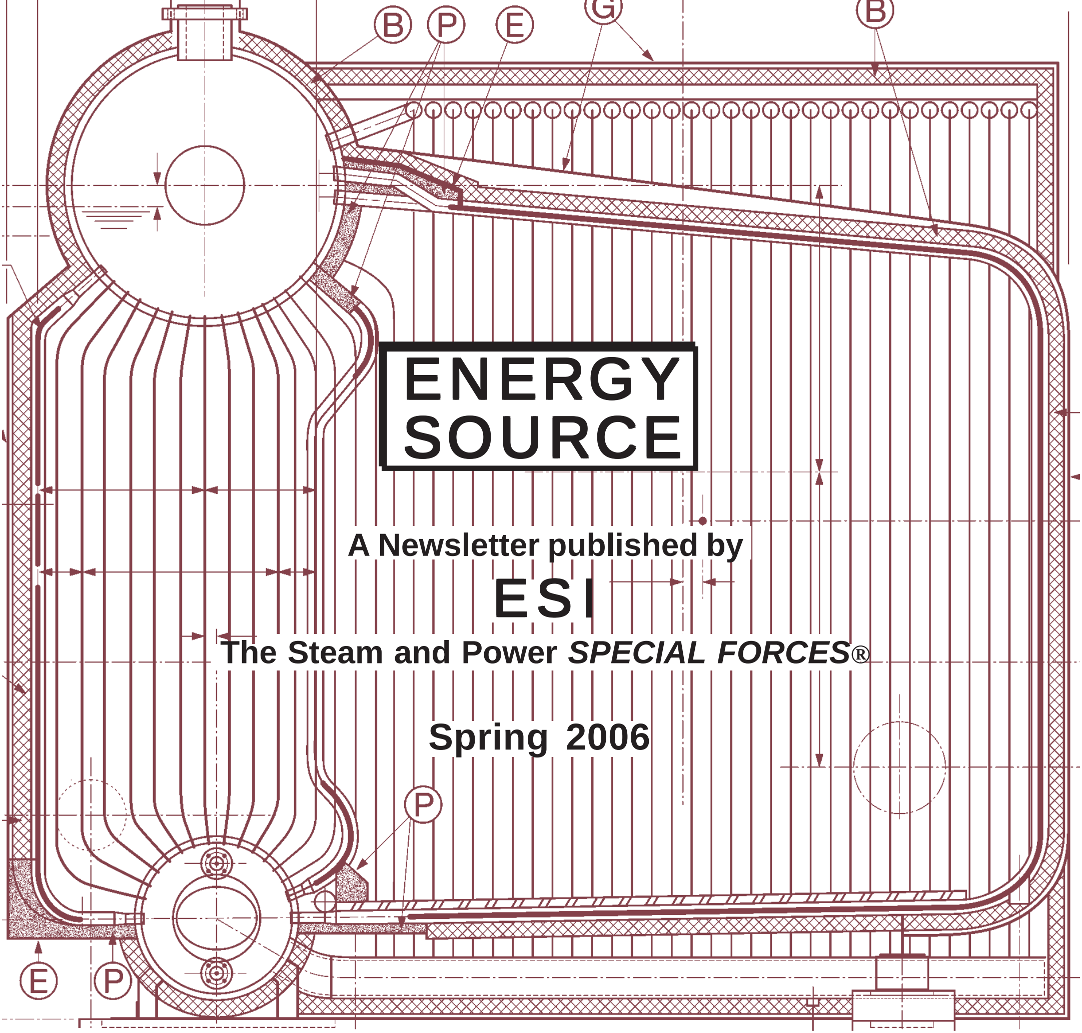


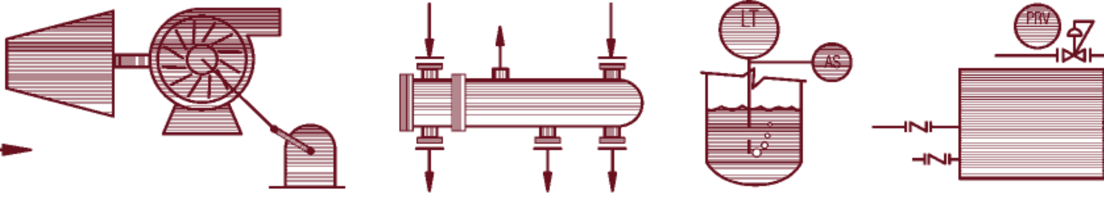
ENERGY SOURCE

A Newsletter published by

ESI

The Steam and Power *SPECIAL FORCES*®

Spring 2006



What Are My Fuel & Technology Choices?

