

# Post-Combustion NO<sub>x</sub> Control - Program 73

## Program Overview

### Program Description

Selective catalytic reduction (SCR) technology has become the technology of choice for meeting stringent nitrogen oxides (NO<sub>x</sub>) emission limits for coal-fired electric generating plants. SCR systems for NO<sub>x</sub> control have been installed on more than 100 GW of coal-fired capacity in the United States.

The Electric Power Research Institute's (EPRI's) Post-Combustion NO<sub>x</sub> Control program (Program 73) focuses on minimizing total costs and maximizing reliability and performance of SCR and other post-combustion NO<sub>x</sub> control systems.

### Research Value

EPRI's Environmental Controls programs develop technologies that minimize the impacts of environmental controls on power plant operations and performance. EPRI helps members objectively evaluate and implement technology options to achieve their environmental performance goals at least cost. Post-Combustion NO<sub>x</sub> Control R&D provides:

- Development and implementation of best practices and operational improvements for SCR systems
- Lowered O&M expenditures, optimized operation, and reduced downtime for units equipped with SCRs
- Enhancements to existing SCR systems, which will allow members to profit from the NO<sub>x</sub> credit market

### Approach

The program develops operating and maintenance (O&M) guidelines and documents best practices and procedures consistent with optimal SCR operation. Assessments, methodologies, and databases provide plant owners and operators with the tools to make informed choices, comply with regulatory mandates, and capitalize on NO<sub>x</sub> credit markets. Interest groups share best practices in SCR catalyst management and assess mitigation methods for large particle ash (LPA).

- R&D develops tools, guidelines, and best practices critical to optimum SCR operation, including catalyst management considerations, catalyst reconditioning options, SCR test protocols, and resolution of critical operability issues including large particle ash (LPA), ammonia, and catalyst deactivation.
- Evaluations of advanced SCR and emerging post-combustion NO<sub>x</sub> control technologies allow members to significantly lower NO<sub>x</sub> emissions with existing SCR systems through improved ammonia/NO<sub>x</sub> mixing technologies and the latest advanced catalysts (higher efficiency, lower cost), and to find cost advantages for the most promising emerging NO<sub>x</sub> control technologies through compliance with near-term regulations and probable future regulations.

### Accomplishments

For more than two decades, EPRI has led the power industry in developing, advancing, and demonstrating cost-effective NO<sub>x</sub> control technologies and best operating practices consistent with compliance achievement at minimal cost and maximum reliability. Accomplishments include:

- Performance assessments of SCR catalyst reconditioning
- Protocol for laboratory testing of SCR catalyst samples
- Annual SCR workshop and webcasts on key issues
- Assessments of improved performance achieved through enhanced ammonia / NO<sub>x</sub> mixing and advanced catalysts
- SCR O&M guidelines, updated annually
- Laboratory and field assessments of continuous ammonia monitors

- Catalyst management software and best practices for total minimization of total cost of operation
- Predictive tool for deposition of ammonium bisulfate (ABS) and subsequent fouling of air heater surfaces
- Case studies of impacts of fuel quality considerations (e.g., Powder River Basin and lignite) on catalyst performance and longevity
- Objective assessments of near-commercial NO<sub>x</sub> control technologies

### Current Year Activities

The program R&D for 2010 will continue to focus on optimization of SCR performance and reliability, with the goal of minimization of NO<sub>x</sub> emissions at least cost. Specific efforts will include:

- SCR catalyst reconditioning guidelines and economics
- Annual SCR workshop, including technical presentations, panel discussions, and plant tour
- Catalyst management issues and best practices
- SCR guidelines update
- Large particle ash mitigation methods
- SCR catalyst disposal and recycling options
- Advanced SCR concepts and emerging NO<sub>x</sub> control technologies
- Boiler / SCR performance optimization
- SCR “101” training
- FTIR / TDL Monitors — NH<sub>3</sub>, NO<sub>x</sub>, SO<sub>3</sub>

### Estimated 2010 Program Funding

\$2.6M

### Program Manager

Anthony Facchiano, 650-855-2494, [afacchia@epri.com](mailto:afacchia@epri.com)

