Texas Industrial Energy Efficiency Program
Newsletter Volume 1, Number 1, October 2019

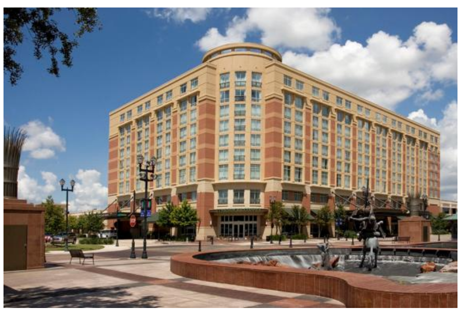
Welcome to the new Texas Industrial Energy Efficiency Program (TIEEP). Working through UH Energy at the University of Houston, and sponsored by SECO, the Texas State Energy Conservation Office, our goal is to build on the successes of earlier programs, and to facilitate the progress of Texas industries towards ever-improving energy intensity and sustainability performance. You can visit our webpage here.

Future Events – Save the Date

April 2, 2020: Energy Forum – East Houston

May 7, 2020: Water Forum – West Houston

Details to be finalized and confirmed.



Our first outreach activity was the Energy Forum / Energy Efficiency Session at the AIChE Southwest Process Technology Conference (SPTC), at the Sugar Land Marriott Town Square, October 1, 2019. Those readers who weren't able to come missed a great event, with excellent technical content and lively atmosphere. Don't miss the next one – see text box. The rest of this newsletter consists mostly of a summary of the session.

Energy Forum Summary, October 1, 2019: Making Energy Efficiency More Attractive

We all want to make our chemical plants and refineries more energy efficient, but too often potentially good projects do not move forward because of poor return on investment (ROI). Our challenge is to find ways to make our projects more attractive. This was the theme of our Energy Forum, *Designing Energy Improvements into Projects,* which was held on October 1, 2019. The forum was collocated with the Energy Efficiency Session at the AIChE Southwest Process Technology Conference, at the Marriott Sugar Land Town Square. The session included four presentations, which are available on the TIEEP webpage:

1. Energy Optimization Early in the Design Process Minimizes Process Energy Consumption and Minimizes Total Projects Costs - Andrew McMullen and David Severson, KBC (A Yokogawa Company)
2. Air Preheat System Upgrade on Coker Heaters - Ashutosh Garg, Furnace Improvements Services
3. Efficient Pollution-Free Steam Generation with Medium Voltage Electric Boilers - David Taylor, Chromalox
4. Address Distillation Process Control During Design Phase to Save Energy and Increase Capacity - Charles Herzog, Herzog Process Services

The session highlighted two main answers to the "attractiveness" problem.

1. Timing is everything. More specifically, major cost savings can be achieved by incorporating efficiency improvements into the initial design, rather than adding them late in the design process or as retrofits. This can have a huge impact on the payback, or the ROI, of an efficiency upgrade.
2. Many energy efficiency projects have non-energy benefits. These can be large, sometimes far in excess of the energy savings themselves. Typical non-energy benefits include increased capacity, reduced maintenance costs, better quality control, improved product characteristics, reduced emissions, and enhanced safety.

Let's look at these issues more closely.

<u>The Greenfield Advantage</u>

There is a great deal of pressure to design and build chemical plants and refineries as fast as possible, and with the lowest capital investment. It is often argued that enhancements, including those that improve energy efficiency, can be implemented later, after the plant is running and producing revenue. However, this logic has at least two weaknesses:

First, it is inevitably more difficult to install equipment after a plant has been commissioned, because you either have to carry out the installation in the midst of a busy, working facility, with all the inconvenience and added hazards that causes; or else you have to do it during a shutdown, which adds to the project costs, and also results in expensive lost production.

Secondly, quite apart from shutdown premiums, the economics of energy efficiency revamps are inherently less attractive than improvements that are incorporated in new designs, because of what I call "the greenfield advantage."

Consider a plant that requires a motor-driven centrifugal pump delivering 500 kW of hydraulic power. The designers consider two options – a "standard" motor/pump combination, and a "premium efficiency" motor/pump combination. The main equipment item cost for the standard option is \$150,000, and for the high-efficiency option it is 10% higher, or \$165,000. If we assume a Lang factor of 4, the total module costs are \$600,000 and \$660,000, respectively – a difference of \$60,000 in total module costs – see Table 1.