By: William L. Reeves, P.E., President, ESI
Jeffrey H. White, P.E., Vice President – Engineering, ESI

Over the past two years, the dramatic rise in natural gas and oil prices has had a crippling effect on the bottom line of any substantial energy user who depends on these fuels. Numerous industrial and non-regulated utility clients have contacted ESI to perform preliminary engineering and feasibility studies to investigate the cost and benefit of switching to a solid fuel. The reasons are obvious. Depending upon the location, companies are forecasting their delivered natural gas pricing going forward at $9.00 to $12.00 per mmbtu. On the other hand, coal and waste wood can be delivered between $2.00 to $3.50 per mmbtu. If your low pressure saturated steam load is approximately 150,000 pph, you are going to use approximately 1.5 million mmbtus per year which means that your annual operating cost savings would range between $8 - $15 million per year.

The first question we get is generally the same. What fuels are economically available and what type of boiler should I put in to burn them? One would think that the answer to this question would be readily simple and easily defined by answering the following questions:

- What is the delivered cost of the cheapest fuel?
- What technology is best able to burn that fuel?

Unfortunately, the analysis becomes much more complex because of several factors, each of which can have a dramatic effect on the results. These factors include, but are not limited to, the following:

- How much real estate is available for the new solid fuel-fired facility?
- How is the fuel delivered, by truck or rail?
- Are long-term contracts available for the preferred fuel at attractive rates?
- How many days of on-site fuel storage are required?
- Is the proposed site a non-attainment area for any existing criteria pollutant?
- What are the key factors that need to be considered in a new air permit?
- What are the trade-offs the company wants to consider regarding capital and operating cost?
- How will the new facility affect the current process and other plant operations?
- How will back-up capacity and redundancy be addressed and provided?
- What is the required corporate return on investment?

The answers to many of these questions are interrelated which makes for a dynamic analysis. However, there are some general principles and guidelines that can help anyone contemplating a capital project for a fuel change. In this and subsequent issues

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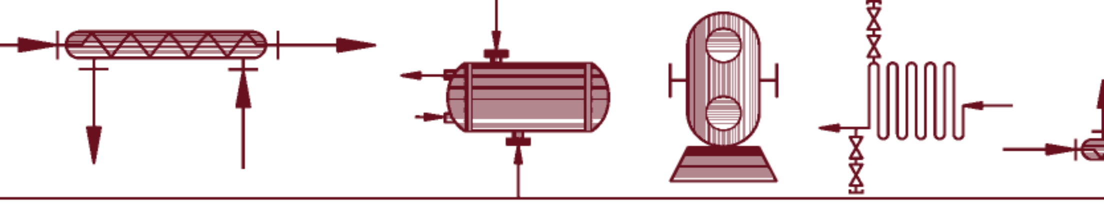
ENERGY SOURCE

The *ENERGY SOURCE* is published quarterly for customers, employees, and friends of ESI Inc. of Tennessee.

ESI is the Steam and Power *SPECIAL FORCES*® providing clients with innovative, cost-effective, and environmentally-friendly solutions.

If you have any suggestions or comments about the newsletter feel free to call us at 770-427-6200 or e-mail us at energysource@esitenn.com.

Deanna White
Managing Editor



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of the *ENERGY SOURCE*, ESI will provide some basic answers to the following questions:

- What are the commercially available technologies for firing solid fuels?
- What are the differences between these technologies?
- What technology is best for a specific fuel?
- What are the differences between firing wood, coal, and other solid fuels?
- What are the critical parameters in a fuel analysis that affect the technology selection and plant design?

What Are The Commercially Available Technologies for Firing Solid Fuels?
Currently there are four primary technologies for firing solid fuels in a boiler:

- Pulverized Coal
- Stoker-Fired
- Bubbling Fluid Bed
- Circulating Fluid Bed

Gasification technology is emerging as a commercially available technology; however, the current experience in this technology is in fairly small systems typically under 100 mmbtu/hr heat input. For this reason, we will not include gasification in this discussion.

Pulverized Coal Technology- A pulverized coal-fired boiler typically fires sub-bituminous and bituminous coal. These boilers range in size between 50,000 pph small industrial size units and large utility boilers up to 1300 MW. With this technology, mine run coal is received on-site where it is typically crushed and then pulverized to pass a minimum of 70% through a 200 mesh screen and 98.5% through a 50 mesh screen. Once sized, the coal is introduced into the furnace through air-staged low NO_x burners. The technology responds very well to load swings. Units utilizing this technology have been in commercial operation since the late 1800's. PC boilers are relatively high NO_x generators as compared to BFB and CFB boilers. The technology must use back end air pollution control equipment to control SO_x, NO_x, particulate, HCL, and mercury emissions. The capital costs for PC units larger than 150,000 pph are relatively low when compared to the newer CFB and BFB units.