## Summary of Projects

Project Number	Project Title	Description
P73.001	Operating and Maintenance Guidelines for Post-Combustion Systems	This project develops tools, guidelines, and best practices critical to optimum SCR operation, including catalyst management considerations, catalyst reconditioning options, SCR test protocols, and resolution of critical operability issues including large particle ash (LPA), ammonia, and catalyst deactivation.
P73.002	Evaluation of Advanced SCR and Emerging Post Combustion NO <sub>x</sub> Control Technologies	This project develops ways to significantly lower NO <sub>x</sub> emissions with existing SCR systems through improved ammonia/NO <sub>x</sub> mixing technologies and the latest advanced catalysts (higher efficiency, lower cost), and to find cost advantages for the most promising emerging NO <sub>x</sub> control technologies through compliance with near-term regulations and probable future regulations.

## P73.001 Operating and Maintenance Guidelines for Post-Combustion Systems (050267)

### Key Research Question

The industry needs reliable SCR O&M guidelines and resolution of critical operability issues for SCR and other post-combustion systems to minimize costs and maximize system performance.

### Approach

This project will produce guidelines, technical reports, software, webcasts, and conferences aimed at minimizing costs and maximizing performance of SCR and other post-combustion NO<sub>x</sub> control systems. Specific efforts will include:

- Assessments of reconditioned catalysts (including activity, mercury, and SO<sub>2</sub> oxidation); catalyst management options
- Understanding and mitigation of large particle ash (LPA) impacts; year-round SCR operation
- Protocols for catalyst testing; advanced instrumentation for monitoring ammonia, NO<sub>x</sub>, and SO<sub>3</sub> (including tunable diode laser and Fourier Transform Infrared Spectroscopy [FTIR])
- Catalyst disposal and recycling alternatives
- Prediction and resolution of air heater fouling
- SCR guideline updates
- Webcasts on specific subjects of interest.

In addition, members of this program can attend the annual 2½-day EPRI SCR Workshop, to find out about the latest developments in SCR technology and share information.

### Impact

- Substantial reduction in the cost of SCR operation, achieved through best O&M practices and resolution of critical operability issues such as large particle ash
- Minimization of system costs through selection of the optimal SCR catalyst management strategy, including consideration of catalyst reconditioning options
- Minimization of SCR downtime
- Capitalization of NO<sub>x</sub> credit market by minimizing outlet NO<sub>x</sub> levels

### How to Apply Results

Members responsible for SCR operation and performance can use the tools and guidelines developed through this project to optimize their SCR system O&M practices, auxiliary hardware choices, testing procedures and protocols, and catalyst management strategies.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>SCR Catalyst Reconditioning / Recycle Guidelines and Economics:</b>            Long-term data will be developed on performance of reconditioned SCR catalysts including deactivation rates, NO<sub>x</sub>, SO<sub>2</sub> oxidation, and mercury oxidation. Economic considerations (such as onsite cleaning and other associated costs) will be assessed. New findings and developments on catalyst regeneration process will be reported.</p>	12/31/10	Technical Report

