Committee on Environment and Public Works
United States Senate
Hearing on Mercury Legislation
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Introduction

Thank you, Madam Chair and members of the Committee, for the opportunity to testify today. My name is Steve Benson, and I am a Senior Research Manager at the Energy & Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, North Dakota. I have conducted and managed research, development, and demonstration projects on combustion, gasification, and environmental control systems for over 25 years, with an emphasis on new technology commercialization for utility applications.

The EERC has worked on mercury-related issues facing industry for over 20 years through projects supported by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), state agencies, and industry and is recognized as a world leader on mercury fate and behavior in combustion systems, mercury measurement, sorbent development, and mercury emission control demonstrations. The EERC has conducted over 2000 bench-scale tests, over 200 pilot-scale tests, and over 80 mercury field tests at more than 60 power plants in the United States and Canada over the past decade related to mercury measurement and evaluation of control technologies. We have made significant progress and have been able to attain greater than 90% mercury removal for selected coals and system configurations. We continue to work on a few projects related to mercury measurement and control for the coal-fired power industry. However, future funding for these efforts have significantly decreased or have been zeroed out.

On February 8, 2008, the U.S. District of Columbia Circuit Court of Appeals voted to vacate the Clean Air Mercury Rule (CAMR). As a result of vacating CAMR, utilities will not be allowed to buy credits at plants where mercury emissions are difficult to control effectively. Instead, the utilities will need to meet the more stringent Maximum Achievable Control Technology (MACT) standard at ALL power facilities rather than follow the CAMR cap-and-trade approach. In addition, a bill, S. 2643, was introduced to amend the Clean Air Act requiring a reduction in emissions of mercury from new and existing electric utility steam generating units of not less than 90%. Mercury control technologies necessary to maintain 90% mercury emission control throughout the coal-fired power industry are not proven because of the wide variability in coal composition and plant configurations. The percent reductions that are typically quoted are generally best case and based on short-term testing; that is, not worst case and not long-term mercury removal averages which are generally lower and likely due to variability in coal and plant operations. Also, the values generally quoted assume (or imply) that the mercury control technology is 100% available. Mercury control solutions for all combinations of coal and plant configurations have not been sufficiently proven and require additional development as well as longer-term demonstration.

This is of critical national importance as our nation faces concerns over energy and electrical shortages yet calls for environmental stewardship.

While advancements have been made, many significant challenges and questions remain, especially in light of CAMR being vacated; new technologies and longer-term testing are vitally needed. Today, I will provide a perspective on the status of mercury control technologies and specific issues associated with the control of mercury emissions from coal-fired plants. These issues include coal characteristics, flue gas composition, control technology application, and system configuration.

Coal Composition and Flue Gas Characteristics

Coal composition dictates the characteristics of the flue gas produced upon combustion. The flue gas components influence the form of mercury and the selection of the optimum mercury control option. Appalachian and interior bituminous coals typically contain high levels of chlorine, sulfur, and iron-rich materials that, when combusted, convert mercury to, mainly, a more easily captured oxidized form, with minor amounts in the more-difficult-to-capture elemental form. Subbituminous coals usually have low sulfur and chlorine levels that produce flue gas where most of the mercury is in the elemental form. Lignite coals are highly variable in composition. The northern Great Plains lignites contain lower sulfur relative to bituminous coals, low chlorine, and ashes that are rich in alkali and alkaline-earth elements and produce flue gases where the elemental form of mercury is dominant. Gulf Coast region lignites typically have higher ash than northern lignites, sometimes higher sulfur contents, and produce a flue gas where the mercury can range from 50% to over 90% elemental. In summary, the mercury forms produced from each coal are different and thus require a different mercury control strategy.

Control Technology Application and System Configuration

The technologies that show the greatest promise for mercury emission control include sorbent injection upstream of existing particulate control systems and chemical addition to oxidize mercury species for capture in downstream air pollution control devices such as sulfur scrubbers:

- Activated carbon injection using an enhanced or chemically treated activated carbon shows promise in attaining mercury removal of over 90% in selected applications (Feeley and Jones, 2008). The utility industry is beginning to install activated carbon injection systems.
- Untreated activated carbon combined with injection of chemical additives called sorbent enhancement additives (SEAs) has shown removal rates of greater than 90% in many applications.
- Inorganic sorbents, such as amended silicates and other materials, have shown mixed success. In full-scale application, amended silicates showed only 40% mercury removal efficiency. In pilot-scale testing, higher levels of control were observed.
- Elemental mercury oxidation through injection of chemical additives into the furnace or added with the coal for removal in scrubbers has shown varying degrees of success, ranging from 44% to 92% removal.
- Mercury oxidation through the use of oxidation catalysts has shown the ability to oxidize elemental mercury for capture in scrubbers. The use of selective catalytic reduction (SCR) for NO_x emission control has shown increases in mercury capture from a baseline of 60% to nearly 90% mercury control for bituminous coals.

The aforementioned levels of mercury emissions control are from specific cases and short-term testing.

