June 2008 • www.power-eng.com

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20th ANNIVERSARY POWER-GEN INTERNATIONAL 1988-2008

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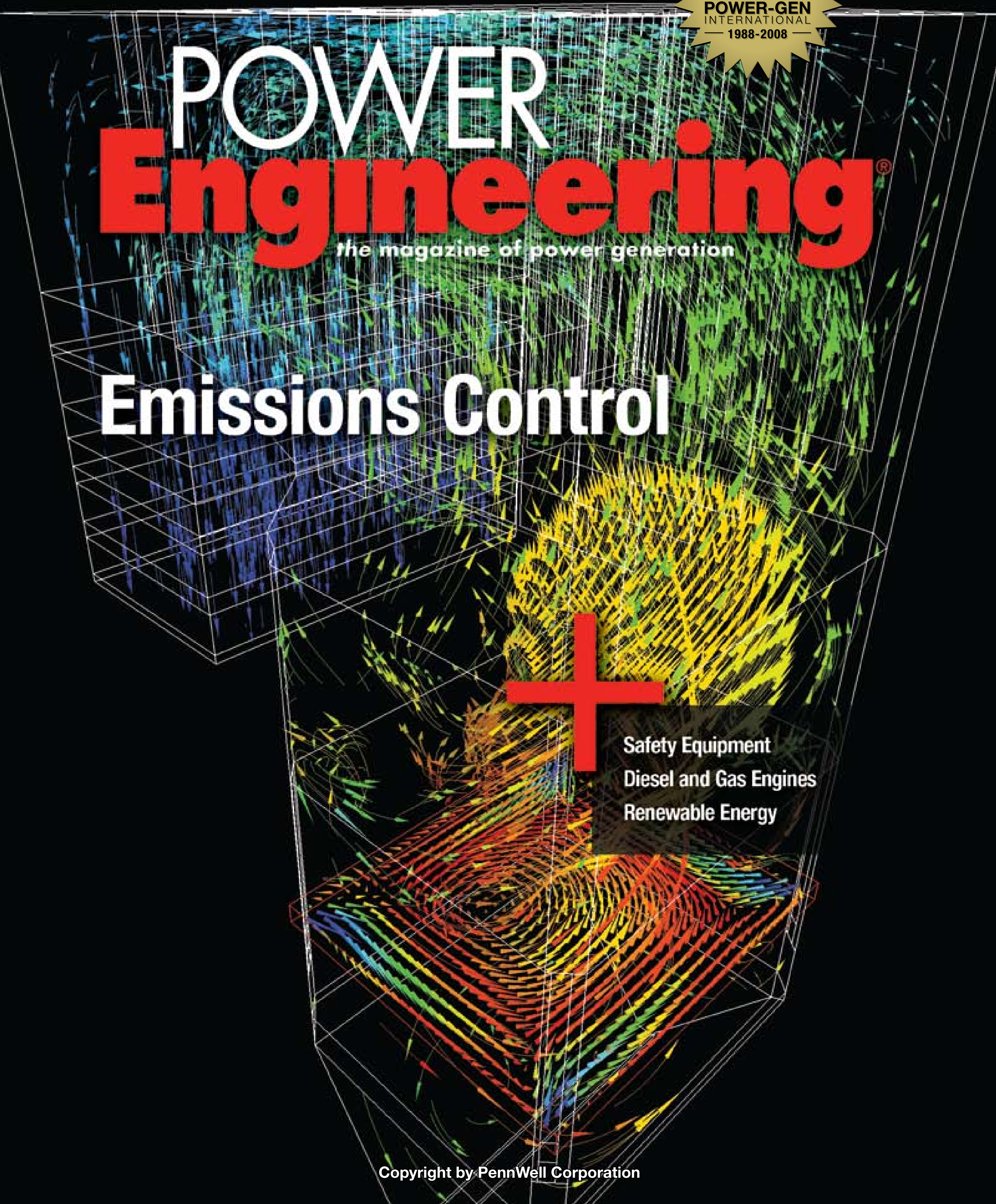

