Upgrading the Combustion System

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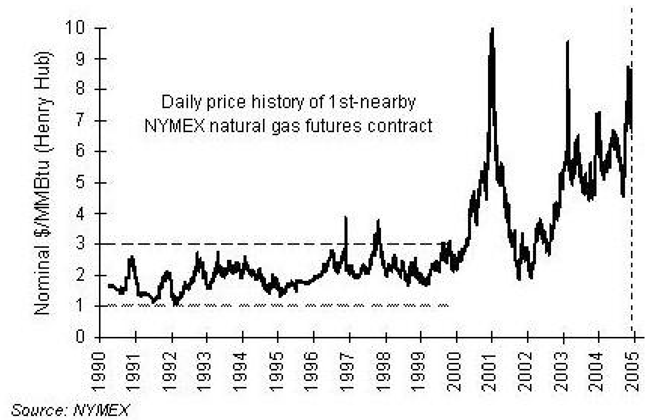
Introduction

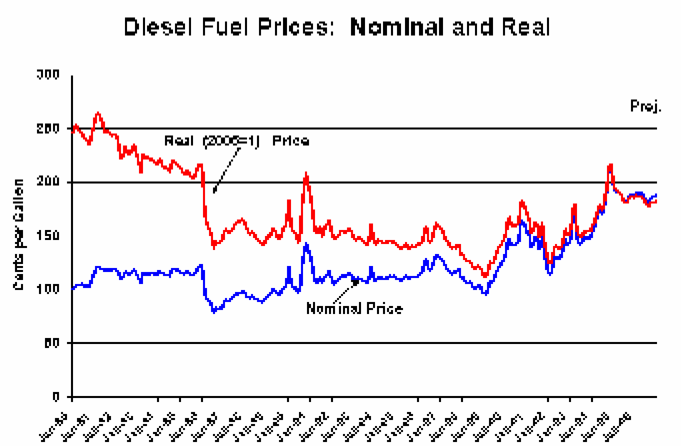
Fossil fuels are the feedstock to power generation. They can represent the greatest operating expense in the boiler room. Ranging over a fifteen year period spanning from 1990 to 2005, the price of natural gas has increased three-fold, evidenced by the rising trend in natural gas futures contract prices shown in Figure 1.

Figure 1. Natural Gas Prices from 1990 to 2004



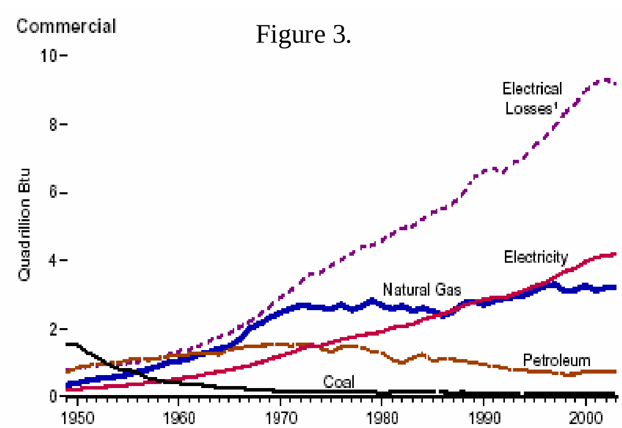
The trend on fuel oil looks similar, with NYMEX (New York Mercantile Exchange) reporting December 2003's price at $0.82 per gallon, and December 2004's price at $1.23 per gallon – a 50% increase over a one year period. Figure 2 shows the trend in U.S. diesel fuel prices – as reported by the Department of Energy - both nominal and real (adjusted for inflation). Since 1999, diesel fuel prices have risen sharply.

Figure 2.



The commercial and industrial sectors are large consumers of natural gas and fuel oil, as reported by the Department of Energy and shown in Figures 3 and 4. Natural gas consumption in these two sectors has increased from about 3.5 to 12 quadrillion Btu's consumed annually, over a fifty year period. Fuel oil consumption in these two sectors has also increased from about 4 to 10 quadrillion Btu's consumed, annually, over the same period.

Figure 3.



In the commercial sector, natural gas consumption is clearly the winner. Combined with the trend in natural gas prices increases, most attention is being paid to natural gas-driven HVAC equipment and processes, such as heating boilers and forced warm-air systems.

