
MATS and Beyond: The Role of Technology Choices in Present and Future Coal Plant Compliance

By Sheila Glesmann and Chethan Acharya

December 20, 2016



Coal conveyed at ADA Carbon Solutions' Red River activated carbon production plant in Louisiana. *Photo courtesy: ADA Carbon Solutions*

Recent implementations of new technologies to comply with the Environmental Protection Agency's (EPA) Mercury and Air Toxics Standards (MATS) are substantially completed. Ongoing compliance is a reality for almost all coal-fired power plants, with stack emissions monitoring and reporting implemented. As plants plan for new standards for coal combustion residuals and effluent from FGD wastewater, they may require renewed assessment of control technology choices, examining cross-media impacts.

Some plants have opted for multiple options on air emissions controls, enabling increased operating flexibility. Others have opted out of major modifications, relying on existing equipment with minimal tweaking (termed variously, co-benefit control or native capture) to achieve the needed air toxics emissions control. These decisions have many complex drivers, and the focus here is on the technologies in common use under MATS and implications for compliance with current air emissions limits as well as upcoming requirements under the CCR and ELG rules.

According to U.S. Energy Information Administration data, as of April 2016, 87 GW of coal-fired power plants are complying with MATS using retrofit technologies, 25 GW retired or switched to natural gas, and 188 GW made no changes since 2014 in response to MATS, including about 2 GW with extensions. This 87 GW of retrofit technologies would not

include many ACI systems that were already installed prior to 2014. State mercury rules, consent decrees and other permit requirements had driven installations prior to 2014 that approximately double this installed base. MATS compliance is now an ongoing concern for most coal plants, with only 2.3 GW of coal-fired electric generating units obtaining compliance extensions to 2017.

The same EIA summary shows that of the 87 GW that retrofit controls since Dec 2014, 73 GW report adding activated carbon injection (ACI), 15 GW sorbent systems (not specifying PAC or another sorbent), 14 GW baghouses and SCR, 12 GW scrubbers, and 14 GW are described as "other compliance strategies." This is relevant because it reflects 1) the prevalence (>70 GW) of ACI as the main recent MATS mercury technology of choice among coal plants, and 2) that many more plants are relying on the co-benefits of either existing or new air pollution control devices to control mercury. However, the EIA summary reflects a distinct time period and many mercury control systems were in place prior to the analysis start date of 2014. Another source for tracking compliance technology selection is the EPA database.

According to the Air Markets Program Database (AMPD) maintained by the EPA, as of May 2016, 739 coal-fired units reported being subject to the MATS program, and 229 of these listed a mercury-specific control technology. The AMPD does not yet reflect complete updates to technologies, as this would leave over 500 units that are relying on native capture from older or newly-retrofitted Air Pollution Control (APC) devices to control mercury emissions under MATS. These units would correlate with the 170-190 GW of units that the DOE EIA summary showed did not recently implement mercury-specific technologies. This number is on the high side since many units are using ACI that are not reflected in the AMPD. However it does indicate that a large number of units are relying on native capture.

The AMPD reports two dominant mercury control technologies, activated carbon injection and additives. Two-hundred-fifteen of the 229 units listing a mercury-specific control, or 93 percent, included activated carbon injection (either halogenated, untreated, or not specified) as part or all of their mercury control technology. 78 or 34 percent of the units listing a mercury control technology are using additives

as part or all of their mercury control technology. It does not elucidate which types of additives, whether on the coal or into the scrubber, so both approaches are included below. The other technologies listed are catalyst used to oxidize mercury (10 units), non-PAC sorbent injection (5 units), sodium-based (2 units) and regenerative activated coke technology (2 units). Many units have multiple technologies installed.

Another technology that has become more prevalent in light of MATS acid gas control requirements and planning for regional haze implementation is dry sorbent injection (DSI). Many power plants are using hydrated lime or sodium-based alkaline injection to control acid gas emissions under MATS, and in some cases for plume management. In the AMPD only 15 units list dry sorbent injection as an SO₂ control technology, but this likely does not account for all the units that are using DSI for other acid gas control including HCl and SO₃. Sodium-based sorbents including Trona and sodium bicarbonate are the dominant DSI sorbent for SO₂ control.

