, are able to reduce their acid gas emissions with these simple-to-install systems.

The MATS rule and the Boiler MACT have driven many facilities to this technology in order to meet HCl limits. SO_2 has been less direct, as there are no stack limits. Instead, it is driven by state allocations or ambient air standards. Facilities treating for SO_2 reduction since 2010 have largely been the result of consent orders negotiated with the state regulators and driven by Regional Haze or NAAQS (National Ambient Air Quality Standards). Utilities and industrial facilities continue to improve their acid gas emissions as more DSI systems are installed.

Figure 2. Tons of SO2 vs. FGD Installed Capacity, Power Industry [8]



4. NOX, VOCS AND OZONE

Ground level ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, and chemical solvents and vapors are some of the major sources of NOx and VOC.

[8] U.S. Energy Information Administration, Forms EIA-767, "Steam-Electric Plant Operation and Design Report" and Form EIA-860, "Annual Electric Generator Report."

4.1 HISTORY OF NOX CONTROL TO MEET EMISSION STANDARDS

NOx emissions contributed significantly to national environmental problems, including acid rain, ground level ozone and elevated fine particulate levels. In response to the emissions from power plants, one of the first regulatory drivers was the Acid Rain Program that was established through Title IV of the amendments to the 1990 Clean Air Act (CAA). This program included a two-phased strategy to reduce NOx emissions from coal-fired power plants, with Phase 1 beginning on January 1, 1996 and Phase II beginning on January 1, 2000.

The primary method of compliance for the Acid Rain Program was through the application of Low NOx burner (LNB) technology and emissions averaging across multiple boilers within a company's fleet of boilers. This was very cost-effective, as it did not require major capital retrofits.

Another driver for the installation of NOx control technologies was established under Title I of the CAA, the NAAQS for ozone. EPA set the 1997 ground-level ozone standard at 80 parts per billion (ppb), which led to the development of the NOx SIP Call Rule of 1998. The NOx SIP Call required 23 eastern states and the District of Columbia to participate in a regional cap-and-trade program.

At the time, conventional technologies, such as low NOx burners, were unable to achieve this level of emissions reduction, spurring ICAC members to develop, refine and apply selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) as post-combustion technologies to control NOx emissions on utility and industrial boilers, gas turbines, process heaters, internal combustion engines, chemical plants, and steel mills. This is key, because in many cases SNCR, a low-capital solution, was sufficient for plants to maintain ozone-season compliance. The regulations that were developed in response to ozone issues spurred the application of (SCR) and (SNCR) on a broad range of industrial sources of NOx emissions.

Emissions reductions of nitrogen oxides on coal-fired power plants and other applications of greater than 90 percent are common with SCR, although this technology may be used economically for lower removal efficiencies as well. SNCR technology provided 20 to 70 percent removal, depending on the type of combustion unit and baseline NOx levels, at a lower capital cost than SCR. The application of these post combustion technologies has allowed plant operators flexibility to apply multiple solutions to meet the overall NOx reduction requirements.

Additional EPA Standards related to NOx and ozone included:

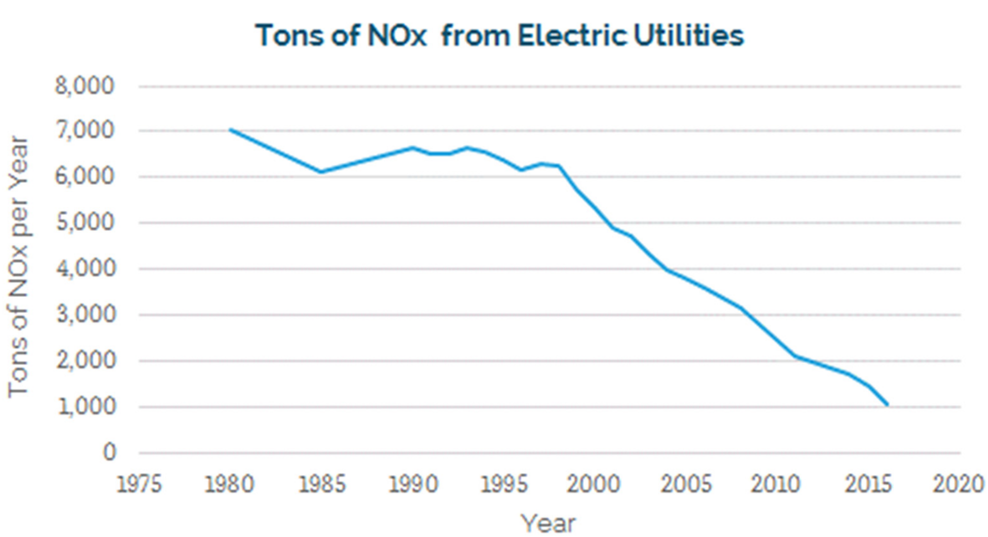
- EPA's 2008 ozone standards of 75 ppb
- EPA's Clean Air Interstate Rule (CAIR)
- the Cross-State Air Pollution Rule (CSAPR)
- The CSAPR Update Rule

- EPA's Regional Haze program/BART rule.

