Memorandum

From: L.D. Carter
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Coal & Power Systems, DOE/FE-26
To: Bill Maxwell, USEPA
Subject: Mercury Control Technologies
Date: January 8, 2004

Introduction

This memo presents DOE's views regarding the status of technologies for control of mercury emissions from coal-fired power plants. DOE, in partnership with the private sector, has funded a multiyear research and development program which is beginning to produce some very promising technologies.

An excellent review of our mercury control technology R&D program was published in October's EM Magazine[1], the Air and Waste Management Association's magazine for environmental managers. I am including a copy of that article as Attachment 1, and will provide a brief overview below. I am also including, as Attachment 2, a tabular summary of the mercury control technology research projects which were being funded under DOE's appropriations, as of Summer 2003. Additionally, I am attaching material describing longer-term field tests of mercury control technologies in projects initiated last Fall, and providing descriptions of our first two full-scale demonstration projects involving mercury emissions control. You will see that there is a broad range of technologies under consideration, consistent with our view that we need a portfolio approach to effectively implement major reductions in mercury emissions from coal-fired power plants. Finally, this memo will explain the temporal relationships between research and development projects, technology demonstration projects, and commercial deployment of new technologies.

Mercury Control Technologies

DOE's mercury R&D program recognizes that conventional air pollution control technologies control about one-third of the potential mercury emissions from coal-fired power plants. EPA has published an excellent report that describes these technologies

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[1] "DOE/NETL's Mercury Control Technology Research Program for Coal-Fired Power Plants," Feeley, et al, EM Magazine, October 2003.

and their effectiveness in reducing mercury emissions.[2] These existing technologies are commercially deployed today, but generally show inconsistent levels of mercury control from plant to plant. The DOE R&D program focuses on ways to make these existing technologies more effective and more consistent at controlling mercury, and on altogether new approaches for mercury control.

There are two overarching goals for the DOE R&D program:

- ❑ To develop control technologies capable of 50-70% mercury capture for commercial demonstration at bituminous coal-fired power plants by 2005, and at lower rank coal-fired power plants by 2007; and
- ❑ To develop lower cost control technologies capable of 90% mercury capture for commercial demonstration by 2010.

The R&D program takes technologies from a conceptual level through bench scale and pilot scale proof of concept. For the more promising technologies, defined in terms of performance and cost, full scale field tests are conducted to generate the information necessary for a multi-year demonstration project. In addition to funding for the mercury R&D program, DOE is also provided funds by Congress to conduct such full scale technology demonstrations under the Clean Coal Power Initiative.

Several categories of technologies are now under development at DOE. These include sorbent injection technologies, technologies that enhance the mercury capture of traditional pollutant controls, such as SO2 "scrubbers" and electrostatic precipitators (ESP's), multi-pollutant control technologies, and novel concepts.

<u>Sorbent Injection Technologies</u>

DOE has supported sorbent injection projects at the bench, pilot, and commercial-scale. This type of technology has the greatest promise for taking mercury control beyond the performance of conventional (non-mercury) technologies in the near-term. During short term tests (one to three weeks), these technologies have achieved reductions as high as 90% of inlet mercury levels on bituminous coals. Performance on subbituminous coal has been as high as 65% reduction. In addition, systems with supplemental fabric filters have been more effective than those with ESP's. Although full scale sorbent injection tests have focused on activated carbon injection, DOE is also sponsoring pilot scale research on lower cost sorbents. DOE is now engaged in longer-term studies of sorbent injection technologies in order to gain the information needed to conduct multi-year commercial demonstrations of this technology. Given the differences in the effectiveness of this technology on coals of different rank and chlorine content, it is likely that several demonstration projects will be necessary to establish predictable cost and

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[2] See <u>Control of Mercury Emissions from Coal-fired Electric Utility Boilers: Interim Report</u>, EPA-600/R-01-109, April 2002.

performance for this type of mercury control.

