PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental & Water Resources

11/2004

NETL

PRIMARY PROJECT PARTNER

ALSTOM Power, Inc.
Windsor, CT
www.alstom.com

CONTACTS

Bruce W. Lani
Project Manager
National Energy Technology Laboratory
412-386-5819
bruce.lani@netl.doe.gov

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

John Marion
ALSTOM Power, Inc.
john.l.marion@power.alstom.com

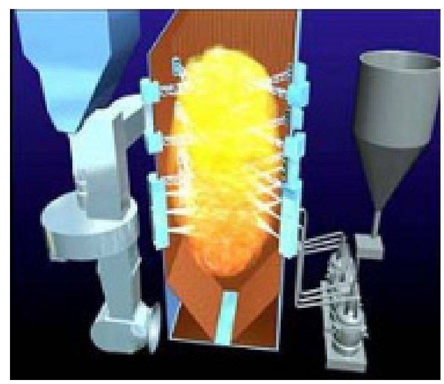
WEBSITE

http://www.netl.doe.gov

ULTRA LOW NO_X INTEGRATED SYSTEM FOR NO_X EMISSIONS CONTROL FROM COAL-FIRED BOILERS

Background

Enacted regulations pertaining to the NO_X SIP Call and potential future regulations in proposed legislation such as the President's Clear Skies Act or EPA's Clean Air Interstate Rule require power producers to seek the most cost effective methods to achieve compliance. In order to address present and anticipated NO_X emissions control legislation targeting the current fleet of U.S. coal-fired boilers, the Department of Energy's (DOE) Innovations for Existing Plants (IEP) Program develops advanced, low cost, NO_X control technologies. Managed by the DOE's National Energy Technology Laboratory (NETL), the IEP Program develops these technologies in order to keep coal a viable part of the national energy mix. Such technologies address issues of health, ground-level ozone, ambient fine particulates, visibility, eutrophication, climate change, as well as "acid rain" precursors.



Under a cooperative agreement with NETL, ALSTOM Power, Inc. has developed an Ultra-Low NO_X Integrated System for Coal-Fired Boilers. The system enhances the performance of ALSTOM's field-proven TFS 2000™ low NO_X firing system to achieve furnace outlet NO_X emissions at or below 0.15 lb/MMBtu for existing tangentially-fired boilers firing a wide range of coals. Target NO_X emissions were obtained without increasing the level of unburned carbon in the fly ash through advances in firing technology including in-furnace combustion process modifications and a post-combustion carbon burnout technology for non-reactive coals.

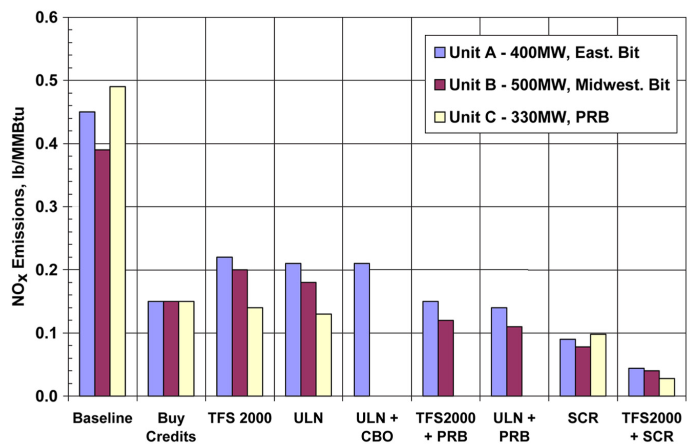
Objectives

The primary project objective was to develop a retrofit NO_X control technology to achieve less than 0.15 lb/MMBtu NO_X from existing tangentially-fired utility boilers when firing Eastern bituminous coals and less than 0.10 lb/MMBtu NO_X when firing western, sub-bituminous coal from the Powder River Basin (PRB) or lignite coals. The economic project objective was to develop this technology at a cost at least 25% lower than the SCR-only technology. The NO_X control technology was to be validated through a large, 15 MW_t, pilot scale demonstration.

Description

The foundation for the integrated system is ALSTOM's field-proven TFS 2000™ low NO_X firing system. The project plan called for the Ultra Low NO_X Integrated System to improve NO_X reduction over ALSTOM Power's current TFS 2000™ system through advances in several areas that overcome present constraints. The five main features of the system include the Flame Front Control Coal Nozzle Tips, Concentric Firing System (CFS™) Nozzles, Close-Coupled Overfire Air, Multi-Level Separated Overfire Air, and the Dynamic™ Classifiers.

