Innovative Mercury Control:

Power Plants, Waste Incinerators and Industrial Boilers

Non-nuclear fossil fuel-burning power generation and some other industrial installations (waste incinerators, steel and aluminum mills, petrochemical plants etc.) are a major source of heavy metal emissions to the atmosphere. Fossil fuel combustion is presently the principal source of Hg, Cd, Pb and As to the atmosphere on a global scale with certain elements such as Hg, contributing to nearly 60% of its global anthropogenic atmospheric releases. The main threats to human health from heavy metals are associated with exposure to mercury, lead, cadmium, and arsenic. Exposure to those metals was proved to cause kidney, skeletal, neurological and psychological damage. Severity ranges from reversible upon cease of exposure to lasting, carcinogenic effects and lethal outcomes[1].

Mercury can harm children's developing brains, including effects on memory, attention, language, and fine motor and visual spatial skills. Mercury and many of the other toxic pollutants also damage the environment and pollute lakes, streams, and fish. The main danger is in the ambient mercury is its propagation and enhancement of the mercury cycle in nature (*Figure 1*). Widespread dispersion and deposition on land and in surface waters provides a relatively direct pathway for eventual accumulation of methyl-mercury (MeHg) in the ecosystem. Bioaccumulation of methyl-mercury in the food chain and ingestion lead to potentially adverse neurological and developmental health effects.

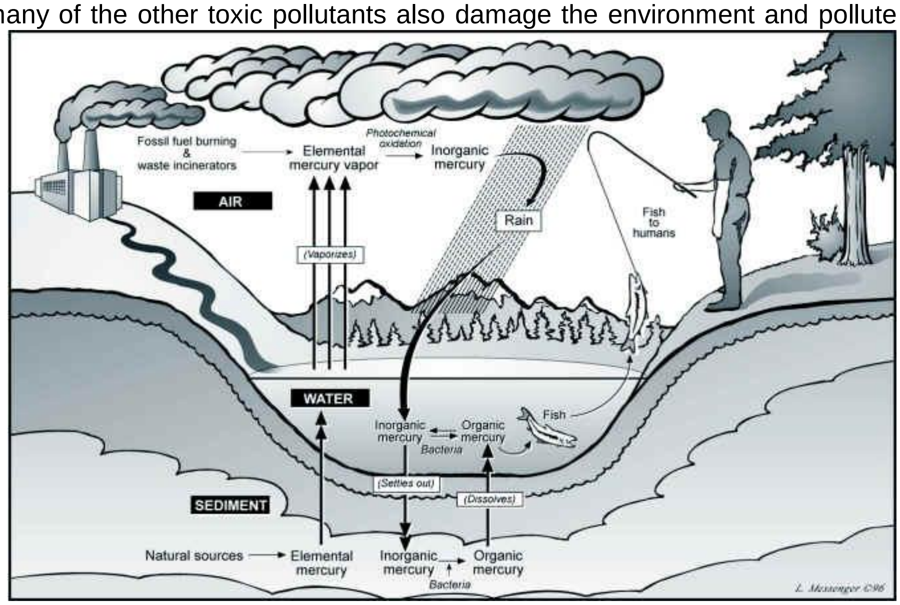

Figure 1. Mercury cycle in nature

In 1990, three industry sectors made up approximately two-thirds of total U.S. mercury emissions: medical waste incinerators, municipal waste combustors, and coal-fired power plants. Two of those sectors became subject to standards and struggle to reduce their mercury emissions. Those regulations have significantly reduced mercury emissions from different sources, such as cement production and steel manufacturing[2].

Among the various hazardous air pollutants (HAPs) generated by power plants, the U.S. EPA concluded in December 2000 that mercury and its compounds presented the greatest concern[3]. In March 2011, EPA proposed the first national standard to reduce mercury and other toxic air pollution from coal power plants.

Mercury appears in the flue gases in two main forms: elemental and ionized (Hg^{2+}). The ratio between the two depends on the type of the coal and the concentration of halogens in it. If not removed they will be discharged to the atmosphere through the stack.

