ZMWG Comments on Guidance on BAT/BEP for Coal-fired power plants and Coal-fired industrial boilers
1 August 2015

General Comments:

The current draft, including the main chapter 5 on "Best Available Technique and Best environmental practices (BEPs) for coal combustion", has the merit of being very informative due to descriptive nature in regards to the various techniques available to prevent or control mercury emissions, albeit incomplete since many more BAT/BEP may be considered.
The Parties need clear guidance on emission levels that are achievable with the use of BAT/BEP in line with the general objective laid down under the Minamata Convention to "[…] protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds" (Article 1).
As per Article 8 paragraph 8 point (a) of the Convention, the guidance shall establish "Best available techniques and [..] best environmental practices, taking into account any difference between new and existing sources <u>and the need to minimize cross-media effect</u>s […]".
For these reasons, the guidance should be improved on the following points:

- *in relation to the cross-media impacts of mercury abatement to the air, the water and residues pathway of mercury releases from coal combustion needs to be better considered and subject to BAT conclusions in line with an integrated pollution prevention approach. Techniques are available to adequately control potential cross-media effects (e.g. hg releases from waste water release of the FGD streams or capture of hg prior to entering into gypsum / wallboard production). Alternative BAT/BEP options which would prevent coal combustion and its associated negative effects beyond mercury emissions or releases should be promoted in the guidance as well (i.e. energy generation through sustainable renewable energy or energy efficiency measures);*
- *the guidance needs to be clear on the performance levels of control (and associated emission standards) considered to constitute BAT/BEP and what technique or combination(s) of technique(s) are considered as BAT for the purpose of drawing meaningful conclusions on what is achievable in the sector under economically and technically viable conditions, in accordance to the human health and environmental protection objectives to be achieved pursuant to the objectives laid down under this Convention. These performance levels need to be set under clear reference conditions in order to enable harmonized enforcement and level playing field;*
- *The guidance lacks emission levels considered as BAT which are achieved by industrial boilers. The scope should be clearly defined (e.g. in section 5)*

Page 12, after the text and above Figure 4

Addition:

"**Measured and verified stack mercury emission concentrations of EU and US coal fired combustion plants with different size, load, age and fuel types confirm that emission levels below 1µg/Nm³ are achieved by co-benefits only from common pollution controls such as SCR+ESP + wFGD or SCR+FF+FGD. For lignite fired plants, levels below 3µg/Nm³ are achieved.**

The Technical Working Group of the revised EU Best Available Techniques Reference Document (BREF) for Large Combustion Plants concluded that <1µg/Nm³ is achieved with specific mercury abatement techniques under technically and economically viable conditions for operators of both lignite and hardcoal fired new and existing sources (>50MW thermal)."

[See in the Annex 1 a table with sources provided]

Rationale: the document should provide clear guidance on what emission levels can be achieved already under technically and commercially viable conditions. The example of Japan is therefore very useful, which confirms also the levels achieved in the EU since more than a decade. The Final EU LCP BREF Technical Working Group meeting in June confirmed that <1µg/Nm³ (annual average, Oxygen level normalised to 6%) of hg emissions to air is achieved through dedicated mercury control techniques for all coal types judged as achieved under economically and technically viable conditions.

1. **Page 18, section 3.2.2.2 (SDA), paragraph "cross media effects for SO2 control devices".**

This issue of mercury sinks / release to water needs to be further developed in this section. WetFGD are the common SO2 abatement in the EU and there are techniques to ensure Hg capture in the wastewater of the FGD unit e.g. Membrane filtration. Additional evidence can be provided by the EEB showing that emission levels of mercury < 0.05µg/l (yearly average) prior to wastewater release are achieved. The Technical Working Group of the LCP BREF review agreed to set the range of concentration of hg emissions after the FGD waste water treatment plant at 0.2-3µg/l (daily averaged). For FGD gypsum used for wallboard the mercury can be removed with dedicated techniques (e.g. activated carbon and hydro-cyclones). This should be further elaborated in this section. Hg in FGD wastewater can be captured and hg in gypsum is also addressed through specific techniques.
As it stands the para suggests these cross-media effects cannot be overcome, which is misleading.

2. **Section 3.2. (at end of description of the common techniques with hg co-benefit)**

Addition (as per point 1):

"**Measured and verified stack mercury emission concentrations of EU and US coal fired combustion plants with different size, load, age and fuel types confirm that emission levels below 1µg/Nm³ have been achieved by co-benefits only from common pollution controls such as SCR+ESP + wFGD or SCR+FF+FGD. For lignite fired plants levels below 3µg/Nm³ are achieved.**

The Technical Working Group of the revised EU Best Available Techniques Reference Document (BREF) for Large Combustion Plants concluded that <1µg/Nm³ is achieved with specific mercury abatement techniques under technically and economically viable conditions for operators of both lignite and hardcoal fired new and existing sources (>50MW thermal)."

