PROGRAM facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental and Water Resources

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MERCURY CONTROL TECHNOLOGY RESEARCH PROGRAM

Background

Mercury exists in trace amounts in fossil fuels (e.g., natural gas, coal), vegetation, crustal material, and waste products. Through combustion or natural processes, mercury vapor can be released to the atmosphere, where it can drift for a year or more, spreading with air currents over vast regions of the globe. Current estimates approximate that 5000 tons of mercury is released annually into the atmosphere from anthropogenic (man-made) and natural sources combined. Anthropogenic sources in the United States account for about 3 percent of the total annual global mercury releases, with U.S. power plants contributing about 1 percent of the world total.

New York State Electric Gas Corporation's Milliken Station

Mercury emissions have fallen in the United States during the 1990s. In 1993, yearly emissions totaled about 242 tons. By the end of the decade, emissions had declined to less than 160 tons per year. Emissions are expected to continue to fall due to a phasing out of mercury in commercial products and restrictions placed on emissions from municipal waste combustion and medical waste incineration.

Coal-fired power plants currently emit about 41 tons of mercury, or about 40% of total U.S. man-made mercury emissions. While mercury emissions from other industrial sectors are being regulated, controls have not yet been placed on electric-utility boilers. However, on December 14, 2000, the U.S. Environmental Protection Agency determined the need to reduce emissions of mercury from power plants through the implementation of maximum achievable control technology (MACT). Under the EPA regulatory finding, final rules are to be in place by 2004, with compliance by 2007. Mercury regulations are also being considered as part of a more flexible three-pollutant control strategy recommended in the President's May 2001 National Energy Policy. Whether regulated under MACT or a market-driven cap-and-trade approach, substantial reductions in mercury from power plants will likely be required over the next decade.

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WHY THE CONCERN?

Concentrations of mercury in air and water are usually low and cause little direct health concerns. In water, however, bacteria can transform mercury into methylmercury, a more toxic and bioaccumulative form of the metal. Methylmercury levels can build up in predatory fish and marine mammals to thousands of times higher than concentrations in surrounding waters.

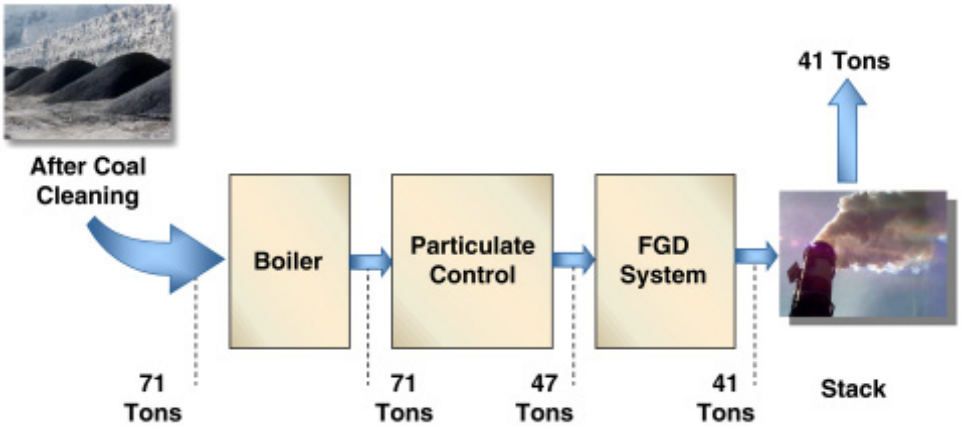
People who consume average amounts of commercially available fish as part of a balanced diet are not likely to take in harmful amounts of mercury. However, fetuses exposed to methylmercury through their mother's consumption of contaminated fish are more sensitive to adverse effects because the developing nervous system is more vulnerable to mercury toxicity.

NETL is working to keep our coal fired electric power generating industry the cleanest and most reliable in the world.

Program Description

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) manages the largest research program in the world focused on the emission of mercury from coal-fired power plants. Working collaboratively with industry, academia, state and local agencies, and EPA since 1990, NETL has greatly advanced our understanding of the formation, distribution, and capture of mercury from electric-utility boilers. However, some degree of uncertainty remains, particularly related to the cost and effectiveness of mercury control technology, and the ultimate fate of mercury once it is removed from flue gas.

The challenges of removing mercury from coal-fired boilers are many. Complicating factors include the type of coal being fired, the design of boiler and combustion systems, the type of emissions control equipment in place, the chemical form of mercury, the properties of the fly ash, and the relatively low concentration of mercury in flue gas.



Mercury reductions through a coal-fired power plant

There is no commercial technology available today that can consistently and cost-effectively remove mercury from power plant flue gas. Based on the 1999 Mercury Information Collection Request, the effectiveness of existing emission controls in removing mercury can vary considerably from plant to plant, and even from boiler to boiler. Mercury removal can range from essentially no control to as high as 90%, depending on the factors noted above.

In response to these challenges, NETL is carrying out a comprehensive research program focused on (1) enhancing the performance of existing air pollution controls (e.g., electrostatic precipitators, fabric filters, and wet scrubbers) and (2) developing advanced control concepts to achieve high levels of mercury removal at costs considerably lower than current technology. NETL is also sponsoring a number of laboratory and field efforts to better understand the emission and fate of mercury from coal-based power systems.

