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Air Pollution Emission Control: Existing Technologies and Mercury Cobenefits

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Summary

The Environmental Protection Agency (EPA) regulates the amount of pollution emitted into the atmosphere by stationary combustion sources. To meet these regulations, stationary sources use various techniques to reduce air pollutant emissions, including installing post-combustion emission control technologies. Some post-combustion technologies reduce the emissions of other pollutants besides the one for which they are designed. These concomitant reductions are called cobenefits. The EPA has proposed regulating mercury emissions from coal-fired electric power plants by relying on the results that these post-combustion emission control technologies achieve through cobenefits. The appropriateness of using cobenefits to set emission limits, the reproducibility and reliability of cobenefits, and the likelihood that new technologies specifically designed to reduce mercury emission will be commercially available in the near future are issues of congressional interest. This report will not be updated.

Introduction

The Environmental Protection Agency (EPA) has proposed regulations to reduce atmospheric mercury emission from coal-fired electric power plants,[1] as a plausible link exists between methylmercury concentrations in fish, a source of mercury-related health effects in humans when consumed, and electric utility mercury emissions. The final EPA regulation will provide either a mercury emission rate per generating unit or alternatively a national mercury emission cap with tradeable emission credits. For more on the EPA Mercury Rule, see CRS Report RL31881, *Mercury Emissions to the Air: Regulatory and Legislative Proposals*, by (name redacted) and CRS Report RL32273, *Air Quality: EPA's Proposed Interstate Air Quality Rule*, by (name redacted) and (name redacted).

These proposals have led to renewed congressional interest in current post-combustion emission control technologies. Under the proposed regulatory frameworks, the required mercury emission reductions would be realized through cobenefits, reductions in mercury which arise as a side effect from current emission control

[1] 69 *Fed. Reg.* 4652-4752, January 30, 2004, and 70 *Fed. Reg.* 12398-12472, March 16, 2004.

technologies designed for capture of other pollutants. This report will discuss these and other current emission control technologies and their application to reducing mercury emissions from electric utilities.

Background

The EPA, under the provisions of the Clean Air Act (42 U.S.C. 7401-7671), has set National Ambient Air Quality Standards for six pollutants. These six pollutants, often referred to as criteria pollutants, are lead, ozone, nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide, and particulate matter. The degree to which stationary combustion sources emit criteria pollutants often depends on the fuel used. For example, combustion of fuels containing larger amounts of sulfur-containing compounds may lead to greater emissions of sulfur dioxide. Approaches to reduce these emissions include pretreatment of fuel, optimization of combustion, and post-combustion control technologies. This report focuses solely on post-combustion control technologies.

The performance of post-combustion emission control equipment depends on many factors, including fuel composition, the design of the emission system, the flow speed of the flue gases (exhaust), the completeness of the combustion process, and the presence of other complementary emission control technologies. Thus, determining the control efficiencies for different technologies without empirical testing is very difficult. Control efficiency models for a given emission control technology usually contain experimentally determined values specific to a particular combustion process.

Companies that own and operate stationary combustion sources may choose to implement different control technologies, so long as pollutant emissions meet the limits established in EPA regulations. A company's choice of post-combustion emission control technology may not be based solely on pollutant control efficiency. Other factors include relative costs, both capital and operating; production of additional waste streams, such as from technologies using liquid solutions to remove pollutants; energy use; and technology interdependence.

Post-combustion Emission Control Technologies

Post-combustion emission control technologies are generally designed to remove a particular pollutant, and may be operated in different combinations. An overview of select post-combustion control technologies is provided below.

Selective Reduction for Nitrogen Oxides. Selective reduction techniques reduce the amount of nitrogen oxides (NO_x) present in the flue gas through injection of ammonia gas, which reacts with the nitrogen oxides to form nitrogen and water vapor. There are two types of selective reduction technologies, catalytic and non-catalytic. Selective catalytic reduction (SCR) employs a bed of materials, such as specially prepared ceramics, which enhances the reaction of ammonia with the nitrogen oxides. Selective non-catalytic reduction (SNCR) involves the same process without the assisting bed of materials, instead operating at higher temperatures.

Scrubbers for Sulfur Dioxide. Flue gas desulfurization (FGD) technologies, also known as scrubbers, are primarily designed to remove sulfur dioxide from flue gas.

Scrubbers fall into two general types: wet and dry. In both cases a material, typically powdered or dissolved limestone, reacts with sulfur oxides present in the flue gas, forming compounds which are later removed.

Wet scrubbers spray a liquid mixture into the flue gas. There are many different configurations of wet scrubbing technology, but they operate on the same principles of gas/liquid interaction. Their energy costs, control efficiencies, and other factors vary by particular configuration. Because of the use of liquids in wet scrubbers, handling and potential treatment of waste liquids is often a design concern.