4.2 ICAC MEMBER TECHNOLOGIES FOR NOX CONTROL

Over the past 25 years, ICAC member companies have provided NOx control solutions using combustion and post-combustion technologies, along with advances in monitoring, to meet the ever-changing NOx emissions standards. The costs of these solutions have continued to decline even while NOx levels are at a fraction of original levels. ICAC members have supported industry and states throughout the years as they implement EPA rules with the ultimate goal of meeting their SIP requirements and NAAQS standards. The ICAC solutions have provided economic flexibility by allowing sources to implement a variety of solutions across their fleets while minimizing any impacts on other plant operations. These solutions have included performance guarantees from ICAC suppliers to allow sources and states to develop compliance strategies and provide certainty for planning and implementation. ICAC member companies stand ready to meet the performance and schedule needs for the next wave of NOx reduction for ozone NAAQS, regional haze or state compliance.

Figure 3. Tons of NOx from Electric Utilities[9]



[9] "Air Pollutant Emissions Trends Data." *EPA.* Environmental Protection Agency, 28 Feb. 2017. Web. 26 July 2017. <https://www.epa.gov/air-emissions-inventories/air-inventories/air-pollutant-emissions-trends-data>.

4.3 VOC CONTROLS

VOC controls have been deployed for over 40 years, and today it is routine to achieve 95% plus VOC control very cost-effectively. The critical aspect of controlling VOC emissions is the maintenance of the control device and regular testing to ensure compliance is met. As with all VOC control devices, performance can change due to a wide variety of process, mechanical, or chemical changes that can impact the efficacy of the device.

VOC consist of a variety of organic compounds such as aliphatic and aromatic hydrocarbons, alcohols, ketones, esters, ethers, formaldehyde, phthalic anhydride and many, many others. VOC are vented or discharged from a wide range of manufacturing processes, from can coating and automobile painting to semi-conductor manufacture, baking, printing and lithography, paper manufacture, textile manufacture, oil production, plastic production and many more. The VOC may be solvents, unreacted feedstock or decomposition products, depending upon the type of process and process conditions.

Broadly speaking, there are two strategies for reducing VOC emissions from industrial sources: 1) altering the manufacturing process to reduce the amount of VOC produced and 2) installing after-treatment controls to destroy the VOC emissions generated. Some VOC emission reduction can be achieved by process modifications, but in most instances, reductions significant enough to meet abatement requirements of more than ninety-five percent require after-treatment devices to oxidize (incinerate) the VOC. In a small number of applications where the gaseous emissions present in the waste gas are valuable enough to be recovered for recycling or resale, or where their volume is too great to incinerate economically, a collection technology such as carbon adsorption, or refrigeration (condensation) may be the economic choice.

To meet tough VOC restrictions, an engineer's first choice is to modify the process to lower or eliminate the emission rate. In a combustion operation, for example, one option would be to use oxygen instead of air for more efficient combustion, but increased oxygen brings safety issues and isn't always viable. By contrast, for processes that use solvents, such as drying or curing operations, one might choose to recycle the emissions via adsorption, condensation or solvent-recycling techniques. For very strict VOC targets, however, stronger mitigation measures are necessary. While air scrubbing is often employed in such cases, oxidation is required to achieve levels of destruction as high as 99%.

As emission control device providers encounter new emission sources, they have a broad array of technologies to deploy to meet just about any situation. Innovations continue to lower the cost of compliance, improve sustainability, and find new ways to use VOC emissions for economic benefit.

5. OZONE MONITORING AND NORTH AMERICAN BACKGROUND LEVELS

One question that Administrator Pruitt raised related to monitoring for background levels of ozone. Perhaps surprisingly, monitoring of ozone began in the 1800s and has been going on now for more than 150 years. However, the accuracy of early monitoring techniques cannot be fully ascertained and the use of such techniques were applied inconsistently, both spatially and temporally. These features make it difficult to rely on early monitoring as evidence of "natural" background or "clean" sites.