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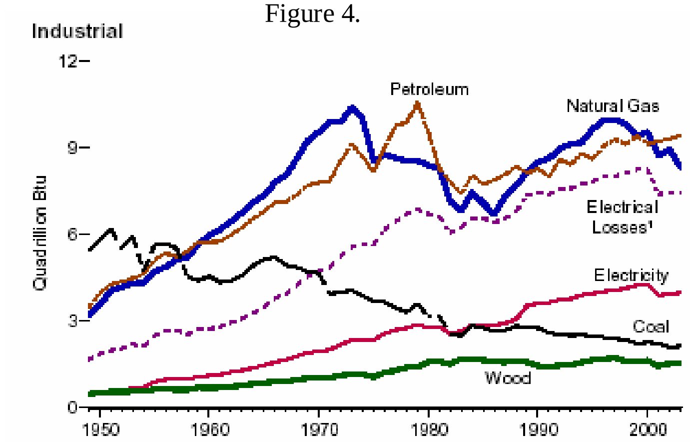
In the industrial sector, natural gas and fuel oil consumption have run parallel over the last twenty-five years, shown in Figure 4. This trend is understandable in that the industrial sector is roughly four to five times the consumer of gas and fuel oil as the commercial sector. While fuel oil prices have risen with natural gas prices, they have not done so at nearly the rate. Therefore, there is an overall fuel price-related incentive to operate HVAC equipment on fuel oil in the industrial sector. However, there are also disincentives with fuel oil combustion, namely storage and handling considerations as well as an environmental impact with NOx, SO_2, and particulate emissions.

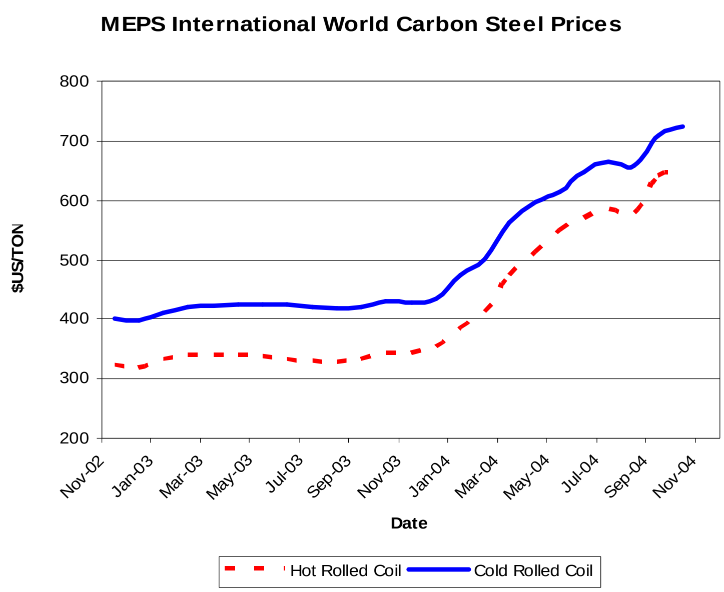
Figure 4.



Since 1990, significant efforts have been made by the Environmental Protection Agency to improve ambient air quality throughout the U.S. Stringent air quality standards (AQS) have been imposed on national, state, and local levels both in the installation of new fossil-fuel burning equipment (new construction), as well as with measures imposed on commercial-industrial manufacturers and facilities' owners to reduce existing emission rates.

These trends suggest that there is an obligation on "management" to intensify efforts in finding opportunities to reduce energy related expenses as well as potentially hazardous emissions from fossil fuel burning equipment. Unfortunately, owners and responsible managers have noted that escalation in fuel prices have coincided with dramatic increases in raw steel prices with subsequent increases in the cost of capital equipment. The trend in rising steel costs is shown in Figure 5, provided by MEPS International. World carbon steel prices, particularly the price of cold and hot rolled steel, have essentially "doubled" since the end of during calendar year 2002. This substantial price increase for steel has also impacted construction equipment costs. Many industrial equipment manufacturers have raised their prices between 1 and 6 percent in 2004 to compensate for increased raw material costs, according to Association of Equipment Manufacturers.

Figure 5.



The HVAC equipment industry including boiler and heat exchanger manufacturers have been particularly hard hit by

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these increases due to the quantity of steel used in their products. As a result, these increases in capital equipment costs have softened the results of "return on investment" analyses for large-scale boiler room renovation projects. If the facilities manager can perform a more detailed investigation into their HVAC operations and subsystems, however, the investigator may discover that there are opportunities for significant improvement and reasonable returns in the boiler room. Since fuel usage does represent one of the largest operating expenses in the boiler room, reduction in its use provides one of the largest opportunities for bottom-line improvement. An investment into upgrading sub-systems of the existing boiler and boiler control systems can yield attractive reductions in operating expenses without requiring a significant capital investment. Listed below are just some of the areas of opportunity:

- **Boiler retrofit with a new, state-of-the art gas, oil, or combination gas-oil burner and management system,**
- **Installation or upgrade in the burner-boiler control systems and packages, including upgrade or installation of new systems such as draft control and burner sequencing (lead-lag) systems for multiple boiler installations.**
- **Simple burner 'mode-of-operation' upgrade or conversion for better load-following capability,**
- **Integrated controls and communications systems that allow the facilities manager real-time data and on-line access to boiler room operations, through both local and wide-area networking.**

This paper sets out to investigate and discuss some of those opportunities. In that endeavor, attention is first given to the basics:

- **The motivating factors for upgrading an existing burner and associated controls, and**
- **Fuel consumption and combustion/system efficiencies, which serves as the cornerstone to a financial justification in making the capital investment for upgrades.**

A sample economic analysis follows with the upgrade of a 200 horsepower boiler with a modern, state-of-the art gas burner subjected to a hypothetical, but typical heating boiler load profile and schedule. Consideration is given to the cost of removal of the existing burner and controls, purchase and delivery of a new burner and controls system and its installation, and re-commissioning of the system, i.e. startup. It will be demonstrated that a modest investment into a new burner and control system can yield an attractive return on investment.