[See in the Annex 1 a table with sources provided]

Rationale: the document should provide clear guidance on what emission levels can be achieved already under technically and commercially viable conditions.

3. **Section 3.4.4 (performance levels of ACI)**

Similar to the previous point the guidance needs further emission levels achievable with the use of these techniques. The EEB has provided some reference plants for consideration, confirming that emission levels below 1µg/Nm³ are considered as BAT/BEP for existing sources. The table provided in *the Annex is based on validated data by the competent authorities (EU plants) and industry + NGOs sources for US data.*

4. Section 3.4.5 (mercury specific techniques)

The list of dedicated mercury techniques is incomplete. Please also include the information submitted on chemically enhanced membranes (Gore Modules). This technique is installed in some US plants (e.g. Cayuga) under commercially operating conditions and should be considered as established techniques. Emission levels achieved are below 0.2µg/Nm³ to ensure compliance with the New York hg state limit.

The EEB wishes that the guideline is complemented with basic description (attached in separate document, see Annex 2). Please extract only the relevant information needed (description, environmental performance, costs/benefits, applicability).

5. Section 3.5 Costs of mercury control technologies

*Modify: "Costs **and benefits** of mercury control technologies"*

Add data on the benefits of avoided hg emissions to the environment, public co-benefits of controls should be considered. This is in line with the objectives of the Minamata Convention (Article 1) based on human health and environmental protection and the definition of BAT (Article 2 (b) point ii). Only costs to operators of sources for installing hg controls are considered. This is a one sided presentation of the picture around mercury controls.

Public benefits (environmental + health protection) and benefits for the operators need to be presented in this section as well. The policy makers have agreed that the Minamata Convention should bring wider benefits, not just costs. The EEB/Greenpeace assessed the health impacts due to tighter air pollution standards, including on what it would mean if the EU would implement a tighter hg limit for coal LCPs. The study is available here http://www.eeb.org/index.cfm/library/eu-health-impacts-technical-report/ US EPA has also made some useful benefit calculations in the MATS rulemaking which should be included here.

6. Section 4 Emerging techniques

Delete: "providing oxidants or catalysts for elemental mercury oxidation to enhance mercury capture in downstream wet FGD"

Rationale: These are well developed and implemented techniques in industrial scale and should not be mentioned here in order to avoid confusion.

Section 4.2 (Non-thermal plasma) and Section 4.3 (Treated activated coke) needs to rewritten in order to provide clarity on what these techniques refer to and sources for performance levels achieved should be indicated.

7. Section 5 "Best Available Technique and Best environmental practices (BEPs) for coal combustion" (introduction)

Addition: (introductory paragraph for the implementation of the guidance)

"This guidance is intended to support Parties in selecting and implementing BAT for new and existing sources and in setting emission limit values accordingly that are consistent with BAT/BEP. The techniques described are generally applicable to the sector as a whole, as are the emission levels associated with BAT This guidance shall be used when selecting and implementing BAT for individual sources or [for coal-fired source categories under Annex D], it

may be complemented by other updated information, where appropriate. *Rationale: An introductory paragraph on how to use this guidance could be added to foster harmonised implementation and level playing field for regulated industry.*

8. Section 5.1.3 (mercury removal through co-benefits)

Modify:

"The combination of SCR, ESP and wet FGD) **covering all ages, sizes, operating hours and variation in abatement techniques** can achieve mercury removal efficiencies up to 74 per cent and below 0.0012 mg Hg/Nm^3 **(1.2µg/Nm^3, normalized to 6 % O_2-content)** of mercury concentration in the flue gas . Moreover usually the cost of controlling mercury as a "co-benefit" is small because it is mainly for other pollutants such as PM, SO_2 or NO_X .

Rationale: the variation of age, size classes, operating hours and abatement techniques type is considered in this range based on the EU reference plants data. The Technical Experts Group of the LCP BREF review confirmed in the Final LCP BREF that levels <1µg/Nm³ can be achieved with the use of Best Available Techniques under technically and economically viable conditions.

9. Section 5.1.4 (conversion / add reference conditions)

Modify:

"The operations of ACI technology in the United States show that mercury concentration in flue gas after ACI and fabric filters are lower than 0.001 mg Hg/Nm^3 **(1µg/Nm^3 normalized to 6 % O_2-content).**

Rationale: provide certainty for reference conditions used. The Technical Experts Group of the LCP BREF review confirmed in the Final LCP BREF that levels <1µg/Nm³ can be achieved with the use of Best Available Techniques under technically and economically viable conditions.