Stoker Fired Technology- Stoker technology can be designed to fire a wide variety of solid fuels which include coal, wood, and other opportunity fuels alone or in combination. Stoker-fired units can vary in size from 15,000 pph to 500,000 pph. As stated, the technology is very versatile in its ability to be designed to fire various fuels; however, once a fuel is selected, the technology is much less forgiving than CFB or BFB for drastic variations in fuels. The technology is not appropriate for biomass or opportunity fuels with fuel moistures in excess of 55%.

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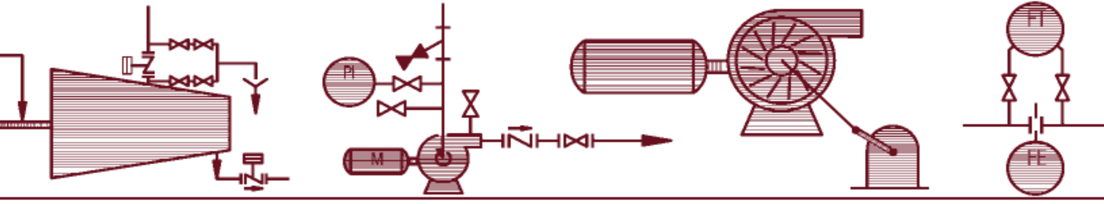

Project Options Got You Confused?

By: Deanna B. White, Marketing Manager, ESI

Has your plant situation recently changed due to higher fuel or power costs, or are you being mandated to comply with recent environmental regulations? Do the possible project options have you confused? ESI engineers are industry experts when it comes to conducting project study and feasibility analysis. We are focused on the development of projects and can quickly filter through options that won't meet your company's necessary return on investment. Our typical study involves analyzing a client's current situation, brainstorming possible scenarios which will most benefit the client, determining budgetary capital and operating costs, and performing a life cycle analysis which will typically include operating costs, financing costs, depreciation and tax effects. We use this analysis to narrow the field and select the appropriate options that will offer the client the best return on investment. We then typically refine our analysis of the selected options' capital and operating costs and run the life cycle analysis again to make sure that the project is viable for funding.

ESI is currently performing several studies to assist our clients in making the best decision for their particular situation. A few we are currently working on include:

- Conversion of a 150,000 pph steam generating facility from natural gas to coal or biomass
- The feasibility of installing a 25 MW biomass-fired merchant power generation facility
- Conversion of an existing 250,000 pph natural gas-fired facility to #6 fuel oil
- Conversion of a 220,000 pph natural gas and wood-fired facility to coal
- The feasibility of a merchant power generation facility which will be fired by coal
- The installation of a carbon burnout facility which will convert over 300,000 tons per year of fly ash to a saleable product
- Reducing the amount of natural gas currently fired by a steam generation facility to maintain load swings by increasing the coal burning capacity
- The feasibility of adding a steam turbine generator to an existing plant to increase its revenue through power generation

ESI can perform a low cost engineering study to assist in the evaluation of your options and determine the best path forward. If you already have the scope determined, ESI provides ± 25% budget pricing as a complimentary service to our clients. For additional information about budget pricing, or conducting an engineering study and feasibility analysis, please contact Jay Garrett with ESI today at 770-427-6200 or info@esitenn.com. We look forward to hearing from you soon!

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With a stoker-fired unit, fuel is metered and distributed across a horizontal surface (grate) inside the boiler with small holes that allow combustion air to pass through. The combustion air passes through the “bed” of burning material on the grate and interacts with the fuel. Additional combustion air is usually introduced above the bed to complete the combustion of any volatile gases. The boiler grate can be either a stationary or a moveable type. Stationary grates are less expensive but require periodic manual de-ashing of the grate. Moving grates come in various combinations including vibrating, chain grates, and traveling grates. All moving grates automatically remove ash from the bed. Stoker boilers can be designed to have a reasonable response to load swings when the fuel is properly sized and the boiler is properly tuned. Stoker technology is among some of the oldest technology having been in operation since the early 1800’s. Stoker systems are relatively high NO_X and CO generators compared to the other solid fuel technologies. The capital cost of this technology is among the lowest, especially in the smaller size ranges.

