

## **77 Continuous Emissions Monitoring**

### **Program Overview**

#### **Program Description**

This program develops, enhances, and evaluates continuous emissions monitoring systems (CEMs), which measure chemical species of regulatory and operational interest. It promotes the development and validation of accurate, robust, and low-maintenance CEMs for compliance with new reporting requirements, such as mercury and continuous particulate mass, and for optimizing pollutant control operation. This program identifies, develops, and demonstrates innovative measurement systems with the potential to significantly reduce CEMs costs. It also guides vendors on ways to improve their products for greater accuracy and functionality in commercial applications.

#### **Industry Needs and Issues Addressed**

- Continuous mercury monitors (CMMs) that are accurate, reliable, robust, and affordable, and can be readily calibrated and audited
- Direct measurement of particulate mass emissions to overcome the uncertainty of indirect measurements and enable monitoring in wet stacks (post-sulfur dioxide [SO<sub>2</sub>] control)
- Proven, affordable emissions monitors for pollutants expected to be regulated or already restricted by permits
- Breakthroughs that enable the development of CEMs at 10–25% of the cost of current technology

#### **Impact**

- Save person-months of plant instrument technician and environmental engineer time needed to make newly procured CMMs work
- Prepare for new mercury regulations that may require measurements below today's detection levels
- Enable credible, non-ash-dependent particulate mass emission measurements made in the stack to benefit from particulate capture by the SO<sub>2</sub> control
- Support NO<sub>x</sub> and/or sulfur trioxide (SO<sub>3</sub>) control operations, or flue gas conditioning for ESP performance, via in situ, continuous measurement systems for ammonia, SO<sub>3</sub>, and sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)
- Learn about new developments and avoid mistakes by using EPRI's periodically updated CEMs Guidelines
- Potentially save hundreds of thousands of dollars per stack if advanced "sensors-on-a-chip" are developed and accepted for power plant applications

#### **Key Accomplishments**

- EPA approval of the sorbent trap method for continuous mercury monitoring and use as a reference method
- EPA approval to use an instrumental reference method in lieu of the complex, costly, slow-turnaround-time Ontario Hydro method
- Accelerated development of National Institute of Standards and Technology (NIST)-traceable calibration procedures for CMMs
- Proposed methodology for calibrating particulate mass emission monitors that avoids need to exceed emission limits for other pollutants.
- Identification of a promising next-generation, multi-pollutant CEM—the quantum cascade laser

### Current Year Objectives

- Updated CMMs guideline, with lessons learned from installation and first one to two years of operation
- Proof-of-concept tests of potential CMMs enhancements to lower detection levels
- Exploratory tests of direct measurements for filterable particulate mass emissions in either dry or wet stacks
- Proof-of-concept demonstration of multi-pollutant (criteria pollutants, ammonia [NH<sub>3</sub>], SO<sub>3</sub>, hydrochloric/hydrofluoric acid [HCl/HF], and mercury [Hg]) laser-based system
- Initial assessment of approaches to measuring carbon dioxide (CO<sub>2</sub>) at 1% concentrations, anticipating a future stringent CO<sub>2</sub> capture requirement

### Industry Involvement

- Estimated 2009 funding: \$1.6M

### Program Technical Lead

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## Summary of Projects

Project Number	Project Title	Value
P77.001	Evaluation of Mercury Monitors	Maintain forum for dynamic interaction among power companies during first years of implementing CMMs. Assist members with issues, and document lessons learned. Seek and test methods for accurate measurements at lower levels than possible in 2008.
P77.002	Monitors for Process Control, Compliance, and TRI Reporting	Seek and test direct methods to monitor filterable particulate mass emissions by direct methods, in both dry and wet stacks. Continue to seek CEMs for pollutants not being monitored currently and to collaborate with the EPRI NO <sub>x</sub> programs to demonstrate in situ NH <sub>3</sub> and SO <sub>3</sub> monitors, as well as CEMs for stack measurements (very low levels).
P77.003	Advanced Monitors - Microsensors, CEMS for Hostile Environments, and Automated Diagnostics	Complete proof-of-concept tests of quantum cascade laser monitor for multiple pollutants, and design complete CEM package, including calibration. Continue Tech Watch for other advanced systems, and initiate proof-of-concept tests if any appear promising. Obtain understanding of CO <sub>2</sub> measurement at 1% concentration level.

## Project Descriptions

### P77.001 Evaluation of Mercury Monitors (051775)

#### Issue

Federal requirements for monitoring mercury emissions from coal-fired boilers are uncertain (as of early April 2008) due to a February 2008 court action vacating the Clean Air Mercury Rule (CAMR). However, it is certain such monitoring will be required in the near future by the federal government. States with independent mercury regulations still require continuous mercury monitors (CMMs), presumably those satisfying the requirements promulgated in support of CAMR. With some states requiring very high removal percentages, the need exists for CMMs that measure accurately at lower emission rates than the first-generation systems being installed in 2008. If ongoing work to make available monitors that are

accurate, reliable, robust, affordable, and readily calibrated and audited is not completed in 2008, the final steps will need to be addressed in 2009. Further, because CMMs are new to the power industry, the suppliers, QA/QC contractors, and regulatory authorities, many issues are certain to arise during the first few years of implementation. A need exists to shorten the learning curve for all parties.

