OPTIMIZE BOILER EFFICIENCY AND REDUCE NOX, CO & CO2 WITH A ROI

Patricia Spiritus Benz, General Manager
Benz Air Engineering, Co., Inc.

ABSTRACT
Industrial steam boilers are used in power-generating facilities, food processing plants, universities, refineries and hospitals among other facilities. Steam boilers, the foundation for the industrial revolution hold a unique opportunity for the companies that rely on the steam they produce. The design, engineering and craftsmanship that created these magnificent mechanical systems will never be matched. Their mission was achieved; create a steam system that was absolutely reliable.

In fact, they were so reliable many individuals don't even know a power plant is providing hot water to their dorm, pack that fruit cocktail in the refrigerator or gave that rug a bright blue color. Steam boilers not only create the world we live in but they are also responsible for contributing to green house gases (NOx & CO), carbon footprint (CO2) and consuming large quantities of fuel and electricity.

The following is a case study of a tomato processing plant located in Woodland, California. The facility produces canned tomato products. The steam boiler plant provides steam for process loads. The boiler plant contains five high-pressure steam boilers. Our case study is the retrofit for Boiler #6, Trane-Murray, water-tube boiler of 150,000 lb. per hour rated capacity (capacity is limited to less than 100,000 lb. per hour before the retrofit); 150 psig steam, currently operating at 82.1% boiler efficiency.

Only within the last decade has the technology been available that is a natural fit for addressing emission reduction through efficiency for steam boilers. The combination of ingenious design and engineering of this original equipment has made most boilers ideal candidates for combustion control instead of part (burner) replacement or boiler replacement. In fact, understanding the boiler system as a whole leads to comprehensive solutions involving several aspects of the boiler plant.

There seems to be a break down between mechanical system know-how and system control, which causes inefficient operation, wasteful fuel consumption and unnecessary emission. The main idea of the following retrofit is to accurately control air flow and fuel flow as a function of the required steam load.

EXISTING REDUCING EMISSION OPTIONS

There are several methods and technologies currently used to reduce nitrogen oxide (NOx) emissions from steam boilers. These methods and technologies emerged after passage of the Clean Air Act of 1990. Companies such as Coen, Todd, Vogt, and John Zink invested heavily into low-NOx burners, and ultra low-NOx burners. The goal of these technologies is to reduce the flame temperature, which is the primary cause of NOx formation. Selective Catalytic Reduction (SCR) systems are a more recent innovation. These remove NOx from the stack flue gas stream, similar to an automobile's catalytic converter.

Most low-NOx technologies and methods result in reduced or unchanged boiler efficiency. Resulting in little or no impact on CO2 reduction. Most require extended boiler down-time and are expensive with no payback. Burner replacement changes the boilers' characteristics, creating a lot of uncertainty including vibration. Often boilers and their burners are from different manufacturers, making trouble-shooting undesirable operating conditions more difficult.

REDUCING EMISSIONS THROUGH CONTROL

Reducing emissions through boiler control takes the

combination of three disciplines; Mechanical Engineering, Combustion Engineering, and Programming. To achieve maximum efficiency, a comprehensive approach is necessary. Simply sticking a variable frequency drive (VFD) on an air fan will not provide optimum results. By understanding the steam operating system and its processes, most power plants can greatly increase efficiency while reducing emissions.

BOILER #6 – CANNING TOMATO'S

The following equipment was identified to optimize boiler efficiency through a comprehensive boiler plant retrofit. Boiler plant optimization takes into consideration the processes involved when evaluating steam load and heat recovery options. The energy efficiency measures for Boiler #6 were:

1) Boiler Plant Feed-water Heat Recovery & De-aerator Control Upgrades

2) Steam Turbine to Electric Feed-water Pump Conversion with a VFD, to eliminate steam venting

3) Combustion Air Inlet Pre-heater, Low Excess Air Burner with Parallel Positioning Control & Fan VFD, and SCR NOx Emissions Control

MEASUREMENT & VERIFICATION (M&V)

Enovity (1) will conduct post-installation measurement and verification on this project, in order to verify the installed energy savings reported to PG&E. The M&V will include measurements of the following system operating parameters, in order to verify the efficiency improvements of the proposed project. The measurements will be compared to the performance parameters used in the savings calculation and if necessary the calculations will be updated based on the post-installation measurements.