However, lime is used to control other acid gases and this may not be reflected in the database. Since the AMPD lists SO₂ control but not broader acid gas control, the systems targeting these other species may not be accounted for. These DSI systems have important interactions with mercury control solutions and also on consideration of future technologies for effluent and CCR management.

What are the implications to ELG and CCR?

Under the ELG key constituents of concern for FGD wastewater in the future are selenium, arsenic, mercury and nitrate/nitrite as nitrogen. Choices of air pollution control technologies impact these constituents in the power plant system. Elements such as Se, As and Hg will end up somewhere in the system, so selection of the next suite of control techniques requires careful consideration of where they are and in what form. It may even drive reconsideration of the approach for control under MATS.

MATS compliance requires a focus on the stack emissions measurement alone. This means that all the underlying cause and effect, process changes, fuel variability, equipment maintenance and complex chemistries are on the plant's

shoulders to manage and contain. The fate of the trace species becomes important as plants plan for compliance with new rules with limits on effluent, as well as solid waste handling. Two key issues arise when combining emissions controls and then layering in planning for new limits: 1) where the trace species are going currently, including the stability in that form (fate of the element such as Hg, Se, As or other RCRA metals); and 2) collateral effects of the new mode of operation on either fate of pollutants or on plant operations more broadly. This is shifting the focus of operators to integration of environmental controls rather than a single-point (such as the stack) solution.

Conducting mass balance for these trace species can be very challenging, both in obtaining accurate measurements and in accounting for variability of the process. Since the implications of non-compliance can range from the operator turning down load, to incurring a violation, to enforcement actions including fines, it is critical for coal plants to find the right solutions while maintaining optimized, cost-effective operations. For example, in the case of mercury control, evaluation of whether constituents are sequestered (and where) using a given air pollution control approach is key. To achieve mercury removal from the flue gas, three steps need to occur in various sequences: contact of mercury with a collection media, conversion of the mercury to an oxidized form, and stable capture of the mercury in a form that can be removed from the plant process without adversely affecting other media (water, solids leachate). The simplest way to do this, with least entropy, is to convert as directly as possible from the gaseous form to the solid, as long as the solid form is stable.

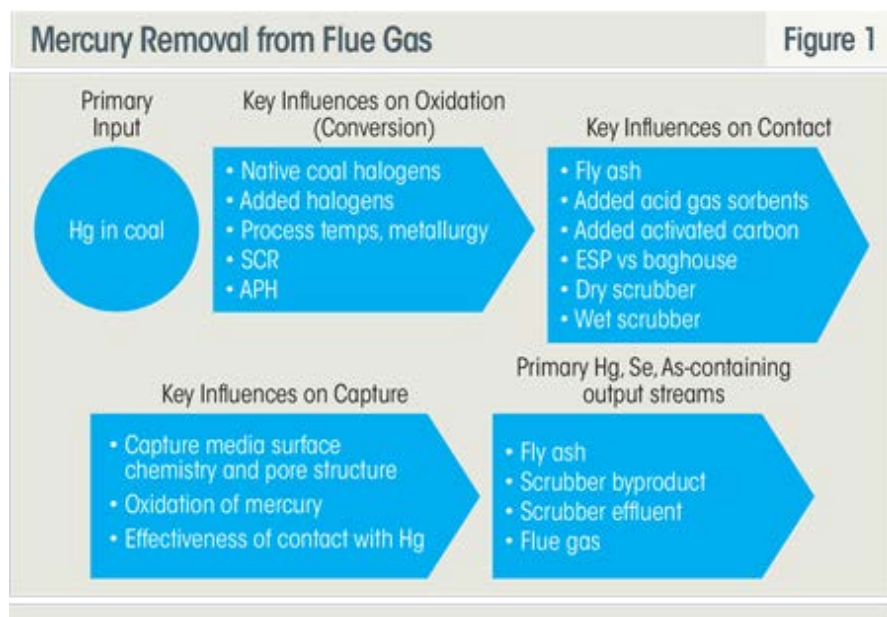


Figure 1 shows the major influences on each of the three key steps, and also the main output streams that are affected by the upstream technology choices. These are just the major contributors. Smaller amounts of mercury can also enter the system through other plant inputs such as lime. Since MATS compliance is determined by a stack CEMS or sorbent trap measurement of flue gas composition, the other streams need to be evaluated to determine the fate of these elements in the total system, in preparation for ELG and CCR requirements.