Finally, if the reader would permit us a moment to briefly introduce our products and services, we are confident that you will look to Power Flame for your future space and process heat requirements.

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Why Replace an Existing Burner and Controls Package?

It is first important to identify what a boiler-burner system does, and its importance to the boiler room operation:

- **A burner consumes large quantities of fuel whose price has been rising at an increasing rate since 1999. Even modest gains in overall efficiency can yield significant savings.**

- **A burner mixes fuel with air for combustion. Mixing effectiveness and efficiency are dependent upon criteria such as the original design, burner setup, firing rate and fuel quality, fuel-air ratio control, and external conditions. With older burners, performance can and does degrade with time. Newer designs and control technology permit tight bandwidth operation and control over a wider range of firing rates and conditions.**

- **A burner follows the plant or building demand profile with varying degree of response and repeatability. Sophisticated PID (Proportional, Integral, Derivative) controls for load following and microprocessor or PLC-based fuel and air metering systems provide superior performance to simple on-off or two-stage firing and legacy jackshaft-linkage control systems. From precise modulation and load following abilities to burner sequencing with multiple unit installations, modern burner and control system packages reduce wasted fuel and its associated cost.**

- **A burner produces emissions, some of which are currently constrained by Rules & Regulations as set forth by the EPA (Environmental Protection Agency) and pertinent AQMD's (Air Quality Management Districts). Today's burner designs not only meet those air emissions requirements, but are more efficient and better controlled than with legacy equipment.**

- **A burner should integrate with other boiler room equipment and control systems for intra-system control and communications, system fault annunciation, data collection and record-keeping. Integrated into building management systems, improvements are shown in overall system efficiency.**

- **A burner requires maintenance to maintain quality performance, requiring varying levels of attention and expense depending on age, usage and quality.**

How well the burner performs these functions and minimizes operating expenses such as fuel consumption and maintenance, is part of the decision-making process as to whether a burner or a sub-component of the burner is a candidate for replacement.

For example, the installed cost associated with replacing an existing 200 horsepower burner mounted to a 200 horsepower boiler can range from $12,000 to $15,000, dependent upon make and model of the burner, level of options purchased, and scope of installation work. Replacement of the entire boiler package can easily cost the end user three to five times this amount. Certainly, the "burner replacement only" scenario represents a significantly lower capital investment than replacement

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of the entire boiler-burner package. This is particularly true if the boiler is still in good operating condition. A burner will be replaced between two and three times inside the lifetime of a boiler. If it can be shown that significant efficiency gains and reduced operating and maintenance expenses can be achieved with a burner or controls package upgrade alone, this alternative may prove to be more attractive to the financial planners and decision makers within the corporation. Therefore, we will examine the components affecting these decisions in more detail.

It can be stated with some level of confidence, however, that the burner package is the "heart" of the boiler room operation. It offers the greatest opportunity for trimming operating expenses at a relatively low investment. In essence, savings are realized through reduction in fuel-related consumption through provision of state-of-the art burner and boiler room controls. To understand how we optimize the process and reduce fuel consumption, we must first discuss the concept of ***efficiency***.

Fuel Consumption and Efficiency Basics

In the boiler room, fuel consumption generally represents the single largest expense in its operation. Typical heating loads for various types of buildings are shown in Table 1 below:

Table 1. Typical Building Heat Loads

Bldg. Type	Size (Sq Ft)	Capacity (MBH)
Large Office	160,000	3,459 – 5,436
Medium Office	49,000	414 - 892
Hotel	315,000	3,582 - 8,860
Hospital	272,000	4,442 – 5,453
Medical Clinic	49,000	514 – 1,241
Large Retail	164,000	622 – 3,555
School	50,000	803 – 3,454

These figures represent the actual heating loads on the system, not the required fuel input into the burner to satisfy those loads. Producing the necessary heat to accommodate the loads shown in the chart above involves two important processes; combustion and heat transfer. How efficiently and how effectively these functions are performed has much to do with total fuel consumption.

Unfortunately, useful energy is "lost" in the fuel-to-heat conversion process, i.e., a significant amount of the incoming fuel is not ultimately transferred to the steam or hot water, but is lost to the environment through hot boiler stack gases, unburned fuel, and boiler jacket radiation and convection losses. We normally associate these losses with the term Thermal Efficiency. Thermal efficiencies typically range in area of 75% - 85%, depending upon many operating conditions and design characteristics of the boiler and burner.
There are also losses associated with:

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- steam and hot water transmission lines,
- leaking or inefficient steam traps,
- boiler blow down,
- boiler-burner cycling and standby,
- burner pre- and post-purging, and more.