- Boiler exhaust stack temperatures after the economizer
- Inlet water temperature to the de-aerator
- New electric pump power and/or VFD speed
- Exhaust stack temperature after the combustion air preheater
- Combustion air inlet temperature (after the pre heater)
- Excess air (%02)
- Fan power and/or VFD speed

ESTIMATED ANNUAL SAVINGS

Natural Gas Energy Savings (therms) 440,563 and Utility Cost Savings (dollars) $430,411, offering a rebate of $496,009, almost half the cost of the installation. In less then one year a California tomato processing plant was able to meet mandated emission levels of 6 ppm, qualify for an energy rebate and within a years time save money.

ANNUAL GREENHOUSE GAS REDUCTIONS

The estimated energy saving listed above may result in the following Green House Gas Reductions:

Metric Tones per Year of CO2: 2,380

The Greenhouse reduction is equivalent to ONE of the following: (2)

- 515 Passenger cars not being driven for one year
- 306 Household's electricity use per year
- 61,026 Number of tree seedlings grown for 10 years
- 801 Tons of waste recycled instead of land filled
- 271,072 Gallons of gasoline
- 20 Acres of forest preserved from deforestation

COMPARABLE BOILERS

It is estimated there are approximately 15,000 boilers in the United States that are similar to Boiler #6. Retrofitting 15,000 would equate to the following emission reductions.

- 7,725,000 Passenger cars not being driven for one year
- 4,590,000 Household's electricity use per year
- 915,390,000 Number of tree seedlings grown for 10 years
- 12,015,000 Tons of waste recycled instead of land filled
- 4,066,080,000 Gallons of gasoline
- 300,000 Acres of forest preserved from deforestation

And

35,700,000 metric Tons of CO2 reduction/year. According to the National CO2 emissions per the EPA, Clean Air Markets there are 2,587,802,129.6 tons of CO2 emissions/ year, (3) assuming Natural Gas Systems account for 25% (4) or 646,950,532.4, retrofitting 15,000 could result in the reduction of 35,700,000 tons of CO2 or 5.5% of the total number of CO2 emissions from Natural Gas Systems.

BOILER EFFICIENCY

Boiler efficiency, in the simplest terms, represents the difference between the energy input and energy output. A typical boiler will consume many times the initial capital expense in fuel usage annually. Consequently, a difference of just a few percentage points in boiler efficiency between units can translate into substantial savings. The efficiency data used for comparison between boilers must be based on proven performance to produce an accurate comparison

of fuel usage. However, over the years, efficiency has been represented in confusing terms or in ways where the efficiency value did not accurately represent proven fuel usage values. Sometimes the representation of "boiler efficiency" does not truly represent the comparison of energy input and energy output of the equipment. (5)

TANGIBLE TECHNOLOGY

The computer based combustion control system was originally designed to reduce NOx. The by product of reducing NOx using a combustion control system is efficiency. Fuel efficiency is the only way to reduce CO2 from the combustion process. Fuel efficiency equates to savings, providing a return of investment.

EFFICIENCY = NOx, CO & CO2 REDUCTION

This approach provides the opportunity to meet environmental standards while lowering the heat rate of boilers. That is, rather than putting financial stress on boiler owners to adhere to environmental regulations we provide an economical incentive to do so. Savings are realized immediately after installation and at boiler start-up.

