PROGRAM facts

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental and Water Resources

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ADVANCED NO_X CONTROL TECHNOLOGY FOR COAL-FIRED POWER PLANTS

CONTACT POINTS

Thomas J. Feeley, III
Product Manager
National Energy Technology Laboratory
(412) 386-6134
thomas.feeley@netl.doe.gov

Bruce W. Lani
Program Coordinator
National Energy Technology Laboratory
(412) 386-5819
bruce.lani@netl.doe.gov

CUSTOMER SERVICE

(800) 553-7681

NETL WEBSITE

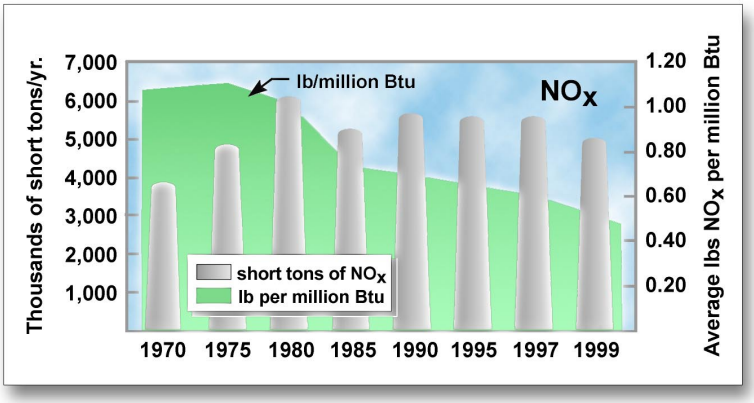
www.netl.doe.gov

Background

A key component of the National Energy Technology Laboratory's (NETL's) Innovations for Existing Plants Program is the research and development of advanced nitrogen oxide (NO_X) control technologies. NETL is focusing on systems capable of controlling NO_X emissions to levels at or below 0.15 pounds per million Btu (lb/MMBtu) at a cost at least 25% lower than selective catalytic reduction (SCR). These technologies would offer alternatives to SCR should further restrictions be placed on the electric utility industry to address concerns about visibility, eutrophication, climate change, ground-level ozone, and ambient fine particulates. The research also involves improving NETL's understanding of the impacts of these advanced technologies and SCR on related issues, such as mercury speciation and capture, unburned carbon, waterwall wastage, and catalyst deactivation. These drivers closely align this program with the National Energy Policy (NEP) that states, "As U.S. energy needs grow, additional innovations will be necessary to continue improving environmental conditions and to meet new environmental challenges."

Description

The Innovations for Existing Plants Program is built upon a strong history of government-industry partnerships for developing useful commercial products. An example is the low NO_X burner (LNB) technology developed in the Clean Coal Technology Program. The figure below shows how these improvements in NO_X control technology have helped to significantly reduce the emissions of NO_X from coal-fired power plants on a lb/MMBtu basis. In addition, a recent National Academy of Science report concluded that NETL's NO_X control research has resulted in tens of billions of dollars in benefits from reduced power plant NO_X emissions. The following project summaries provide an overview of the NO_X control technologies being developed through this program.



INNOVATIONS FOR EXISTING PLANTS

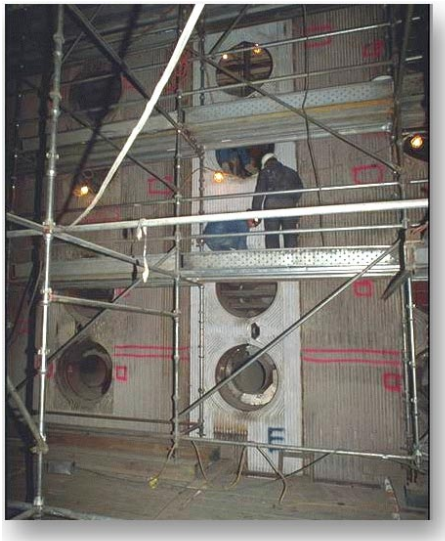
The Innovations for Existing Plants Program goal is to develop fully integrated pollutant control systems that address air, water, and solid waste effluents in an affordable manner. The program strategy is to work collaboratively with industry (power producers and technology developers), the research community (public and private sector), and the planners and regulators (EPA) in developing reliable data and bring cost effective R&D products to the commercial market. There are three key elements of this strategy:

- Develop high quality data on environmental releases and technology performance that are accepted as an "honest broker" information base for policy and regulatory decisions.
- Use a systems approach to integrate air, water, and solid waste management issues and identify the critical areas for research and development.
- Maintain a science based program grounded in a fundamental understanding of pollutant generation and control, emissions transport, and byproduct utilization and disposal.

