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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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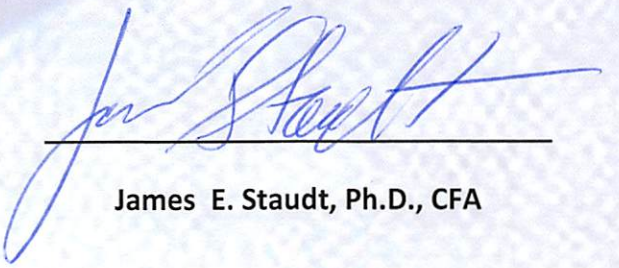

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Purpose

The purpose of this effort is to estimate annual operating costs associated with the Mercury and Air Toxic Standards (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 In effect, what the impact would be in terms of operating costs if MATS was rescinded.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 Activated Carbon Injection (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 Dry Sorbent Injection (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 monitoring Hg and HCl

Although there were some scrubber and Electrostatic Precipitator (ESP) upgrades performed for MATS, these generally do not result in an increase in operating or maintenance costs. Also, any fabric filter retrofits performed for MATS (which were few in number) cannot be "undone". Therefore, rescinding the MATS rule will not make a change in the operating costs for those units that retrofit fabric filters in response to MATS.

This methodology will estimate the costs that were incurred in 2018 as that is the last full year of operating data. This update is important for a number of reasons.

1. The complexion of the coal utility fleet has changed substantially over the past few years, as many units, particularly unscrubbed units, have been retired. This impacts the need for consumables such as activated carbon which is used mostly on unscrubbed boilers.
2. Those facilities that have continued to operate are often operating at a lower capacity factor than they were a few years ago, which also impacts the operating costs.
3. There is more data available on the operation of air pollution control and monitoring technologies than there was during the previous estimate, making current estimates more accurate and reflective of actual costs being incurred.

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, as determined by the Department of Energy, the primary reason for the increased use of natural gas versus coal was sustained low natural gas prices.[1] As a result MATS had a very small impact on decisions to increase use of natural gas for power generation. Another impact

[1] United States Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability", August 2017, pg 13.

that is not explored here is the effect of MATS 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, in part due to the competition from natural gas and other generating technologies, 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 did not already have state rules in place would be impacted with regard to mercury monitoring and controls in the event MATS were rescinded. On the other hand, these facilities would be impacted with respect to other MATS emissions requirements.

Finally, some facilities use more capital intensive technologies, such as capture membranes, that have low operating costs. These facilities are also relatively few in number. Because of the small numbers and the low operating costs associated with these technologies, they will not be addressed in this study.

The US Environmental Protection Agency's 2018 Air Markets Program Data (AMPD) was used to determine the pollution controls installed, the level of generation, the capacity,[2] the number of units and the number of chimneys.[3] This is shown in Table 1. For unscrubbed facilities, it was assumed that these facilities had ACI for mercury controls even if no mercury controls were reported. Also, if DSI was reported for a facility that also had a scrubber, it was assumed that the DSI system was for SO3 rather than HCl because the scrubbers were adequate for HCl compliance (below 0.20 lb/MMBtu SO2). Besides, these are few in number and will not impact the total by much. For the purpose of this effort the operating costs for mercury controls on facilities in states with mercury rules that predate MATS and would stay regardless of rescinding of MATS are shown, but are subtracted from the costs that would be saved in the event of rescinding of MATS.

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 about 0.10 mill/kWh to about 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 0.30 to 0.70 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. In many cases 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 more

[2] Capacity in MW was estimated as dividing the reported rated heat input in MMBtu/hr by 10.5 (assuming a heat rate of 10.5 million Btu/MWhr

[3] Because of common chimneys at some plants, there are fewer chimneys than electric generating units.

widespread use of activated carbon. In fact, in 2017 64% of coal combustion products (CCPs) were reutilized, a record.[4] If fly ash is sold, there is no waste impact. If fly ash is disposed ofit 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. Control Technologies