We combine these losses with the aforementioned losses to consider the System or Overall Efficiency. It is common for Overall Efficiencies to range in the neighborhood of 50% to 60%, when all losses are accounted.

There is a financial penalty associated with these losses. The efforts of the facilities' manager must be directed toward improving inefficiencies through careful consideration of process improvements and capital investments for new HVAC equipment and controls.

We will first take a closer look at what these "efficiency" terms are and mean, how they are affected, and how they impact fuel consumption and costs.

Efficiency

Probably one of the most varied and misunderstood terms in the industry surround the concepts of <u>combustion</u>, <u>thermal</u>, <u>fuel-to-steam</u>, and <u>system</u> or overall efficiency. These terms are essentially interpreted differently by different professionals in a variety of industries. Within the boiler industry alone, a rather quick study of the various boiler and fired heat-exchanger manufacturers' websites indicate there is no real consensus in this area.

In this paper, we will not attempt to resolve these differences but rather to set our own definitions which hopefully appear rational in accordance with practice, industry standards, and traditional thermodynamic and heat transfer principles.

Combustion Efficiency

Combustion efficiency is defined as the amount of heat ***transferred*** during combustion divided by the heating value of the fuel, regardless as to whether that heat is completely transferred to the medium requiring heating. A combustion efficiency of 100 percent indicates that the fuel is burned completely and the stack gases leave the combustion chamber at room temperature, and thus the amount of heat released and transferred during a combustion process is equal to the heating value of the fuel. It is used essentially as a "snapshot" in time as to how a burner is operating and how effective the heat exchanger is, at a given steady-state load condition. Simply stated,

$$Combustion\_Efficiency,\% = \frac{FuelHHV - losses}{FuelHHV} \times 100$$

where, the term ***FuelHHV*** represents the higher heating value of the fuel. The term ***losses*** shown in the numerator of this equation is comprised of several key factors:

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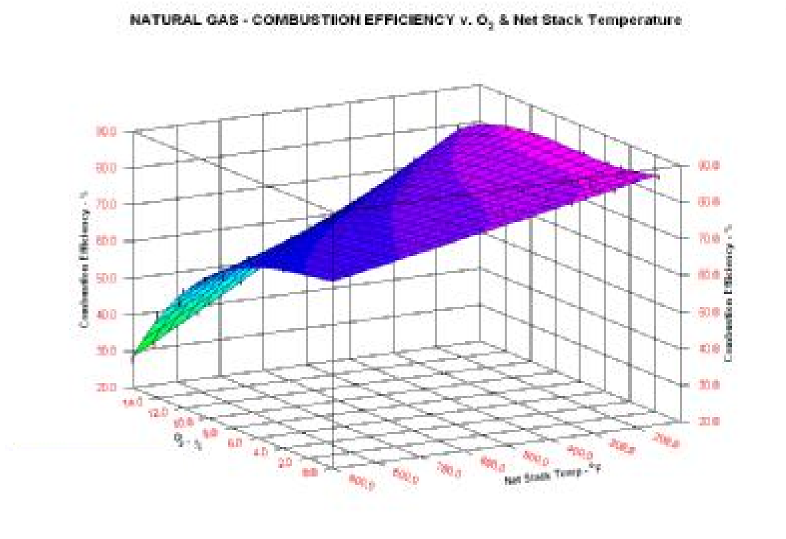
1. **Heat lost from the stack (to the environment) in hot gases,**
2. **Heat to produce water vapor from the moisture formed as a product of combustion (if there is hydrogen in the fuel)**
3. **Heat associated with heating up the moisture in combustion air**
4. **Unburned fuel, such as unburned carbon.**

Relatively sophisticated instrumentation and metering equipment are required to gain an accurate view of combustion efficiency. A specific protocol for measuring and calculating combustion efficiency is detailed in the ASME Power Test Code, Section 4. Very specific procedures and calculations are outlined including considerations give to levels of measurement certainty, based on equipment calibration and measurement technique. Combustion efficiencies typically range from 75% – 85%, based on the gross calorific value of the fuel.

Figure 6.



Natural gas combustion efficiency for a given fuel composition (not considering jacket losses) is shown diagrammatically in Figure 6 as a three-dimensional surface with stack gas oxygen content plotted against the net stack gas temperature. This graph represents "gross" efficiency, i.e., latent heat present in the water vapor is considered as useful – if only it could be recovered. Europeans tend to speak and evaluate performance in terms of "net" efficiency, i.e., that this latent heat is not recoverable and therefore no penalty is associated with not being able to recover this heat. The fuel's net heating value is used. Depending on fuel composition, the gross heating value of natural gas is approximately 10% higher than the net heating value, and therefore gross efficiencies appear lower than net efficiencies.