Product Title & Description	Planned Completion Date	Product Type
<b>Annual SCR Workshop and Proceedings:</b> This project sponsors EPRI's annual SCR workshop, which includes presentations on recent operating experiences from end users; content on key issues such as SO <sub>3</sub> mitigation, large particle ash, catalyst management strategies, and the latest developments from manufacturers; panel discussions; and a plant tour.	12/31/10	Workshop, Training, or Conference
<b>Catalyst Management Issues and Interest Group:</b> Documentation of catalyst management considerations and issues. Case studies with program members to formulate catalyst management strategies and best practices that can serve as models. Specific topics may include purchase decisions, catalyst installation and removal, and testing.	12/31/10	Workshop, Training, or Conference
<b>SCR O&amp;M Guidelines Update:</b> Key topics covered in the long-standing SCR O&M guidelines will be annually updated.	12/31/10	Technical Update
<b>Large Particle Ash (LPA) Mitigation Methods and Interest Group:</b> This report will provide documentation of performance and best practices for LPA mitigation. Site-specific case studies will be conducted. The LPA Interest Group will be continued as a forum in which best practices can be shared and R&D priorities identified.	12/31/10	Technical Report
<b>Spent SCR Catalyst Disposal Options:</b> This project provides further study of cost-effective options to dispose of spent catalyst, considering future regulations. It may be conducted as a co-funded effort with EPRI's Environmental Sector.	12/31/10	Technical Update
<b>SCR O&amp;M Webcasts:</b> Three webcasts will be conducted, focusing on key SCR O&M topics of interest to operators of SCR systems. Examples of pertinent topics include SCR ammonia injection system tuning, large particle ash (LPA) mitigation methods, year-round operation, ammonia measurement, and low-load operation.	12/31/10	Workshop, Training, or Conference
<b>Boiler/SCR Performance Optimization Methodology:</b> A methodology will be developed to enable SCR operators to determine the SCR inlet NO <sub>x</sub> level that results in the optimum combination of boiler- and SCR-related NO <sub>x</sub> control operating and maintenance expenses. It will weigh SCR-related expenses against boiler-related expenses, such as waterwall wastage and initially will be available as a service to funders. It will incorporate CATREACT, UMBRELLA, and a simplified corrosion predictor and be a joint Program 71-73 effort.	12/31/10	Technical Update
<b>SCR 101 training:</b> "The Fundamentals of SCR" may be combined with another SCR forum such as the Annual SCR Workshop or LPA/Catalyst Management Interest Group meeting. Alternatively, it may be presented as a series of webcasts.	12/31/10	Workshop, Training, or Conference
<b>Operating Experience with Annual SCR Operation:</b> An update of EPRI report 1014257 (a 2007 publication) will identify design deficiencies and operating problem areas that have been exposed by recent experience with annual SCR operation. A survey of Program 73 members' experiences will document how operating methods and hardware have been modified to improve SCR performance and reliability.	12/31/10	Technical Update

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Annual SCR Workshop and Proceedings:</b> This project sponsors EPRI's annual SCR workshop, which includes presentations on recent operating experiences from end users; content on key issues such as SO <sub>3</sub> mitigation, large particle ash, and catalyst management strategies; latest developments from manufacturers; panel discussions; and a plant tour.	12/31/11	Workshop, Training, or Conference
<b>SCR O&amp;M Webcasts:</b> Three webcasts will be conducted, focusing on key SCR O&M topics of interest to operators of SCR systems. Examples of pertinent topics include SCR ammonia injection system tuning, large particle ash (LPA) mitigation methods, year-round operation, ammonia measurement, and low-load operation.	12/31/11	Workshop, Training, or Conference
<b>SCR O&amp;M Guidelines Update:</b> Key topics covered in the long-standing SCR O&M guidelines will be annually updated.	12/31/11	Technical Report
<b>Catalyst Management Issues and Interest Group</b>	12/31/11	Workshop, Training, or Conference
<b>SCR Catalyst Reconditioning / Recycle Guidelines and Economics</b>	12/31/11	Technical Report
<b>Large Particle Ash Mitigation Methods and Interest Group</b>	12/31/11	Technical Report
<b>Reagent Storage, Handling and Delivery System Operating Experience:</b> An update of EPRI reports 1004054 and 1004148 (2002 publications) will identify which systems for reagent storage, handling, and delivery have proven to be most reliable and cost effective. A survey of Program 73 members' experiences will be the means of making this assessment.	12/31/11	Technical Update

## P73.002 Evaluation of Advanced SCR and Emerging Post Combustion NO<sub>x</sub> Control Technologies (046821)

### Key Research Question

To comply with anticipated regulations and to capitalize on the emerging NO<sub>x</sub> credit market, the performance of existing SCR systems will need to be enhanced through advanced catalysts, enhanced NO<sub>x</sub>-to-ammonia mixing methods, and advanced instrumentation. In addition, alternative NO<sub>x</sub> mitigation technologies (e.g., to SCR and selective noncatalytic reduction [SNCR]) need to be objectively evaluated and demonstrated.

