Motor Energy Saving Tips

Industrial fans, pumps and air compressors use more than 50 percent of the total motor related electricity used. According to the U.S. Department of Energy (DOE), industry could reduce energy used by motors by 11 to 18 percent if it implemented all existing cost-effective technologies and practices for improved efficiency.

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 50 percent of this electricity. Reducing electricity use by motors will help improve Minnesota's air quality.

As of October 1997, the Energy Policy Act (EPACT) requires all motors sold in the U.S. to meet efficiency standards. In 2001 a new class of premium efficiency motors was designated, setting efficiency standards for new motors beyond those of EPACT.

Although high efficiency motors have been available for years, they make up less than 10 percent of all industrial motors in current use.

If your motors are not part of this 10 percent, they could be using excess electricity—increasing your operating costs. This fact sheet will help you calculate your motor operating costs, develop a policy for motor repair and replacement and develop strategies to reduce energy used by motors at your facility.

Motor Energy Costs

Use the following equations to calculate demand and energy costs. Together these equal your annual cost to operate motor driven equipment. Once you have calculated your annual cost, compare it to the annual cost to operate EPACT and premium efficiency motors.

To calculate the energy cost per year, multiply:

- motor's horsepower (hp)
- conversion factor 0.746 kW/hp
- number of operating hours per year (hr/yr)
- cost per kilowatt-hour ($/kWh)
- load factor (LF)

Divide the product by the motor's efficiency. Load factor is the fraction of the motor's horsepower actually used to drive a load. One way to determine load factor is to measure the amperage (amp) draw of the motor under load then divide by the motor's full load rating.

Energy cost per year =

$$\frac{(\text{hp})(0.746\ \text{kW/hp})(\text{hr/yr})(\$/\text{kWh})(\text{LF})}{\text{motor efficiency}}$$

To calculate the demand cost per year, multiply:

- motor's horsepower (hp)
- conversion factor 0.746 kW/hp
- load factor (LF)
- cost per kilowatt amp per month ($/kW/mo)
- 12 months per year (12 mo/yr)

Divide the product by:

- motor's efficiency
- motor's power factor

The cost per kW is found on your electric bill. A power factor—ratio of true power used to the power drawn from the source—is found on a motor's specification sheet.

Demand cost per year =

$$\frac{(\text{hp})(0.746\ \text{kW/hp})(\text{LF})(\$/\text{kW/mo})(12\ \text{mo/yr})}{(\text{motor efficiency})(\text{power factor})}$$

(continued)

MnTAP is funded by a grant from the State of Minnesota to the University of Minnesota, School of Public Health.

Example Calculations

For the example calculations that follow use these factors:

- Motors are five horsepower
- Motors run 4,000 hours per year
- Motors run at 0.75 load factor
- Energy cost is $0.05 per kWh
- Unit demand cost is $3.00 per kW per month

	Standard	EPACT	Premium
Efficiency	83%	86%	88%
Power Factor	0.82	0.84	0.86

The following is an example of how to calculate the annual energy, demand and total cost of a standard efficiency motor.

Energy cost per year =

$$\frac{(5\text{ hp})(0.746\text{ kW/hp})(4{,}000\text{ hr/yr})(\$0.05\text{/kWh})(0.75)}{0.83}$$

= $674 per year

Demand cost per year =

$$\frac{(5\text{ hp})(0.746\text{ kW/hp})(0.75)(\$3.00\text{/kW/mo})(12\text{ mo/yr})}{(0.82)(0.83)}$$

= $148 per year

The total annual cost to operate the motor is $822.

After 10 years the motor's operating cost exceeds its purchase cost more than 20 times.

The table below summarizes the cost for each motor. Payback periods for EPACT and premium efficiency motors, compared to standard efficiency motors, are based on purchase price and energy savings.

	Standard	EPACT	Premium
Purchase price	$375	$445	$575
Energy cost (yr)	$674	$651	$636
Demand cost (yr)	$148	$140	$133
Operating cost (yr)	$822	$791	$769
Payback years	—	2.3	3.8

Motor Repair and Replacement Policy

Implement a motor replacement policy to replace older, rewound motors. This can benefit your operation in many ways, including:

- Increased efficiency, which lowers operating costs
- Reduced downtime, which lowers production costs
- Lower operating temperatures, which lowers maintenance costs

Policy Example

The following policy was developed by the Industrial Electrotechnology Laboratory. It covers open drip-proof (ODP) and totally-enclosed fan-cooled (TEFC) motor enclosures.

- When purchasing a new motor or piece of equipment, specify energy efficient motors.
- When an existing motor fails:
  - If it is energy efficient, send it for repair. This applies to ODP and TEFC enclosures and one to 200 hp motors.
  - If it is not energy efficient and is an ODP enclosure replace it with an energy efficient model. This applies to one to 200 hp motors.
  - If it is not energy efficient and is a TEFC enclosure use the table below to select a breakpoint horsepower—a motor size that provides at least a two year payback—for the number of hours you operate motors.

Annual Operating Hours	Horsepower*
One shift (2,912 hr/yr)	25
Two shifts (5,824 hr/yr)	70
Three shifts (8,736 hr/yr)	130

* For energy cost at $0.05 per kWh.

When a motor is larger than the breakpoint horsepower send it for repair. When a motor is smaller than the breakpoint horsepower replace it with an energy efficient motor.

- When repairing a motor will cost more than 60 percent of the purchase cost of a new energy-efficient motor, buy the new motor.

Conservation Strategies

Energy efficient motors. When purchasing a new motor choose the most energy efficient one you can afford. Premium efficiency motors cost about 20 percent more, but will payback in under four years

(continued)

with one-shift operation and a cost of $0.05 per kWh. Payback will be shorter for a 24-hour, seven-day-per-week operation.

Oversized motors. Motors are oversized when they power end uses that require less horsepower than the motor is capable of producing. For example, when a 10 hp motor is used for an application that calls for a five horsepower motor, the motor is 100 percent oversized, or operates at 50 percent full-load. At smaller load factors motor efficiency is lower, leading to increased operating costs. Select a lower power motor and operate it at a higher load factor and near optimal efficiency to help justify the motor replacement. Motors operated at low load factors have lower power factors.

Motor replacement. Some motors may warrant replacement before they fail. Evaluate motors that are used for two or more shifts per day and are oversized.

Synchronous belts. Optimize transmission efficiency by using synchronous belts instead of v-belts. V-belts can slip and deteriorate efficiency at higher loads.

Variable speed drives. Consider using a variable speed drive motor system instead of traditional motors when loads vary significantly over the course of daily use.

Voltage. The voltage at the motor should be as close to the design limits, found on the nameplate, as possible. Changes of more than five percent can lead to two to four percent drops in efficiency and increase temperatures, which decrease the motor's life. Voltage at the motor that is not within the design limits leads to a decrease in power factor. Low power factors may be penalized by your power company.

For More Information

Find links to additional information and energy conservation tools in the online version of this fact sheet at <mntap.umn.edu>.

MnTAP has a variety of technical assistance services available to help Minnesota businesses implement industry-tailored solutions that prevent pollution at the source, maximize efficient use of resources, and reduce energy use and cost. Our information resources are available online at <mntap.umn.edu>. Or, call MnTAP at 612/624-1300 or 800/247-0015 from greater Minnesota for personal assistance.