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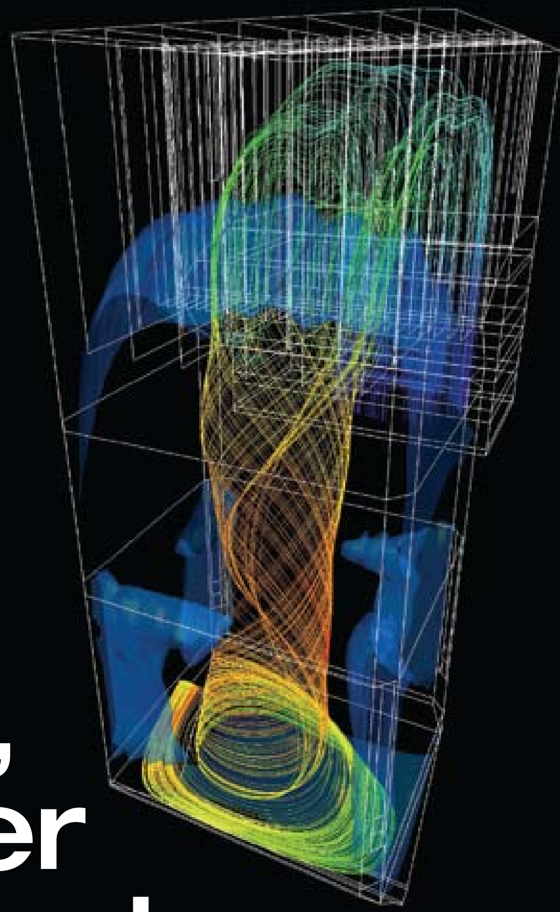
Computational fluid dynamics model of Santee Cooper, Cross Station Unit 2. Swirling lines depict the chemical path coming from an injector as it flows through the furnace. Lines are color-coded for temperature: red is the hottest and blue is coolest.



Facing Rising Energy Costs, Santee Cooper Bucks the Trend

SO_3 mitigation program yields payback beyond emissions control

By Michael B. Davis, Santee Cooper and Kent W. Schulz, Fuel Tech Inc.

With the utility industry driven by ever-increasing regulatory guidelines and growing economic considerations, the emphasis has shifted to more cost-effective technologies to improve boiler operational efficiency. So how does a plant "buck the trend" of rising fuel prices, growing concerns about air quality and higher electrical demands?

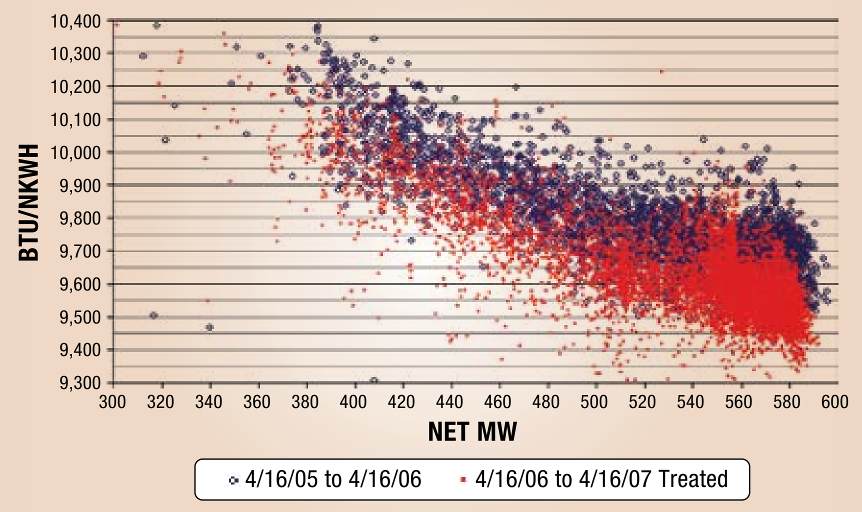
Santee Cooper, South Carolina's state-owned electric utility, has demonstrated that an innovative SO_3 mitigation initiative could not only solve an environmental challenge, but more than pay for itself in additional performance benefits. This "win-win" result is in contrast to most environmental solutions, which require additional capital, result in higher operating/maintenance costs and typically offer little or no financial payback. In this case, not only is the environmental problem solved, but the cost of the technology more than pays for itself.