Thermal and Fuel-to-Steam Efficiencies

Thermal efficiencies are lower in that they consider that some of the available fuel energy is lost due to radiation and convection losses from boiler surfaces, and therefore not transferred to the medium being heated. Boiler or heat exchanger surface heat losses can represent another 0.1 to 1.5 efficiency percentage points, and is heavily dependent upon skin temperatures (how well the unit is insulated), operating, and environmental conditions. For our purpose, we consider thermal efficiency and fuel-to-steam efficiency as equivalent. In the strictest sense taking the term "fuel-to-steam" efficiency literally and at face value, a further reduction in efficiency would result from the fact that the steam in a typical low or high pressure saturated steam is not completely steam, but a portion of

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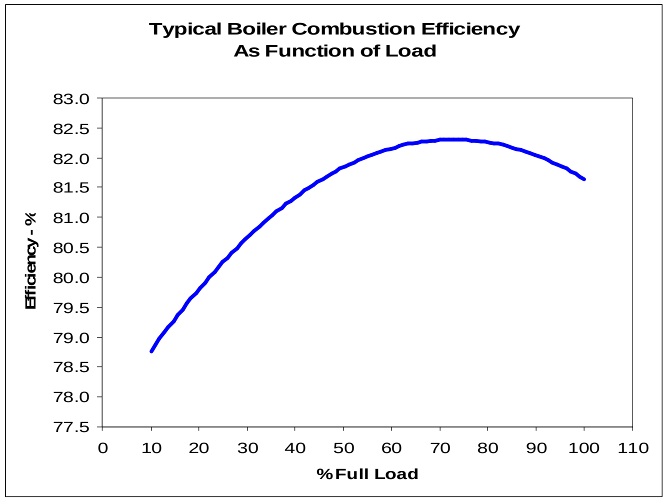
which is still in liquid form. In this case we consider steam "quality". However, even in liquid form some of the heat contained within is ultimately transferred for useful purposes, and therefore we draw no real distinction between the two formats.

How is combustion efficiency impacted?

Figure 7. Combustion Efficiency of a Gas-Fired Boiler



For a typical boiler-burner, the ability of the burner to mix air and fuel at reduced firing rates or boiler loads has an impact on the combustion efficiency of the package, combined with the heat exchanger effectiveness of the boiler. This is evidenced by Figure 7 which shows an ideal efficiency curve for a boiler fitted with a high turndown (HTD) burner. While net stack temperatures are generally lower at reduced firing rates, excess air levels must be increased at lower firing rates to ensure strong mixing of fuel and air to avoid incomplete combustion. This unfortunate consequence of flow dynamics results in additional useful heat being rejected through the boiler stack to the environment.

As stated previously, combustion efficiencies for boiler-burner packages firing natural gas typically range from 75 – 85% at steady-state conditions. With fuel oils such as a #2 distillate, combustion efficiencies are between two and three percentage points higher than natural gas due to the fact that there is a higher carbon-to-hydrogen ratio in fuel oils. Because of this lower fraction of hydrogen in fuel oil than with natural gas, less energy is tied up in the form of latent heat energy of water vapor as a result of combustion. While fuel oils do offer greater combustion efficiencies than with natural gas or other gaseous fuels containing hydrogen, other considerations such as fuel prices, storage and delivery, emissions, and the potential for fouling and sooting need to be evaluated with firing fuel oils. Fuel oils come in all grades, subject to availability and price. The lighter distillates and lower sulfur-bearing fuels, such as #1 and #2 fuel oils produce minimal objectionable emissions and minimize heat exchanger fouling. The best of all worlds, of course, is the ability to accommodate both fuels with a combination gas-oil burner. The ability to change fuels based on current price and curtailment offers flexibility to the owner-operator.

As Figure 7 indicates, combustion efficiency is not constant across a burner's firing range and is a function of at least these parameters:

- Burner turndown capability,
- Burner ability to mix air and fuel efficiently,
- Burner repeatability. and
- Boiler design and total heat transfer surface

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The burner's performance is further impacted negatively by the burner's age, its legacy design, and "repeatability" factors such as:

- **Hysteresis that is accentuated by worn linkages, bearings, bushings and inaccurate drive motors in jackshaft driven systems**
- **Fuel delivery and air metering systems fatigue and wear:**
  - **Control valves lose preciseness in positioning and lose repeatability,**
  - **Fuel oil pumps drop in delivery pressure and flow rate, gas injection ports become plugged or corroded, fuel oil atomizers wear - affecting fuel flow rates, oil droplet size and droplet size distribution over time**
- **Off-ratio firing occurs and becomes accentuated with modulating burners. This leads to inefficiencies in excess air levels, elevated combustibles, and poor load following**
- **Controls lose precision over time, particularly with legacy designs incorporating electro-mechanical components and older-style analog devices.**

Today's burner designs incorporate state-of-the art electronics and microprocessor-based controls and components for optimizing fuel-air ratio across the firing range. The ability for a burner to respond to changes in heat requirements or load demand is better than ever. Significant gains have been made in increasing efficiencies over the load-tracking capabilities of burners designed and installed in the past, even as short as five-to-ten years ago.

