



This fact sheet about air compressors will help you calculate their operating cost, understand your system and identify easy to implement energy conservation strategies.

Air compressor energy-saving tips

Approximately 70% of all manufacturers have a compressed air system. These systems power a variety of equipment, including machine tools, material handling and separation equipment, and spray painting equipment. Energy audits conducted by the U.S. Department of Energy (DOE) suggest that over 50% of compressed air systems at small to medium sized industrial facilities have low-cost energy conservation opportunities.

Significant air emissions are released when electricity is produced. In Minnesota, one-fourth of the energy-related emissions of carbon dioxide, sulfur dioxide, lead and mercury are from generating electric power. Industry uses over 34% of this electricity. Reducing electricity used by compressed air systems will help improve Minnesota's air quality.

Compressed Air Energy Cost

Compressed air is one of the most expensive uses of energy in a manufacturing plant. About eight horsepower of electricity is used to generate one horsepower of compressed air. Calculating the cost of compressed air can help you justify improvements for energy efficiency.

To find the annual cost of electricity used to power a compressed air system, calculate the cost for running the system under loaded and unloaded conditions. For each, multiply:

- horsepower (hp)
- conversion factor 0.746 kW/hp
- total operating hours per year (hr/yr)
- cost per kilowatt-hour (\$/kWh)
- % time fully-loaded or unloaded
- % full-load hp, loaded or unloaded

Divide the product by the motor's efficiency.

Cost per year =

$$\frac{(\text{hp})(0.746 \text{ kW/hp})(\text{hr/yr})(\$/\text{kWh})(\% \text{ time})(\% \text{ full-load bhp})}{\text{motor efficiency}}$$

Calculate the cost of compressed air for specific end uses. This allows you to determine if compressed air should be used in specific applications (ie. as fans or blowers), or if other electric-motor operated equipment would be more efficient.

First calculate the volume of air produced annually for a specific operation by multiplying:

- horsepower (hp)
- cubic feet per minute per horsepower (cfm/hp)
- total operating hours per year (hr/yr)
- 60 minutes per hour (60 min/hr)
- % time fully loaded
- % full-load horsepower

Volume of air produced annually =

$$(\text{hp})(\text{cfm/hp})(\text{hr/yr})(60 \text{ min/hr})(\% \text{ time})(\% \text{ full-load bhp})$$

Then calculate the cost per 1,000 cubic feet (cf) by dividing the total energy cost to operate the air compressor by the volume of air produced annually, then multiply by 1,000.

Cost per 1,000 cf =

$$\frac{\text{energy cost}}{\text{air produced}} \times 1,000 \text{ cf}$$

Example Calculations

The following example represents a typical small job-shop manufacturer.

A facility operates a 100 hp air compressor 4,160 hours annually. It runs fully loaded, at 94.5 % efficiency, 85 % of the time. It runs unloaded—at 25 % of full load—at 90 % efficiency, 15 % of the time. The electric rate is \$0.06 per kWh, including energy and demand costs. The cost per year to power the air compressor will be as follows.

Fully loaded =

$$\frac{(100 \text{ hp})(0.746 \text{ kW/hp})(4,160 \text{ hr})(\$0.06/\text{kWh})(0.85)(1.0)}{0.945} = \$16,748$$

Unloaded =

$$\frac{(100 \text{ hp})(0.746 \text{ kW/hp})(4,160 \text{ hr})(\$0.06/\text{kWh})(0.15)(0.25)}{0.90} = \$776$$

The total annual energy cost to operate the air compressor is \$17,524.

The following calculation shows how much it will cost to use compressed air to operate a specific end use. Assume 3.6 cfm per horsepower and that this rate applies when the compressor is fully loaded.

Volume of air produced annually =

$$(100 \text{ hp})(3.6 \text{ cfm/hp})(4,160 \text{ hr})(60 \text{ min/hr})(0.85)(1.0) = 76,377,600 \text{ cf}$$

Cost per 1,000 cf =

$$\frac{\$17,524 \text{ per year}}{76,377,600 \text{ cfm}} \times 1,000 \text{ cf} = \$0.23$$

Over the life of a compressor, energy costs will be five to 10 times the compressor's purchase cost. Energy savings can rapidly recover the extra capital required to purchase an energy-efficient air compressor motor.

A 1.17 rated horsepower air operated mixer uses 45 cfm at 80 pounds-per-square-inch (psi) and operates 40 hours per week. The cost of the compressed air to operate this motor over a year is \$1,292. A comparably sized electric motor of Energy Policy Act (EPACT) efficiency, rated for hazardous locations, is around \$350. The cost to operate the EPACT motor under the same conditions is less than \$100 per year. Including installation, payback is under one year.

Understand Your System

Before implementing energy reduction strategies, be familiar with all aspects of your compressed air system.