Solutions that work for MATS compliance today all have collateral effects however, and species that are regulated now or may be in the future at some other location in the process need special attention. Future equipment and process changes also will need to be evaluated in light of the selected MATS compliance option. For example, when a scrubber is utilized as a primary compliance method to capture mercury in the liquid form, where does that mercury go?

The fate of the mercury and other components need to be assessed and identified to evaluate the impacts on future ELG compliance technologies as well as leachability from any landfilled solids and impact on co-benefit use. A flue gas treatment system that appears effective when considering only stack mercury may complicate scrubber effluent control by shifting metals within the plant system. Scrubber mercury removal requires a high degree of the mercury to be in the oxidized form, which may impact the location of other metals as well. The scrubber becomes a multi-metal removal device, in addition to its primary function of acid gas control.

In a high Oxidation Reduction Potential (ORP) scrubber, the mercury is primarily in the liquid phase and can re-emit if process upsets occur, unless a scavenger such as PAC is added to the scrubber. When evaluating ELG solutions, this should be considered carefully. Mercury control technologies that remove the mercury from the system in a stable form upstream of the scrubber, avoiding relying on scrubber chemistry, can prevent this potential interference problem.

There has been some excellent work done in describing mass balances and the fate of elements within the plant under various coal, configuration and process conditions. This work can be simplified to state that it can become predictable. The caveat would be that the work needs to be done at a specific unit to make that predictability a reality, and even so some conditions may arise that are outside the confines of the assumptions made or data obtained during a model or prediction development. Therefore, excellent metrics and feedback parameters are needed to know where the plant is operationally, and this information can be utilized to improve performance over time and minimize adverse events such as downtime, excursions and defect rates, and improve availability.

A second consideration in the event that a mass balance is achieved and understood/predicted, is that the process conditions that are present to achieve the control under APC standards/MATS are key to that outcome (the stack emissions meeting the limit) and changes in those conditions may have collateral effects beyond the shifting of elements within the mass balance. A change that results in higher nitrates or selenium in the scrubber water may impact water treatment systems needed for ELG compliance.

Impacts on Technology			Table 1
Technology	Pro	Con	Managing the Con
ACI: Non-halogenated	Controls oxidized Hg very effectively, sequesters Hg in pore structure for good stability of capture. Reduces Hg load on scrubber for ELG.	May have insufficient Hg conversion (oxidation) PAC is in ash – concrete color and possibly air entrainment formulations may be affected	More effective current PACs avoid interference, also ash can be treated or managed to retain sales.
ACI: Halogenated	Contact, conversion and capture in one step. Advanced PACs are highly efficient and provide active control.	Halogens can cause corrosion in storage equipment.	Coat silo internals
Additives: Halogen on coal	Improves conversion (oxidation) of Hg, especially in combination with SCR.	Delivers all the halogen to the flue gas phase. Possible corrosion to plant equipment (coal handling, boiler fouling, back pass, air preheater), depending on amount, location added and type. No contact or capture medium provided for Hg control other than natively present species. Bromine lowers Se reporting to ash; increases Se load on scrubber for ELG. Bromine in effluent may be problematic	Coat APH baskets, use higher grade materials Can be used in conjunction with ACI for contact and capture
Additives: Scrubber additives - sulfides	No conversion provided. Precipitates Hg ²⁺ into a solid form for removal with byproduct	ORP reduction in scrubber, impacting bulk chemistry (if ORP too low, interferes with gypsum formation. If too high, re-emissions can occur)	Tightly control scrubber pH and ORP
Additives: Scrubber additives - PAC	No conversion provided. Adsorbs Hg ²⁺ into a solid form for removal with byproduct	Gypsum color affected if not separated with hydrocyclones	Hydrocyclones minimize color impact to enable sale of gypsum
Alkaline (Lime or Sodium-based) injection (DSI)	HCl control SO ₂ control – plume mitigation and improved PAC Hg efficiency. Se removal with ash – takes some burden off WWT. Maximize.	Scavenges flue gas halogens needed for oxidation of Hg. Unreacted alkaline sorbent increases pH in landfill, may mobilize trace metals. Is Se stable? Need to capture securely without leaching.	Can use treated PAC to induce oxidation on sorbent Evaluating RCRA metals impacts Developing sorbents to retain Se
Native capture: SCR / ESP / WFGD	SCR improves conversion (oxidation) of Hg, especially in combination with higher flue gas halogen content. WFGD can contact and capture oxidized Hg, if conditions are controllable.	Conversion dependent on catalyst life cycle, not controllable by operator. Passive control. Scrubber is large sink for elements but may not be stable. Cycling scrubber up to manage ELG by reducing effluent flow rate is limited by chloride (halogen) concentration. Ash and unburned carbon have a loose hold on mercury, is it stable?	Managing ORP and pH of scrubber can improve Hg retention. Still builds up concentrations of each component in liquor. RCRA metals fate under evaluation. Removal of elements from system is needed, understanding fate of elements is important.

