APS Solutions for Business

Energy Answers for Motors

Motors consume more than 20% of all the electricity generated in the United States. Among APS business customers, motors represent varying degrees of total electricity consumption, from 10% for the average large office building to 50% for industrial customers. Improvements in motor efficiency can produce significant savings for businesses. This fact sheet offers basic background on motors, strategies for reducing motor energy use and a list of resources for more detailed information.

Motors 101: The Basics

Most motors in the commercial sector power fans and pumps in the heating, ventilation and air conditioning (HVAC) systems. Smaller motors abound in refrigeration equipment. "Induction" motors are used in approximately 90% of all commercial applications, so chances are you have quite a few of them in your facility. These motors are reliable and operate on single-phase or three-phase power.

There are five common characteristics to consider when comparing motors: enclosure type, operating speed, power, efficiency and service factor.

ENCLOSURE TYPE: Referring to the motor casing, the two most common enclosure types are Open Drip-Proof (ODP) and Totally Enclosed Fan-Cooled (TEFC). ODP motors have ventilation openings positioned to keep liquid or particles from falling into the motor. They are common in HVAC fans and pumps. TEFC motors have enclosed casings to keep out moisture and particles and they have an integral fan for cooling. Because TEFC motors are used in harsher environments, their capital costs are typically higher.

SPEED: More than 50% of all motors are 1,800 revolutions per minute (rpm). Motors of 1,200 and 3,600 rpm also are fairly common. Efficient motors tend to operate at a slightly higher full-load speed than standard motors (usually by about 5-10 rpm for 1,800 rpm motors).

POWER: The motor's capacity to perform a physical task is commonly measured in horsepower (hp) and kilowatts (kW). 1 hp is equivalent to 0.746 kW.

EFFICIENCY: Nominal efficiency, stamped on the nameplate, is an average value obtained through standardized testing of a given motor model population running at full capacity. Compare motors using nominal efficiency at the expected load factor.

Motors labeled as "NEMA Premium" are about 1%-3.5% more efficient than standard-efficiency motors. Since operating costs comprise the majority of lifetime equipment costs, even a 1% gain in efficiency can make a big difference. The higher purchase price for premium efficiency motors is recouped in lower electricity bills. NEMA Premium motors also run cooler and are more likely to better withstand voltage variations and harmonics.

SERVICE FACTOR: This represents the allowable overload that a motor can be run continuously at nameplate voltage and frequency. A service factor of 1.0 indicates that prolonged operation above full load can damage the motor. A service factor of 1.15 is typical for motors one horsepower and above, and indicates that the motor can work at 1.15 times its rated horsepower without failing.

DID YOU KNOW?

The operating cost of a typical motor far exceeds the initial capital expense. A heavily-used motor may cost ten-times its purchase price to operate per year.

QUICK TIP

When replacing a pump or fan motor, select a model with a full-load rpm rating equal to or less than that of the motor being replaced.

Motors 201: Reducing Energy Use

Following are some basic strategies for reducing motor electricity use. Since motors operate as one component of a larger system, it is critical to evaluate the related impacts of any change before making a decision. Consult with your building engineer and reference the equipment manufacturer's specifications prior to implementing energy efficiency improvements.

Turn It Off

Are your motors running when they are not needed? This increases energy costs and equipment wear. Can you turn off motors for hot water circulation, air compressors or ventilation fans at night? In some situations, it is appropriate to switch off the motor manually. For most applications, you can make the task easier by employing timers or sensors to switch the motor on and off.

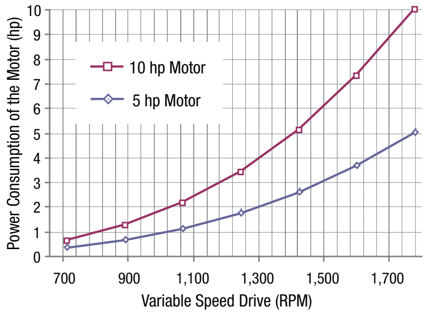
DID YOU KNOW?

The electricity used to power fan motors comprises a significant portion of space conditioning costs.

Turn It Down

You can cut energy use significantly simply by reducing the speed of an HVAC fan. The energy consumption of fans and pumps varies according to the speed raised to the third power, so small changes in speed can make big changes in energy consumption. *(See Figure 1)* HVAC equipment can often be reset on-site by an HVAC technician if a slower speed will still deliver the necessary airflow. Be sure that reducing fan speeds won't adversely affect indoor conditions. Most air conditioning equipment is designed to deliver about 400 cubic feet per minute of airflow per ton of cooling capacity in order to function properly.