Enhanced Conventional Technologies

Air pollution systems designed to capture sulfur dioxide (SO2) and particulate matter (PM) generally capture some mercury as well. DOE is investigating methods to enhance the performance of such systems on mercury capture. In general, these systems seek to increase the oxidized fraction of mercury present in the power plant's flue gas, and decrease the fraction of elemental mercury, which is more difficult to capture. DOE has had mixed results from injecting chemicals to enhance the mercury removal by wet scrubbers designed for SO2 capture. This research is continuing.

URS Corporation is working with DOE to develop catalytic approaches to oxidizing elemental mercury in flue gases. This program began in 2001 and will continue through 2004.

Multi-pollutant Capture Technologies

Multi-pollutant approaches have potential synergies which could increase pollution reduction and lower control costs. Work with the Electro-catalytic oxidation process under development by Powerspan Corporation was initiated in 2001 and will continue through 2004. Early pilot-scale results have been encouraging, but the inlet mercury for these tests was much lower in elemental mercury than levels expected at many commercial sites. Additional elemental mercury is being added to the test system to simulate removal at other sites.

Calcium based sorbents and oxidizing agents are being evaluated under a cooperative agreement between DOE and the Southern Research Institute. These systems could remove both SO2 and mercury. Oxidizing agents could be helpful particularly with lower rank coals.

Novel Approaches to Mercury Control

It has long been observed that poorly tuned coal burners generate higher levels of unburned carbon in coal ash than properly tuned burners. This unburned carbon, although undesirable from an efficiency perspective, can function like activated carbon injection and adsorb mercury emissions. DOE has patented a process to take advantage of this phenomenon by extracting partially combusted coal from the furnace, and reinjecting it in the flue gas after the air preheater. Pilot-scale tests have been very promising.

DOE is also investigating the ability of a specific wavelength of ultraviolet light to oxidize elemental mercury to a form more easily captured by conventional air pollution control equipment.

Longer-term field tests

In contrast to most of DOE's short-term mercury R&D projects, in September 2003, DOE initiated a series of eight longer-term, large-scale field tests that will investigate the potential for improvements and more wide-spread applicability of mercury control using one or more of the approaches outlined above. The actual testing varies by project, but generally will begin in early 2004 and last for several months. Technologies to be evaluated include both sorbent-based approaches, like activated carbon injection, as well as oxidation-based approaches intended to improve mercury collection by more traditional air pollution control technologies. Attachment 3, "Phase II Field Testing of Advanced Mercury Control Technologies", provides more detail on these longer term tests.

Initial Mercury Demonstration Projects

As discussed above, the DOE R&D program is complemented by a demonstration program within the Clean Coal Power Initiative. In January 2003, DOE announced the first awards under this program[3], including the following two projects that would demonstrate mercury reduction technologies:

- ❑ Wisconsin Electric Power Company's Presque Isle plant will evaluate the TOXECON process combined with chemical additives as an integrated mercury, particulate matter, SO2, and NOx emissions control system. In this project, sorbents, including powdered activated carbon for mercury control and chemicals for NOx and SOx control, will be injected into flue gas for subsequent reaction with pollutants and collection in a pulse-jet baghouse that is installed downstream of the existing particulate control device. The TOXECON configuration allows for separate treatment or disposal of the ash collected in the primary particulate control device. The duration of the project is estimated to be 5 years, and its overall cost is $75 million.
- ❑ The City of Colorado Springs is teaming with Foster Wheeler to demonstrate an advanced circulating fluidized bed combustor, with integrated pollution controls expected to reduce mercury emissions by over 90%. This 6 year project carries a total cost of just over $300 million.

These projects evidence the commitment of project participants, including DOE, to invest the resources needed to bring promising mercury control concepts to commercial readiness. We believe the nature of the mercury control challenge is so complex that a number of additional demonstration projects will be needed, but we are confident that resources will be made available to pursue those projects and solutions will be developed that have broad application.

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[3] See http://www.fe.doe.gov/news/techlines/03/tl_ccpi_2003sel.html .