Bubbling Fluid Bed Technology- Bubbling fluid bed (BFB) technology is designed to fire relatively high moisture (over 45%) fuels with relatively low heating values. Fuels ideal for this technology include various biomass fuels, most sludges, and some waste fuels. Boiler sizes range from 30,000 pph to 500,000 pph systems. BFB fired boilers larger than this are now being considered. With this technology, fuel is introduced to a lower portion of the boiler or combustor that has been designed to hold an inert bed of material. The bed is heated to a temperature between 1400°F and 1700°F. Combustion air is introduced to the bed via fluidizing air nozzles which are located in the bed thereby fluidizing the bed and fuel mixture into a low density state much like boiling water. Additional combustion air is introduced above the bed to combust the volatile gases driven off in the bed combustion process. Bubbling fluid bed technology is very adaptable to many fuel types as long as the moisture content does not get too low and the alkali content in the fuel does not get too high. Alkalis include potassium and sodium which can cause bed agglomeration. Ash is removed from the bed by a bed drain system that is typically screened to remove any sand taken out with the bed drains. The sand is re-injected back into the bed. Fluidized bed boilers can respond well to load swings; however, due to the high thermal mass from the bed of the boiler, they are not as responsive as stoker or pulverized coal-fired units. Fluid bed technology is among some of the newest commercially viable solid fuel combustion technologies, having been in existence since the 1970’s. Besides the fuel flexibility of the technology, one of the other chief advantages of this technology is the relatively low emissions. Due to the low combustion temperatures of a fluidized bed, NO_X generation is very low. Another advantage is that if the fuel has high sulfur content, limestone can be introduced into the bed to control the sulfur dioxide emissions. Fluid bed technology remains a relatively high capital-intensive technology when compared to stoker-fired technology.

Circulating Fluid Bed Technology- The latest generation in commercial combustion technology is the circulating fluid bed (CFB). This technology is the most versatile when considering the various fuels which are capable of being combusted. Fuels widely ranging in higher heating value (HHV) and moisture content from anthracite coal to biomass to petroleum coke have all been successfully fired with this technology. Boiler sizes using this technology range from 100,000 pph to over 600 MW utility boilers. Like the BFB technology, fuel is introduced into a lower portion of the boiler or combustor which has been designed to hold a bed of inert material and fuel. Using conventional burners, the bed is heated to a temperature between 1400°F and 1700°F. Combustion air is introduced to the bed via fluidizing air nozzles which are located in the bed and fluidize the bed material. However, with a CFB, the material is fluidized to

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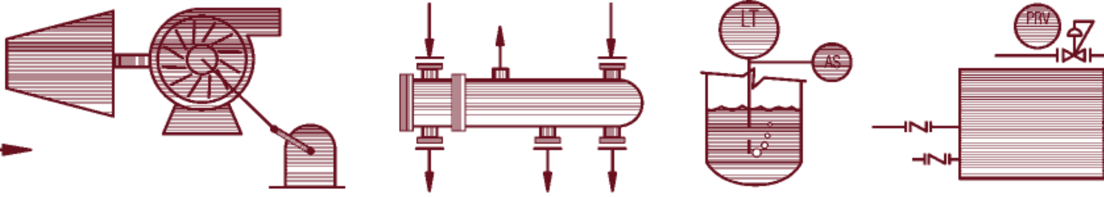

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the point that it actually travels up the furnace and is allowed to exit the furnace. Once the material leaves the furnace, it is captured by either large high-efficiency cyclones or multicyclones where it is recirculated back to the bottom of the furnace. Additional combustion air is introduced above the lower furnace to combust the volatile gases driven off by the combustion process. Ash is removed from the bed by a bed drain system. Circulating fluid bed boilers can respond well to load swings; however, due to the high thermal mass from the bed of the boiler, they are less responsive than pulverized coal-fired units. CFB technology is among the newest commercially viable combustion technology, having been in existence only since the 1980’s. Besides the fuel flexibility of the technology, one of the other chief advantages is the relatively low emissions. Due to the low combustion temperatures of a CFB, NO_x generation is very low. Another advantage is that if the fuel has a high percentage of sulfur, limestone can be introduced into the bed to control the sulfur dioxide emissions. Fluid bed technology remains the highest capital cost technology compared to all other technologies.

ESI hopes this brief introduction into the various technologies available for steam and power generation has been informative. The next article in the series will outline specific differences in the various technologies including emissions limit capabilities, fuel limitations, and more. If you are currently evaluating your options for solid fuel firing, give the experts at ESI a call to discuss your options. Contact Jay Garrett at 770-427-6200 or info@esitenn.com.

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