In contrast, dry scrubbers, also known as spray dryer adsorbers (SDA), react powdered, dry material with the flue gas. Dry scrubbers usually create significant particulate matter during their operation, and are often coupled with a particulate matter control technology to remove the additional powdered material. The sulfur dioxide emissions reduction in a dry scrubber are generally less than in a wet scrubber, but dry scrubber use avoids generating a liquid waste stream.

Particulate Matter Controls. Three common technologies specifically for particulate matter (PM) control are mechanical collectors, electrostatic precipitators, and fabric filters. The choice between mechanical collectors, electrostatic precipitators, and fabric filters depends on the amount and size of PM generated. PM control is also a cobenefit of wet scrubbing.

Mechanical Collectors. Mechanical collectors, also known as particle scrubbers (PS), use gravity or inertia to extract particulate matter from the flue gas. Baffles and chambers that allow large particles to settle from the flue gas are examples of mechanical collectors. Also in this category are cyclones, in which the flue gas is induced to travel in a spiral pattern so that centrifugal force pushes the particulate matter out of the gas onto the walls of the cyclone, where it is collected and disposed of. Mechanical collectors are most efficient for removal of large particulate matter.[2] In situations where multiple emission control technologies are being used, cyclones are sometimes used to remove the majority of large particulate matter, with finer particulate matter being reduced subsequently by another technology.

Electrostatic Precipitators. Electrostatic precipitators (ESP) use a strong electric field between electrodes to draw particulate matter out of the flue gas. The efficiency of this process hinges on several factors, including the length of the precipitator (longer precipitators have higher efficiencies), the strength of the electric field (stronger electric fields have higher efficiencies), and the electrical resistivity of the particles in the flue gas (only particles within a range of electrical resistivity are efficiently removed). Electrostatic precipitators are referred to as cold-side (CS-ESP) or hot-side (HS-ESP) depending on their location in the flue exhaust stream. Properly designed electrostatic precipitators are very effective at reducing particulate matter. Particles removed from the flue gas and collected at the electrodes are later removed.[3]

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[2] *Stationary Source Control Techniques Document for Fine Particulate Matter*, U.S. Environmental Protection Agency, October 1998, Section 5.1.

[3] *Stationary Source Control Techniques Document for Fine Particulate Matter*, U.S. (continued...)

Fabric Filters. Fabric filters (FF), also known as baghouses, are large filters of fabric, often sewn into long bags, which physically sieve particles from the flue gas. Particulate matter collects on the surface of the fabric and is periodically removed by shaking the filters, pulsing gas through them, or reversing the air flow through the filter. The performance of the fabric filter depends on the type and amount of fabric used and the regularity with which the fabric is cleaned.[4] High fabric filter control efficiencies have been reported, and they can be effective in controlling small particulate matter.

Wet Scrubbers. Wet scrubbing technology, a form of flue gas desulfurization (FGD), discussed above, has also been used to reduce particulate matter concentrations. The impact of the liquid droplets on the particles in the flue gas draws the particles into the droplets, which are collected and removed.

Removal of Mercury Using Existing Control Technologies

Existing post-combustion control technologies are being assessed for their ability to remove mercury from the flue gas. Because of the many equipment configuration and coal types already found in electric utilities, both the limitations and advantages of these technologies are important in considering EPA's proposed cobenefits-focused regulation.

Elemental mercury is a liquid at room temperature, but it evaporates easily, and is considered difficult to remove from the flue gas stream. In contrast, mercury compounds which form ions, charged atomic or molecular species, present in flue gas are more easily removed. In combustion emissions, mercury can react with or attach to particles in the flue gas, so particulate control can provide mercury removal as a cobenefit.

Partly because of the difficulties in predicting mercury capture by existing control technologies, the EPA in 1998 issued an information collection request to electric utilities to gather information regarding the effectiveness of current control technologies with respect to mercury removal. Analysis of this data showed a wide variation of mercury emission control as a cobenefit, with significant variation occurring between different coal types for a given emission control technology. See **Table 1**. The control efficiencies estimated by the EPA analysis were based on the technologies currently in use by the electric utility industry. These control technologies were not reoptimized for mercury capture, but rather operated under normal conditions.

Policy Issues

Several technology-related policy issues regarding regulation of mercury emissions include the maximum feasible level of mercury reduction from cobenefits of current emissions control technologies; the likely level of mercury emissions reduction using alternative control technologies not currently used by the electric utility industry; and the maturity and availability of these alternative technologies.

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[3] (...continued)
Environmental Protection Agency, October 1998, Section 5.2.

[4] *Stationary Source Control Techniques Document for Fine Particulate Matter*, U.S. Environmental Protection Agency, October 1998, Section 5.3.

