Managing Process Costs in Manufacturing Facilities

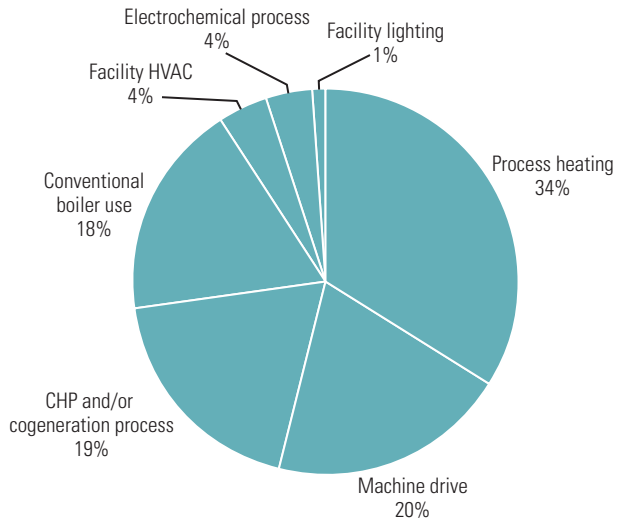
Manufacturers' number one goal is to produce quality parts as efficiently as possible. Applying the same principles to facility operations can also improve efficiency while providing quick and low-cost savings. Though some of the energy-saving measures discussed here may temporarily disrupt operations, their benefits of lower energy bills and increased operational efficiency can help recover lost production time.

How Manufacturing Facilities Use Energy

The industrial sector accounts for approximately 31 percent of all energy consumption in the United States—consuming just over 21,000 trillion Btu annually—and much of this energy is used for manufacturing processes. **Figure 1** shows a breakdown of energy use for the five manufacturing subsectors that consume the most overall energy. Although energy consumption varies across manufacturing subsectors, four common categories—process heating, drivepower, cogeneration, and conventional boiler use—emerge as the most common top energy users. Facility HVAC and lighting are just slightly lower on the list.

Figure 1: Top five manufacturing subsectors' end-use energy consumption

End-use consumption varies greatly depending on the subsector. This chart shows how energy is used by the five largest energy-consuming subsectors: Petroleum and Coal, Chemicals, Paper, Primary Metals, and Food.



Note: CHP = combined heat and power.

Rapid Reduction Solutions

Most manufacturing processes can benefit from low- or no-cost energy-reducing actions. Often, these actions can be as simple as turning off unused machines or cleaning equipment.

Turn Things Off

Turning equipment off might seem like too small an action to make a significant difference, but it does. Remember that if you save 1,000 kilowatt-hours (kWh) per year by turning something off, you can take $100.00 off your utility bill annually, assuming electricity costs of $0.10 per kWh.

Walk-through audits. To identify energy-efficiency opportunities, walk through your facility after hours. Much of the equipment that is left on overnight or over the weekend in an empty building is a good candidate for energy savings. Consider recruiting volunteers from each shift to shut down equipment when they leave.

Motors. Identify motors that are running unnecessarily, and turn them off. Ideal targets for shutoff are ceiling fans operating in unoccupied spaces or cooling tower fans still running after temperature setpoints have been met.

Perform Regular Maintenance and Cleaning

Keeping the facility and process equipment in good working order is important, both to save energy and to protect equipment.

Process heating. There are various ways to improve energy efficiency in process heating. Optimizing the ratio of air to fuel using flow metering or flue-gas analysis is one of the simplest ways to maximize burner efficiency. For indirect heating

systems, it's a good idea to regularly inspect and clean heat-transfer surfaces to avoid soot, scale, sludge, or slag buildup that can significantly weaken system efficiency. Reduce air infiltration into the heating process by repairing system leaks and keeping furnace doors closed whenever possible.

Motors. Electric motors fail prematurely primarily due to mechanical problems. Routine lubrication, adequate and clean ventilation, and measures to prevent voltage imbalance will help motors achieve their full-life potential while simultaneously minimizing their energy consumption.

Fans, bearings, and belts. Inspect fan blades, bearings, and belts at least once a year to prevent failure and maintain efficiency. During your inspection, fan blades should be cleaned, bearings should be checked for adequate lubrication, and belts should be adjusted and changed if necessary.

Boilers. Develop a program for treating makeup water to prevent equipment damage and efficiency losses. Buildup inside the tank can decrease heat transfer to the water and necessitate more-frequent blowdown, which wastes both water and energy. In addition, the air-fuel ratio has the largest impact on combustion efficiency, so check it periodically to ensure that the combustion process is operating efficiently.

Air compressors. Regularly check hoses and valves for leaks, and make repairs if necessary. A poorly maintained system can waste between 25 and 35 percent of its air due to leaks alone, and it can effectively double the cost of compressed air. Because leaks also reduce pressure at the endpoint, operators can compensate by setting pressure levels higher than would otherwise be necessary, thereby increasing energy consumption. A leak detector can provide long-lasting benefits and can pay for itself in less than six months. Routinely cleaning intake vents, air filters, and heat exchangers can increase both equipment life and productivity.

Deeper Process Upgrades

Although the actions described in this section may briefly interrupt production and require more effort to implement, they can dramatically increase the efficiency of your manufacturing process.

Process Heating

Process heating is the largest energy consumer within the manufacturing sector, using almost one-third of a facility's energy. Monitoring the heating process from start to finish and maintaining the equipment can greatly curtail facility energy costs.

Waste-heat recovery. With most fuel-fired heating equipment, the largest heat loss occurs when spent combustion gases are exhausted because these gases still contain significant thermal energy. This waste heat can be recovered and used in various processes, including preheating combustion air before it enters the system, preheating load material before it enters the heating process, generating steam for secondary processes, and heating hot water or occupied spaces.