**Description**

EPRI will maintain the web-based forum created in 2008 for members to share their experiences and for EPRI or others to suggest solutions. By tracking the dialog and contacting members of the program, EPRI will assemble the industry’s lessons learned in a document that suggests best practices, which EPRI will publish annually. As necessary, EPRI will drive work to bring commercial CMMs with reasonable calibration procedures to the market. EPRI also will investigate the feasibility of using advanced technologies (e.g., cascade lasers) as CMMs, to reduce cost and complexity or to measure lower emission rates.

**Value**

- Avoid noncompliance and over-compliance costs due solely to inaccurate or incorrectly certified continuous mercury monitors.
- Benefit from the shared experiences of others to save months of time on the part of plant instrument technicians and plant and corporate environmental compliance engineers during system shakedown.
- Prepare for future mercury measurement challenges, such as lower emission limits.

**How to Apply Results**

Plant instrument technicians and plant and corporate environmental compliance engineers can obtain answers to their questions about CMMs through the EPRI website and staff technical support. They also will be able to compare their operations to best practices documented by EPRI and use the report to determine if improvements to their systems or procedures are warranted. Planners can gain a sense of future CMMs developments from the periodic updates on advanced instruments.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Continuous Mercury Measurement Guidelines – 2009 Update:</b> Update of 2008 interim report on lessons learned and best practices, incorporating experience during first full year of operation, with some in a compliance mode (states with independent mercury regulations). Continuation of interactive website and individual technical support if demand continues. Progress report on search for advanced monitors to enable lower mercury concentration measurements and lower-cost, less complex CMMs.	12/31/2009	Technical Report

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Continuous Mercury Measurement Guidelines – Annual Update:</b> Update of 2009 report, with additional experience documented and explained. Progress reports on advanced technologies for lower emission levels or simpler systems.	2010	Technical Report

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Product Title & Description	Planned Completion Date	Product Type
<b>Continuous Mercury Measurement Guidelines – Final Report:</b> Final report, with guidance based on up to four years experience as well as newer developments/advances. Similar to well-known periodic CEMS Guideline updates.	2011	Technical Report

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## **P77.002 Monitors for Process Control, Compliance, and TRI Reporting (058198)**

### **Issue**

Regulators increasingly require continuous measurement of particulate mass (PM) emissions. Although monitors are commercially available, none measures mass emissions directly; therefore, some uncertainty exists about their accuracy as particle properties change. Furthermore, even current technology is not routine in wet stacks following a wet scrubber, where measurements would recognize the benefits of particulate capture by the SO<sub>2</sub> scrubber.

Increasingly, permits for new plants limit emissions of ammonia, sulfuric acid, HCl/HF, and fine particulates (e.g., PM 2.5 to address visibility or as a surrogate for trace metals). Therefore, the industry needs proven, affordable emission monitors for these species. The industry also needs ammonia and SO<sub>3</sub> measurements at locations in the flue gas to optimize operation of the selective catalytic reduction (SCR) for NO<sub>x</sub> control, alkali injection for SO<sub>3</sub> control, or SO<sub>3</sub> injection for ESP performance enhancement.

### **Description**

EPRI will obtain and test devices identified in 2008 as potentially viable for direct measurements of particulate mass, including in wet stacks. For the fine fraction, EPRI will seek ways to differentiate between the filterable (solid) and condensable particulate. For the vapor species to be monitored, EPRI will focus on laser-based systems such as Fourier Transform Infrared Spectroscopy (FTIR) or quantum cascade. EPRI will seek one or more power plants willing to serve as host(s) for the particulate and vapor measurements and test the proposed monitors against standard extractive methods, as was done for mercury monitors.

### **Value**

- Provide approved monitoring methods that enable boiler operators to take advantage of the particulate capture by their SO<sub>2</sub> scrubber.
- Ensure thoroughly proven monitors are commercially available when needed, and are reasonable to operate and certify for SO<sub>3</sub>, NH<sub>3</sub>, and other species which might be regulated.