Although we now have much more reliable monitoring techniques, more complete monitoring networks and more continuous monitoring, the issue of determining background continues to be technically difficult. The complicating issues include medium and long-range transport, increased ozone levels world-wide, downward transport of stratospheric ozone and "exceptional" or episodic weather events. For a discussion of some of these issues, click on the following link to review a paper by Dr. Alan Lefohn: http://www.asl-associates.com/back.htm

ICAC believes that a more robust (EPA funded) network of monitors would provide EPA with greater insight regarding the presence and sources of tropospheric ozone around the country. That is not to say more monitors would fully address the background vs. anthropogenic question. But there is no doubt that EPA could improve scientific understanding of atmospheric chemistry through an expanded ozone monitoring network.

In any event, ICAC stands ready to assist EPA in further understanding ozone monitoring methods and technology as it relates to natural background, consistent with the understanding that there is substantial research regarding the health effects of the ozone molecule regardless of its origin as anthropogenic or "natural."

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As the foregoing discussion demonstrates, for more than five decades, ICAC has been at the forefront of developing reliable conventional pollution control technology at costs that are lower than projected. It has done so by working together with industry, EPA and relevant stakeholders. A key to success in this area has been creation of a policy environment that provides ICAC and its customers with a stable planning horizon. ICAC has a long history of working with EPA on a range of regulations and policies, as seen in Attachment A, which lists ICAC comments and white papers written by our members. ICAC members look forward to working with Administrator Pruitt and EPA to achieve similar successes in the days and months ahead.

ATTACHMENT A
ICAC Publications List

WHITE PAPERS AND OTHER DOCUMENTS

- ICAC Submits Comments on Updates to EPA Cost Manual Chapters on VOCs (December 2016).
- White Paper: Dry Sorbent Injection for Acid Gas Control: Process chemistry, waste disposal, and plant operational impacts
- ICAC Submits Comments on Quad J Portion of EPA Revisions to Test Methods, Performance Specifications, and Testing Regulations for Air Emission Sources (80 FR 54146) (December 2015)
- ICAC Submits Comments on SNCR Chapter of EPA Cost Manual (September 2015)
- Guidance Document on Startup and Shutdown Under MATS (July 2015)
- Process Implementation Guidance for Powdered Sorbents at Electric Generating Units(February 2015)
- ICAC Submits Comments on Carbon Pollution Emissions Guidelines for Existing Stationary Sources: Electric Utility Generating Units (December 2014)
- Improving Capture of Mercury Efficiency of WFDGs by Reducing Mercury Reemissions (June 2014)
- ICAC Submits Comments on Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Generating Units (May 2014)
- ICAC Submits Comments on MATS Startup and Shutdown (August 2013)
- White Paper: Guidelines for Specifications & Selection of Data Acquisition & Handling Systems for Continuous Emissions Monitoring Applications (May 2013)
- White Paper: Guide to FTIR Technology for Compliance Testing, Performance Specification, & Continuous Emissions Monitoring (CEM) of Target Gases (May 2013)
- White Paper: Monitoring of HCl (January 2013)
- White Paper: Conducting A Successful Mercury Control Demonstration Test At A Coal-fired Power Boiler (January 2013)
- White Paper: Ammonia Measurement for Combustion Sources (June 2011)
- White Paper: Selective Catalytic Reduction (SCR) for NOx Emissions from Fossil Fuel-Fired Electric Power Plants (May 2009)
- White Paper: Design and Operation of Fabric Filter and Electrostatic Precipitator Hoppers with High-Carbon Ash (October 2007)
- White Paper: Options and Incentives to Rebuild/Replace VOC Oxidation Equipment (June 2003)
- Guidance for Estimating Gas Consumption in RTOs (July 2002)
- White Paper: Guidance for Sampling of NOx Concentrations for SCR System Control in Gas-Fired Applications (October 2000).
- White Paper: Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions (February 2008)
- White Paper: Guidance for Sampling of NOx Concentrations for SCR System Control in Coal-Fired Applications (July 1999).

