New Power Plant Optimization Options

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Introduction:

Deregulation and privatization are requiring power companies to operate their generation assets more efficiently and cost-effectively, while at the same time, information-based economies are creating an increasing demand for energy. Because of this rapidly changing, often unpredictable environment, power generation facilities are looking for ways to do what once seemed impossible – comply with tighter air quality regulations while operating profitable, reliable, more productive plants.

Among the most complex environmental challenges facing coal-fired power generators is the reduction of nitrogen oxide (NOx) emissions. NOx is a by-product of combustion – the hotter the flame temperature used in the combustion process, the more NOx the process produces. NOx emissions are also prevalent in industrial areas and regions of heavy automobile activity or traffic congestion. When combined with volatile organic compounds in hot stagnant weather, NOx emissions can lead to smog, or ground-level ozone pollution, which can cause respiratory problems in humans, particularly children and older people. When seeking NOx emissions cuts to avoid continual smog problems, regulators often look to coal-fired power plants for reductions.

Traditionally, reducing NOx levels in a power plant, or from any industrial boiler application, is expensive. Equipment like low NOx burners, flue gas recirculation and selective catalytic reduction (SCR) can be costly. Fuel switching, blending or remediation can increase operating costs, and take the fuel handling equipment far off the design parameters. Additionally, NOx reduction equipment installation can extend scheduled outages beyond typical time frames.

These often-lengthy outages and can result in lost revenue for a deregulated or privatized generator. In some plants, even expensive new equipment may not achieve compliance without extensive tuning and testing to meet NOx regulations, and other plants that are able to achieve compliance teeter close to the edge, certain to stumble into violations during peak energy-use seasons. These peak seasons can also correspond to Ozone compliance seasons further complicating the operation of the generation asset.

Reducing the flame temperature in the boiler can also reduce NOx formed during combustion (prompt or thermal NOx), but this method is often costly as well. In most cases, reduced flame temperature means sacrificing boiler efficiency. Lower

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flame temperatures often result in higher loss on ignition (LOI) or higher levels of carbon in ash, causing plants to generate less electricity from the same amount of fuel. According to the Electric Power Research Institute (EPRI), even expensive low NOx burners can have unacceptable increases in unburned carbon. In today's competitive power marketplace, high LOI means increased fuel costs and can reduce the opportunity to market fly ash for other uses.

A Technological and Cost Effective Option:

A number of years ago, engineers and scientists began working with neural networks, a type of artificial computer intelligence based on the process of how the human brain "learns." By applying the principals of learning to the complex, automated processes that produce electricity, a neural network system can "learn" or model the process. These models can be inverted to come up with strategies that can be used to refine controls, improving a process until it runs at the most efficient and cost-effective rate possible for the equipment. Operating experience over a wide range can expose the neural network to patterns that appear when NOx is the lowest. These patterns then can be categorized into a model of plant operations that reflect a desirable goal. These models can then be analyzed for the components that contribute to the desirable goals, sometimes referred to as sensitivity analysis. This newly gained knowledge then can be applied to build or design a prediction model that can estimate the NOx levels. The modeled data then can be used to predict settings that would result in operating at the lowest NOx levels.

Neural network technology, which becomes even more reliable when coupled with other advanced computer modeling techniques, such as statistical process control (SPC), data validation, sensor replacement data, and proven linear modeling techniques. This technology can help power plants achieve the critical balance between NOx reduction and boiler efficiency, further decreasing emission levels and increasing the life of combustion equipment – including expensive NOx reduction equipment added to the combustion system.

Optimization software tools that employ this advanced computer technology feed plant set points, biases and other operating parameters directly into a power plant's main control computer or distributed control system (DCS). In the case of NOx emissions, software tools optimize the combustion process using conventional fuel-to-air relationships, secondary air registers, and over-fire air ports to affect the fuel-to-air ratio at each burner location. An optimizer working in closed-loop fashion stabilizes emission levels and provides constant process adjustments to provide more consistent and lower NOx levels. Optimizers can check and adjust numerous parameters affecting NOx production every few seconds, enabling the operator to oversee and troubleshoot all other operating processes in a generation facility.

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What Optimization Can Really Do – Or Not Do:

Power generators can reasonably expect to see NOx production fall between 15 and 35 percent with the use of optimization software products. While optimization alone may not be enough to bring some plants into compliance, these software tools provide a low-cost way to achieve a reliable reduction based on which future compliance needs can be evaluated.