10. Section 5.1.4. (new) Add "Mercury emissions to water from waste water treatment plant"

Addition: after this section / or within each paragraph

"**Emission levels of mercury to water <0.05 µg/l (yearly) and 0.2-3µg/l (daily averaged) after the wastewater treatment plant from flue gas cleaning is achieved, such as by membrane filtration. The values are based on 24-hour flow-proportional composite samples. Mercury emission to water should be prevented e.g. through Zero Liquid Discharge Techniques due to environmental quality standards and compliance with the OSPAR Convention.**"

Rationale: this issue of mercury sinks / release to water needs to be further developed in this section. WetFGD are the common SO2 abatement in the EU and there are techniques to ensure Hg capture in the wastewater of the FGD unit e.g. Membrane filtration. Simple transfers of mercury release from t air to water should not be allowed. The levels are based on evidence provided by the EEB showing that emission levels of mercury < 0.05µg/l (yearly average) prior to wastewater release are achieved. The Technical Working Group of the LCP BREF review agreed to set the range of concentration of hg emissions after the FGD waste water treatment plant at 0.2-3µg/l (daily averaged). Significant emission reductions are necessary for the compliance to the OSPAR Convention.

11. Section 5. 2 Best Environmental Practices

Modify: "Effective pollution control management strategies, well-maintained facilities, well-trained operators, and constant attention to the process are all important factors in controlling and where feasible, reducing the emissions of mercury from coal combustion. As such, these practices, applicable to existing and new sources, are considered to be the BEPs, **and should**

be performed in a manner which facilitates and ensures compliance with BAT associated levels of control or emissions."

Rationale: BEP and BAT are complementary whilst the intended outcome should be the same. It is important to give guidance on what "best" could mean in this context.

Annexes

Annex 1:

Relevant to section 3.2.4 Emission Values achieved with Co-Benefit Techniques

The table below shows measurement values of mercury emissions for different hard-coal combustion plants, achieved through co-benefits for pollution controls. The table provides an overview of good performing EU and US-plants with different size, load, age and fuel types (if not mentioned otherwise data from 2010)

Plant	Emission level [µg/Nm³] @$O_2$6%	Averaging period	Boiler size (MWth)	Flue gas treatment technique
				Wet Systems
Federico II – Brindisi (IT)	0.69 in 2010	periodic	1,700	ESP+SCR+wFGD
Torrevaldaliga Nord (IT)	0.99 in 2010	cont.	1,420	FF+SCR+wFGD 2008
Impianto termoelettrico di Fusina (IT)	0.8 in2010	Periodic	431	FF+SCR+wFGD
Heyden (GER)	<0.8 in 2012 <0.32 in 2011 0.5 in 2010	periodic	2,150	ESP+SCR+wFGD
FHKW Mellach (AT)	0.5 in 2010	periodic	543	FF+SCR+wFGD
				Dry Systems
Brindisi BR III & BR II (IT)	0.5 in 2010	periodic	857	ESP+SCR
Krefeld, Currenta (GER) (Industrial boiler)	0.2 in 2010	periodic	105	FF
Salem Harbour (USA)	0.2 -0.4	annual 12 monthly rolling average.	unknown	FF

The table below shows measurement values of mercury emissions for different lignite combustion plants, achieved through co-benefits for pollution controls. The table provides an overview of good performing EU -plants with different size, load, age and fuel types

Plant	Emission level [µg/Nm³] @$O_2$6%	Averaging period	Boiler size (MWth)	Flue gas treatment technique
				Wet Systems
Power plant Tusimice (CZ)	2.6 in 2010	periodic	890	ESP+wFGD
Neurath, A and F (GER)	3.0 in 2010	periodic	855	ESP+wFGD
				Dry Systems
Teplarna Tabor (CZ)	3.3 in 2010	periodic	199	ESP

Relevant to Section *3.4.4*

The following table contains emission values with dedicated mercury abatement techniques for plants with hard coal and lignite.

Name	Emission level normalised [µg/Nm^3] @$O_2$6%	Averaging period	Boiler size [MWth] / Fuel	Flue gas treatment technique
				Wet Systems
Lünen (GER)	0,42 in 2014	periodic	1.705	ESP+SCR (TRAC-CAT)+wFGD
Southern Co. Units A-G Unit F (USA)	<1 (0.71 - 0.97 lb/TBtu	monthly/cont.	865 / hard coal	ACI+ESP+SCR+wFGD Unit B: ACI+FF+SCR+wFGD
				Dry Systems
Oak Grove, Boiler 1 USA	<0.80 in 2012	monthly/ cont.	870 / lignite	FF+SCR+FGD + ACI
PPI Montana Corette (USA)	<1 (0.79 lb/TBtu)	Cont.	163 / hard coal	ACI with C-PAC + ESP
Midwestern US (USA)	<1	unknown	Unknownt / hard coal	C-PAC + ESP
Brayton Point, Units 1,2,3 (combined), Massachusetts, USA	< 1 (0.12 – 0.18) lb/TBtu	Annual, 12-month rolling average	unknown	ACI
Bridgeport Harbor, Unit # 3	< 1 (0.16 – 0.47) lb/TBtu	periodic	400 / hard coal	ACI + ESP