Through the incorporation or upgrade of burner-boiler controls, further improvement in overall or system efficiencies can be realized. This is discussed next.

Overall or System Efficiency

The Overall or system Efficiency of a boiler not only considers losses associated with the combustion process and minor heat losses associated with radiation and convection, but from other inefficiencies associated with:

5. **Boiler blow down,**
6. **Boiler cycling,**
7. **Boiler standby,**
8. **Burner load following effectiveness,**
9. **Draft and other system losses such as in hot water/steam transmission piping losses and steam traps, etc.**

This is the big picture of efficiency that exposes how a system performs over time. With somewhat less effort and level of sophistication, a view of overall system efficiency can be generated by simply dividing the accumulated load by the accumulated fuel usage for some given operational time period. To accumulate this data, some instrumentation is still required; a dedicated totalizing gas or fuel oil meter on the input side and a totalizing steam flow or Btu meter (for hot water) on the demand side.

$$Overall\_Efficiency, \% = \frac{Cumultive.Load}{Cumulative.Input} \times 100,$$ **For some given time period.**

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Considering all losses associated with operating a boilers and burners, it is not unreasonable to see overall system efficiencies in the range of 55 – 65%.

Furthermore, an older burner is typically accompanied by poorly responding or near inoperative controls. Newer burners and controls packages are offered with advanced features including:

- **High turndown capability and lower excess air levels at lower firing rates, reducing cycling losses and premature component failures,**
- **Parallel Positioning – or independent fuel, air, and flue gas recirculation (FGR) metering for precise and highly repeatable control of air fuel mixtures across the burner firing range. With these systems, air, fuel, and FGR (if required for NO_x emissions control) are controlled independently by small motors or servos and a central microprocessor-based or programmable logic controller according to predefined ratios. Feedback systems are employed to ensure relative positions of these subsystems to ensure proper positioning and repeatability**
- **Oxygen or Fuel Trim Systems – many times employed with parallel positioning systems, these systems monitor the oxygen concentration in the stack and employ precise adjustments to the fuel or air flow to ensure that the predefined air-fuel ratios are maintained. Changes in fuel calorific values, air temperature and density, barometric pressure and humidity, all affect the amount of air being delivered to the combustion zone and excess air (O_2) levels.**
- **Emissions Control systems – modern burner designs are available with NO_x emissions reduction systems:**
  - **FGR Reduction Systems – precise and repeatable metering of the flue gas ensures optimal combustion efficiency meeting regulated emissions levels across the burner firing range.**
  - **Premix Reduction Systems – operating at elevated O_2 levels, precise and repeatable excess air control to maximize combustion efficiency.**
  - **Fuel staging and other NOx reducing technologies.**

Installing a new burner with one or more of these optional systems can significantly reduce fuel costs over an older, existing burner with legacy controls. Overall efficiency gains on the order of 5-10 percentage points can be realized with a new burner and state-of-the art controls through tighter combustion control across the firing range.

What Other Burner Related Systems Affect the Overall System Efficiency?

- **Draft – varying draft conditions and off-cycle heat losses from the boiler can have a negative impact on burner-boiler performance, air-fuel ratios, and total heat input requirements (costs).**

  Today's burners can be integrated with state-of-the art draft control systems, sequencing with the burner to minimize off-cycle draft (energy) losses and maintain over-fire draft conditions to keep air-fuel ratios on ratio.