System supply. Analyze the supply side of your compressed air system for the types of compressors used and the type, suitability and settings of capacity controls and other operating conditions. Understand the basic capabilities of the system and its various modes of operation.

Verify that air compressors are not too big for end uses. For example, an air compressor is oversized if the end use only requires air pressure that is 50 % of the pressure that the compressor is capable of producing.

Once the big picture is in view, supply side operating conditions can be modified, within the constraints of the compressed air unit, to better match the demand side uses of compressed air.

System demand. Identify all the uses of compressed air in the plant. Quantify the volume of air used in each application and generate a demand profile, quantity of air used as a function of

time, for the compressor. Equipment specifications for operations that use air are good resources for obtaining data on air volume use rates. The profile highlights peak and low demand. A general assessment of compressed air use will help identify inappropriate uses of air.

System diagram. Develop a sketch of your compressed air system—including compressors, air supply lines with dimensions, and compressed air end uses—to provide an overall view of the entire compressed air process.

Distribution system. Investigate the distribution system for any problems related to line size, pressure loss, air storage capacity, air leaks and condensation drains. Verify that all condensation drains are operating properly because inadequate drainage can increase pressure drop across the distribution system.

Maintenance. Evaluate maintenance procedures, records and training. Ensure that procedures are in place for operating and maintaining the compressed air system, and that employees are trained in these procedures.

Conservation Strategies

Identify easy to implement energy conservation opportunities in your compressed air system by conducting a walk-through assessment. Simple conservation opportunities can result in savings up to 25% of the current cost to run the compressed air system.

Leaks. Routinely check your system for leaks. A distribution system under 100 pounds-per-square-inch gauged (psig) of pressure, running 40 hours per week, with the equivalent of a quarter-inch diameter leak will lose compressed air at a rate of over 100 cfm costing over \$2,800 per year. In noisy environments an ultrasonic detector may be needed to locate leaks.

Compressor pressure. The compressor must produce air at a pressure high enough to overcome pressure losses in the supply system and still meet the minimum operating pressure of the end use equipment. Pressure loss in a properly designed system will be less than 10% of the compressor's discharge pressure—found on a gage on the outlet of the compressor. If pressure loss is greater than 10%, evaluate your distribution system and identify areas causing excessive pressure drops. Every two pounds-per-square-inch decrease in compressor pressure will reduce your operating costs 1.5%.

Identify artificial demands. Artificial demand is created when an end use is supplied air pressure higher than required for the application. If an application requires 50 psi but is supplied 90 psi, excess compressed air is used. Use pressure regulators at the end use to minimize artificial demand.

Inappropriate use of compressed air. Look for inappropriate uses of compressed air at your facility. Instead of using compressed air, use air conditioning or fans to cool electrical cabinets; use blowers to agitate, aspirate, cool, mix, and inflate packaging; and use low-pressure air for blow guns and air lances. Disconnect the compressed air source from unused equipment.

Heat recovery. As much as 80 to 90% of the electrical energy used by an air compressor is converted to heat. A properly designed heat recovery unit can recover 50 to 90% of this heat for heating air or water. Approximately 50,000 British thermal units (Btus) per hour is available per 100 cfm of compressor capacity when running at full load. For example, consider a 100 hp compressor that generates 350 cfm at full load for 75% of the year. If 50% of heat loss is recovered to heat process water, the savings, at \$0.50 per therm, would be about \$4,100 per year in natural gas.

Inlet air filters. Maintain inlet air filters to prevent dirt from causing pressure drops by restricting the flow of air to the compressor. Retrofit the compressor with large-area air intake filters to help reduce pressure drop.

Compressor size. If your compressor is oversized add a smaller compressor and sequence-controls to make its operation more efficient when partially loaded. Sequence-controls can regulate a number of compressors to match compressed air needs, as they vary throughout the day.

Air receiver/surge tank. If your compressed air system does not have an air receiver tank, add one to buffer short-term demand changes and reduce on/off cycling of the compressor. The tank is sized to the power of the compressor. For example, a 50 hp air compressor needs approximately a 50-gallon air receiver tank.

Cooler intake air. When intaking cooler air, which is more dense, compressors use less energy to produce the required pressure. For example, if 90° F intake air is tempered with cooler air from another source to 70° F, the 20° F temperature drop will lower operating costs by almost 3.8%.

V-belts. Routinely check the compressor's v-belts for proper tightness. Loose belts slip more frequently which reduces compressor efficiency.



For More Information

MnTAP has a variety of technical assistance services available to help Minnesota businesses implement industry-tailored solutions that maximize resource efficiency, prevent pollution, increase energy efficiency, and reduce costs. Our information resources are available online at <mntap.umn.edu>. Please call MnTAP at 612.624.1300 or 800.247.0015 for personal assistance or more information about MnTAP's services.