	Investment, k$	Operating, k$/year	Payback, years
Standard Efficiency		500	
Major Equipment Items	150		
Total Module Cost	600		
High Efficiency		450	
Major Equipment Items	165		
Total Module Cost	660		
Delta (New)	60	50	1.2
Delta (Retrofit)	165	50	3.3

Table 1: Pump Upgrade Payback Comparison for New Plant and Retrofit Cases

The annual electric power costs for the two options are \$500,000/year and \$450,000/year, respectively – a difference of \$50,000/year in energy costs.

The simple payback on the upgrade to the high-efficiency combination is therefore 60,000/50,000, or 1.2 years – assuming the upgrade is made in the initial design.

Let’s suppose that the plant is built with the standard motor/pump combination, to minimize initial costs. The plant owners later consider a revamp project to replace it with the high-efficiency combination. The savings are the same as in the new plant analysis (\$50,000/year), because we are comparing the performance of the same two equipment options. However, the revamp project must bear the full cost of the new, high-efficiency motor/pump combination. If we assume that all of the existing infrastructure (foundations, piping, control, etc.) can be retained in the revamp, the total cost of the revamp would be little more than the cost of the main equipment items, or \$165,000. The simple payback is now 165,000/50,000, or 3.3 years. This is nearly 3 times longer than if the upgrade had been made in the original design.

This is an oversimplified example, and it contains many assumptions that an astute reader might reasonably challenge. However, the overall conclusion is clear: When you replace an existing piece of equipment with an upgrade, you typically pay full price for the new item, while only gaining the incremental benefit between it and the old equipment. If you incorporate the upgrade in the initial design, however, you get the same benefit with much less incremental cost. Consequently, the overall economics of incorporating energy-efficient equipment into manufacturing facilities are generally much more favorable in new plant designs than they are in revamps. It is also beneficial to incorporate upgrades as early as possible when designing manufacturing facilities, as this can reduce engineering costs (Presentation 1).

These observations apply not only to pumps and motors. They are equally applicable to a wide range of equipment types, including boilers, furnaces, heat exchangers, and insulation.

Non-Energy Benefits

While there are compelling advantages in incorporating upgrades in new “greenfield” plants, there are also many attractive revamps that improve energy efficiency. However, most of the best energy-efficiency revamp opportunities arise when equipment needs to be replaced or upgraded for other reasons. This might happen, for example, when a boiler or a pump reaches the end of its useful life. In these situations, the minimum investment option is usually a like-for-like replacement. However, it is usually possible to install high efficiency equipment for a relatively small incremental cost, in which case the economics can be very favorable, just as in the new plant “greenfield” case. Doing a like-for-like replacement is a wasted opportunity.

High-efficiency equipment or upgraded systems (e.g., heat integration) can also often be justified when new facilities are needed to debottleneck an existing plant. Indeed, there are many cases when limitations on heat recovery, or other energy transfer restrictions, are the main constraints on plant capacity. In these situations, improving heat recovery efficiency can be the main mechanism for debottlenecking (Presentation 2).

Another common situation that can require replacements or upgrades is environmental compliance, and this can also create viable opportunities to install more energy-efficient equipment. For example, improving the energy efficiency of a furnace or boiler has a direct impact on CO_2 emissions, and the same boiler or furnace upgrade can also be used to reduce other emissions, such as CO, NO_x, and particulates. There is also a trend towards electric boilers and furnaces for some chemical applications, and these can completely eliminate combustion-related emissions from the production site (Presentation 3).

Quality control is closely tied to variability in processes. Minimizing the variability means less off-spec material, and therefore less product that needs to be reprocessed or discarded – and therefore less energy usage. Furthermore, if we can reduce the fluctuations in product compositions in chemical processes – for example, in distillation – we can eliminate the need to over-purify product streams to ensure that we meet specifications. This is a further energy saving (Presentation 4).

Other energy efficiency improvements also reduce process hazards. For example, low-density polyethylene (LDPE) was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process, with pressures of over 100 MPa (1000 atm). Over time, new processes have been developed, requiring much lower pressures. This not only reduces the amount of compression energy required; it also lowers equipment costs and mitigates the hazards inherent in handling combustible gases at high pressure. These advances also led to new grades of polyethylene with properties that are superior to the original LDPE product in a range of applications.

In Closing…

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