Furnace pressure controllers. When hot combustion gases are exhausted into ambient air that is at a significantly lower temperature, negative pressure builds within the furnace. This allows cooler ambient air to infiltrate the furnace through the flue or through other leaks and openings within the system, lowering system efficiency. Furnace pressure controllers adjust air pressure within the furnace to maintain a positive pressure, reducing cool-air infiltration into the heating system.

LFL monitoring equipment. If your process heating applications require the removal of flammable solvents, consider using lower flammable limit (LFL) monitoring equipment. When flammable solvents are used in production processes, flammable vapors can be emitted. The National Fire Protection Association sets LFL guidelines for concentrations of low-vapor solvents and requires proper ventilation ratios to reduce solvent-vapor concentration to appropriate levels. LFL monitoring equipment tracks the solvent-extraction rate in real time and adjusts the ventilation rate according to system needs, maintaining a safe ventilation ratio while saving energy.

Motors

Motors are responsible for almost 70 percent of electricity consumption in the manufacturing sector. Proper maintenance, sizing, and overall system care can help eliminate waste losses.

Properly size motors. Although motors often operate under varying load conditions, they are generally selected based on the highest anticipated load. For this reason, manufacturers often purchase more-costly motors than necessary and risk underloading them. Consider selecting a motor based on the load duration curve (LDC) of its specific application rather than the motor's highest anticipated load. Using the LDC, you can select smaller, less-expensive motors that operate more efficiently over the equipment's lifetime.

Use high-efficiency motors. Improve motor efficiency by rebuilding existing motors or by upgrading to new, higher-efficiency models. Rebuilding old motors can improve efficiency by a few percentage points. As of 2010, U.S. federal standards mandate premium-efficiency levels for virtually all new motors. Thus, new motors can more than make up for their cost difference in energy savings. In general, replacing a standard motor with an energy-efficient motor is only cost-effective once the standard motor has failed—replacing a motor before failure may not provide the necessary cost savings to justify the measure.

Install VSDs. When loads change, variable-speed drives (VSDs) can alter the speed of a motor accordingly, often significantly reducing electricity consumption. VSDs can be installed in most existing systems because they are designed to operate standard induction motors.

Compressed Air

Although compressed air is often viewed as an essentially free resource, these systems account for nearly 10 percent of overall electricity consumption and are often poorly designed or maintained.

Match your supply to your load. Generate compressed air at the pressure required; halving pressure can result in energy savings of more than 50 percent. Additionally, when demand is at less than full capacity, sequence your machines to ensure that one or more compressors are shut off entirely, instead of having several machines operating inefficiently at part load.

Switch off compressors. Turn off compressors when production is down. Also, consider altering your piping to enable operators to shut off compressed air to production areas when those spaces don't require it.

Boilers

Boilers account for the largest nonprocess consumption of natural gas within the manufacturing sector. Optimizing operational setpoints and maintaining boilers regularly can ensure that systems are performing efficiently.

Use boiler controls. Take advantage of a boiler control system's onboard efficiency strategies, such as outside-air reset and outside-air high-temperature shutoff. If no strategies exist, consider retrofitting boiler controls onto your system to optimize performance and eliminate unnecessary cycling.

Install a waste-heat recovery system. On average, stack loss from boilers is around 15 percent, and blowdown produces waste heat that is lost through drainage. Consider installing waste-heat recovery systems for both processes. The heat released from the boiler and stack can also be captured from the boiler room to preheat the intake air or makeup water for the boiler.

Maintain steam traps. Steam traps are automatic valves that release condensed steam from the boiler while preventing the loss of live steam. If traps develop small leaks, thousands of dollars' worth of energy can be lost. An ultrasonic leak detector can effectively detect faulty traps by isolating sound frequencies, comparing the frequencies to those of a properly functioning steam trap, and showing the results to users via a digital display.

Operate boilers at peak efficiency. For facilities with more than one boiler, optimizing load management across boilers can help save energy by operating them at peak efficiency. When demand increases, bring the most efficient units online first; when demand decreases, take the least efficient units offline first.

Building Systems and O&M Programs

Making improvements to building systems and operations and maintenance (O&M) programs is vital to the success of any energy-saving strategy.

Upgrade your O&M program. One simple way to improve the energy efficiency of facilities with little or no capital investment is to ensure that the building shell—and the expensive systems within it—are properly operated and maintained. Implementing a rigorous O&M program requires equal buy-in from senior management and O&M staff. Ensuring that O&M activities are thoroughly documented and that staff are well trained and well equipped also helps.

Consider electric forklifts. Diesel- or propane-fueled forklifts require extra ventilation in the facility, which adds to the HVAC load in conditioned spaces and increases overall energy use. Because electric forklifts have higher initial costs (capital plus installation) but lower energy and total operating costs, the total lifecycle costs are comparable. One often unexpected cost when deploying electric forklifts is increased demand charges, but these can be avoided by using a timer to only charge the forklift batteries during off-peak hours.

Upgrade materials-handling control systems. Some facilities have sophisticated systems in place for conveying and sorting manufactured items and work in process; these systems can offer savings opportunities if existing conveyors are constantly moving at top speed regardless of their load. Designed to meet functional requirements, custom equipment can be used to slow down or switch off the distribution system when possible, saving energy.

Resources

U.S. Department of Energy, Energy Efficiency & Renewable Energy, Advanced Manufacturing Office, **www1.eere.energy.gov/manufacturing/index.html**. The Department of Energy provides a web portal dedicated to energy efficiency for manufacturing, including incentive information, process-specific tips, and case studies.

U.S. Department of Energy, Energy Efficiency & Renewable Energy, Federal Energy Management Program, "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Release 3.0, **www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf**. This resource presents best practices and O&M tips for facilities and process equipment.