- CEMS and EPA's Any Credible Evidence Rule (March 1999)
- Portable Electrochemical Analyzer Conditional Test Method (April 1999)
- Using VOC Control Technologies to Help Your Bottom-Line (July 1998)
- White Paper: Air Emissions Monitoring for Safe and Efficient Medical Waste Incinerator Operation (September 1997)
- White Paper: NOX Control Installation Timing for Industrial Sources (December 2006)
- Design and Operation of Fabric Filter and Electrostatic Precipitator Hoppers with High Carbon Ash (October 2007)(pdf)

TECHNICAL GUIDELINES

- HG-1 Bid Specification and Information Requirements and Bid Evaluation Form for Activated Carbon Injection Systems (2010).The document will assist purchasers of activated carbon injection systems compile information necessary to procure meaningful bids from suppliers of activated carbon injection systems. The document includes bid specification information requirements, a bid evaluation and a sample bid specification.
- *PM CEMS -Guidelines for Preparing Bid Specifications and Bid Evaluations for Particulate Matter Continuous Emissions Monitoring Systems*(2008). Guidelines for specifing and collecting information necessary to solicit bids fo suppliers of PM CEMS as defines in 40CFR Part 60 Appendix B, Performance Specification 11 and Appendix F Procedure 2.
- *CEM-1 Guidelines for Preparation of Bid Specifications and Bid Evaluations for CEMS*(1998). Guidelines for specifying and collecting information necessary to solicit bids from CEMS suppliers.
- *EM-2 Guidelines for Specification of Calibration Gases for Continuous Emissions Monitoring Systems and Portable Stack Analyzers* (2000). Guidelines for determining and collecting data necessary to solicit bids from suppliers of calibration gases and related gas handling equipment for use with CEMS and portable stack gas measurement instruments.
- *CEM-2 Guidelines for Preparing Bid Specifications and Bid Evaluations for Continuous Opacity Monitoring Systems* (2004). Guidelines for specifying and collecting information necessary to solicit bids from COMS suppliers.
- *EM-4 Guidelines and Recommended Practices for Preparing Bid Specifications and Bid Evaluation for Sample Transport Bundle* (2006) Guidelines for preparing a specification for the solicitation and evaluation of bids for sample transport bundles.
- *EM-3 Guidelines for Specification and Selection of Data Acquisition and Handling Systems for Continuous Emission Monitoring Applications* (rev. 2007). Guidelines for helping CEMS users to understand the scope of supply that DAHS vendors provide, and provide a road map for satisfactory DAHS procurement.
- PACE-1 Guidelines For Evaluating and Selecting Portable Analyzers for Combustion Emissions Measurement (2007). Guidelines to ease the process of purchasing a portable emissions analyzers and to help customers specify and obtain analyzers to that best meet their needs.
- *G-2 Factors to Consider in Selecting GEC Equipment* (1982). Worksheet with explanatory text designed to help purchasers of gaseous emission control equipment outline their needs.

- *F-5 Types of Fabric Filters* (rev. 1991). Descriptions and schematic diagrams of different fabric collector arrangements, with brief explanations of their uses and operation.
- *F-6 Baghouse Operation and Maintenance Log for Assessment of Stack Test Results*(1994). Log for collecting fabric filter O&M data necessary for determining whether stack test results are valid and representative of expected operations.
- *F-7 Fabric Filter Gas Flow Model Studies* (1996). Provides information on and establishes design criteria for modeling gas flow in fabric filters.
- *EP-1 Terminology for Electrostatic Precipitators* (rev. 2000). Definitions of key terms relating to electrostatic precipitators and their operation, with diagrams of precipitators included.
- *F-3 Operation and Maintenance of Fabric Collectors* (rev. 2002). General guide to start-up, operation, maintenance, and troubleshooting of fabric filters collectors.
- *EP-7 Electrostatic Precipitator Gas Flow Model Studies* (rev. 2004) Guidelines for modeling gas flows in electrostatic precipitators in order to ensure flow uniformity in the finished unit.
- *EP-10W Bid Specification Information Requirements and Bid Evaluations Forms for Wet Electrostatic Precipitators* (2008). This publication contains forms and accompanying text for collecting data necessary to solicit bids from vendors for wet electrostatic precipitators, preparing specifications and bid documents, and for collecting the elements of and evaluating the bids received.
- *EP-8 Structural Design Criteria for Electrostatic Precipitator Casings* (rev. November 1993). Outline listing criteria for the structural design of casings for electrostatic assure precipitators in order to both the structural soundness of the casings and uniformity throughout the industry.
- *F-8 Structural Design Criteria for Fabric Filters* (2001). Sets minimum criteria for the structural design of fabric filter casings
- *SCR-2 Structural Design Guideline for SCR Reactor Structures* (2002).