The Timing of Technology Development and Commercialization

The normal flow of development of new technologies is R&D at the bench scale and pilot scale (typically 2-4 years), followed by large scale testing (typically one year under a range of operating conditions and technology configurations at a facility), followed by one or more cycles of commercial demonstrations (typically 6 years each).

In implementing the Clean Coal Technology Program, DOE has gained extensive experience with the process of demonstrating emerging air pollution control technologies. Table 1 shows the time required for a dozen SO2 and NOx retrofit technology demonstrations. The typical project required a little over 6 years from selection of the project to reports on its technical performance. This time period excludes the administrative time needed to solicit and evaluate proposals. In addition, the actual project duration was truncated for one-half of these projects to exclude unusually lengthy reporting periods following completion of the technology testing period.

Although DOE is continuing to pursue some mercury control technologies at the bench and pilot scale, much work has been completed at this small scale. Some technologies, like sorbent injection, have entered the large scale field testing stage, and we have initiated a commercial demonstration project for sorbent injection technology. It appears that these technologies, with at least 50-70% mercury reduction, will be ready for broader commercial demonstration on bituminous coal in 2005, and on subbituminous coal and lignite in 2007. If these demonstrations are successful, commercial deployment could occur on a large scale after 2011 and 2013. Assuming two years to permit and construct such commercial units, large scale operation of the technology is feasible by 2013 and 2015. It is important to note that reliable and predictable performance will be achieved only if such demonstration projects can be completed on a range of coal types with a range of characteristics (such as mercury, chlorine, and sulfur content), and at plants with a range of hardware (ESP's of varying relative sizes; spray dryers on coals with low chlorine content). Additional technologies, perhaps much lower in costs, should follow in 2-4 additional years.

Greater mercury reduction performance is part of DOE's mercury control technology development program. A second wave of technologies operating at 90% reduction should be ready for commercial demonstration by 2010, leading to effective reductions after 2018.

An important caveat to these time projections is that they could be extended if the same units being retrofit for mercury emissions must contemporaneously focus on installing separate pollution control systems for other pollutants. The significance of this potential problem will vary with the type of control technologies being installed.

Conclusions

Substantial progress in mercury control technology development has been achieved through a partnership between government and industry. A broad portfolio of technologies is beginning to emerge. These technologies will probably be able to provide 50-70% reduction of mercury in the period after 2015, with up to 90% reduction on many applications after 2018.

Table 1.	**Elapsed Time (Months)**			**Total Time (Years)**	**Reporting time truncated**
Project name	**Preaward**	**Design & Construction**	**Operation & Reporting**		
AirPol, Inc.: SO2 Gas Suspension Absorption	10	24	32	5.5	
Bechtel Corp.: FGD	10	24	20	4.5	
LIFAC- NAm: Sorbent Injection (SO2)	11	22	33	5.5	Y
Pure Air: Advanced FGD	15	30	48	7.8	
Southern Co Serv.: Chiyoda Thoroughbred-121 (FGD)	19	30	38	7.3	Y
Average for SO2 systems	**13**	**26**	**34.2**	**6.1**	
Sunflower EPC LNB & Boiler optimization	14	18	6	3.2	
Southern Co Serv.: LNB / AOFA / GNOCIS (NOx)	15	6	154	14.6	
B&W Co.: Cyclone coal reburn (NOx)	19	20	27	5.5	
B&W Co.: Cell burner retrofit (NOx)	10	14	28	4.3	Y
EERC: Gas reburning & LNB (NOx)	10	25	38	6.1	Y
Southern Co Serv.: SCR w/ Hi-S coal unit	20	37	36	7.8	Y
Southern Co Serv.: LNB/AOFA T-fired unit	24	8	31	5.3	Y
Average for NOx systems	**16**	**18.3**	**45.7**	**6.7**	
Average for all systems	**14.8**	**21.5**	**40.9**	**6.4**	
Source: Clean Coal Technology Programs: Project Fact Sheets 2003, USDOE, October-2003					
http://www.lanl.gov/projects/cctc/factsheets/factsheets_t.html					