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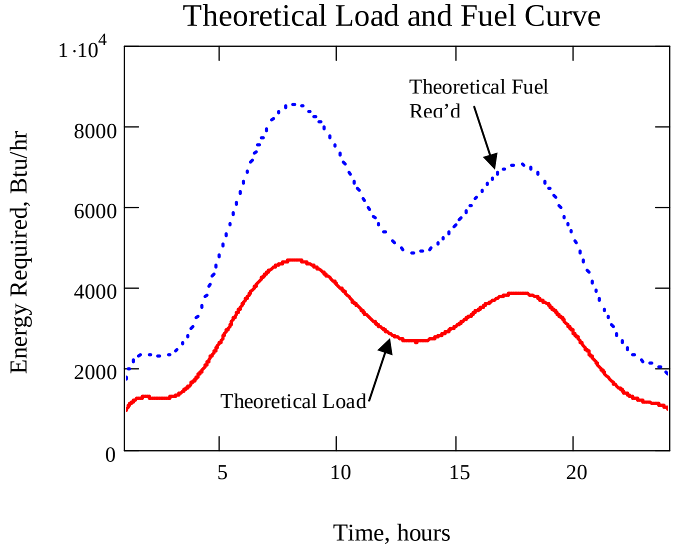
- **<u>Boiler Sequencing</u> for Multiple Units – with single boiler installations, the boiler-burner is sized for peak load. In many applications, peak load is realized only on occasion, if at all, over the life of the boiler. Losses associated with cycling and low, partial load operation affects the overall efficiency and life of the system and its components. Multiple boilers sized for partial load carrying capability, as well as for system redundancy and scheduled maintenance require sequencing control.**
- **<u>Better Burner-Boiler Matching</u> – one of the greatest fears of the specifying engineer or facility's manager is under-sizing equipment. The implications of under-sizing a heating boiler or process boiler should be obvious. As a result, burners and boilers are frequently oversized for their application. In those instances, an existing larger burner can be replaced with a smaller burner that is fitted up with state-of-the art controls as suggested above. Cycling and its associated energy losses are reduced and overall efficiencies are improved. As well, reductions in maintenance and component replacement expenses have been shown due to reduced cycling of motors and starters as well as enhanced combustion leading to reduced fouling and boiler cleaning requirements.**

To better understand the concept of overall efficiency, consider the hypothetical load and theoretical fuel input curves over a 24-hour period as shown in Figure 8.

Figure 8.
Theoretical Load and Fuel Curve



The theoretical fuel required at anytime during this 24-hour cycle is much greater than the actual load requirement. In this case, system efficiency is approximately 55%. The challenge to the facilities manager is to bring the *Fuel Required* curve closer to the *Theoretical Load* curve.

Considering the aforementioned opportunities for improving thermal efficiencies and the overall system efficiency, fuel related operating expenses can be greatly reduced through retrofit of the burner alone – at a much lower capital investment and

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disruption to plant operations than, say, replacement of the entire boiler system. This opportunity will be examined next with a simple performance – economic analysis considering the retrofit of an existing boiler with a new burner package.

Burner Upgrade Economics

The following, simple economic analysis is predicated on what should be reasonable assumptions. Even with the most sophisticated measuring tools and data collection systems, precise determination of the operating variables and their relative impact on overall efficiency is difficult. Just maintaining experimental settings or compensating for experimental setting changes (such as in load demand) to perform a meaningful "before-after" analysis, is in itself a challenge and left to the experimenter to resolve. However, for our purpose of demonstrating the economic viability of burner retrofit, the following simple analysis is presented.

To demonstrate what a five (5) percentage point overall operational efficiency gain represents in annual fuel operating expenses, several assumptions are required, namely:

- Average boiler-burner load is 40% over the operating hours of the equipment
- Boiler size is 200 horsepower
- Average annual hours of operation is 5,500 hours
- Average natural gas cost is $6.00/MMBtu
- Overall efficiency before burner and controls upgrade, $h_1 = 0.55$ or, 55%.
- Boiler-burner efficiency after burner and controls upgrade, $h_2 = 0.60$ or 60%.

The annual savings in fuel expenses, ***Annual$***, would be:

$$Annual\,\$ = 200_{BHP} \times 33{,}475 \frac{Btu}{hr - BHP} \times 5{,}500 \frac{hr}{yr} \times 0.40 \times \frac{\$6.00}{10^6\,Btu} \times \left(\frac{1}{0.55} - \frac{1}{0.60} \right) = \$13{,}390 / yr$$

To an end-user, a new 200 hp high turndown gas burner fitted with parallel positioning control would cost in the range of $12,000 to $15,000 installed. The simple payback period on such a capital investment would range from 11 to 14 months. The Return on Investment (ROI) for the first year would range from 89% to 111%.

Further savings may be realized through replacement of the boiler with a more effective heat exchanger, thereby increasing the system efficiency above what a burner replacement alone can achieve. However, the increased capital investment for replacing the entire boiler-burner package may not yield an ROI as attractive as replacing the burner and burner-boiler related controls, alone.

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What Can Power Flame do for me?

Power Flame has a nation-wide network of manufacturer representatives experienced in commercial-industrial heating applications and are experts in matching the right equipment with your needs.

Working directly with the end-customer, the specifying engineer, or consultant, our representatives will carefully evaluate your heating or process requirements. They will also consider other parameters, such as site conditions, fuel availability, electrical service, insurance requirements, codes and emission regulations before making any recommendations to modify or upgrade your burner system. During this process they have ready access to our experienced Customer Service representatives or engineering staff, both of which can answer technical questions or assist with specific application concerns.

With over 50 years in the commercial/industrial heating business, we have the products and services to ensure your upgrade expectations are met. Your local Power Flame representative can be found online at www.powerflame.com or by calling our office at 1-620-421-0480.

Why Choose Power Flame?

Simple. We build burners and burner-boiler room control systems that make both you and your boiler room operations look good.