FIGURE 1. Change in Power Consumption as a Function of the Pump Speed for 5hp and 10hp Motors Rated at 1780 RPM Full Load Speed



Match Speed to Need

Many motors operate at a constant speed all the time, regardless of need. A variable speed drive (VSD) matches the motor's speed to the load, allowing the motor to be continually adjusted relative to the power needed. A VSD can cut energy use and reduce wear and tear on the motor and its related components. A 20% reduction in fan speed, for example, can reduce energy consumption by nearly 50%. *(See Table A)* Good applications for VSDs include large motors that can operate for several hours at reduced speed and motors with loads that vary from day to night or seasonally.

Another advantage of VSDs is that they are often equipped with soft starting features that decrease motor starting current to about 1.5 to 2 times the operating current. VSDs can dramatically reduce the impact of fan starts on an electrical system. VSDs also reduce the voltage sag that can occur when a large motor starts quickly. Voltage sags can dim lights and cause other equipment to shut down or restart.

Table A. Potential Savings from Variable Speed Drives for Fans and Pumps

Average Percent Speed Reduction	Potential Energy Savings	Annual Energy Cost Savings for a 5 Horsepower Motor	Annual Energy Cost Savings for a 10 Horsepower Motor
10%	22%	$272	$543
20%	44%	$543	$1,087
30%	61%	$753	$1,506
40%	73%	$901	$1,803
50%	83%	$1,025	$2,050
60%	89%	$1,099	$2,198

NOTE: The annual cost savings estimate assumes a 5 or 10 horsepower motor operating 3500 hours per year at the average speed reduction shown in the chart. The potential energy savings assume:

- *approximately 5% energy losses due to the VSD*
- *$0.0825/kWh energy cost*
- *87.5% EPACT Efficiency Standard for 5hp motor*
- *89.5% EPACT Efficiency Standard for 10hp motor*

Lighten Up

You may be able to reduce the load on a motor and save energy by reducing pressure losses in pipe and duct runs with low-pressure loss elbows and fittings. Duct and pipe systems with lower pressure losses (usually expressed as "static pressure") can often use a slower speed fan or pump to deliver the same amount of flow. This can result in big savings. Other ways to reduce the load on a motor system include aligning the motor drive and replacing inefficient drivetrains such as belts, chains, and gears with direct drive systems.

FIGURE 2. A VSD can cut energy use and reduce wear and tear. *Photo courtesy of Schneider Electric.*

Eye on Quality

Address any power quality problems. To improve motor reliability and efficiency, it is important to maintain the correct voltage and phase balance, identify and eliminate current leaks, and prevent harmonics in the electrical supply. It is a good idea to have an electrical engineer review the electrical system periodically, especially before installing a new motor or after making changes to the system and its loads.

Shop Around

Is your aging motor still operable? Now is the time to contact motor dealers to review the efficiency and prices of available motors. After identifying the most cost-effective replacement model, you must decide whether to purchase it and keep it on hand as a spare, or wait to purchase it until the existing motor fails. The Motor Decisions Matter web site (www.motorsmatter.org) contains a motor management planning kit that can help you evaluate your options and create a decision plan.

Motors 301: Repair, Rewind, Replace?

When you have a motor failure you'll need to decide if you should buy a new motor or fix the old one. For Your motor has failed. Should you buy a new motor or fix the old one? To justify a major rebuild, the original stator and rotor must be in serviceable or reasonably-repairable condition. Repair of significant rotor or stator core damage is generally only cost-effective on larger motors.

Motor windings are a common culprit in motor failures and the solution often is to rewind the old motor. Rewinding is typically economical to rewind motors above 40 horsepower. It is generally cost-effective to replace a motor under 40 horsepower with a new premium-efficiency motor, if the motor operates often. Be aware that the rewinding process often reduces motor efficiency. Consider the cost difference between the rewind and a new high-efficiency motor and include the potential increase in energy costs of a rewound motor that is less efficient than the original. If you decide to rewind make sure that the repair shop uses low temperatures, under 700 deg F, and performs a core loss or loop test to ensure the motor is in good health.

