Benchmark the Fuel Cost of Steam Generation

Best Practice Tip 112

Benchmarking the fuel cost of steam generation, in dollars per 1,000 pounds ($/1,000 lb) of steam, is an effective way to assess the efficiency of your steam system. This cost is dependent upon fuel type, unit fuel cost, boiler efficiency, feedwater temperature, and steam pressure. This calculation provides a good first approximation for the cost of generating steam and serves as a tracking device to allow for boiler performance monitoring. Table 1 shows the heat input required to produce 1 lb of saturated steam at different operating pressures and varying feedwater temperatures. Table 2 lists the typical energy content and boiler combustion efficiency for several common fuels.

Table 1. Energy Required to Produce One Pound of Saturated Steam, Btu*

Operating Pressure, psig	Feedwater Temperature, °F				
	50	100	150	200	250
150	1178	1128	1078	1028	977
450	1187	1137	1087	1037	986
600	1184	1134	1084	1034	984

*Calculated from steam tables based on the difference between the enthalpies of saturated steam and feedwater.

Table 2. Energy Content and Combustion Efficiency of Fuels

Fuel Type, sales unit	Energy Content, Btu/sales unit	Combustion Efficiency, %
Natural Gas, MMBtu	1,000,000	85.7
Natural Gas, thousand cubic feet	1,030,000	85.7
Distillate/No. 2 Oil, gallon	138,700	88.7
Residual/No. 6 Oil, gallon	149,700	89.6
Coal, ton	27,000,000	90.3

Note: Combustion efficiency is based on boilers equipped with feedwater economizers or air preheaters and 3% oxygen in flue gas.

Data from the tables above can be used to determine the cost of usable heat from a boiler or other combustion unit. The calculations can also include the operating costs of accessories such as feedwater pumps, fans, fuel heaters, steam for fuel atomizers and soot blowing, treatment chemicals, and environmental and maintenance costs.

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Suggested Actions

- Determine your annual fuel costs based on utility bills.
- Install a steam flowmeter in your facility and calculate your steam generation cost. Compare this with the benchmark value.
- Using a systems approach, do a thermoeconomic analysis to determine the effective cost of steam. (See page 2: Effective Cost of Steam.)

Best Practice Tip Sheet information is adapted from information provided by the Industrial Energy Extension Service of Georgia Tech and reviewed by the DOE Best Practices Steam Technical Subcommittee. For additional information on industrial steam system efficiency, contact the EERE Information Center

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Example

A boiler fired with natural gas costing $8.00/MMBtu produces 450-pounds-persquare-inch-gauge (psig) saturated steam and is supplied with 230°F feedwater. Using values from the tables, calculate the fuel cost of producing steam.

$$\text{Steam Cost} = (\$8.00\ \text{MMBtu}/10^6\ \text{Btu/MMBtu}) \times 1{,}000\ \text{lb} \times 1{,}006\ (\text{Btu/lb}) / 0.857$$
$$= \$9.39/1{,}000\ \text{lb}$$

Effective Cost of Steam
The effective cost of steam depends on the path it follows from the boiler to the point of use. Take a systems approach and consider the entire boiler island, including effect of blowdown, parasitic steam consumption, and deaeration. Further complications arise because of the effects of process steam loads at different pressures, multiple boilers, and waste heat recovery systems. To determine the effective cost of steam, use a combined heat and power simulation model that includes all the significant effects.

Multi-Fuel Capability
For multi-fuel capability boilers, take advantage of the volatility in fuel prices by periodically analyzing the steam generation cost, and use the fuel that provides the lowest steam generation cost.

Higher Versus Lower Heating Values
Fuel is sold based on its gross or higher heating value (HHV). If, at the end of the combustion process, water remains in the form of vapor, the HHV must be reduced by the latent heat of vaporization of water. This reduced value is known as the lower heating value (LHV).

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