ATTACHMENT B

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Consulting to the Air Pollution Control Industry

Update of the Cost of Compliance with MATS – Ongoing Cost of Controls

White Paper

By

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Purpose

The purpose of this effort is to estimate annual operating costs associated with MATS. In effect, what the impact would be in terms of operating costs if MATS was rescinded. These operating costs include:

1. Operating and maintenance costs associated with ACI – this includes the cost of activated carbon as well as any energy used for the systems, waste disposal and maintenance costs.
2. Operating and maintenance costs associated with DSI - this includes the cost of lime or trona as well as any energy used for the systems, waste disposal and maintenance costs.
3. Operating and maintenance costs associated with chemical injection – this would include the costs associated with bromine (or other oxidizing chemicals) as well as chemicals used to control reemission of mercury in wet scrubbers
4. Operating and maintenance costs associated with fabric filters – this will include the costs associated with the energy demand associated with the increased pressure drop across the device, periodic replacement of filter media, and other maintenance or operating labor or materials. It is worth noting that were MATS rescinded, these costs would not go away because the fabric filter cannot be simply "turned off" in the manner that ACI, DSI or the chemical addition can. Rescinding MATS would therefore have no impact on these costs.
5. Operating and maintenance costs associated with monitoring Hg and HCl and increased frequency of PM measurements

Although there were some scrubber and ESP upgrades performed for MATS, these generally do not result in an increase in operating or maintenance costs.

The methodology for this effort will also differ from the methodology used in the past.[1] In that earlier effort Andover Technology Partners (ATP) examined how the United States Environmental Protection Agency (EPA) overestimated the cost of compliance with MATS when they issued the final rule. While EPA provided information about the MW of capacity retrofit in various means, EPA only provided limited detail of the components of the cost. Moreover, EPA's analysis included costs associated with changes in the fuels used in the generation fleet. As a result, the method used to assess how much EPA overestimated the cost of controls was by necessity using their estimated total cost as a starting point and then backing out various cost components per the actual installations and using the cost methodology used by EPA that is described in the documentation for the integrated planning model.

If the previous method examined cost from a "top-down" approach that started with the total cost estimated by EPA, in this effort the operating costs will be built up from a "bottom up" approach. This is done by looking at the total installations of various technologies and determining the associated operating cost. This approach will not examine any costs associated with changes in the fleet fuel mix that might be attributable to MATS. First, because the cost of natural gas is so much less than the expected cost of natural gas when MATS was promulgated, it is likely that MATS had a very small impact

[1] Declaration of James E. Staudt, Ph.D., CFA, United States Court of Appeals for the District of Columbia Circuit, White Stallion Energy Center, LLC, et al, v United States Environmental Protection Agency, Case No. 12-1100, Argued December 10, 2013, Decided April 15, 2014, Declaration submitted September 24, 2015.

on decisions to increase use of natural gas for power generation. Also, this is a question whose answer is almost indeterminable because many different factors influence fuel switching and plant retirement decisions. Another impact is the effect of retirements. While there were a substantial number of coal retirements during the time period leading up to the MATS compliance dates and even coincident with MATS dates, most of these facilities were uneconomical even without MATS and were destined for retirement.

Also, in examining the impact of MATS versus state rules requiring mercury control it was determined that only those facilities that installed Hg controls in 2014 through 2016 would be regarded as being subject to MATS as opposed to a state rule. Therefore, facilities that installed mercury controls either before or after that period are not included in this estimate.

For the purpose of this effort it will be assumed that all MATS control technology was installed in the years 2014 through 2016. Installations prior to 2014 were likely the result of state regulations, consent decrees, or other requirements. It is possible that some installations during 2014-2016 were in response to requirements other than MATS, such as state regulations; however, it is likely that the large majority of the installations in those years were for MATS compliance. In any event, EIA Form 860 data indicates that most facilities installed technology for MATS compliance from 2014-2016 and very few facilities installed mercury controls in 2013. The results of an analysis of EIA form 860 Environmental Association, EIA form 860 generator data and EIA Form 923 unit generation data are shown in Table 1. The 2016 generation is the 2016 generation associated with the facilities installed with a particular technology in a given year and will be used to help estimate variable operating costs associated with that equipment. In making estimates of future cost it is assumed that all of the associated facilities continue to operate at a level similar to that of 2016, except for those where announcements to retire by 2018 were made.

Operating and Maintenance Costs Associated with ACI installed for MATS Compliance

Operating costs for ACI include variable operating costs associated with sorbent consumption (VOMR), waste disposal, if needed (VOMW), power consumption (VOMP) and fixed operating and maintenance costs (FOM). Variable operating costs for sorbent consumption for any application will vary based upon the conditions. Table 2 shows estimated VOMR for activated carbon for a range of applications.

The costs therefore range from under 0.10 mill/kWh to under 1.0 mill/kWh. The most costly conditions are those where there is SO_3 conditioning or high sulfur coal. These, fortunately, are not the most common situations. The more common situations utilize lower treatment rates, resulting in costs on the order of 0.60 mills/kWh or less.