Particulate Control – ESP-Only

Numerous short-term tests, from a few hours to monthlong periods, have been conducted on a wide range of coal types in plants configured with a cold-side electrostatic precipitator (ESP) only. The results of testing injection of chemically treated activated carbons or injection of untreated carbons with SEAs upstream of cold-side ESPs show that removal rates of over 90% can be attained, but removals vary widely with coal characteristics. For example, in flue gases containing even minor amounts of SO_3, the removal rates were significantly decreased, especially for some bituminous coals. The SO_3 competes with or "poisons" the active sites on the enhanced activated carbons, impeding mercury capture. Limited testing has been conducted with hot-side ESP's 60% to 73% control has been achieved.

Particulate Control – ESP and Fabric Filters

In plants configured with the combination of an ESP and fabric filters, a Toxecon™ configuration, the combination has shown the ability to have high removal rates with both untreated and treated activated carbon. However, handling and storage of the activated carbon and ash may be an issue because of its ability to ignite and burn in hoppers. Additionally, this method requires a very large capital addition (fabric filter) to the power plant.

Dry Scrubbers

The injection of activated carbon, enhanced activated carbon, and SEA combined with activated carbon has shown removal efficiencies of over 90% in spray dryer absorber and fabric filter (SDA–FF) applications.

SCR and Dry Scrubber

Initial testing of SEA and activated carbon injection in a plant configured with SCR and an SDA–FF showed high mercury removal efficiencies of greater than 90%. However, recent testing showed much lower removal efficiencies, likely due to minor deactivation of the SCR catalyst. Testing is ongoing.

ESP–Wet Scrubbers

Chemical additives to increase the oxidation of elemental mercury have shown a range of removal rates from 60% to 92%. These removal rates are highly dependent upon coal composition. Reemission of mercury from the scrubber can often cause reduced removal rates. While technologies for preventing mercury reemission have been developed, their performance again varies with coal characteristics and system design and operation.

SCR ESP–Wet Scrubber

The use of SCR for NO_x emission control has shown an increase in mercury capture from a baseline of 60% to nearly 90% mercury control for bituminous coals, during limited testing.

In summary, the testing results show promise in removing mercury from flue gases. However, attaining greater than 90% removal for all coal types and system configurations has not been demonstrated.

Remaining Issues

- **Lack of Long-Term Testing**
  Only short-term, approximately monthlong, tests have been completed for the technologies described above. While some technologies have shown promise, many issues remain unresolved, such as long-term performance, reemission of mercury, the impact of SO_3, balance-of-plant impacts, the impact of blending coal with renewable fuels, and possible unwanted (unknown) environmental side effects.

- **Limited Number of Plants and Coal Types Tested**
  The MACT standard will require that all 1200-plus plants/units in the United States apply mercury control technologies. To date, fewer than 10% have been tested. Consequently, many coal types, blends, unit configurations, and variations in operating parameters have not been tested. This lack of data leads to uncertainty for utilities in making decisions as they determine what technologies will work best given their coals and individual unit configurations.

- **Combustion By-Product Utilization**
  Limited progress has been made to develop mercury sorbent materials that will not impact utilizing the ash for cement replacement and other applications.

- **Development of Long-Term Mercury Sampling and Analysis**
  Robust systems that are reliable and economical are still needed to meet the tremendous market need for the power sector.

- **Integrating Mercury Capture with Gas Conditioning for CO_2 Separation and Capture Technologies**
  Many of the CO_2 technologies require extremely clean flue gas. Mercury is known to have a negative impact on many of these systems, and its impact on others is under investigation. As a result, increased levels of mercury and trace element control will likely be required to enable the use of some CO_2 capture technologies.

- **Development and Testing of Multipollutant Control Technologies (including CO_2)**
  Development and testing of new-generation multipollutant control devices must continue to provide more integrated and cost-effective solutions that address all pollutants of concern collectively, rather than on a single-pollutant basis. Multipollutant technologies and their impact on advanced energy conversion systems using elevated pressures and temperatures must be tested to ensure system reliability and continued emission performance.

Conclusions

Over the past 5 years, significant progress has been made in the development and testing of mercury control technologies for coal-fired power plants. However, with this significant progress, unresolved issues remain. The wide range of coal types and plant configurations increases uncertainties in the ability to effectively control mercury emissions. Each plant has a unique design, configuration, operating parameters, and suite of fuels fired that make broadly applying mercury control technologies very difficult.

To date, short-term testing has been conducted, but in order to further develop and demonstrate mercury control technologies, a logical product development path must be followed to ensure required performance and reliability. Most product and technology failures are due to insufficient or poor testing. For mercury emission control, the path must include longer-term tests to reveal any unintended environmental effects and tests on a range of power plant configurations and fuel properties. Longer-term testing programs must be designed to address the remaining challenges as well as to refine the technologies to ensure that the electric utility industry can meet new mercury standards while providing low-cost and reliable electricity in the future.

References

Thomas J. Feeley and Andrew P. Jones. An Update on DOE/NETL's Mercury Control Technology Field Testing Program. www.netl.doe.gov/technologies/coalpower/ewr/mercury/pubs/netl%20Hg%20program%20white%20paper%20FINAL%20Jan2008.pdf (accessed Jan 2008).