SDA:	Spray Dry Absorber
ESP	Electrostatic Precipitator
FF	Fabric Filter
SCR	Selective Catalytic Reduction
wFGD	Wet Flue Gas Desulphurisation
ACI	Activated Carbon Injection
TRAC-CAT	Mercury specific Oxidation Catalyst
C-PAC	Cement friendly Pulverized Activated Carbon

Annex 2: Background information on GORE technique

GORE MERCURY CONTROL SYSTEM

Description

The GORE® Mercury Control System (GMCS) is based on a novel, fluoropolymer-based Sorbent Polymer Composite (SPC) material (Fig. 1) which efficiently removes both elemental and oxidized mercury from the flue gas stream. As such, it is insensitive to fuel or process changes that affect mercury speciation. Mercury is strongly bound within the SPC which has a high capacity for mercury storage allowing for long life without the need for regeneration. The SPC can operate even in very wet gas streams, making it ideal for location above the mist eliminators in a wet FGD system. The removal of SO2 is a co-benefit as it is converted to sulfuric acid which is expelled out of the hydrophobic SPC material into the absorber vessel below (Figure 2). When installed in a scrubber the GMCS serves as a barrier to mercury reemissions, since it is located at the outlet of the scrubber and effectively removes elemental mercury. This allows a plant to avoid the need for re-emissions additives, and focus the scrubber operation on avoiding other unwanted problems like selenate formation. Unlike many activated carbon sorbents, the presence of SO3 does not inhibit mercury capture by the SPC, making it a very effective solution for high sulfur coals or units with SO3 gas conditioning.

Operation is passive. There are no moving parts and adjustments are not needed to maintain performance as unit operations change. Since there are no injected sorbents, there is absolutely no concern over fly ash contamination or creating additional particulate matter that needs to be collected.

Chemicals for oxidation are also not needed thus eliminating halogen-induced corrosion concerns or wastewater treatment complications. The GMCS is modular in design with the SPC material arranged in open channels for low pressure drop. The modules are resistant to fouling or plugging, in part due to the smooth, non-stick nature of the SPC, and in part due to the continual acid wash created by the conversion of SO2 to liquid sulfuric acid. The modules can be stacked in the direction of gas flow to achieve the desired mercury removal efficiency.