Variable operating costs will also include disposal costs for waste. Activated carbon will increase the amount of fly ash that must be disposed of. Generally, it does not adversely impact fly ash sales because suppliers have developed “concrete friendly” carbons and are also able to utilize much lower treatment rates than in the past. Trends have been for increases in fly ash utilization, despite the increased use of activated carbon. In fact, in 2015 52% of coal combustion products (CCPs) were reutilized.[2] If fly ash is sold there is no impact on the cost of waste disposal. If fly ash is disposed of it will increase the cost of disposal in proportion to the carbon used. If disposal cost is $50/ton ($0.025/lb) and carbon costs around $1/lb, disposal cost is roughly 2.5% of the cost of purchasing the carbon. In light of the increased utilization of fly ash that will mitigate the likelihood of disposal, this assumption is a conservative one.

Table 1. Installation of control technologies associated with MATS from 2014-2016 and associated generation in 2016. Developed from EIA data – Forms 860 and 923

Year	Tech	number	Capacity (MW)	2016 Generation (MWh)	Capital Cost ($1000)
2014	ACI	21	8,470	34,337,506	222,988
2015	ACI	88	39,608	183,651,033	496,218
2016	ACI	88	38,256	186,905,590	322,191
Total	ACI	197	86,333	404,894,129	1,041,397
2014	LIJ	1	641	3,384,917	2,307
2015	LIJ	2	1,398	8,369,775	1,646
2016	LIJ	5	2,065	9,400,899	17,000
Total	LIJ	8	4,104	21,155,591	20,953
2014	DSI	1	477	2,469,155	81,240
2015	DSI	9	2,918	11,504,817	179,155
2016	DSI	14	6,176	24,552,813	94,201
Total	DSI	24	9,571	38,526,785	354,596
2014	OT	1	151	62,319	11,800
2015	OT	18	5,983	32,928,191	26,227
2016	OT	12	3,648	8,752,470	303,387
Total	OT	31	9,782	41,742,980	341,414
2014	BP	9	4,614	25,387,390	402,076
2015	BP	11	4,539	21,010,362	495,120
2016	BP	11	6,833	32,147,754	420,248
Total	BP	31	15,986	78,545,506	1,317,444
ACI = activated carbon injection LIJ = Lime injection DSI = Dry sorbent injection OT = Other BP = Pulse jet baghouse					

[2] American Coal Ash Association, "Coal Ash Recycling Reaches 52 Percent As Production and Use Trends Shift", October 12, 2016, https://www.acaa-usa.org/Portals/9/Files/PDFs/News-Release-Coal-Ash-Production-and-Use-2015.pdf

Table 2. The variable operating cost of sorbent for current, state of the art, commercial carbons.[3]

Coal-Fired Site	Product	AQCS	Fuel	DSI	FGC	% Removal Hg	mill/Kwh
1	DARCO® Hg-LH EXTRA SP	SCR/FF	Low Chlorine Subbit.	None	None	94	0.086
2	DARCO® Hg-LH EXTRA SP	CS-ESP	Local W.Subbit	None	None	80	0.222
3	DARCO® Hg-LH EXTRA SP	CS-ESP	Local W.Subbit	None	None	80	0.244
4	DARCO® Hg-LH EXTRA SP	CS-ESP	Low Chlorine Subbit.	None	None	87	0.328
5	DARCO® Hg-LH EXTRA TR	CS-ESP/wFGD	High Sulfur Bit.	Calcium-based	None	82	0.375
6	DARCO® Hg-LH EXTRA TR	CS-ESP	PRB/Bit. Blend	Sodium-based	None	88	0.663
7	DARCO® Hg EXTRA	CS-ESP	Low Chlorine Subbit.	None	SO_3 (6ppm)	90	0.789
8	DARCO® Hg-LH EXTRA SR	CS-ESP	PRB	None	SO_3 (7ppm)	90	0.872
9	DARCO® Hg EXTRA SR	SNCR/ESP/wFGD	High Sulfur Bit.	None	None	96	0.980

Other variable operating costs include energy, estimated as about $0.01/MWh of generation from the Sargent & Lundy study on mercury control. [4]

Fixed operating costs for operation and maintenance are estimated at 1.4% of capital cost, including overhead, per the Sargent & Lundy study.