COMPU-NOx SOLUTION

Compu-NOx is a comprehensive boiler operation system that optimizes the combustion process, reducing emissions and increasing boiler efficiency. Compu-NOx continuously controls the fuel to air ratio to achieve the best possible combustion efficiency and minimize excess oxygen available to form NOx. Further NOx reduction is achieved with flue gas recirculation (FGR). Flue gas recirculation has been successful in prior applications to inhibit NOx formation. However, FGR alone is rarely effective enough to meet EPA emissions standards. Compu-NOx controls the fuel, air, and flue gas mixture at the optimum ratios throughout the boiler's operating range to meet these requirements.

The Compu-NOx system provides the following advantages:

- •Significantly more cost effective – Compu-NOx installation ensures rapid payback through efficiency gains and parasitic load reduction.
- •Minimal impact to current infrastructure – Installation involves little down-time, allowing for shorter outages and minimal boiler modifications. Uses original fans and burners to further reduce costs.
- •Real-time Boiler Response – Boiler controls respond automatically to changes in load or operation.
- •Qualify for Efficiency Rebates – can be as much as half the cost of the installation.

Compu-NOx systems have been successfully installed in a wide range of industries. Most boilers over 75,000 lb/hour are good candidates for a controls retrofit offering a payback in less then two years. Many universities, food processing plants, brewing companies, hospitals, military bases, refineries are running Compu-NOx systems. Emission reduction is immediate, the saving are immediate and the technology has been proven and third party source tested to verify results.

CO2 REDUCTION OPTIONS

Widespread carbon reduction technologies for industry aren't being implemented as they are difficult and expensive. Carbon Sequestration and planting trees are hopeful plans for reducing CO2 emissions but will not provide noticeable results for years, perhaps decades. Steam Efficiency, available now, will save fuel, while lowering carbon emissions.

ONE TOMATO PLANT

Boiler #6 located in Woodland California had third party source test results of 3 ppm NOx levels and excess O2 of less than 2%. Efficiency increased to_87.7% from 82.1% with a stack temperature of less than 200 F. Operational flexibility was greatly enhanced with a turndown of > 50:1. The boiler displays and extraordinary reliability and stability. Electrical consumption for boiler operation has been decreased by over 50%. This verification underlines the impact of a single retrofit with immense savings and emission reduction. As outlined in the M&V report. The associated steam system including condensate tanks and the de-aerator could get past wasteful operation. Steam venting has been eliminated from the DA system. Steam consumption has been minimized and a sporadic unreliable control has been replaced with steady and continuous level and pressure control. Additional control flexibility is available to the operators to respond to process changes. Comprehensive system monitoring and trending allows for effective operation and preventive maintenance.

PROVEN RESULTS TO MOVE FORWARD

Boilers - the foundation for the industrial revolution, now have the opportunity to move into the next century and be a driving factor in the green revolution. With the immediate reduction of greenhouse gas emissions the industrial sector has the opportunity to be a part of the solution without destabilizing their operation and without imposing a financial burden. Many approaches using unproven, theoretical technologies without economic returns have been hurting plant operations and decrease profits which have already been marginalized by the fluctuating fuel market. The technology, the savings, the lower emissions - the results have been proven.

REFERENCES

i Enovity's Commercial Industrial Boiler Efficiency Program offers incentives to large commercial and industrial customers in PG&E service territory to implement boiler system energy efficiency improvements that will result in natural gas and/or electrical energy savings. The program combines boiler engineering evaluations and technical implementation assistance with financial incentives to make implementing boiler system energy efficiency measures more economically attractive.

ii This information is derived from the Greenhouse Gas Equivalencies Calculator developed by the U.S. Climate Technology Cooperation Gateway which is sponsored by the U.S. Environmental Protection Agency and the U.S. Agency for International Development.

iii United States Environmental Protection Agency, Clean Air Markets, Operating Year 2007.

iv Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, Executive Summary, Figure ES-5 – 2005 Sources of CO2.

v The Natural Gas Boiler Burner Consortium, Solutions for Efficiency, Emissions, and Cost Controls. Provided by Cleaver-Brooks.

vi The Natural Gas Boiler Burner Consortium, Solutions for Efficiency, Emissions, and Cost Controls. Provided by Cleaver-Brooks.

www.benzair.com