- All of our burners and control systems are designed and assembled in Parsons, KS, and serviced by authorized representatives and service agencies throughout the U.S.
- Incorporating both proprietary designed components for optimal combustion efficiency and control components from industry leaders such as Honeywell, Fireye, Siemens, ASCO, Baldor, Marathon and others, you have the backing of the strongest leaders in the combustion and controls industry.
- Our full range of burner products from 150 MBH to 63,000 MBH input ensures that we have a system which will meet your needs.
- We have the capability to fire most liquid and gaseous fuels including waste gases and oils.
- With over 1,400 low NOx burner systems operating we have the most experience in the industry to meet today's stringent emission requirements.
- Our UL certified laboratory enables us to perform application testing on all makes and models of boilers and heat exchangers. Power Flame burners are ULB labeled with nearly every commercial and industrial boiler manufacturer in the United States.
- Our ongoing R&D activities respond to the specific needs of our customers developing their own new products, as the demands within the combustion market dictate lower emissions and higher efficiency operation.

Quality, performance and value are associated with each and every burner we build. We stand behind our products and take pride in being a market leader. Let us assist you with your next burner project.

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The Power Flame Product Offering

We offer a number of products to accommodate your space and process heating needs.

From straight gas, light to heavy oil, to combination fuel burners Power Flame has the solution.

Power Flame burners and controls package well-known, industry leaders in combustion controls and control panel equipment including Honeywell, Fireye, and Siemens. We use non-proprietary components to ensure you have ready access locally for replacement controls or fuel train components.

Here's a quick overview of our product range:

- ***X4 small diameter gas burner (150 to 725 MBH).***
- ***Type JA small to medium range gas burner (300 to 2,200 MBH).***
- ***Type C high performance gas, oil or combination gas/oil burner (98 to 19,100 MBH).***
- ***Type CMAX high capacity gas, oil or combination gas/oil burner (1,260 to 36,000 MBH).***
- ***Vector industrial gas, oil or combination gas/oil burner (25,200 to 63,000 MBH).***
- ***Nova Premix non-FGR low NOx gas burner (250 to 2,200 MBH).***
- ***Nova Plus ultra low NOx gas burner (2,000 to 25,200 MBH).***
- ***TYPE CX small diameter tube immersion burner (50 to 2,500 MBH)***
- ***Type FD and FDM high turndown direct or indirect fired air heating gas burner (30 to 3,500 MBH).***
- ***DC3 microprocessor-based draft controls.***
- ***Micro IV microprocessor-based lead lag control system.***
- ***Director annunciator and supervisory control systems.***

All of our products can be customized to fit your specific needs and application requirements.

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Conclusion

Significant savings in annual fuel-related expenses can be achieved in the boiler room though component level analysis of the HVAC system. While in some instances the replacement of an entire boiler or heating system is warranted and can be financially justified, escalating capital equipment costs and tight capital budgets have dampened returns and have corporate financial planners and managers looking toward lower initial investments for reasonable returns on investment.

There are attractive opportunities in reducing fuel consumption and maintenance costs through upgrading combustion systems, particularly in the boiler retrofit market. Simple payback periods on the order of one year may be realized through retro-fitting existing boilers and heat exchangers with modern, state-of-the art gas and oil burners and controls. Combustion efficiencies can be improved through:

- **Lower excess air requirements,**
- **Precise and repeatable air-fuel metering, load following, and load response through parallel positioning systems and state-of-the art PID control,**
- **Reduction in boiler-burner cycling and off-cycle heat losses with high turndown burners,**
- **Over-fire and stack draft control, and**
- **Boiler-burner staging in multiple boiler installations through microprocessor based lead-lag control systems.**

Simultaneously, environmental concerns and regulations can be addressed with state-of-the art emissions control systems such as that offered by Power Flame. Reduced NOx emissions ranging from sub-9 ppm to sub-30 ppm meeting all Air Quality Management Districts Standards throughout the U.S. are available in our NOVA™ series products incorporating these technologies:

- **Internal fuel gas recirculation (NOVA® LN and LNI)**
- **Premixed fuel and air (NOVA Premix™ and NOVA Plus™)**
- **Staged combustion (NOVA®)**
- **Combinations of aforementioned technologies, such as with our CMAX™ product line that combines IFGR and Staged combustion to produces low NOx emissions at the lowest cost.**
    - **This latest burner offering from Power Flame, the CMAX™, performs at sub-60 ppm NOx without IFGR, and sub-30 and sub-20 ppm performance with IFGR on most applications.**

<u>Now</u> is the time to review your boiler room operation. If you are confident that a major upgrade is required and a new boiler package is justified, ensure that your new boiler is equipped with a Power Flame burner and control system for optimal performance and fuel utilization. If a new burner or burner-boiler control system proves to be a more attractive investment, look to one of our qualified representatives located throughout the United States to assist you in making the right choices for your heating equipment needs. Together, you can make your operation the "best in the business".

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