Using these factors and the information in Table 1, the costs for operating ACI systems is estimated to be:

Table 3. Operating costs for ACI systems installed for MATS compliance

VOMR	$242,936,000	**FOM**	$14,580,000	**Total VOM + FOM**
VOMW	$6,073,000			
VOMP	$4,049,000			
VOMTotal	$253,058,000		$14,580,000	$267,638,000
			Cost in $/MWh	$0.66

Operating and Maintenance Costs for DSI Systems installed for MATS compliance

EIA Form 860 shows both lime injection systems (LIJ) and DSI systems. DSI systems potentially include trona as well as lime injection systems. The average cost of the LIJ systems in EIA Form 860 are significantly lower than those of the DSI systems ($5/kW compared to $37/kW), suggesting that the LIJ systems were primarily used for SO3 control while many of the DSI systems were for HCl control.

VOMR is estimated by assuming roughly 2 lb of lime reagent per lb of total acid gas (using SO2 since it is usually present in much larger quantities than HCl), an average 2lb SO2/MMBtu coal, average heat rate

[3] Fessenden, J., Satterfield, J., "Cost Effective Reduction of Mercury Using Powder Activated Carbon Injection", March 2, 2017

[4] Sargent & Lundy, "IPM Model – Updates to Cost and Performance for APC Technologies Mercury Control Cost Development Methodology Final", March 2013, Project 12847-002, Systems Research and Applications Corporation

of 10,500 Btu/kWh, and a cost of activated lime equal to $125/ton. [5] It should be noted that for units that fire coal from the Powder River Basin (PRB), the lime consumption would be much less and in many cases no lime would be necessary to be added – the DSI system is added primarily as a precaution.

Variable operating costs will also include disposal costs for waste. DSI will increase the amount of fly ash that must be disposed of. Generally, it does not adversely impact fly ash sales because the most commonly used reagent is lime, which will generally improve fly ash marketability. If fly ash is disposed of, it will increase the cost of disposal in proportion to the lime used. Disposal cost is estimated at $50/ton. Since 52% or more of the industry's coal ash is recycled, it is reasonable to assume that 48% of the facilities need to dispose of waste.

Other variable operating costs include energy, estimated as about $0.39/MWh from the Sargent & Lundy study on DSI. [6]

Fixed operating costs for operation and maintenance are estimated at 1.4% of capital cost, including overhead, per the Sargent & Lundy study. The Sargent & Lundy study includes two additional operators for a DSI system. This is not correct. DSI systems are simple systems that generally do not require additional operators.

Using these factors, the costs for operating DSI and LIJ systems is estimated to be:

Table 3. Operating costs for DSI and LIJ systems installed for MATS compliance

VOMR	$78,333,000	**FOM**	$5,257,000	**Total VOM + FOM**
VOMW	$32,228,000*			
VOMP	$23,276,000			
VOMTotal	$133,837,000		$5,257,000	$139,094,000
Total cost $/MWh				$2.33
* assumes 48% of facilities dispose of waste				

This is a very conservatively high estimate of cost because in many cases not as much reagent is needed because sulfur and HCl content may be low, as in the case of PRB fuel. Moreover, many of these systems are likely to be primarily for SO_3 control rather than HCl control and therefore use much lower reagent treatment rates. Also, the additional calcium may actually make the fly ash more attractive for beneficial reuse, lowering the waste disposal costs.

[5] Treatment rate from: Fitzgerald, H., "Hydrated Lime DSI - Solution for Acid Gas Control (SO3, HCl, and HF)", MARAMA /ICAC SO2/HCl CONTROL TECHNOLOGIES WEBINAR, July 19, 2012
Also, USGS Minerals Yearbook, shows 2014 cost of lime of $122/metric ton, or about $110 per short ton. $125/short ton is than assumed in this evaluation.

[6] Sargent & Lundy, "IPM Model – Updates to Cost and Performance for APC Technologies, Dry Sorbent Injection for SO2 Control Cost Development Methodology – Final", March 2013, Project 12847-002, Systems Research and Applications Corporation

Operating and Maintenance Costs for Other technologies installed for MATS compliance

EIA Form 860 includes a category of "other" for other technologies. Most are listed as used for mercury control. Because of the capital cost of many of these technologies (averaging $35/kW) this may include chemical addition, but likely also includes ESP and FGD upgrades. ESP and FGD upgrades do not entail any additional operating or maintenance costs. Chemical additives do. Hg oxidation and scrubber additives for mercury control were estimated in the 2015 ICAC Market forecast[7] to be in the range of $80-$100 million for the years 2018-2019. For the purpose of this work, we will assume a cost of $90 million per year. Energy used for chemical addition systems are minimal.