Optimization software, used in conjunction with other NOx reduction methods, can also create breathing room for plants anticipating the need for further pollution abatement. Through the emissions consistency gained through optimization use, plants may even see a longer life span for more expensive NOx reduction equipment. Some claims have been made for even higher rates of reduction – as high as 60 percent – but power plants should take a closer look at too-good-to-be-true claims. Many available software packages run "steady-state" optimization, or optimize parameters for NOx reduction only when the plant is operating at a steady rate of generation – not during a plant's naturally dynamic processes, such as startup, shutdown, load swings and dispatched operation. Deregulation and privatization will create increased revenue opportunities for traditionally base-loaded facilities that choose to follow dispatch regulation. With steady-state systems, NOx reductions are sporadic at best, and cannot claim to be consistent, continuous, stable or effective for compliance. For reliable reductions, power generators should require packages that are as dynamic as the facility itself.

Generators should also consider prior applications of a manufacturer's optimization product at similar locations. An optimization tool applied to an older coal-fired plant, perhaps one that has been mothballed for some time or one that has seen few modifications over the years, may appear to reduce NOx significantly. A closer look will show the software to be part of an overall NOx reduction plan that probably includes new process equipment, other pollution abatement tools like low NOx burners, or even an entire plant equipment retrofit.

As every plant operator knows, each power plant is different. Generation in different plants is affected by a different set of variables – both internal and external. Optimization software that can be tailored to meet the needs of each specific plant has a better chance of providing true NOx reduction and return on investment. Plant engineers and operators should be skeptical of optimization systems that arrive like off-the-shelf software, shrink-wrapped with installation instructions, assuming each steam generator operates under the same set of factors. There are times when the plant has been "de-tuned" to reduce maintenance work, or to reduce alarms from running near operational limits. The performance monitoring aspects of the plant come under scrutiny to insure a fair "before and after" evaluation of the results of an optimization package. The best optimization packages include manufacturer support for installation, service and maintenance related to generation issues and changes in the plant.

Case Study Wisconsin Electric:

In response to evolving ground-level ozone standards in the United States, Wisconsin Electric Power Company began a proactive, comprehensive strategy to prepare for new regulations and reduce nitrogen oxides (NOx) emissions at its Valley Generating Station in Milwaukee. SmartProcess Optimization Software played a key role in the program.

A coal-fired 300-megawatt combined power plant, Valley serves as a steam heat source for the city of Milwaukee in addition to producing electricity. A cycling plant, Valley is rarely baseloaded and normally is on automatic dispatch. Wisconsin Electric began its efforts with low NOx burners, but, due to its dual provider role in the city, was concerned about compromising reliability when the time came to take the next step in reducing NOx.

Valley achieved a critical balance with help from optimization software that, by fine-tuning the plants automation controls, allowed Wisconsin Electric to get additional NOx reduction on Valley's number four boiler without losing efficiency.

Real-time data collected at one-second intervals and averaged over two 24-hour periods (with similar load profiles) showed NOx emissions from Valley's number four boiler decreased 15 percent by using an optimizer. Additionally, the system reduced Valley's excess oxygen by 18 percent further limiting the formation of NOx. Valley Station followed up its success with boiler #4 by installing optimization software on its other three boilers at the plant in 2001. Wisconsin Electric is achieving additional NOx reductions, increasing the life of expensive pollution abatement equipment and may at some point have NOx credits to trade with others in the Wisconsin area looking for environmental compliance.

Case Study Ostroleka Power Plant, Poland:

The Ostrolêka Power Plant in Ostrolêka, Poland, installed flue gas desulfurization equipment, low NOx burners and electrostatic precipitators to meet Poland's increasingly stringent air quality standards. But the owners of the Ostrolêka plant wanted to see even lower emissions, particularly of NOx.

The facility consists of three 200-megawatt units, fueled by pulverized coal and is located about 100 miles north of Warsaw. It provides electricity for both the city of Ostrolêka and the Polish national power grid.

Using optimization software, the Ostrolêka Plant has seen consistently positive results, decreasing NOx emission levels by 15 to 25 percent while reducing LOI. The system has provided a small but measurable increase in boiler efficiency; stabilized overall boiler performance; improved response to load changes; improved steam temperature control; and, reduced carbon monoxide (CO) levels in flue gas. This plant was one of the first European power generation facilities to embrace advanced software programs for on-line real time optimization of the process. The plant has used two generations of the software as the technology improved over the implementation schedule of the three units. They are embracing the concept of

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using the latest advances in modeling and optimization for sustained operational benefits.

Part of an Overall Plan:

As the combustion process occurs with the software tool monitoring and adjusting it, the optimizer allows the plant to achieve the best possible NOx levels, consistently and reliably. Generators should not consider optimization software to be a complete cure for NOx emissions, but rather part of an overall NOx reduction plan which includes all necessary and appropriate reduction equipment, be it low NOx burners or selective catalytic reduction. Properly selected optimization software will provide plants with a first line of NOx reductions, as well as a consistent emission rate, which increases the life span of equipment and balances the scales between plant efficiency and emission production.

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