### Approach

This project will develop and demonstrate technologies that significantly reduce NO<sub>x</sub> in existing SCR systems, including the evaluation of the next generation of SCR catalysts — which, in addition to offering greater NO<sub>x</sub> removal efficiency, will increase Hg oxidation while minimizing SO<sub>2</sub> conversion. In addition, this project will identify, assess, and demonstrate post-combustion NO<sub>x</sub> control technologies with potentially cost-effective intermediate NO<sub>x</sub> control capability (e.g., between SNCR and SCR). Engineering evaluations and assessments will provide unbiased information about new vendor offerings with respect to the costs and capabilities of nearly and recently commercialized novel NO<sub>x</sub> control technologies.

## Impact

- Significant reduction in NO<sub>x</sub> emissions from existing SCR systems through improved ammonia/NO<sub>x</sub> mixing technologies and advanced catalysts, resulting in higher efficiency and lower cost
- Cost advantages for the most promising emerging NO<sub>x</sub> control technologies through compliance with near-term regulations and probable future regulations
- Capitalization of NO<sub>x</sub> credit market by minimizing outlet NO<sub>x</sub>

## How to Apply Results

Members can use information and findings developed through this project to enhance the NO<sub>x</sub> reduction capabilities of their existing SCR systems through improved ammonia-to-NO<sub>x</sub> mixing, use of superior catalysts, and other means. In addition, documented performance demonstrations of emerging post-combustion NO<sub>x</sub> control technologies will help members to make informed decisions regarding future NO<sub>x</sub> control systems needed for ratcheted NO<sub>x</sub> levels and to capitalize on the emerging NO<sub>x</sub> credit market.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Advanced SCR Concepts, Emerging NO<sub>x</sub> Controls:</b> Objective assessments will be provided of performance and operational impacts of emerging post-combustion NO <sub>x</sub> control technologies, which will be added to EPRI's Post-Combustion Emerging Technologies website. Application of advanced SCR concepts applicable to existing systems, including evaluation of next-generation of SCR catalysts, will be examined. Additional concepts may include the viability and development status of thin-wall catalysts (e.g., impacts on regeneration) and low-temperature catalysts.	12/31/10	Technical Report
<b>Multipoint monitors:</b> Assessments will be made of continuous monitor performance (NH <sub>3</sub> , NO <sub>x</sub> , or SO <sub>3</sub> ), along with case-study evaluations of implementation approaches, operational benefits, and associated costs. Follow-on efforts will include studies of how continuous multipoint data can be integrated within process control and the use of optimization systems.	12/31/10	Technical Report
<b>Intermediate NO<sub>x</sub> Control Technologies Field Assessments:</b> This project will provide field assessments and data on emerging post-combustion NO <sub>x</sub> control technologies, such as induct SCR or other, more cost-effective approaches.	12/31/10	Technical Report
<b>Ammonia Injection Grid:</b> Based on the conceptual design developed in 2009, a simple version of an automated ammonia injection grid will be demonstrated on a host SCR unit that employs a delta-wing AIG. The system will use feedback from online ammonia and NO <sub>x</sub> monitors to continuously tune ammonia flow control valves, optimizing the ammonia distribution in the SCR reactor in order to achieve and sustain a high level of NO <sub>x</sub> reduction throughout the load range of the unit.	12/31/10	Technical Report
<b>Catalyst Deactivation Reduction Methods:</b> Technology options to extend catalyst life through the reduction of deactivation mechanisms such as poisoning, erosion, and plugging will be assessed, including costs, long-term catalyst deactivation performance, and potential issues. Field case studies will be incorporated.	12/31/10	Technical Update

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Integration of multipoint monitors for process control:</b> A demonstration will be conducted of continuous multipoint data integrated with process control or optimization systems.	12/31/11	Technical Report
<b>Demonstration of advanced catalysts:</b> A full-scale demonstration of advanced SCR catalysts will be conducted.	12/31/11	Technical Report