

More Electricity, Fewer Emissions from Coal-Fired Boilers

NICE³

Nitrogen oxides (NO_x) produced by fossil fuel combustion are recognized as hazards to the earth's biosphere and are regulated by the Environmental Protection Agency (EPA). These pollutants are major precursors to ozone and photochemical smog formation and have been associated with respiratory disorders.

To remain competitive while meeting emission limits, utilities must maintain or improve thermal efficiencies in large, fossil-fueled plants. Through the NICE³ grant program, sponsored by the U.S. Department of Energy (DOE) and EPA, Pegasus Technologies Corporation of Painesville, Ohio, will modify its NeuSIGHT for Heat Rate Improvement system to include combustion control of NO_x , sulfur dioxide (SO_2), and carbon dioxide (CO_2) emissions from pulverized-coal-fired boilers.

■ **Challenge:** Nitrogen in the coal accounts for as much as 80% of total NO_x from coal combustion. Currently, the only available methods for reducing NO_x emissions from coal-fired boilers are (1) installing catalytic conversion equipment for stack gas treatment and (2) retrofitting low- NO_x burners in the flue-gas stream. Although each technology reduces NO_x emissions by 30% to 75%, each technology costs more than \$5 million to install in an 800-MW plant.

■ **Solution:** Combustion control is an emerging alternative for reducing emissions. Pegasus Technologies has developed a prototype neural-network system for improving the thermal efficiency of large, coal-fired utility plants. For less than \$250,000, Pegasus Technologies can install the NeuSIGHT system to control NO_x emissions.

The neural-network core of the product is a generalized process optimizer, called CAD CHEM, that was developed by AI WARE, Inc., of Cleveland, Ohio. The software has the unique ability to model nonlinear physical processes. The AI WARE neural-network core contains a functional link network and GESA algorithm that are particularly effective for modeling real-time physical processes.

Optimizing a boiler for both thermal efficiency and emissions reduction requires that dynamic set-point targets be generated in real-time to balance trade-offs between NO_x emission control, heat-rate improvement, and unburned carbon. Pegasus Technologies uses the neural network to identify 50 to 100 set-point parameters that include plant output, emissions requirements, ambient operating conditions, equipment age, and maintenance. The NeuSIGHT computer model adjusts the plant control system for on-line response to changes in the combustion process.

■ **Energy Savings:** Preliminary test results by Pegasus Technologies on its computer model have shown heat rate improvements of 0.5% to 5.0%, depending on set-point recommendations. If neural-network-derived optimization occurs in 10% of U.S. coal-fired generation plants and improves thermal efficiency by 1%, Pegasus Technologies estimates an annual energy savings in 1998 equivalent to 1.13 million tons (1.02 megatonnes)/yr of coal.

■ **Environmental Benefits:**

Pegasus Technologies estimates that combustion control alone will provide NO_x reductions of 20% to 60% for plants with no current NO_x control plan. In plants already fitted with low- NO_x burners, the company expects an additional decrease of 5% to 25% in NO_x emissions. Also, CO_2 and SO_2 emissions are reduced in direct proportion to the amount of fuel burned. For example, each 1% reduction in fuel consumed reduces SO_2 emissions by 1%.

■ **Economic Savings:** A 1% improvement in thermal efficiency for a 400-MW plant would save an estimated \$400,000/yr in fuel costs. This amounts to a payback period of less than 8 months for the neural-network system.

Current removal costs using low- NO_x burners are estimated to be about \$1,000/ton of NO_x removed for a 400-MW boiler. By reducing NO_x emissions with combustion control at only 10% of the large-capacity plants, utilities could save \$120 million/yr over low- NO_x burner systems use.

■ **Applications:** These neural-network control systems can be installed in pulverized-coal-fired electrical generation plants worldwide. Pegasus Technologies estimates that by 2010, about 37% of the domestic market and 25% of the international market will be using the technology.

■ **Regional Utilities:** Centerior Service Company (electricity), East Ohio Gas Company (gas).



Partners: Pegasus Technologies Corporation, Ohio Edison, Ohio Department of Development's Office of Energy Efficiency
SIC Codes: 4911, 7371, 3823
Cost: \$240,000 (Industry share: \$105,000)
Energy Savings: 25.0 trillion Btu (26.4 exajoules)/yr
Environmental Benefits: NO_x emissions reduced by 120,000 tons (108,600 tonnes)/yr; SO_x emissions reduced by 50,000 tons (45,250 tonnes)/yr
Economic Savings: Fuel cost savings of more than \$30 million/yr
National Impact (2010): NO_x emissions reduced by 444,000 tons (402,708 tonnes)/yr; SO_x emissions reduced by 186,000 tons (169,074 tonnes)/yr
Applications: Pulverized-coal-fired boilers
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NATIONAL INDUSTRIAL COMPETITIVENESS through ENERGY ENVIRONMENT ECONOMICS

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