Table 1. Average Mercury Capture by Existing Post-combustion Control Configurations Used for Pulverized Coal Fired Boilers

Post-combustion Control Strategy	Post-combustion Emission Control Device Configuration	Average Total Mercury Capture by Control Configuration		
		Bituminous Coal	Subbituminous Coal	Lignite
PM Control Only	CS-ESP	36 %	3 %	-4 %
	HS-ESP	9 %	6 %	not tested
	FF	90 %	72 %	not tested
	PS	not tested	9 %	not tested
PM Control and Dry FGD System	Dry FGD + ESP	not tested	35 %	not tested
	Dry FGD + FF	98 %	24 %	0 %
	Dry FGD +FF + SCR	98 %	not tested	not tested
PM Control and Wet FGD System	Wet FGD + PS	12 %	-8 %	33 %
	Wet FGD + CS-ESP	74 %	29 %	44 %
	Wet FGD + HS-ESP	50 %	29 %	not tested
	Wet FGD + FF	98 %	not tested	not tested

Source: Environmental Protection Agency, *Control of Mercury Emissions From Coal-fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02*, EPA-600/R-01-109, April 2002.
Note: See text for definition of acronyms.

In Use Technologies. Experts disagree over the degree of mercury reduction resulting from cobenefits of existing emission control technologies. **Table 1** shows that average mercury reduction by existing control technologies is highly dependent both on the type of emission control technology being used and the type of coal used as fuel in the electric generating unit, varying from 0% to 98%. (The two negative results are presumably artifacts of the testing procedure.) The EPA has stated that the maximum amount of mercury collection for some existing control technologies has significant uncertainty because of both small sample size and difficulties in measurement.[5] Moreover, because these values were obtained without maximization of mercury capture, it is unclear whether they should be considered representative of potential maximum mercury capture. Further optimization of current emission control technologies to enhance the capture of mercury might lead to higher collection of mercury emissions. However, attempting to optimize mercury capture by already installed emission control technologies might also degrade their ability to control other pollutant levels.

[5] 69 *Fed. Reg.* 4652-4752, January 30, 2004, at p. 4698.

New Technologies. Alternative technologies for mercury emissions reduction are under development for use in the electric utility industry.[6] No commercial electric generating unit in the United States has installed a mercury-specific emissions control technology. Mercury emission reduction technology, such as activated carbon injection (ACI), has been used on other combustion systems, such as municipal incinerators, to achieve substantial mercury emissions reduction. Performance of activated carbon injection technologies are being assessed in field tests on commercial plants. These results show mercury emissions reduction ranging from 60 to 90%, depending on coal fuel type and carbon injection rates. The use of ACI in municipal incinerators, along with initial test results with electric generating units and the serious health effects of mercury, cause some to argue that the alternative technologies for mercury emissions reduction should be considered when determining the regulatory emissions level for electric generating units. However, the operating conditions of electric generating units are different than those in municipal incinerators, and contention exists among stakeholders over whether equivalent reduction in mercury emissions would be obtained in electric generating units under normal operating conditions. Supporters of a cobenefits approach to mercury regulation argue these technologies are not yet proven nor commercially available for use in the electric generating units and thus their inclusion in a rulemaking would be inappropriate.

Stakeholders disagree over how much and how fast mercury emissions reduction can be achieved. The EPA estimates that a generating unit specific emission limit based on cobenefits would reduce the mercury emissions 29% by 2008.[7] Emissions control technology manufacturers state that it is feasible to reduce mercury emissions 50 to 70% by 2008 using cobenefits and near-term mercury specific technology, such as activated carbon injection.[8] Testing of activated carbon injection and other alternative control technologies by the Department of Energy indicates that technologies achieving at least a 50 to 70% reduction of mercury will likely be available for large scale commercial deployment after 2011 to 2013.[9] Other analysts disagree with this time frame, asserting that transfer of mercury control technology from municipal waste incinerators to electric generating units is straightforward, and, therefore, commercialization would occur quicker than the Department of Energy projects.[10]

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[6] A brief overview of Department of Energy funded research and development in several alternative technologies is found at 70 *Fed. Reg.* 12398-12472, March 16, 2004.

[7] 69 *Fed. Reg.* 4652-4752, January 30, 2004.

[8] Letter from David Foerter, Executive Director, Institute of Clean Air Companies, to Michael Levitt, Administrator, EPA, June 29, 2004, available online at [http://www.icac.com/hgmonitoring62904.pdf].

[9] Memorandum from L.D. Carter, Department of Energy, to B. Maxwell, EPA, regarding Mercury Control Technologies, January 8, 2004, available online at [http://www.epa.gov/mercury/control_emissions/mercurytechnologiesjan04.pdf].

[10] NESCAUM, "Northeast States New Report Shows Over 90% Reduction In Power Plant Mercury Emissions Is Achievable," *NESCAUM Press Release*, November 4, 2003.