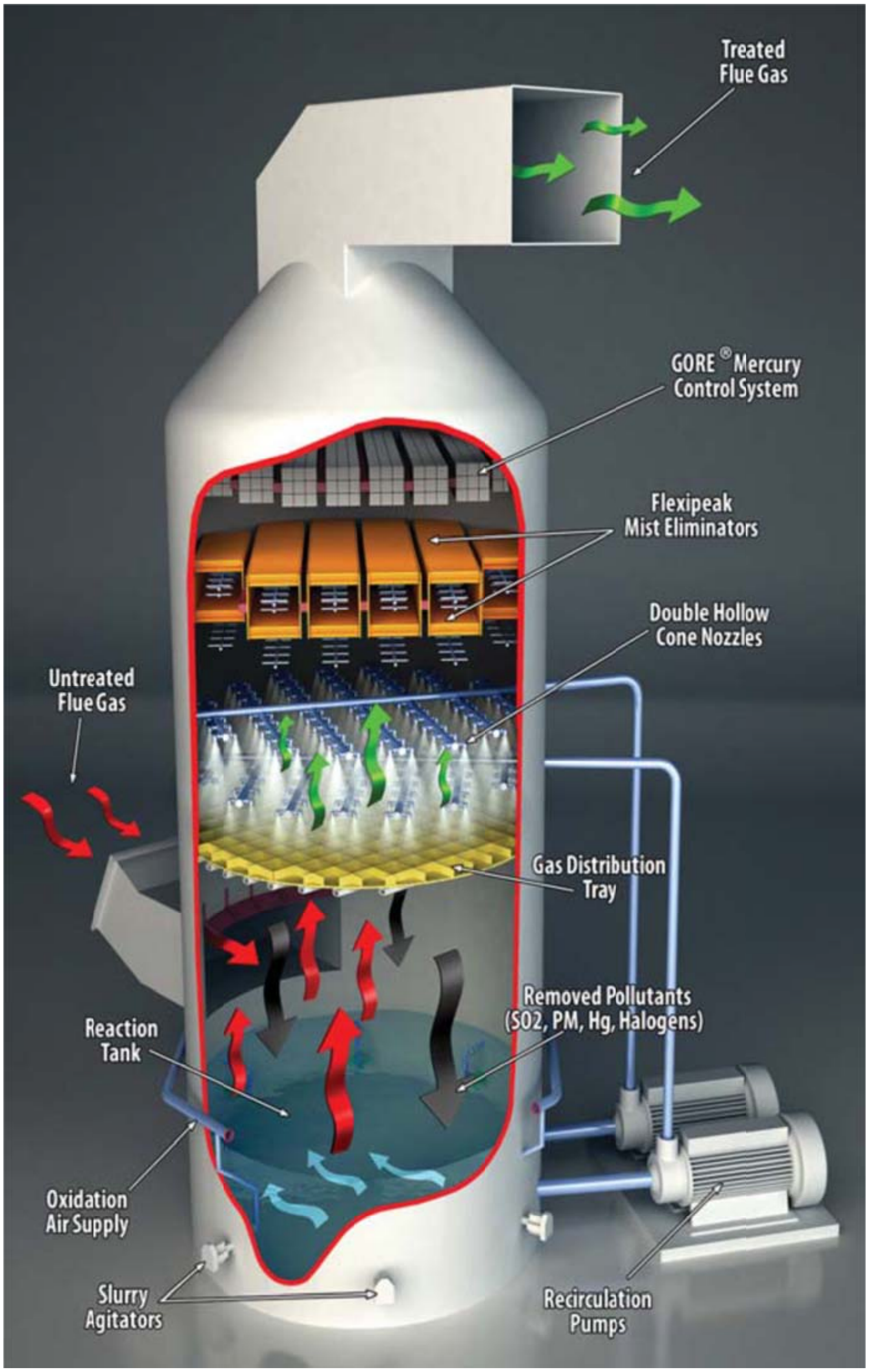

Figure 1: Gore Mercury Control System in a wet FGD scrubber

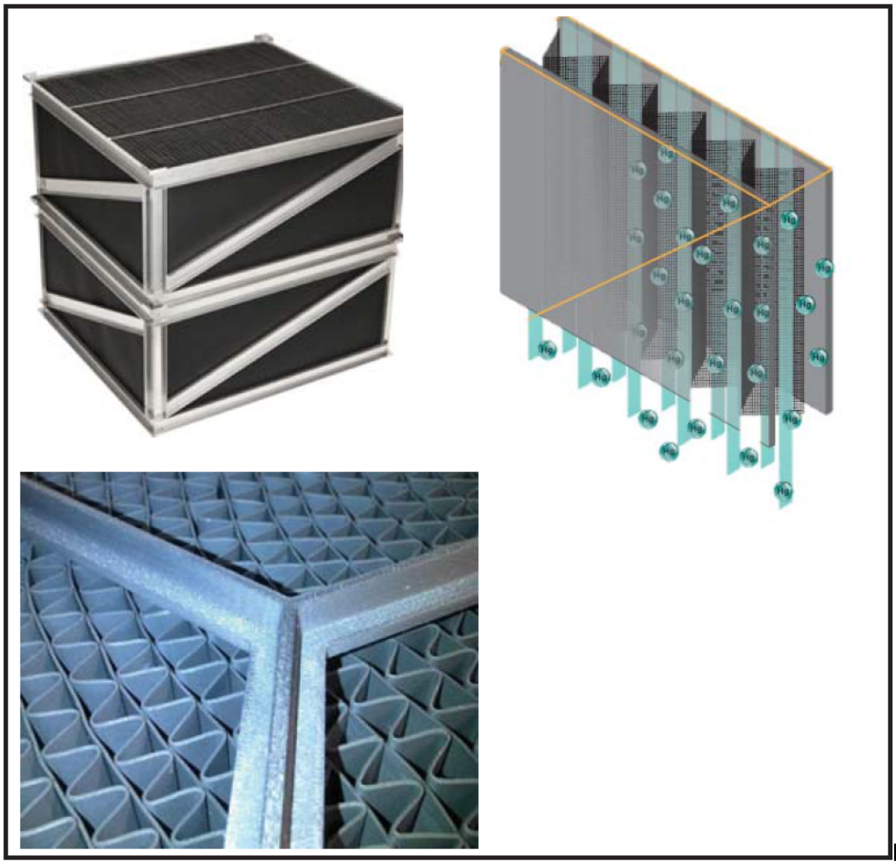

Figure 2: Construction of the Sorbent Polymer Composite

The GMCS can be designed to achieve required mercury removal efficiency approaching or exceeding 90% depending on the number of modules and gas velocity (Figure 3).