Applying the three mechanisms to the key technologies currently applied to a wide range of coal plants, and to the use of native capture by an SCR/wet scrubber combination, Table 1 highlights some of the MATS, ELG and CCR-related impacts for each technology.

Several items mentioned in the table represent constraints on the use of the technology with respect to other unintended effects, underscoring the need for system integration. For example, the capture of Se by lime injected for acid gas control. The positive aspect is the reduction of Se loading in the scrubber. The need for Se control from coal to effluent approximates 99.9 percent, so in order to completely avoid Se treatment in the wastewater a sorbent would need to be highly efficient in Se capture. It is also important to evaluate the stability of the Se in the ash. Ongoing projects by EPRI, ADA

Carbon Solutions and others are evaluating improvement of Sequestration by sorbents.

Another example is the color impact of scrubber PAC on gypsum. This is important for gypsum that is used in wallboard, and less important for gypsum used for agricultural, although farmers are also aware of coloration and the site may need to work with the farmer to accept any changes. In either case the need for low moisture content could drive use of dewatering systems such as vacuum belt filters. If a hydrocyclone is used, it also separates the PAC-containing fines from the gypsum, minimizing discoloration. This approach has been successfully used to support ongoing sales.

The integration of MATS, effluent and CCR management comes together most closely when zero liquid discharge is targeted. In this case the scrubber water balance is tightened and as much water as possible is recycled back to the scrubber. The small blowdown/purge stream then is mixed with ash (and in some cases other additives such as lime) to encapsulate it into a stable solid. Where higher halogen content is present, such as with higher sulfur bituminous coals, chloride/halogen concentration can be the constraint that limits cycling water back into the scrubber to reduce the effluent stream to a manageable level. This approach can drive a wastewater treatment (WWT) solution rather than zero liquid discharge. When WWT is utilized, the consistency of the input water's chemical composition and flow rate affect WWT technologies. Biological systems in particular are sensitive to wastewater chemical composition such as TDS and nitrates, which may limit scrubber water cycling.

Philosophically, getting the trace elements from the coal (in solid form) to the flue gas (gaseous form) and back to the solid form is the most efficient way to go with the least entropy. There are inefficiencies in each transfer of the contaminant from one phase to the next as well as interferences from emission system chemistries and operating procedures, making trace element removal even tougher and more costly.

Taking the next step and putting components into the liquid phase in a scrubber and then removing it from the liquid is less efficient than removing it as a solid upstream. It also opens the door to potential re-emissions and alters the focus of the scrubber to a multi-pollutant, multi-metals control device.

These shifts in chemistry can have adverse effect on the primary function of the scrubber and result in less stable pollutant capture. The bottom line is that consideration of future new compliance requirements must include a strong focus on the integration of all emissions controls at the plant, including how these feed into each other and the fate of elements over the range of process conditions.

Author

Sheila Glesmann is senior vice president of Environmental and External Affairs at ADA Carbon Solutions, LLC. **Chethan Acharya** is research engineer at Southern Company Services.