	MW rating	# of chimneys	# of units	Total MWh
No State Hg Rules (total)	**244,150**	**387**	**438**	**1,001,117,603**
ACI	5,475	13	14	12,407,787
ACI	18,668	37	38	82,057,285
ACI DSI	6,829	8	9	29,613,640
FF	3,949	8	16	16,282,022
FF PAC	10,067	17	17	44,922,314
FF PAC DSI	1,792	3	3	9,417,212
Scrubber, ESP no ACI	67,893	87	106	247,908,135
Scrubber, ESP ACI	15,555	24	24	71,234,233
Scrubber, ESP, ACI, DSI	447	1	1	1,373,206
Scrubber, FF no ACI	67,137	115	127	275,712,012
Scrubber, FF ACI	42,796	66	73	204,409,791
Scrubber, FF, ACI, DSI	741	2	2	3,128,205
HS ACI	446	2	3	742,376
HS ACI	637	1	1	979,761
HS ACI FF	813	1	1	427,082
HS ACI FF	906	2	3	502,544
State Hg Rules (total)	**61,169**	**116**	**125**	**215,058,853**
ACI	4,408	10	12	14,118,051
ACI	5,771	14	15	17,339,033
ACI DSI	3,571	5	8	10,480,991
FF	1,197	7	8	3,632,220
FF PAC	250	1	1	103,496
FF PAC DSI	751	2	2	2,753,440
Scrubber, ESP no ACI	18,329	28	33	71,270,330
Scrubber, ESP ACI	6,577	9	11	18,187,734
Scrubber, FF no ACI	7,781	22	17	19,946,891
Scrubber, FF ACI	11,881	16	16	55,786,497
HS ACI	274	1	1	465,408
HS ACI	380	1	1	974,763
Grand Total	**305,319**	**503**	**563**	**1,216,176,456**

[4] American Coal Ash Association, "Coal Ash Recycling Reaches Record 64 Percent Amid Shifting Production and Use Patterns", November 13, 2018, https://www.acaa-usa.org/Portals/9/Files/PDFs/Coal-Ash-Production-and-Use-2017.pdf

Table 2. The variable operating cost of sorbent for current, state of the art, commercial carbons.[5]

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 from the Sargent & Lundy memo on mercury control. [6]

Fixed operating costs for operation and maintenance are estimated at 1.4% of capital cost, including overhead, per the Sargent & Lundy memo. ACI capital costs are assumed to be $15/kW on average.

Using these factors and the information in Table 1, the costs for operating ACI systems are shown in Table 3. This is a significant drop from what was estimated only about two years ago. The reason is twofold. First, generation levels for facilities that are equipped with ACI are much lower than they were. Second, facility owners and mercury sorbent suppliers have optimized their operation and sorbent products to reduce the amount of material that is needed.

Table 3: Estimated operating costs for ACI systems

	VOMR	VOMW	VOMP	FOM	Total
ACI in States without Hg Rules	$99,757,000	$2,494,000	$4,729,000	$22,666,000	$129,646,000
ACI in states with Hg rules	$29,897,000	$746,000	$1,239,000	$7,364,000	$39,246,000
Total	$129,654,000	$3,240,000	$5,968,000	$30,030,000	$168,892,000

Operating and Maintenance Costs for DSI Systems installed for MATS compliance

DSI systems potentially include trona as well as lime injection systems. VOMR is estimated by assuming roughly 2 lb of lime or trona reagent per lb of total acid gas (using SO_2 since it is usually present in much larger quantities than HCl), an average 0.50lb SO_2/MMBtu coal[7], average heat rate of 10,500 Btu/kWh,

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

[6] 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

[7] The average weighted outlet SO_2 emission rate for DSI equipped units was 0.20 lb/MMBtu. Assuming an average SO_2 capture rate of 60% (about midway between 50% and 70% - the typical rates for ESP or FF equipped units, respectively) results in and uncontrolled rate of 0.50 lb/MMBtu

and a cost of hydrated lime or trona equal to $150/short ton. [8] It should be noted that for units that fire coal from the Powder River Basin (PRB), the lime or trona consumption would be much less and in many cases no lime or trona 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 64% or more of the industry's coal ash is recycled, it is reasonable to assume that 36% of the facilities already need to dispose of waste.

Other variable operating costs include energy, estimated as about $0.39/MWh from the Sargent & Lundy memo on DSI. [9]

Fixed operating costs for operation and maintenance are estimated at 1.4% of capital cost, including overhead, per the Sargent & Lundy memo. The Sargent & Lundy memo includes two additional operators for a DSI system, which would increase operating costs from what is assumed. This is not correct. DSI systems are simple systems that do not require additional operators. In any event, the impact of this is small compared to the VOMR.

