It Makes Sense to Condense:

cold facts about the benefits of condensing economizers

For years it was assumed — and in most cases, assumed correctly — that heat recovery was viable only to a point. And that point was about 250° F. Heat recovery from flue gasses cooler than this would trigger the law of diminishing returns in terms of costly corrosion of equipment from sulfurous fuels. Such damage could be avoided by fabricating a system from high-end non-corrosive materials. But the costs of these materials would again diminish returns.

An eventual transition to clean-burning natural gas made lower-temperature heat recovery feasible in terms of equipment protection. But the discovery in the US of massive reserves of untapped natural gas drove the price to stable new lows, once more giving rise to the question of whether it was workable in terms of cost.

In this white paper, we will examine the question of cost tradeoffs in low-temperature heat recovery, including both direct and indirect returns on the investment in equipment and installation. We will also consider other potential benefits of low-temperature heat recovery that cannot be quantified by cost. And finally, we will identify the situations and circumstances in which this technology may be most effectively applied.

Vaporizing energy dollars

Typically, the combustion products of natural gas include 11 to 12 percent moisture. During gas combustion, water is vaporized and escapes into the atmosphere with the heated boiler gases. Each molecule of the vapor takes with it a parcel of heat absorbed during the process of evaporation. In essence, then, 11 to 12 percent of the heat input is lost in a system configured with a traditional economizer only.

In order to reclaim heat from water vapor, it must be forced to “give up” its energy content by returning to liquid form. This change of phase requires that the flue gas be cooled to a temperature below its dew point, which is around 135° F.

To understand how the process works, picture a glass of cold lemonade sitting outside on a hot day. As the moisture, or “humidity,” in the atmosphere comes in contact with cold glass, it changes phase, turning into beads of condensation. In the process, the vapor loses its power of motion, transferring this kinetic energy to the condensing surface on which it settles.

Pulling money out of the air

A natural gas-fired boiler with a traditional economizer cools flue gas to about 250° F — well above the dew point of the water in the gas vapor. This type of system generally yields fuel efficiencies of 80-85 percent, and allows water vapor to be escape the system by going up the flue with the boiler gases. Reclaiming this lost energy requires the installation of a secondary recovery unit that capitalizes on the heat-releasing effects of condensation.

Condensing systems generally take one of two forms, direct contact or indirect contact. However for certain reasons, the latter offers greater benefits in heat recovery operations.

In direct contact condensing, cold water flows right through the hot gas stream. This method suffers from two inherent drawbacks. The first is that because the dew point of natural gas is typically 135° F, the maximum temperature yielded in recovered heat is just that — 135°. The second drawback is that water used in this method of heat recovery becomes contaminated by pollutants in the gas stream. This necessitates the addition of a secondary heat exchanger in order to keep separate this contamination from the product stream.

Indirect contact systems use a closed cooling system that circulates non-deaerated cold water (usually 55° F–65° F) through specially fabricated metal tubes. This method not only avoids contamination of the feedwater, but also allows a higher degree of heat recovery. A condensing economizer can net an additional 100° F of heat recovery as gases cool to temperatures below their dew point.

Jamie Tighe, general manager and chief engineer for E-Tech said that his company's designs often yielded 180° or more of recovered heat prior to deaeration. The resulting energy yield would be 1,000 Btus for each pound of condensate, and the resulting energy efficiency would top 90 percent, representing an improvement up to 10 percent or better over traditional systems.

Getting to the bottom line

While the numbers can be impressive, the question remains whether they actually represent a true financial incentive to install a condensing economizer, especially given the current low price of natural gas. The answer, said Tighe, is an unreserved "yes."

On average, he explained, his company's condensing economizers paid back their cost — including installation — within one to two years. Beyond this point, all savings were "free money." And given an average life expectancy of 10 to 15 years for an E-Tech condensing economizer, energy savings could be huge. "If you're talking about a $5 or $10 million annual fuel bill, that can add up to the point where you're talking about some real money," Tighe concluded.

He went on to point out that payback could be even faster for businesses able to take advantage of government grants and rebate programs for energy-saving equipment upgrades. As an example, he mentioned a California program that gave a one-time payment of $10 per dekatherm for year-over-year demonstrated savings. At current gas prices, this would represent nearly a 2:1 payback rate, Tighe noted.

