A novel approach to industrial energy efficiency

Worldwide, the industrial sector uses more energy than any other end-use sector, consuming about half of the world’s total delivered energy. World industrial energy demand is projected to increase by an average of 1.5% per year through 2035.[1] In Singapore, the industrial sector similarly makes up the largest energy consumer, accounting for almost half of the nation’s energy consumption.[2]

Fierce competition, volatile energy prices and the motivation to reduce the environmental impact of energy use are some of the drivers for industrial companies to reduce their energy consumption. Energy efficiency projects often take a piecemeal approach based on individual manufacturing processes, which can be a complicated affair due to the variability of processes.

With a new approach to industrial energy efficiency, however, complicated manufacturing processes are broken down into distinct energy systems that can be addressed with fundamental principles. Called the “Integrated Systems plus Principles Approach” (ISPA), this approach provides a unified way of understanding and approaching energy saving opportunities.

Systems-based Approach

Based on the experience of 850 industrial energy audits, Integrated Systems plus Principles Approach focuses on the following twelve systems that make up virtually all manufacturing processes:

- Electrical distribution
- Motor drive
- Lighting
- Fluid flow
- Compressed air
- Process heating
- Process cooling
- Heating, Ventilation & Air-conditioning
- Steam
- Industrial refrigeration
- Combined Heat and Power
- Renewable energy

Any manufacturing process can then be broken down into these energy systems, which will be the target of energy efficiency efforts. By focusing on these systems rather than individual manufacturing processes, it is possible to develop expertise in a finite group of energy systems rather than an almost infinite number of manufacturing processes.
Principles of Energy Efficiency

Under the Integrated Systems plus Principles Approach, the following principles have been applied to the above industrial systems to good effect by bringing significant energy efficiency.

- **Think Inside Out**: This approach begins inside the plant with the end-use and asks how much and what type of energy is required to accomplish the objective. After appropriate type of energy is determined and end-use energy minimised, the distribution system is analysed for efficiency opportunities. After opportunities are identified, the energy conversion equipment is considered. With this approach, energy savings identified on the “inside” are multiplied as they pass back to the “outside”.

- **Maximise Control Efficiency**: Most systems operate at part load most of the time, while designed for peak load; thus output of energy conversion systems must be controlled to meet the load. Energy efficiency of energy conversion equipment varies with load. Recognising and modifying systems with poor part-load efficiency can result in significant savings.

- **Employ Counter Flow**: In counter flow exchange, hot and cold fluids travel in opposite directions. As heat is exchanged, the temperature of the hot fluid decreases and the temperature of the cold fluid increases. However, the outlet temperature of the hot fluid can approach the inlet temperature of the cold fluid, which results in greater heat transfer and effectiveness. This improved effectiveness reduces losses and results in energy savings.

- **Avoid Mixing**: Exergy analysis shows that useful work is always destroyed with mixing. In manufacturing, mixing streams with different temperatures, pressures or humidity frequently results in additional energy use. Thus, minimising mixing usually saves energy.

- **Consider Whole Systems Over Whole Time Frames**: When seeking engineering optimums, it is important to consider the whole system over the whole time frame of the device. In engineering this is called life-cycle analysis (LCA), which considers purchase, operating, and end-of-life costs using a consistent methodology. Failure to use LCA generally leads to non-optimal designs that use excess energy. Similarly, defining the system boundary too narrowly generally leads to sub-optimal designs.

*Figure 2: Parallel flow vs Counter flow heat transfer*

*Exergy: In thermodynamics, exergy of a system is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir.*
- **Match Energy Source to End Use**: Energy efficiencies of energy delivery systems vary widely. Matching the appropriate energy source to the end use can result in significant savings.

- **Benchmark Against Minimum Energy Use**: Always ask “how much energy is really required?” The answer is often “much, much less than is being used”. Calculating or estimating the minimum energy use required to accomplish a task is often an excellent way to conceptualise more energy efficient process.

The Integrated Systems plus Principles Approach to energy efficiency has proven to provide a coherent and reproducible approach to industrial energy efficiency. With the widespread adoption of this approach, reduction in industrial energy intensity can be accelerated, leading to cost savings and meeting of carbon emissions reduction goals.

*Contributed by H2PC Asia resource team of E2 writers. Please contact byap@h2pcasia.com*