Fuel Tech Inc. and Santee Cooper have cooperated over the past 18 months to evaluate the effectiveness of a Targeted In-Furnace Injection™ (TIFI) program at the Cross Generating Station. The program's impetus arose from a fuel switching initiative on Cross Units 1 and 2, each a 600 MW boiler outfitted with a selective catalytic reduction (SCR) system for year-round nitrogen oxide (NO_X) control. The new coal had a higher sulfur and iron content and was characterized by a lower ash fusion temperature. Most problematic was the coal's iron content, 1 lb. per million Btu, compared with a boiler design of 0.56 lbs per million Btu. Ash fusion temperatures ranged from 2,000 F to 2,100 F, compared with a boiler originally designed for 2,500 F.

When Santee Cooper switched to the new coal, the slag and fouling in Unit 1 (as well as SCR fouling caused by the formation of large particle ash—"popcorn ash") also intensified. In addition, the formation of hard and dense pieces of slag, "clinkers," resulted in higher clinker grinder maintenance and related expenses. Slag formation required removal with explosives, sometimes delaying the start up coming out of

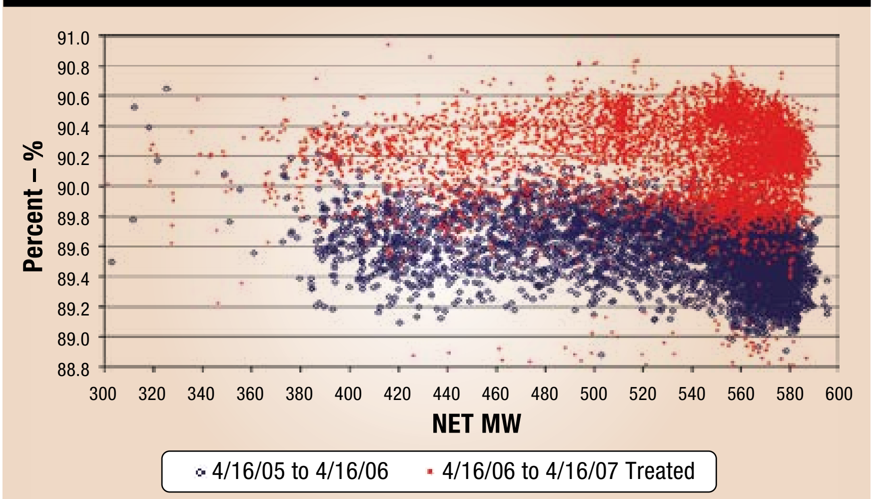
Santee Cooper, Cross Station shown during normal operations with Targeted In-Furnace Injection program on line.

Figure 1 NET HEAT RATE COMPARISON



Two years of data measuring net heat rate in Btu's/kWh. Period without treatment is blue data points (April 2005 ending April 2006). Red data points show improved heat rates during the treated period (April 2006 to April 2007).

Figure 2 Boiler Efficiency Comparison



Two years of data measuring boiler efficiency in percent. Period without treatment is in blue (April 2005 ending April 2006). Data points in red show improved boiler efficiency during the treated period (April 2006 to April 2007).

outage by 24 to 36 hours. Popcorn ash forced SCR on-line cleaning which also resulted in additional expense. Unit 2 also experienced a higher slag tendency and performance related issues following the fuel switch.

With the introduction of higher sulfur/iron coal, both units began experiencing opacity issues caused by sulfuric acid, which arose from the formation of sulfur trioxide (SO_3). SO_3 formation is caused by several different mechanisms; however, high iron levels in the ash can increase catalytic oxidation of SO_2 to SO_3. In the SCR, the SO_2 to SO_3 conversion increases and becomes even more problematic.

