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).

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)

---

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

<table>
<thead>
<tr>
<th>Operating Pressure, psig</th>
<th>Feedwater Temperature, °F</th>
<th>Energy Required (Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>150</td>
<td>1,178</td>
<td>1,128</td>
</tr>
<tr>
<td>450</td>
<td>1,187</td>
<td>1,137</td>
</tr>
<tr>
<td>600</td>
<td>1,184</td>
<td>1,134</td>
</tr>
</tbody>
</table>

* 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**

<table>
<thead>
<tr>
<th>Fuel Type (sales unit)</th>
<th>Energy Content (Btu/sales unit)</th>
<th>Combustion Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas (therm)</td>
<td>100,000</td>
<td>81.7</td>
</tr>
<tr>
<td>Natural Gas (cubic foot)</td>
<td>1,030</td>
<td>81.7</td>
</tr>
<tr>
<td>Distillate/No. 2 Oil (gallon)</td>
<td>138,700</td>
<td>84.6</td>
</tr>
<tr>
<td>Residual/No. 6 Oil (gallon)</td>
<td>149,700</td>
<td>86.1</td>
</tr>
<tr>
<td>Coal (ton)</td>
<td>27,000,000</td>
<td>87.6</td>
</tr>
</tbody>
</table>

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.

\[
\text{Steam Cost} = \frac{0.3 \ ($/\text{therm})}{100,000 \ (\text{Btu/therm})} \times 1000 \times 1006 \ (\text{Btu/lb}) \times \frac{100}{81.7} = $3.69/1000 \text{ lbs}
\]
About DOE’s Office of Industrial Technologies

The Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. OIT is part of the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy.

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:

- Agriculture
- Forest Products
- Mining
- Aluminum
- Glass
- Petroleum
- Chemicals
- Metal Casting
- 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.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Eric Lightner
Office of Industrial Technologies
Phone: (202) 586-8130
Fax: (202) 586-1658
Eric.Lightner@ee.doe.gov
www.oit.doe.gov/bestpractices

OIT Clearinghouse
Phone: (800) 862-2086
Fax: (360) 586-8303
clearinghouse@ee.doe.gov

Please send any comments, questions, or suggestions to webmaster.oit@ee.doe.gov

Visit our home page at www.oit.doe.gov

Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, D.C. 20585

DOE/GO-102000-1115
November 2000
Steam Tip Sheet #15