### **How to Apply Results**

Engineers responsible for CEMS procurement and compliant operation can use the performance data developed under this project to determine if instruments are ready for commercial operation, how they need to be installed and operated, and what to require in their bid package.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Particulate Mass Emission Monitors for Dry and Wet Stacks – Status Report:</b> Preliminary results of tests on newly found or developed technology that measures mass emissions directly. Tests first in dry flue gas, then wet flue gas. Lab pilot or field tests, whichever is most cost-effective.	9/30/2009	Technical Update
<b>In Situ SO3 and NH3 Measurements for Emissions Monitoring and Process Control – Status Report:</b> Final field tests of monitors currently under development (e.g., tunable diode laser, FTIR). Test locations range from the SCR outlet, air preheater outlet, and ESP inlet for process control to the stack for future compliance reasons.	9/30/2009	Technical Update
<b>Monitors for Compliance with Newly-regulated Species – Scoping Study:</b> Summary of fact-finding at EPA and conferences concerning potential emission limits on other pollutants that might require continuous monitoring. Assessment of need to find or develop suitable CEMs, and preparation of a work plan to meet this objective.	6/30/2009	Technical Resource

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>CEMs for Newly Controlled Species–Update:</b> Field test results for potential CEMs for newly controlled species, assessment of their capabilities and remaining issues, and recommendations for next steps.	2010	Technical Update
<b>Optimized Process Monitoring by Automated Feedback from Continuous Gas Species Measurements – Proof-of-Concept:</b> Preliminary trials of microsensors in automated air pollution abatement process control (e.g., ammonia slip for SCR control, SO <sub>3</sub> for alkali injection control) (combined report for P77.002 and P77.003).	2010	Technical Update
<b>CEMs for Newly Controlled Species–Guideline:</b> Final test results and recommendations on sampling and analysis systems for continuously measuring emission rates of these newly regulated species and for using them for process control (combined report for Project 77.002 and Project 77.003).	2011	Technical Report
<b>Optimized Process Monitoring by Automated Feedback from Continuous Gas Species Measurements – Initial Demonstrations:</b> Longer-term trials and additional sites for tests of microsensors in automated air pollution abatement process control.	2012	Technical Report

## P77.003 Advanced Monitors - Microsensors, CEMS for Hostile Environments, and Automated Diagnostics (046727)

### Issue

Industry has learned to live with current CEMS technology, including individual analyzers for each pollutant, and to accept its high costs, but competition drives a continuous search for approaches that reduce both capital and O&M costs. Recent advances in microchip and nanotechnology offer the promise of drastic reductions in CEMs costs, both through miniaturization and multi-pollutant measurement capabilities in a single system. However, given the small market size of the power industry relative to other industries that use microsensors, sensor developers are not devoting resources to sensors for the species and measurement environments experienced in power plants; hence, the power industry needs to lead the effort to gain the benefits. The industry also needs to prepare for probable CO<sub>2</sub> emission limits in the future, which will require CO<sub>2</sub> measurement at just 1% concentration levels.

### Description

EPRI found a promising new technology in 2006, a quantum cascade laser, that offers promise of meeting these needs. Starting in 2008, EPRI is testing this approach for the range of currently monitored pollutants, first using simulated gases in the laboratory and then in a configuration designed to operate and survive in a power plant. The plant-capable design will incorporate the supporting system needed to enable daily calibration, as required by EPA.

Simultaneously, EPRI will continue to search for other promising micro-technology-based sensors and, if warranted, begin testing them.

### Value

- Reduce the capital and operating labor costs of CEMs to as little as 10–25% of those of current systems, with equal or superior performance.
- Reduce ammonia, alkali sorbent, or SO<sub>3</sub> consumption for SCRs, SO<sub>3</sub> abatement, or flue gas conditioning for ESP performance through low-cost, easy, instantaneous feedback of process outlet species concentrations (ammonia for SCR, SO<sub>3</sub> for other two applications). (Supports the process control effort in P77.002 by providing the microsensor technology.)

### How to Apply Results

Planners considering the next round of CEMs replacements will be able to anticipate significantly advanced monitors with greater confidence.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Microsensors for Continuous Flue Gas Species Monitoring in the Power Industry – Status Report 2009:</b> Field tests of a quantum cascade laser-based multi-pollutant monitoring system and lab tests on any promising new sensor types. Preliminary design for a sampling system based on these microsensors.	12/31/2009	Technical Update
<b>CEMs for Future Plants with Stringent CO<sub>2</sub> Controls – Scoping Study:</b> Literature review and discussions with CEMs suppliers on the capability of current instruments to monitor accurately CO <sub>2</sub> levels around 1%, as would be found in the stack of a power plant with high-CO <sub>2</sub> -collection- efficiency systems.	6/30/2009	Technical Resource

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**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Strategies for Monitoring Low-level CO<sub>2</sub> Emissions</b> Demonstration tests of CO <sub>2</sub> CEMS measuring at levels around 1% CO <sub>2</sub> . May be prototype or commercial unit, depending on supplier offerings.	2011	Technical Report
<b>Microsensors for Continuous Flue Gas Species Monitoring in the Power Industry – Status Report 2010:</b> Update of 2009 report, presumably with final field tests on a fully operational quantum cascade laser-based system and early field tests on any other promising new sensor types for emissions compliance or process control.	2010	Technical Update
<b>Guideline on Advanced Sensors for Continuous Flue Gas Species Monitoring:</b> Guidance on the selection, procurement, operation, and use of microsensors for emissions compliance monitoring and for flue gas species monitoring for automated process control (combined P77.002 and P77.003 report).	2011	Technical Report

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