There are two main and several co-beneficial methods of controlling mercury emission from the flue gases. In the table below the two main methods compared to the Lextran solution are presented.

	Method	Reagent	CapEx/OpEx	Disadvantages	Co-benefits
Activated Carbon Injection (ACI)	Activated carbon absorbs gaseous Hg, converting to particle Hg that is captured in downstream PM control device.	Powdered Activated Carbon	Low/High	- Downstream PM control needed - Ineffective on high-sulfur coals - Ineffective if SO_3 is present - Toxic waste (bag-filters containing high levels of mercury)	Some capture of dioxins/furans
Halogen Addition	Halogen (bromine) addition to flue gas increases oxidized Hg that is easier to capture in a downstream scrubber or in PM control device.	Halogen containing additive	Negligible/High	- High OpEx - Demands an FGD infrastructure	None
Lextran	Lextran reagent forms a very strong and stable complex with Hg. On the basis of coal-fired boiler producing 10-30μg/m3, the amount of Lextran material present is sufficient to absorb over three years before regeneration in a separate process.	Lextran reagent (regeneration once in 3-5 years)	High/Very low	- Demands an open spray tower	- 98% De-SOx - ~70% De-NOx - Highly profitable byproducts (fertilizers) - No toxic waste

Co-benefit Methods of Control:

PM Controls (ESP, FF, multicyclone) – Captures particle-bound mercury
Dry Sorbent Injection – Increases co-benefit and ACI Hg capture by removing SO_3, which suppresses mercury capture
Dry Scrubber with Fabric Filter – Hg captured in downstream fabric filter
Wet Scrubber – Oxidized mercury captured in wet scrubber
NOx Catalyst – Catalyst in SCR increases oxidation of Hg that is more effectively captured in downstream wet scrubber

The conventional "Halogen Addition + lime-FGD scrubbers" technology not only provides just a partial solution for the high concentrations of mercury in the flue gases, but might also pose an environmental threat from the byproducts which may contain high volumes of mercury and other heavy metals. As occurred in many “contaminated dry-walls” cases[4] the hazardous materials do not stay at the landfills or near the pollution centers but also find their way to our homes, schools and offices. Furthermore there is not fully explained effect of mercury re—emission from the WFGD systems.

Selecting technology that includes lime-FGD can introduce a regulatory problem. Concurrently with the hazardous air pollutants regulations, governments are also tightening surface water discharge trace metals’ and salts’ limits. Most lime-FGDs discharge wastewaters that are either slurry of water, dissolved solids, and/or suspended solids laden with heavy metals and salts. Thus, the further use of lime-FGDs is in conflict. For example, in most European countries the sludge water is classified as hazardous[5]. Therefore, utilities must also develop a strategy for wastewater treatment systems for the scrubber purge stream.

Lextran innovative mercury removal for Industry and Power Plants

Lextran Ltd. has developed a very simple (Figure 2) and cost effective technology to remove mercury and other heavy metals from combustion flue gases. Lextran offers a highly amenable solution that involves no byproducts and is very effective and technologically reliable. Our innovative de-Hg process demonstrates unprecedented rates **(98%)** of mercury removal. With virtually **no traces of mercury** in the flue gases, any plant can enjoy the good of both worlds: low operational cost, simple operation that involves no toxic byproducts, and no mercury pollution.

The process is conducted in an open spray tower. At the heart of the process is Lextran organic reagent which is injected into the tower and reacts with the mercury rich flue gases. The reagent in a form of water emulsion is fed from the bottom to the top of the absorption tower and as it flows down it selectively reacts with mercury to form a stable complex. From the bottom of the absorption tower, the reagent is returned to the top for additional absorption - thus completing the cycle.

