Add Economizers to Boilers to Recapture Heat from the Flue Exhaust (Arc 2.2421)

(The analysis below was extracted from one of the assessment reports by the Clemson University Industrial Assessment Center (IAC). This is only an example recommendation and hence, not all the background information and sources for numbers are included here.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Est. Gas Consumption Savings</td>
<td>= 11,157.4 MMBtu/yr</td>
</tr>
<tr>
<td>Est. Gas Consumption Cost Savings</td>
<td>= $47,531/yr</td>
</tr>
<tr>
<td>Est. Implementation Cost</td>
<td>= $15,500</td>
</tr>
<tr>
<td>Simple Payback Period</td>
<td>= 3.9 months</td>
</tr>
</tbody>
</table>

**Recommended Action:**
It is recommended that an economizer be added to the boiler systems to recapture the heat from the flume exhaust and use it for pre-heating the boiler feed water.

**Background:**
The plant uses two Clayton Industries Model E504 Standard boilers with 500HP capacity fueled with natural gas. One of the boilers is running throughout the year and the other one is used only for redundancy cases. Economizers are air-to-liquid heat exchangers designed to preheat boiler feed water. They may also be used to heat process of domestic water, or to provide hot liquids for space heating or make-up air heating equipment.

Most economizers have finned tube heat exchangers constructed of stainless steel while the inlet and outlet ducts are carbon steel lined with suitable insulation. Maximum recommended waste gas temperatures for standard units are around 1,800°F.

According to economizer manufacturers, fuel consumption is reduced approximately 1% for each 40°F reduction in flue gas temperature. The higher the flue gas temperature, the greater the potential for energy savings. The following graph shows the effect of pre-heating combustion air on available heat:

![Figure 1. The effect of pre-heating combustion air on available heat.](image-url)
The average annual natural gas consumption for the plant from years 2015 and 2016 has been 114,226 MMBtu. The average unit cost that the plant is being charged for natural gas is $4.26/MMBtu.

**Anticipated Savings:**
The gas-fired combustion efficiency of the boiler was measured at 79.2% using the Bacharach Insight Plus analyzer. According to operations management the steam requirement of the plant is typically around 50% of the boiler capacity. The boiler specifications presented in figure below indicate that the nominal heat input for the installed boiler is about 20.412 MMBtu/h (Figure 2) using natural gas fuel.

![Figure 2. Boiler specifications for Model E504 Standard](image)

Therefore, the annual estimated energy consumption of the boiler, $EEC$, can be determined as follows:

$$EEC = \text{Heat input (MMBtu/h)} \times \text{Steam load (\%)} \times \text{Operational hours}$$

$$EEC = 20.412 \text{ MMBtu/h} \times 50\% \times 8760\text{h} = 89,402.7 \text{ MMBtu}$$

A high quality recuperator could recover up to 60% of this waste heat. Accordingly, the potential energy savings from the installation of a recuperator on the process boiler, AES, can be determined as:
\[ AES = EEC \times (1 - \text{Eff1}) \times RC \]

where \( RC \) is the percent of energy recoverable by recuperator, so

\[ AES = 89,4012.7 \times (1 - 0.792) \times 0.6 = 11,157.4 \text{ MMBtu} \]

Finally, the estimated annual energy cost saving, \( AECS \), can be determined based on the unit energy consumption charge for natural gas:

\[ AECS = AES \times (\$4.26/\text{MMBtu}) \]

\[ AECS = 11,157.4 \times (\$4.26/\text{MMBtu}) = \$47,531 \]

**Implementation Cost:**

Many boiler companies sell off-the-shelf boiler recuperators of various sizes and efficiencies. The cost of a recuperator capable of handling the exhaust flow rate of the boiler as well as having efficiency greater than 70% would be about $10,000 and the anticipated installations costs would run to about $5,500. Therefore, the implementation cost, \( IC \), would be approximately around $15,500.

*Implementation Cost (IC) = $15,500*

**Simple Payback Period:**

The *simple payback period, SPP*, is the time required to pass before the estimated total cost savings equal the estimated implementation cost, and is calculated by:

\[ SPP = \frac{IC}{AECS} \times 12 \text{ months/year} \]

\[ SPP = \frac{15,500}{47,531} \times 12 \text{ months/year} \]

\[ SPP = 3.9 \text{ months} \]