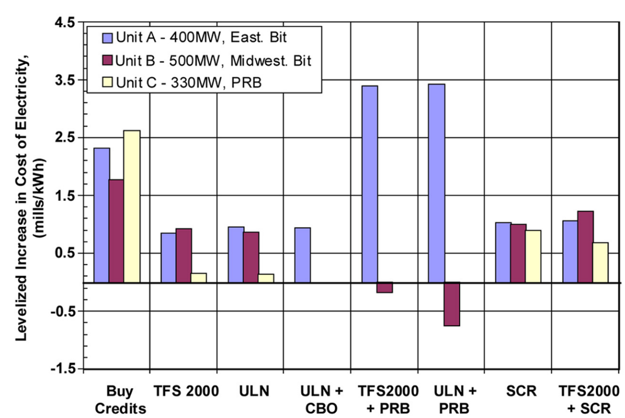
Low NO_X oxidizing pyrolysis burners, based on ALSTOM Power's LNCFS™-P2 coal nozzle tips, were designed to promote higher fuel-bound nitrogen release through more rapid heating of coal particles in the near-burner zone, coupled with the generation of additional near-burner turbulence to create a more uniform, high intensity, fuel rich zone. The low NO_X oxidizing pyrolysis burners were tested in ALSTOM Power's Boiler Simulation Facility (BSF). High velocity overfire air (HVOFA) was evaluated through CFD modeling as well as through pilot-scale testing. Multiple levels of separated over-fire air (SOFA) were used to maximize NO_X reductions while limiting CO emissions or increases in unburned carbon. For certain types of coal, DYNAMIC™ Classifiers were added to the pulverizers to control coal fineness and further limit unburned carbon.



For particularly unreactive coals, where higher levels of unburned carbon in the fly ash might prevent selling the ash to cement manufactures, a bubbling bed Carbon Burn Out™ (CBO) combustor, developed by Progress Materials, was evaluated as an option to reduce carbon in ash to acceptable levels. The ability to reduce the carbon content of fly ash to commercially acceptable levels coupled with the recovery of the thermal output from the CBO combustor creates an additional degree of freedom for NO_X control.

Combustion tests were performed for the three coals over the range of 30—60 MMBtu/h to quantify the impact of the proposed system improvements on NO_X emissions. Baseline NO_X emissions increased with coal rank 0.49, 0.56, and 0.66 lb/MMBtu for the PRB, hvb, and mvb coals, respectively. The Ultra-Low NO_X firing system technology achieved NO_X emissions of 0.08, 0.12, and 0.17 lb/MMBtu for the three fuels for approximately 75-85% reduction over the baseline NO_X emissions.

As expected, the quantity of unburned carbon in the fly ash increased with coal rank. For the PRB fuel, the low NO_X firing system technology had little impact on the unburned carbon levels that were always less than 0.1% carbon in the fly ash. In the case of the mvb coal, unburned carbon exceeded 8% in the ash. Implementation of microfine coal grind (96% -325 mesh) reduced the unburned carbon by 50% as well as reduced the NO_X emissions by 0.02 lb/MMBtu. These pilot tests demonstrate the potential of combustion-based minimization of NO_X emissions. Actual performance in full scale boilers has yet to be demonstrated, but prior experience has shown performance is likely to vary due to the wide diversity of furnace geometries, operating conditions, and fuel types that exist in commercial operation today.



An engineering and economic analysis was performed for 3 tangentially-fired utility boilers in the U.S.: a 400MW unit on the East coast firing a low sulfur compliance coal (hvb), a 500MW unit in the Midwestern U.S. firing a local bituminous coal (hvb), and a 330MW unit in the Western U.S. firing a sub-bituminous coal from the PRB. The NO_X reduction strategies analyzed included: buying NO_X credits, TFS 2000™ firing system, Ultra-Low NO_X firing system, SCR, and fuel switching to PRB coal. As might be expected, the "best" NO_X reduction strategy is unit specific. The Ultra-Low NO_X firing system is the recommended option for the unit firing the PRB coal as firing system modifications alone can achieve the 0.15 lb/MMBtu emissions target. Fuel switching to PRB, along with the Ultra-Low NO_X firing system is the most attractive option for the Midwestern unit, while the economics for the East coast unit are very dependent upon the price of NO_X credits and PRB fuel. Nineteen commercial boilers firing subbituminous coal that utilize aspects of the technologies demonstrated in this project are achieving NO_X emissions at or below 0.15 lb/MMBtu.