While the total capital cost of "OT" items is $342 million, most of that cost is likely to be associated with technologies other than chemical addition (scrubber or ESP upgrades, perhaps). In any event, FOM cost will be assumed to be 1.4% of total capital cost, similar to ACI or DSI. The costs are shown in Table 4.

Table 4. Operating and Maintenance costs for Chemical Addition

VOM	$90,000,000
FOM	$4,780,000
TOTAL	$94,780,000
$/MWh	$2.19

Operating and Maintenance Costs for Baghouses installed for MATS compliance

There are no reagents used with baghouses (aka. "fabric filters"). Baghouses require some labor from operators and also require power and periodic replacement of filter media. Total VOM and FOM are estimated as $0.42/MWh and $0.68/kW-year, respectively. [8] Costs are shown in Table 5. It is important to recognize, however, that if MATS is rescinded, these costs will not go away because a fabric filter, unlike the other technologies, cannot simply be turned off without also turning off the rest of the associated boiler.

Table 5. Operating and Maintenance costs for Fabric Filters

VOM	$32,989,000
FOM	$10,870,000
TOTAL	$43,859,000
$/MWh	$0.56

[7] Institute of Clean Air Companies, 2015 Annual Market Study, pp 19-20. Available at www.icac.com
[8] Sargent & Lundy, "IPM Model – Updates to Cost and Performance for APC Technologies, Particulate Control Cost Development Methodology – Final", March 2013, Project 12847-002, Systems Research and Applications Corporation, pg 8

Operating and Maintenance Costs of Hg CEMS

Operating costs of Hg CEMS include the labor and materials for operating and maintaining the equipment as well as the cost of Relative Accuracy Test Audits and other compliance requirements of the CEMS. This was estimated as roughly $100,000 per year in a 2010 NESCAUM Report. At the end of 2016 there were 664 coal units in the United States operating that generated 1,158,929,439 MWh of electricity. Of them, 233 units among 84 plants had common chimneys. The total number of common chimneys was 111 for the 233 units. Therefore, there are a total of 542 chimneys in the US coal fleet that must be monitored. This means that the total ongoing cost of monitoring is roughly $54 million across the coal fleet for a total cost of $0.05/MWh. This cost estimate likely overestimates the cost because many facilities already had requirements imposed upon them by state Hg control regulations.

Operating and Maintenance Costs of HCl monitoring

Scrubbed units for the most part can demonstrate compliance with the HCl requirements of MATS maintaining adequately low SO_2 emission rates. Therefore, for most scrubbed units there is no additional monitoring need for HCl. For units that are not equipped with scrubbers, stack testing of HCl is necessary. Based upon a sort of 2016 AMPD data, at the end of 2016 there were 266 unscrubbed coal utility or small power producer units that generated 252,190,593 MWh of electricity. Of these, 165 units had individual chimneys and 101 units had common chimneys. Those 101 units had among them 39 common chimneys, resulting in a total of 204 chimneys for all of the unscrubbed units.

It is assumed that the cost of monitoring HCl is similar to that of Hg at $100,000/year per chimney. Therefore, the ongoing operating cost of monitoring HCl emissions is $20.4 million in total. Dividing that by the 2016 generation for those units results in $0.08/MWh

Operating costs associated with increased PM measurement frequency

For those facilities that do not already have a PM CEMS due to Consent Decree or other requirement, facilities will need to increase PM measurement frequency to quarterly. Some facilities may already have quarterly measurement requirements that are imposed by the state. Others may only have annual requirements. It is not possible to determine the incremental cost of increased PM measurement due to MATS frequency industrywide because of the use of PM CEMS under Consent Decrees and other factors. However, like Hg and HCl measurement costs, it will be substantially less than the cost of controls and likely less than the incremental cost of HCl measurement and reporting.

Total operating costs for all MATS technologies

Total operating costs for all MATS technologies for all 664 coal units, including fabric filters is as shown in Table 6 and totals roughly $620 million. If fabric filter operating costs are removed, the total operating costs are roughly $576 million.

Table 6. Total Operating Costs for MATS technologies.

ACI	$267,638,000
DSI	$139,094,000
OT	$94,780,000
FF	$43,859,000
Hg CEMS	$54,200,000
HCl monitoring	$20,400,000
Total	$619,971,000

The total cost (including FF cost) divided by total 2016 generation for all 664 units results in a cost of $0.53/MWh. If FF costs are excluded, the cost per MWh is $0.50/MWh. It is reasonable to exclude FF costs because a fabric filter (or, baghouse) cannot be turned off without turning off the power plant. Therefore these costs would not go away if MATS were rescinded or relaxed.