Project Summaries

"Optimize Fuel-Injector Design for Maximum In-Furnace NO_X Reduction and Minimum Unburned Carbon"

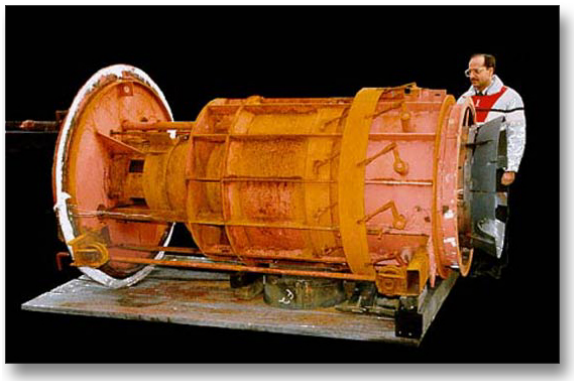
Reaction Engineering International is developing combustion systems to minimize NO_X emissions and reduce the carbon in the fly ash. The research includes: evaluation of commercial low NO_X burner-fuel fundamental studies at laboratory- and bench- scale to define NO_X reduction mechanisms in flames and reburning jets, and demonstration of commercial-scale coal-injector reburning.



Low NO_X burners being installed in the wall of a boiler

"Second Generation Advanced Reburning Technology Development"

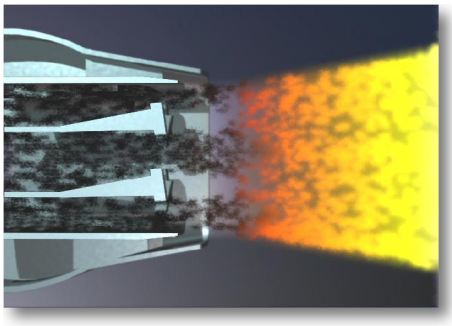
GE-Energy and Environmental Research Corporation is developing a family of novel NO_X control technologies known as Second Generation Advanced Reburning (SGAR), capable of achieving 90% or greater reduction in NO_X. In a SGAR system, the N-agent is injected into the reburning zone along with overfire air, or downstream in the burnout zone. Advanced reburning (AR) configurations being tested include: AR-Lean, AR-Rich, and Multiple-Injection Advanced Reburning (MIAR). The N-agent can also be injected in a normal selective non-catalytic reduction (SNCR) configuration, downstream of AR-Rich or AR-Lean zone.



Advanced low NO_X burner in fabrication

"Ultra Low NO_X Integrated Systems for NO_X Emission Control"

Alstom Power is developing an ultra low NO_X integrated system for coal-fired power plants that will achieve furnace outlet emission levels at or below 0.15 lb/MMBtu. The reduced NO_X emissions will be obtained without increasing the level of unburned carbon (UBC) in the fly ash through advances in control systems, combustion process modifications, and post-combustion carbon burnout technology. The cost of this system is expected to be less than half that of SCR systems. The target market is tangentially fired (T-fired) coal boilers, which represent about 40% of the boilers currently listed in the State Implementation Plan (SIP) Call region.



Ultra low NO_X burner coal nozzle tip

"NO_X Control Options and Integration for U.S. Coal-Fired Boilers"

Reaction Engineering International is carrying out a second project to optimize the performance of the combined application of low NO_X firing systems (LNFS) and post-combustion controls. The project will assess real-time monitoring equipment to evaluate waterwall wastage, soot formation, and burner stoichiometry. In addition, the impact of various coals on SCR catalyst activity will be investigated, along with novel UBC/fly ash separation processes. The primary target of the research will be cyclone boilers, which represent about 20% of the U.S. generating capacity.

"Cost-Effective Control of NO_X with Integrated Ultra Low NO_X-PC Burners and SNCR"

In another advanced low NO_X burner project, McDermott Technology and Fuel Tech are teaming to develop an integrated system comprised of ultra LNBs, coupled with SNCR. The overall goal of this project is to develop a cost-effective control system deployable by the year 2002 and capable of achieving NO_X levels below 0.15 lb/MMBtu for a wide range of coals. The primary market for the ultra LNB/SNCR technology are front- and opposed-wall-fired boilers within the NO_X SIP Call region, with cell-fired, roof-fired, and arch-fired boilers also among the candidate boilers.

Pilot testing of METHANE de-NO_X burner

"METHANE de-NO_X for Utility Boilers"

The Gas Technology Institute (formerly the Institute of Gas Technology and Gas Research Institute) is developing a pulverized-coal (PC)-combustion system. The technology integrates natural gas-fired coal preheating, low NO_X burners with internal combustion staging, and additional natural gas injection with overfire air. Preheating the coal promotes the conversion of fuel-bound nitrogen to molecular nitrogen rather than to NO_X. The Gas Technology Institute estimates the market for the technology to include more than 21,000 burners (over 260,600 MW) in the 37 eastern states encompassing wall-fired (wet- and dry-bottom), T-fired, roof-fired, and cell burners.

