NETL's Innovations for Existing Plants NOx Control Program – Addressing Lower Limits

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Summary

The U. S. Department of Energy (DOE) has established a set of national priorities through its Strategic Plan that includes the goal to promote secure, competitive, and environmentally responsible energy systems that serve the needs of the public. To achieve this goal, the Innovations for Existing Plants (IEP) program, managed by the DOE's National Energy Technology Laboratory (NETL), develops advanced, low cost, environmental control technologies for coal-based power systems. The program also provides high-quality scientific information on present and emerging environmental issues for use in regulatory and policy decision-making.

An important component of the IEP program is the research and development of advanced nitrogen oxide (NOx) control technologies. This effort is focused primarily on combustion systems capable of controlling NOx emissions to achieve near-term NOx targets of 0.15 lb/MMBtu by 2005, an intermediate-term NOx target of 0.10 lb/MMBtu by 2010 at a cost significantly lower than today's state-of-the-art technology, defined as Selective Catalytic Reduction (SCR). The corresponding projects also provide an improved understanding of the impact of these advanced technologies on related issues such as unburned carbon, waterwall wastage, and mercury speciation and capture. The research is driven by continuing pressure for further reductions in NOx emissions from coal-fired utility boilers to address ground-level ozone and other environmental considerations including ambient fine particulates, visibility, eutrophication, climate change, as well as "acid rain" precursors.

The Challenge

New regulations, resulting from Title I of the Clean Air Act Amendments of 1990 (Interstate Air Quality Rule, NOx SIP Call, and 126 Petition) and from the President's proposed Clear Skies Act which will require NOx emissions as low as 0.12 lb/MMBtu, continue to ratchet down permissible NOx emissions. In the future, regulations that endorse the concept of a "near zero emissions" boilers may reduce this target to 0.01 lb/MMBtu.

To meet these challenges, power producers will need to retrofit existing boilers with additional NOx control technologies, some of which will adversely impact plant efficiency and performance. Hardest hit economically will be the smaller, older, less efficient facilities that are not easy retrofit candidates for the current state-of-the-art SCR NOx control equipment because of space constraints and the reluctance of owners to make substantial investments in the aging plants during a period of increasing market competition. These facilities, with a generating capacity of 300 MW or less, comprise 66% of the boilers in the US and have an average age of 38 years as compared to the remainder of the fleet with an average age of 24. The geographical location of these plants in the eastern US prohibits the option of utilizing an affordable source of a more reactive subbituminous coal as part of a NOx control strategy. The new NOx requirements, which demand an increase in R&D, capital, and operating expenditures from utilities to implement, come at an inopportune time for the industry that has been adversely impacted financially by deregulation and the associated capital market pressures, aging facilities, homeland security, in addition to the environmental issues. It is estimated that if advanced forms of combustion control are successful in achieving a targeted NOx emissions rate of 0.10 lb/MMBtu by 2018, the generating stations of 300 MW and less would realize a capital expenditure savings of $2.0 billion when meeting the NOx reductions identified in EPA's modeling results of

the Clear Skies Act.

The Program

The NETL NOx control program focuses on pilot- and field testing-scale research and development of advanced NOx control technologies to meet the future needs of the US coal-fired generating fleet. The key to its success is the close coordination and cooperation with industry. As a result, the program has developed a strong reputation for assisting in the development of useful commercial products. Notable projects in recent history include:

- **Ultra Low NOx Integrated Systems for NOx Emission Control**
  Alstom Power developed a combination of firing system modifications referred to as an Ultra Low NOx Integrated System for tangentially-fired power plants. The project achieved furnace outlet NOx emission levels of 0.08 lb/MMBtu for subbituminous coal and 0.12 lb/MMBtu for high volatile bituminous coal in a 60 MMBtu/h test facility. The reduced NOx emissions were obtained without significantly increasing the level of unburned carbon in the fly ash. Nineteen commercial boilers firing subbituminous coal that utilize aspects of the technologies demonstrated in this project are achieving NOx emissions at or below 0.15 lb/MMBtu.

- **Oxygen-Enhanced Combustion for NOx Control**
  Praxair demonstrated a novel concept in which a small fraction of combustion air is replaced with oxygen to enhance operation of an existing low NOx combustion system, namely low NOx burners with over-fire air. Pilot-scale tests conducted on a 25 MMBtu/hr burner generated NOx emissions as low as 0.11 lb/MMBtu when firing Illinois 6 coal. Demonstrations at two utility boilers have shown that this process reduces both unburned carbon in the fly ash and opacity while decreasing the NOx emissions.

- **NOx Control Options and Integration for U.S. Coal-Fired Boilers**
  Reaction Engineering International optimized EPRI's Rich Reagent Injection (RRI) technology on two commercial-scale cyclone burner utility boilers. The concept of RRI applied to staged cyclone-fired furnaces is to use a nitrogen-containing additive to increase the NOx reduction rate in the lower furnace. The results of these tests demonstrated that RRI in combination with over-fire air could achieve NOx reduction from a baseline of 1.2 lb/MMBtu to between 0.38 to 0.27 lb/MMBtu with less than 1 ppm ammonia slip. Although the target emission of 0.15 lb/MMBtu was ambitious for the cyclone burner, these results are substantial when compared to the CAAA Title IV NOx limit of 0.86 lb/MMBtu for this style of burner.

In continuing these efforts with regards to the proposed multi-pollutant legislation, NETL has recently issued a solicitation to target even lower NOx emissions for existing boilers. The challenge is to develop NOx control technologies for the smaller, older, less efficient facilities that are not easy retrofit candidates for SCR NOx control equipment and do not have a suitable source of highly reactive coal. The solicitation addresses the need for strategic research, development, and testing of efficient, cost-effective NOx control technologies, processes, and concepts that are to be retrofitted to this target group of pulverized coal-fired electric utility boilers. The requested proposals are to focus primarily on combustion systems capable of controlling NOx emissions to achieve near-term NOx targets of 0.15 lb/MMBtu by 2005, an intermediate-term NOx target of 0.10 lb/MMBtu by 2010, or develop advanced SCR concepts that achieve 90% NOx reductions based on inlet NOx levels of 0.10 to 0.40 lbs/million Btu. A levelized cost savings on a dollar-per-ton of NOx removed of at least 25% over the current state-of-the-art SCR is to be demonstrated by these technologies. The proposals are to also address the impact of these advanced technologies on related issues such as unburned carbon, waterwall wastage, heat transfer surface fouling, sulfur trioxide generation, and mercury speciation and capture where appropriate.

In conducting this development effort, data is sought to: (1) verify technology performance in terms of NOx reduction, (2) determine preliminary process/equipment and operating costs, (3) quantify potential balance-of-plant (BOP) impacts, (4) develop process monitoring/control tools to assist in management of NOx control equipment, and (5) measure and assess potential mercury control associated with multiple pollutant or co-control technology. The benefits of this program will be realized by both the existing fleet and new capacity as the NOx control technologies are adopted.