Benchmark the Fuel Cost of Steam Generation

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, deaeration, etc. Further complications arise due to the 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 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).

For additional information on industrial energy efficiency measures, contact the OIT Clearinghouse at (800) 862-2086.

Benchmarking the fuel cost of steam generation ($/1000 lbs 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 one pound 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	1,178	1,128	1,078	1,028	977
450	1,187	1,137	1,087	1,037	986
600	1,184	1,134	1,084	1,034	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 (therm)	100,000	81.7
Natural Gas (cubic foot)	1,030	81.7
Distillate/No. 2 Oil (gallon)	138,700	84.6
Residual/No. 6 Oil (gallon)	149,700	86.1
Coal (ton)	27,000,000	87.6

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

Data from the above tables can be used to determine the cost of usable heat from a boiler or other combustion unit. The calculations can also include 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.

Example

A boiler, fired with natural gas costing $0.30/therm, produces 450 psig saturated steam and is supplied with 230°F feedwater. Using values from the tables, calculate the cost of producing steam.

$$\textbf{Steam Cost} = \frac{0.3\ (\$/\text{therm})}{100{,}000\ (\text{Btu/therm})} \times 1000 \times 1006\ (\text{Btu/lb}) \times \frac{100}{81.7} = \textbf{\$3.69/1000 lbs}$$

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 sidebar: Effective Cost of Steam)

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OIT encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following nine energy and resource intensive industries:

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- Mining
- Petroleum
- Steel

OIT and its BestPractices program offer a wide variety of resources to industrial partners that cover motor, steam, compressed air and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The *Energy Matters* newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at **www.oit.doe.gov/bestpractices** or by contacting the OIT Clearinghouse at **800-862-2086** or via email at **clearinghouse@ee.doe.gov.**

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