Using these factors, the estimated costs for operating DSI systems is shown in Table 4

Table 4. Estimated operating costs for DSI systems

	VOMR	VOMW	VOMP	FOM	Total
DSI operating costs	$16,600,000	$5,608,000	$21,604,000	$4,789,000	$53,812,000

This is lower than previously estimated, largely because the previous estimate was based upon an assumed SO_2 rate that turned out to be far too high as most DSI systems are in fact on lower sulfur coal units. Other factors include lower generation rates and retirements.

Operating and Maintenance Costs for Other technologies installed for MATS compliance

Chemical additives for Hg compliance add operating cost. Hg oxidation and scrubber additives for mercury control were estimated in the 2015 ICAC Market forecast[10] to be in the range of $80-$100 million for the years 2018-2019. It was estimated at a cost of $90 million per year. On the other hand,

[8] 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 2018 Minerals Commodity Summary , shows 2018 cost of lime hydrate of $150/metric ton, or about $135 per short ton. $150/short ton is than assumed in this evaluation. Trona had similar costs.

[9] 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

[10] Institute of Clean Air Companies, 2015 Annual Market Study, pp 19-20

this needs to be adjusted for revised generation levels versus the assumptions used at that time. In that previous estimate a total coal generation level of about 1 billion MWh[11] was assumed for units with wet FGD, versus 728 million MWh actually experienced on units with wet FGD systems 2018. Therefore, the $90 million value previously assumed is adjusted for the lower generation to about $66 million, shown in Table 5. This is distributed between those states with state rules versus those without on the basis of generation with wet FGD in those states.

Table 5. Operating costs for Chemical Addition

States without Hg rules	$52,858,000
States with Hg rules	$12,675,000
Total	$65,533,000

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 $40,000 per year[12] and with 387 chimneys in states without Hg rules and 116 chimneys in states with Hg rules. This results in costs of shown in Table 6. The $40,000/year estimate is lower than previous estimates and is based upon more recent, published information.

Table 6. Operating costs for Hg CEMS

States without Hg rules	$15,480,000
States with Hg rules	$4,640,000
Total	$20,120,000

[11] 998,749,500 MWh, this was taken from Andover Technology Partners' proprietary model which assumed a 70% capacity factor.

[12] Estimated from slide 20 Wilber, K., "EGU MATS Compliance - Hg CEM Systems Challenges and Opportunities", Electric Utility and Energy Confernce, February 16-18, 2015, San Diego

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. There are 133 chimneys on unscrubbed units. Most facilities will comply through periodic stack tests with EPA Method 26A. Since, like a PM test it is an extractive sample, this is estimated to cost in the same range as a PM stack test (which is also performed quarterly at an estimated price of $8500/time[13] or $34,000 per year). This equates to $4.5 million per year in total as shown in Table 7.

Table 7. Operating and Maintenance costs of HCl Monitoring

Total	4,522,000

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 have had to increase PM measurement frequency to quarterly measurements as a result of MATS. 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.

Total possible cost savings industrywide in the event of MATS being rescinded

Total annual operating costs for all MATS technologies that would be reduced or eliminated in the event MATS was rescinded are shown in Table 8. These do not include those costs associated with mercury controls and monitoring in those states that have Hg rules that predated MATS and would stay in effect regardless of whether or not MATS was rescinded. As shown, the total impact is on the order of $203 million. It is true that this does not account for the cost associated with PM or non-mercury metals measurements. However, these should be small compared to the $203 million for other costs. The impact on generation costs nationwide would average only about $0.17/MWh for energy generated by coal-fired power plants, which accounts for less than one-third of all generation.[14]

[13] $8500 per quarter, from https://www.powermag.com/simplify-mats-compliance-particulate-matter-continuous-emission-monitors/?printmode=1

[14] In 2018 total generation from coal was only 27.4% of total generation https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

Table 8. Total Annual Operating Costs for MATS technologies.

ACI in States without Hg Rules	$129,646,000
DSI	$53,812,000
Hg CEMS (no state rules)	$15,480,000
HCl	$4,522,000
Scrubber Chemicals (no state Hg rules)	$52,858,345
Total incremental cost of MATS	$203,460,000
Total 2018 MWh gross – all electric utility coal units	1,216,176,456*
$/MWh gross savings	$0.17*
Note: Not included in the above are mercury control and monitoring costs in states with pre-existing mercury rules that would remain in effect regardless of MATS * Net generation from coal in 2018 is reported as 1,146,000,000 MWh, which would result in a cost of $0.18/MWh.	