PLAN TO PREVENT PROBLEMS

Proper maintenance goes a long way to improving efficiency and equipment life. For maximum performance and greatest energy efficiency, lubricate drivetrains (bearings, chains and gears), keep drive belts at their proper tension, clean fan blades, check pump impeller blades for wear, and replace air filters regularly. Motors should have good ventilation and be periodically inspected for increased vibration or power supply problems. Most maintenance actions pay for themselves with longer lasting equipment and less downtime; energy savings shorten the payback even further.

Safeguard against thermal damage by avoiding conditions that contribute to overheating. These include dirt, under and over-voltage, voltage imbalance, harmonics, high ambient temperature, poor ventilation, and overload operation (even within the service factor).

Bearing failures account for nearly one-half of all motor failures. If not detected in time, the failing bearing can cause overheating and damage insulation, or can fail drastically and do irreparable mechanical damage to the motor. Vibration trending is a good way to detect bearing problems in time to intervene.

ENERGY ANSWERS FOR MOTORS

Size Matters

An oversized motor will run at low efficiency and increase energy costs. It also costs more to buy. The efficiency of most motors peaks around 75% to 80% of full load and drops off sharply below 40% to 50% of full load, although these ranges vary by design and manufacturer. To optimize efficiency, a motor should be sized to operate with a load factor between 60% and 75 %. Motors loaded below 50% may be attractive candidates for replacement. Since the relationship between efficiency and load varies among different types and sizes of motors, be sure to check with the manufacturer or building engineer before replacing an oversized motor.

Can We Help?

APS offers incentives for qualified efficiency measures, including premium efficiency motors and VSDs. Learn more about the Solutions for Business program at aps.com or call 866-277-5605. aps.com

Maximize Energy Efficiency

When replacing an existing motor or when specifying new equipment, consider a premium efficiency motor. These motors can produce significant savings in annual electricity costs and quickly pay back the purchase price. *(See Table B)* The APS Solutions for Business program provides incentives to business customers to offset the incremental cost of more efficient motors. Contact APS for more information.

Select a motor that meets the performance requirements of the motor system. A good motor specification should define performance requirements and describe the environment in which the motor operates. Use the Department of Energy's MotorMaster software program to analyze a new motor purchase, rewind of a failed motor, or replacement of a working motor.

Remember to specify a new motor with a full-load speed no greater than the motor it is replacing. Efficient motors tend to operate at a slightly higher full-load speed than standard motors (usually by about 5-10 rpm for 1800 rpm motors). Centrifugal loads, like pumps, fans, and compressors, will be affected by this higher speed with slightly more fluid or air being delivered. In these situations, consider changing pulley sheeves, trimming pump impellers or changing fan cages to match the flow under original circumstances. Depending on the system, higher motor speeds will likely increase energy use and partly offset savings from more efficient motors.

Additional Resources

U.S. Department of Energy: Find industry best practices, tips and publications. Download MotorMaster+ software tools to help make motor comparisons and selection on a broad range of motors. www1.eere.energy.gov/industry

Motor Decisions Matter: Download a motor management planning kit. www.motorsmatter.org

National Electrical Manufacturers Association (NEMA): Information on the NEMA Premium standards. www.nema.org

Electrical Apparatus Service Association (EASA): Provides guidelines on motor repair/rewind practices. www.easa.org

National Electrical Manufacturers Association: Provides Product Scope and Efficiency Levels for NEMA Premium Electric Motors www.nema.org/premiummotors

Table B. Annual Energy Cost Savings with 1800 rpm NEMA Premium-Efficiency ODP Motors Rated 600 Volts or Less

HP	RPM	Standard Efficiency Source: Motor Master	Nema Premium Efficiency Source: www.nema.org	kW Reduction	Annual Energy Cost Savings
1	1800	76.50%	85.5%	0.07	$19.39
1.5	1800	77.40%	86.5%	0.10	$29.40
2	1800	79.70%	86.5%	0.10	$29.30
3	1800	82.60%	89.5%	0.15	$44.59
5	1800	84.10%	89.5%	0.20	$58.16
7.5	1800	85.90%	91.0%	0.29	$82.39
10	1800	86.90%	91.7%	0.36	$103.40

Assumes 3500 hours per year of operation, 100% Load, Same rpm for both Standard Motor and Premium Motor, $0.0825/kWh energy cost.

The APS Solutions for Business program is funded by APS customers and is approved by the Arizona Corporation Commission.