Project Summaries

In September 2000, NETL awarded projects for full-scale testing of two approaches to improve the mercury-capture efficiency of existing air pollution control equipment. The goal is to provide technology options by 2005 that can achieve 50 to 70% mercury removal at ½ to ¾ current costs.

- Babcock and Wilcox, in conjunction with McDermott Technology, Inc., Allison, OH, is demonstrating an approach to enhance the removal of mercury across wet flue-gas desulfurization ("wet scrubber") systems. About 76 gigawatts, or approximately ¼ of existing coal-fired electric-generating capacity is equipped with wet scrubbers to capture SO_2. The concept adds very small amounts of a liquid reagent to the scrubbing solution to attain at least 90% mercury removal. The MTI process will be tested at full scale at Michigan South Central Power Agency's 55-megawatt Endicott Station in Litchfield, Michigan, followed by testing at Cinergy Corporation's 1300-megawatt Zimmer Station near Cincinnati.

- ADA Environmental Solutions, Littleton, CO, is testing a sorbent-injection technology at four different utility power plants. The technology involves the injection of a dry sorbent, such as fly ash or activated carbon, which adsorbs the mercury and makes it more susceptible to capture by the particulate control devices. Testing will be performed at Alabama Power's Gaston plant, equipped with a fabric filter and COHPAC. Wisconsin Electric Power Company is providing a second test site (Pleasant Prairie) that burns Powder River Basin coal and has an electrostatic precipitator for particulate control. PG&E will provide the final two sites at the Salem Harbor and Brayton Point power stations that fire bituminous coals and are equipped with electrostatic precipitators and carbon/ash separation systems.

Jim Kilgroe (EPA), Scott Renninger (DOE/NETL), and George Offen (EPRI) discussing strategy during the ADA-ES sorbent injection kickoff meeting at the Southern Company Gaston Station on April 18, 2001.

MERCURY AND POWER PLANTS

Mercury is found naturally in coals throughout the world. The amount of mercury found in coals can vary greatly depending on coal type and origin. Because mercury is highly volatile, when coal is burned nearly all of the mercury vaporizes and is in the flue gas exiting the boiler.

The speciation or form of mercury in flue gas is typically elemental mercury or oxidized mercury. The particular form that mercury takes within the gas plays an important role in how the mercury can be removed. The oxidized form of mercury is more easily removed and preliminary data has demonstrated that existing pollution control devices, such as scrubbers and particulate control systems, achieve some degree of mercury removal. The control and removal of elemental mercury is much more complex. Better understanding of the underlying chemistry of all forms of mercury is critical to the development of cost effective control measures.

The mercury control technology research program is a part of NETL's larger Innovations for Existing Plants (IEP) Program. The IEP Program seeks to create technology options that will enable the current fleet of coal-fired power plants and gasification systems to comply with future environmental regulations at low cost.

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In June 2001, NETL selected six new projects focused on developing novel concepts for mercury control that could provide utilities with a wider range of options. These technologies are to be available by 2010 and capable of 90% or greater capture of mercury, as well as other air pollutants. Testing will be performed at the bench- and pilot-scale level.

ADA sorbent feed system at the Gaston power plant

- **The Energy & Environmental Research Center at the University of North Dakota**, Grand, Forks, ND, is developing an advanced particulate collector that combines the best features of baghouses and electrostatic precipitators and offers the potential of removing 90% of all mercury emissions released by a coal-fired combustor.
- **URS Group. Inc.,** Austin, TX, is developing catalysts that can convert elemental mercury into an oxidized form that can be removed by flue gas "wet scrubbers" that may become more commonplace on coal-fired power plants.
- **CONSOL, Inc.,** Library, PA, is adapting a mercury control system now used on municipal waste combustors to coal-fired power plants to remove not only mercury but also sulfur pollutants that can create visible plumes and other balance-of-plant problems.
- **Southern Research Institute**, Birmingham, AL, is testing the effectiveness of calcium-based chemicals — such as lime and silica lime additives — to capture and oxidize mercury into a form more easily removed from a power plant's flue gas. The calcium sorbents also remove sulfur pollutants.
- **Powerspan Corp**., Durham, NH, is testing a multi-pollutant removal system that uses an electrical discharge to convert mercury to mercuric oxide, nitrogen oxides to nitric acid, and sulfur dioxide to sulfuric acid. In its oxidized form, mercury can be captured in a wet electrostatic precipitator along with other tiny solid particles.
- **Apogee Scientific, Inc.**, Englewood, CO, is studying the effectiveness of up to a dozen carbon-based and other chemical sorbents that show promise in removing more than 90% of mercury and costing 40 to 75% less than currently available commercial sorbents.

Related Projects

In support of the control technologies being developed, NETL is also sponsoring research to better understand the speciation and fate of mercury in coal-combustion flue gas.

- **The Energy & Environmental Research Center at the University of North Dakota**, Grand, Forks, ND, is assessing the effects that full-scale selective catalytic reduction (SCR), selective noncatalytic reduction (SNCR), or flue gas conditioning systems have on the speciation of mercury and its subsequent impact on total mercury removal.
- **CONSOL, Inc.,** Library, PA, is evaluating the impact of controlling mercury from coal-fired utilities on the use and disposal of coal byproducts (e.g. fly ash). Leachability and other tests are being conducted to determine the final fate of mercury in coal-fired power plant byproducts.