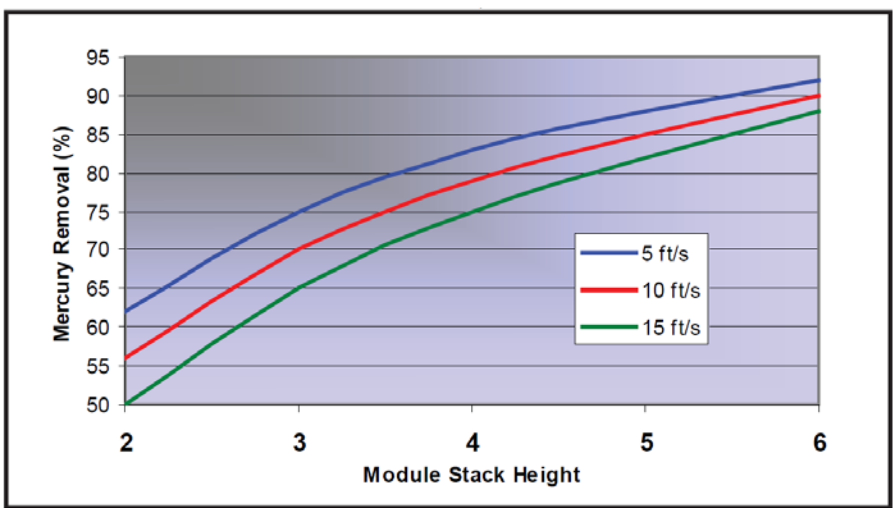

Figure 3: Stacked Modules Design for Desired Removal Efficiency

A GMCS installed within a scrubber absorber requires no additional footprint thus minimizing capital costs. The system is also very cost-effective to operate with module replacement required only on a very infrequent basis.

Environmental Benefit

Gore Mercury Control System captures elemental and oxidized mercury, does not require additives or chemicals and does not transfer mercury into the waste water or gypsum. It is insensitive to common sorbent poisons (SO3, VOCs) and can be installed in existing wet FGD scrubbers.

Operational Data

In July 2013, a full scale 75 MW system was installed in one scrubber at Xcel's Sherburne County (Sherco) plant in Minnesota, and operated for ~5 months. The system achieved an average of 60-70 % efficiency.

Figure 4 shows mercury inlet and outlet concentrations at Sherco.

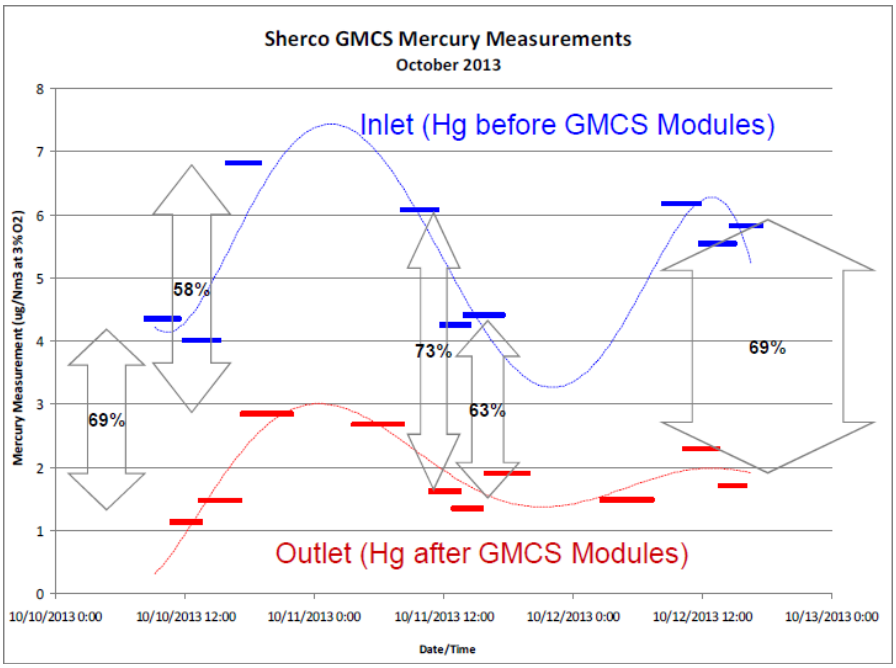

Figure 4: GMCS Inlet and Outlet Hg Concentration at Sherco

In June of 2014, a full-scale commercial 550MW system was installed at a confidential site in the Eastern U.S.. This site has operated continuously since installation and will reach one year of operation this summer.

In October of 2014, a full-scale commercial 160 MW system was installed at Cayuga Operating Company's Cayuga plant in New York. This plant operates this unit based on demand, and is subject to a more stringent state limit of 0.6 lb Hg /TBtu, which took effect on January 1, 2015. Typical uncontrolled Hg levels at the stack (prior to installation of the GMCS) are in excess of 2 lb/TBtu. The plant has been in compliance since start-up of the GMCS, with typical outlet mercury readings around 0.3 lb Hg/TBtu. See Figure 5.