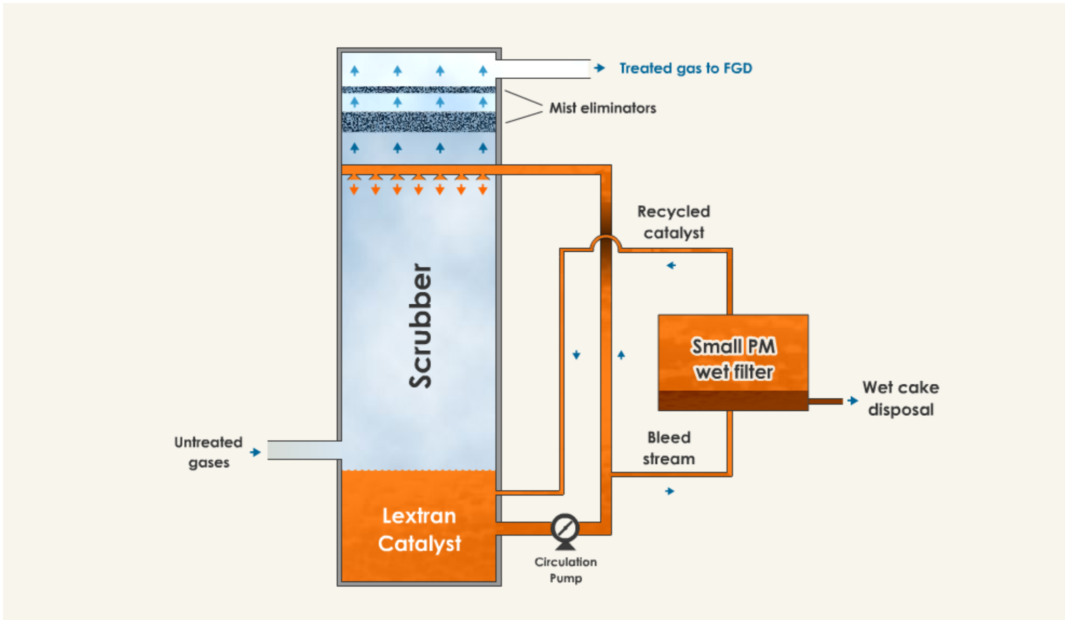

Figure 2. Schematic diagram of de-Hg process

The full abatement of mercury will be reached at the optimal flue gases speed of 3-4 m/sec and in wide range of temperatures (of the surroundings and the flue gases). The complex is strong and stable so there is no re-emission or "mercury slip". Mercury saturated reagent does not affect the reaction and remains stable until it is re-generated in an offline separate process.

Based on a 500MW unit, the typical tower, depending on the specifics of the treated installation, would measure 16-18 meters (52-59 ft) of height and 15 meter (50 ft) in diameter - just over 175 m^2 (~1900 ft^2) of operational area. The unit producing 2.5 *mil* m^3 of flue gases and emitting ~20 µg of mercury per hour can enjoy non – stop abatement for over four years (!!). The volume of reagent provided with the tower ensures saving on down time, expenses on maintenance, cleaning or regeneration.

The uniqueness of the process is not only in the extraordinary rates of abatement, but also in the fact that Lextran provides totally closed-cycle operation. It produces neither liquid waste, thus eliminating the need in water treatment facilities nor solid waste or byproducts effectively crossing out the disposal and treatment expenses from the capital and operational balance.

[1] Jarup L., "Hazards of heavy metal contamination", *British Medical Bulletin* (2003) 68 (1), pp. 167-182.

[2] *Power Plant Mercury and Air Toxics Standards: Overview of Proposed Rule and Impacts*, U.S. Environmental Protection Agency, available at: http://www.epa.gov/airquality/powerplanttoxics/pdfs/overviewfactsheet.pdf

[3] *Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units – Final Report to Congress*, U.S. Environmental Protection Agency, EPA-453/R-98-004a, February 1998; *Control of Mercury Emissions from Coal-fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02*, U.S. Environmental Protection Agency, EPA-600/R-01-109, April 2002

[4] http://www.propublica.org/series/tainted-drywall

[5] Kikuchi R.," Alternative By-Products of Coal Combustion and Simultaneous SO_2/SO_3/NO_x Treatment of Coal-Fired Flue Gas: Approach to Environmentally Friendly Use of Low-Rank Coal", in Kenneth S. Sajwan et al. ed., *Coal Combustion Byproducts and Environmental Issues*, (New York: Springer, 2006), pp.23-24