Bob Hanson, sales manager for E-Tech, offered a black-and-white example of the savings that might be immediately realized from the installation of a condensing economizer: "Consider a 100,000 PPH boiler firing natural gas costing $8 per thousand cubic feet. The boiler operates, on average, at 70 percent load 7,200 hours per year.

"An E-Tech condensing economizer raises the feedwater temperature from 55 degrees Fahrenheit to 175 degrees, for an average fuel savings of 8.4 dekatherms per hour. At a boiler efficiency of 80 percent, the fuel costs avoided are over $600,000 per year and the resulting net efficiency is over 90 percent."

Beyond these direct effects on a company's bottom line, Tighe mentioned other benefits that could be just as important, if less immediately obvious.

The first of these, he said, is the ability to do business with customers who impose stringent energy use restrictions on vendors. "A condensing unit can put you into a different tier of operating possibilities," Tighe explained. "There are some legislations both local and state that necessitate certain efficiencies in operation. In California, for instance, if you're going to sell ethanol you have to have a certain efficiency or they won't buy from you, whether you're in California or out of state. For one of our customers that made the difference."

A further benefit — one with both financial and brand image implications — is that of reduced CO2 emissions.

In recent years, much attention has been focused on their effects on both air quality and global warming. And the statistics are astonishing. Every MMBTU (or dekatherm) of natural gas conserved means at least 100 pounds less CO2 in the environment.

"These days good environmental citizenship is important," Hanson remarked. "In addition, there are environmental footprint noises being made at legislative levels now. People don't know what the requirements will be but they're getting ready for it."

Hanson added that for many companies doing business overseas, those requirements were already in place. For some of them, the carbon reduction provided by a condensing economizer is already making a difference, he said. "We do have some customers abroad that are signed on to carbon requirements and they have been able to sell their carbon credits through the EU."

Additionally, Hanson remarked, the ability to reduce carbon output could enable increased productivity from a plant. "If people are going to be restricted on carbon output, this opens potential capacity for them. If they reduce their footprint, they can increase their output," he explained.

Qualities of a good application

As you consider adding a condensing system, you will need to consider several factors that determine whether your facilities will meet system requirements.

- First and most obviously, physical facilities must have room for the addition of the condensing economizer and other equipment needed for its operation. Needs for ducting, support steel, transitions, expansion joints, by-pass ducting and the like must all be taken into consideration. E-Tech designs are customized to make the most of available space and also accommodate existing systems.
- Extra fan capacity may be required to compensate for the additional heating surface and the lower density of flue gas at reduced temperatures. Further, a traditional carbon steel stack may need to be replaced with one made of stainless steel or fiberglass in order to prevent corrosion from saturated flue gases.
- For the best possible return on investment, a condensing economizer must have access to a large amount of cold water. Cold water may be sourced from municipal facilities, wells, boiler makeup, or plant process. Though not a hard and fast rule, about 50 percent makeup or its equivalent is a general guideline. To provide adequate water supplies, E-Tech has in many instances designed systems that use makeup water from multiple boilers fed into a single condensing economizer.
- In order to protect the inside of the heat exchange tubes, all cold water should be softened and free of contaminants.
- To prevent damage to the system, fuel fired must be clean burning and sulfur free. Examples of desirable fuels include natural gas, propane and hydrogen.
- Before entering the condensing economizer, flue gases must pass through a primary economizer, which recovers sensible heat and reduces the gas temperature to around 250° F. In installations where a primary heat recovery system is not already in use, E-Tech can provide a design for a complete system.
- To facilitate condensation, gas should ideally flow either horizontally or vertically down through the condensing economizer.

An energy service contractor (ESCO) can help you begin the assessment process, says Tighe, but the company designing your economizer should be able to provide clear, detailed and complete answers to your specific questions throughout the consulting, design and installation process.

In fact, one of the most important characteristics to look for in a system engineer is their ability and willingness to communicate effectively and fully with you. Said Tighe, "The customer does need to ask and verify that what a bidding engineering firm is offering is possible and achievable."