FIGURE 5

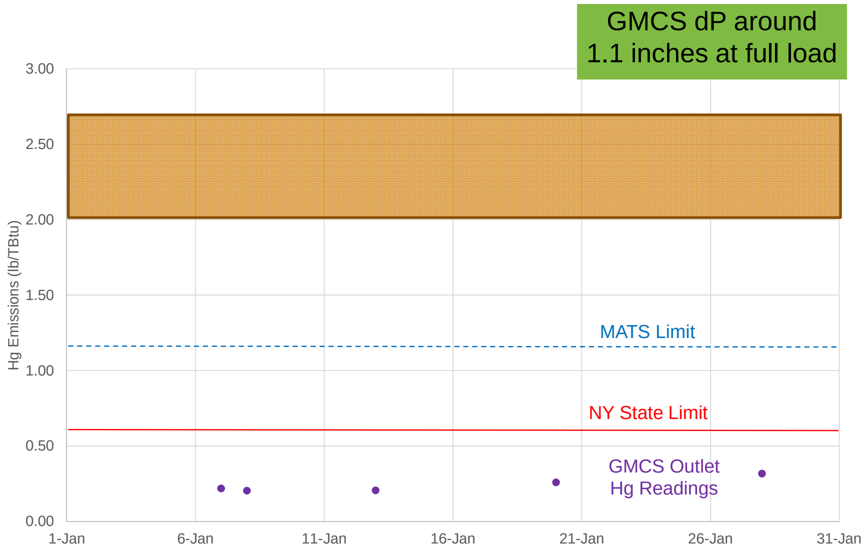

Figure 5: Outlet concentrations measured at Cayuga Operating Company via sorbent traps at the outlet of the Gore Modules.

In coal-fired power, another full-scale commercial installation sized at 450MW will be starting up in May of 2015 – construction is nearly complete and modules have been delivered. This will bring the installed capacity up to over 1000 MW. Two more large full-scale commercial units will start up in early 2016 (contracts are already signed and design work is underway), so that by the summer of 2016, the installed capacity will be approximately 2100 MW.

Pressure drop of the Gore Mercury Control System is less than 400 Pa. (The pressure drop through a single module layer is approximately 60 Pa at a gas velocity of 4 m/s.).

The SPC can retain over 5% of its weight in mercury without a drop in removal efficiency, equating to 1 to 2 tons of mercury holding capacity for a 1000 MW plant (see figure 6). As a result, the projected module lifetime for most power plants is around 10 years, based on the average mercury concentration in the flue gas after a wet scrubber.

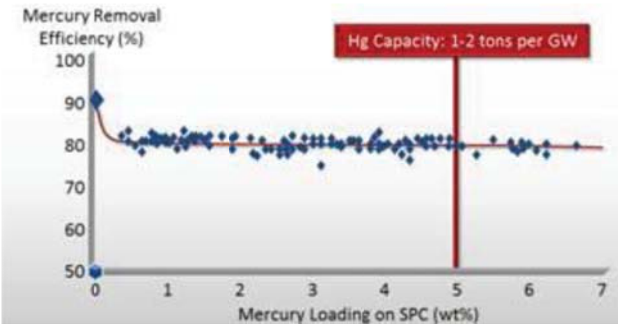

Figure 6: Hg Efficiency as a function of SPC Hg Capacity

Cross-media effects

Mercury is not shifted from flue gas to waste water, gypsum or any other media. The Gore modules are the sink for the captured mercury.

When the modules have reached end-of-life, the SPC material can be removed for disposal while the housing can be reused. Options for material disposal include landfill in an approved hazardous waste landfill or sending to a retort facility for mercury removal and disposal in a non-hazardous landfill. The quantity of SPC material that needs to be disposed of at the module end-of-life is at least several orders of magnitude smaller than the quantity of injected sorbents that would be used to control mercury with a sorbent injection system for the same period of time. As a result, the disposal costs are typically considerably lower than with competing approaches for mercury control.

Applicability

The Gore modules can be located in a wet FGD system above (downstream of) the mist eliminators where they can be an effective barrier to mercury re-emissions from the scrubber. If mist eliminators do not leave sufficient room above for installing the GMCS, they can be reconfigured and lowered so as to provide sufficient room for module installation.

For plants that do not have wet FGDs installed, this technology can be applied after a dry scrubber, or even as a stand-alone solution for mercury and SOx. Depending on the application, an evaporative cooler may be installed upstream of the Gore Modules to cool the gas stream to around 85 °C for maximum effectiveness. Although these non-wet FGD installations require a separate structure to house the modules, which increases capital costs and space requirements, many of the other advantages are maintained. The GMCS has been successfully tested in various other applications such as mercury removal from cement kiln flue gas, and is being considered for a wide variety of industrial applications beyond coal-fired power plants.

In addition to coal-fired power applications, several full-scale installations in sewage sludge incinerators are under way and will start-up before spring 2016. Although the application is different, the installation approach is similar, with several layers of modules being placed at the outlet of the wet venturi scrubber providing the necessary mercury control to achieve compliance. These applications have higher mercury concentrations and smaller gas flow rates compared to coal fired power, but the modules function in the same fashion.