NO_X IN COMBUSTION

Most of the NO_X formed when a fuel burns is mainly the result of two oxidation mechanisms: (1) reaction of nitrogen in the combustion air with excess oxygen, referred to as thermal NO_X, and (2) reaction of nitrogen that is chemically bound in the coal, referred to as fuel NO_X. Thermal NO_X generally represents about 25% of the total and fuel NO_X about 75%. In addition, minor amounts of NO_X are formed through complex interaction of molecular nitrogen with hydrocarbons in an early phase of the flame front; this is referred to as prompt NO_X.

Generally, the fundamental methods behind all NO_X control technologies involve one of the following two strategies:

- Delaying the mixing of the fuel and air or "staging" the introduction of fuel into a furnace reduces the combustion temperature and inhibits the formation of NO_X. Low NO_X burners (LNB), overfire air (OFA), and reburning are technologies that utilize this strategy.

- Injecting a reducing agent, typically ammonia or urea that reacts with NO_X to form nitrogen and water. Technologies representative of the strategy are selective catalytic reduction (SCR) and selective noncatalytic reduction (SNCR).

Advanced NO_X Control Technology for Coal-Fired Power Plants

PARTNERS

Alstom Power
Windsor, Connecticut
www.power.alstom.com

American Electric Power
Columbus, Ohio
www.aep.com

EPRI
www.epri.com

Fuel Tech, Inc.
Batavia, Illinois
www.fueltechnv.com

Gas Technology Institute
Chicago, Illinois
www.gastechnology.org

GE-Energy and Environmental Research Corporation
Irvine, California
www.gepower.com

McDermott Technology
Alliance, Ohio
www.mtiresearch.com

Praxair Inc.
Tonowanda, New York
www.praxair.com

Reaction Engineering International
Salt Lake City, Utah
www.reaction-eng.com

University of North Dakota Energy and Environmental Research Center
Grand Forks, North Dakota
www.eerc.und.nodak.edu

U.S. Environmental Protection Agency
www.epa.gov

Project Summaries (continued)

"Oxygen-Enhanced Combustion for NO_X Control"

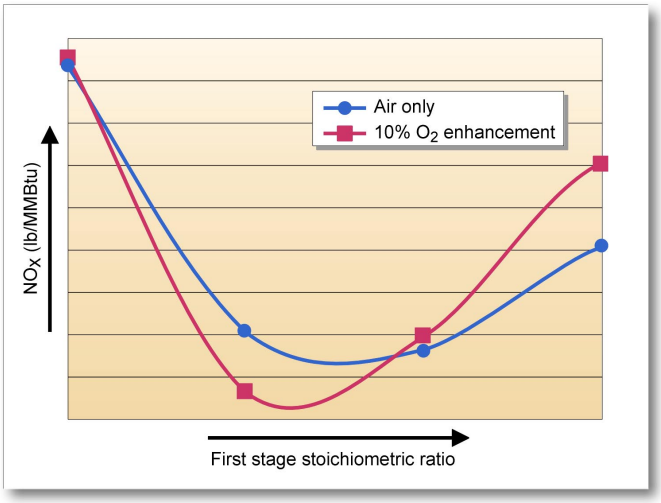
Praxair is developing oxygen-enhanced combustion and oxygen-enhanced reburning technologies for controlling NO_X. Oxygen-enhanced combustion can be used to control both thermal and fuel NO_X. The key to this project is the use of controlled conditions to take advantage of the combustion benefits of oxy-fuel firing to reduce NO_X emissions below 0.15 lb/MMBtu.

"Cardinal 1 Selective Noncatalytic Reduction (SNCR) Demonstration Test Program"

In partnership with American Electric Power, NETL has evaluated the performance of a commercial-scale SNCR system. The project was sited at AEP's Cardinal Plant Unit 1, a 600 MW_e pulverized coal-fired boiler. The objective of the project was to reduce NO_X by an additional 30% beyond that achieved by existing LNBs while maintaining ammonia concentrations in the flue gas at or below 5 ppm. Long-term testing of the SNCR showed that the unit could provide 30% reduction in NO_X across the load range tested while minimizing slip.

"Evaluation of Mercury Speciation at Power Plants Using SCR and SNCR NO_X Control Technologies"

Through field evaluations, the University of North Dakota Energy and Environmental Research Center (UNDEERC) is determining the impact of SCR, SNCR, and flue gas conditioning (FGC) systems on the speciation of mercury. Prior bench and pilot-scale tests indicate that SCR catalysts have the potential to promote the formation of oxidized and/or particulate bound mercury that may be removed by downstream particulate removal or flue gas desulfurization systems. SNCR and FGC systems can utilize ammonia-based reagents like SCR but do not utilize catalysts and therefore the impact on mercury could be different.



Effect of oxygen-enhancement on NO_X emissions