An Upstream Approach

The TIFI program employs an "upstream" approach, injecting reagent into the boiler furnace. The illustration on page 30 depicts a computational fluid dynamic (CFD) model snapshot representing Santee Cooper's No. 2 boiler. The blue "cloud" is an isothermal depiction of all locations where the flue gas has a temperature of 2,050 F, which is equivalent to the reducing fusion temperature typical of the coal with higher slag characteristics. "Streamers" depicted in the middle of the model is the predicted path of the chemical coming from a strategically placed injector. One primary reason for creating a boiler model is to develop an injection strategy that produces the most efficient coverage of the chemical for controlling slag, fouling and SO_3.

The chemical additive, primarily highly reactive magnesium hydroxide ($Mg(OH)_2$), is mixed with air and water and targeted at regions favoring chemical reactions for SO_3 formation and/or problem surface areas needed for heat transfer. The chemical additive penetrates existing slag deposits to alter the physical characteristics, thus reducing the slag's structural integrity. As slag becomes more friable, it is more easily cleaned from surfaces, particularly the heat transfer surfaces. A cleaner furnace operates more efficiently and generates less SO_3.

A TIFI program was deployed on Unit 1 in April 2006 with the following objectives: reduce SO_3 related opacity issues, reduce popcorn ash and SCR fouling, reduce coal-related slag and fouling issues and increase fuel flexibility. After approximately four months, early success prompted the initiation of the same TIFI program on Unit 2. The TIFI program was found to provide significant performance improvements and more than pay for itself.

SO_3 Control

There was a dramatic reduction in SO_3 concentrations throughout the boiler at high load. Treating Unit 2 with highly reactive $Mg(OH)_2$ significantly reduced SO_3 concentrations at the economizer outlet, SCR outlet and air heater outlet. The bottom line was greatly reduced opacity emissions. Interestingly enough, the TIFI program effectively controlled the SO_3 related opacity irrespective of the fuel characteristics. Data indicated that SO_3 at the air heater inlet was reduced by 66 percent.

TIFI contributed to the reduction in popcorn ash on Unit 1, which significantly reduced SCR fouling and the need for SCR cleanings. Better furnace cleanliness and reduced SCR fouling from popcorn ash also resulted in improved unit availability. The overall increase in availability was 44.5 MWe.

The TIFI treatment significantly reduced slag and fouling and this resulted in improved heat transfer in the furnace and convective pass. Boiler efficiency, a measure of the ratio of heat absorbed in steam to the heat supplied in fuel, increased by 0.65 percent over the load range. Average net heat rate improved 120 Btu/kWh, despite a reduction in average fuel heat content of 225 Btu/lbs, which impairs heat rate. A significant reduction in slag and fouling, even with higher slag forming coals led to more than 50 percent reduction in outage cleaning times.

Additional Benefits

Enhanced fuel blending technique allowed Cross Station to utilize lower ash fusion temperature coals having nearly twice the iron content. Typically, lower fusion coals are less expensive and TIFI generated additional fuel savings by increasing fuel flexibility. Regardless of coal type, boiler efficiency improvements were recorded throughout the TIFI treatment period. Furthermore, ash sales were not affected by this program and the plant continues to sell its ash to the cement industry and the ready mix market.

Additionally a reduction in total toxic release (TTR) air emissions of 20 percent, specifically with a 35 percent reduction in sulfuric acid mist emissions. This reduction on Unit 1 was generated over a nine-month period with further reductions expected for a full-year reporting period.

The TIFI program successfully contributed greater than 4 to 1 return on investment from improved unit performance and additional savings from increased fuel flexibility. As a result, Santee Cooper is the recipient of cheaper energy: a trend not often seen today.

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Kent Schulz is a Market Development Manager for Fuel Tech Inc. He has a bachelor's degree in Chemistry with a Mathematics minor and a Masters degree. His technical skills are utilized for developing applications of the company's chemical injection technologies to improve boiler performance and mitigate SO_3 formation. pe