Economics

Gore has conducted several dozen system designs for U.S. power plants in which the capital and operating costs are compared to various alternative approaches such as carbon injection or calcium bromide coal additives. In nearly all cases evaluated, the GMCS can be installed in the existing wFGD, and the GMCS approach offers compelling economic advantages over the alternatives being considered by those plants. In particular, the operating costs of the GMCS tend to be very low, and the risk of certain unintended consequences (lost fly ash sales, bromine induced corrosion) is eliminated. Since the economics are typically fairly site-specific, it is recommended that interested plants contact Gore and provide some specific plant information in order for a more accurate cost projection to be provided. Figure 7 shows a typical cost comparison.

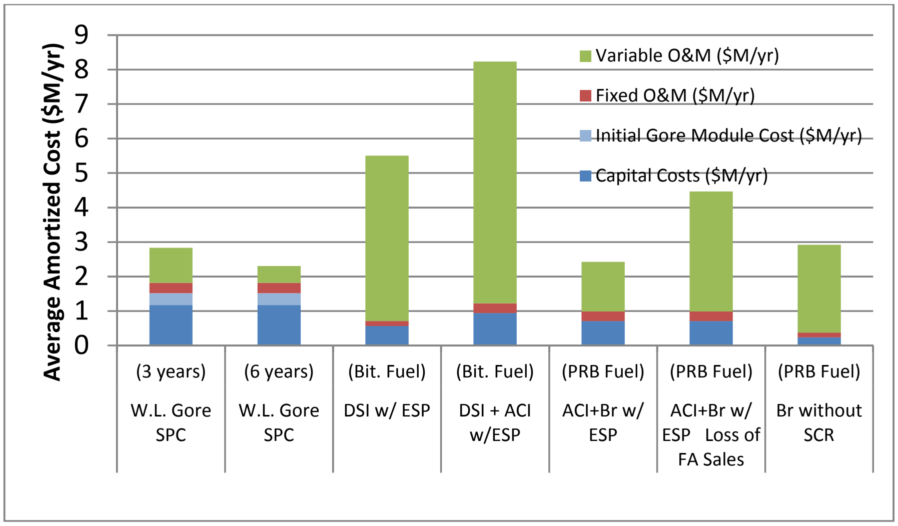

Figure 7 Cost Comparison of Gore Technology with Other Mercury Control Technologies (Power)

Summary of Benefits of GORE™ Mercury Control System

- Low Impact
  - Requires no carbon injection with no concerns about resulting fly ash contamination or additional particulate loading
  - Requires no bromine injection eliminating corrosion and wastewater concerns
- Low Maintenance
  - Has no moving parts
  - Does not require adjustments to maintain mercury removal
  - Does not need regeneration
- Robust Performance
  - Removes elemental and oxidized mercury species with equal effectiveness
  - Is insensitive to SO_3
  - Provides re-emissions barrier when installed in a wet FGD absorber
- Cost Effective
  - Has long module lifetime
  - Demonstrates low operating cost
  - Has a zero footprint in a wet FGD absorber
  - Removes SO_2 as a co-benefit
- Mercury Removal Guaranteed

Driving Force for Implementation

- Legal requirements

Reference Plants

1. Xcel Sherburne County
   - Coal-fired power plant, Minnesota
   - Single Absorber, ~75 MW
   - July – December 2013
2. Confidential Site
   - Coal-fired power plant, U.S.
   - 550 MW Absorber
   - Operating continuously since June 2014
3. Cayuga Operating Company
   - Coal-fired power plant, New York
   - Single Absorber, ~160MW
   - Started up and operated intermittently since Oct 2014
4. Confidential Site
   - Coal-fired power plant, U.S.
   - Two Units, ~450MW each

- Fabrication underway
- First Unit start-up May 2015, second unit start-up May 2016

5. Confidential Site
    - Coal-fired power plant, U.S.
    - 550MW Absorber
    - Scheduled start-up April 2016

Reference Literature

- Klingspor, Jonas (AECOM), Roll, Douglass (Cayuga Operating Company), Kolde, Jeff (W.L. Gore). “Installation of a Gore Mercury Control System at Cayuga”, EUEC conference in San Diego, Feb 17, 2015
- Klingspor, Jonas (URS), Kolde, Jeff (W.L. Gore). “URS/Gore: Gore Mercury Control System”, Reinhold APC Conference in Louisville KY, July 15, 2014
- Kolde, Jeff (W.L. Gore) et al, Machalek, Tom (URS) et al, Henningsgaard, Robert (Xcel Energy), Pazarsky, Jaren (Great River Energy) et al, Chang,Ramsay (EPRI). “Field Results of Fixed Structure Sorbent Technology for Mercury Reduction”, PowerGen conference in Orlando, Nov 13, 2013