# ENERGY Answers for Business

# ENERGY-EFFICIENT MOTOR APPLICATIONS

Motors consume more than 50 percent of all the electrical energy generated in the United States and more than 30 percent of all the electricity used in the commercial sector. Most motors in the commercial sector are used to power fans and pumps in the heating, ventilation and air conditioning (HVAC) systems. It's not unusual for a motor to consume many times its capital cost in electricity every year. For all these reasons, it's clear that the motors in your building probably offer significant opportunities for savings.

## Types of Motors

"Induction" motors are by far the most common type found in commercial buildings. They are used in approximately 90 percent of applications, so chances are you have quite a few of them in your facility. They are reliable and inexpensive and operate on single-phase or three-phase power, although most motors larger than one horsepower are three-phase. When comparing motors, the most common characteristics to be aware of include: enclosure type, speed, efficiency and service factor. When replacing a motor, be sure to compare these specifications on the replacement motor with those recommended by the equipment manufacturer.

**Enclosure type –** The motor enclosure refers to the casing of the motor and is designed to match the motor to its operating conditions. The two most common types are Open Drip-Proof (ODP) and Totally Enclosed Fan-Cooled (TEFC). ODP motors are made with ventilation openings in the casing that are positioned to keep liquid or particles from falling into the motor from above. They are a very common motor for HVAC fans and pumps. TEFC motors have enclosed casings, as the name implies, to keep moisture and particles out. They are equipped with an integral fan for cooling and typically are used in dirtier or wetter environments.

**Speed –** Induction motors are available in a wide range of speeds although 1,800 revolutions per minute (RPM) is the most common, accounting for more than 50 percent of the motor population. Motors of 1,200 and 3,600 RPM also are popular enough to be stocked by distributors and manufacturers.

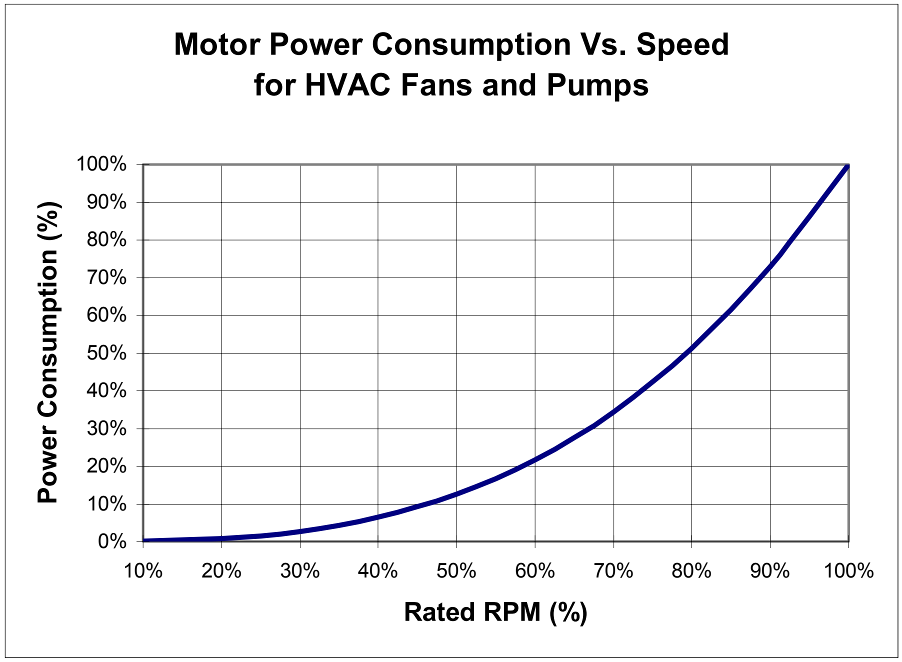
**Efficiency –** Standard-efficiency and energy-efficient three-phase motors are available from most manufacturers of ODP and TEFC motors in speeds of 1,200, 1,800 and 3,600 RPM. Some manufacturers also offer a line of premium efficiency motors. Higher efficiency motors are built with higher quality materials and other design features that improve their performance over standard models.

**Service factor –** The service factor specifies the capacity of the motor to withstand prolonged overload conditions. 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.

## Ways to Save on Motor Energy Costs

**Turn it off –** The simplest and most obvious method of saving motor energy is simply to turn it off when its not needed. Motors often run unnoticed when they are not needed, increasing energy costs. Motors can be switched manually and this is a fine solution for many applications, but there are also timers and sensors available that will turn them off automatically. Examples of motors that could be turned off at night include those for service hot water circulation, air compressors and ventilation fans.

**Reduce the speed on a fan motor –** Another simple method of reducing motor energy costs is to reduce the speed of an HVAC fan. 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. The chart below shows the relationship of fan speed in revolutions per minute (RPM) to power consumption. Most HVAC equipment comes from the factory with fan motor speeds preset, although they can often be reset on-site by an HVAC technician if a slower speed will still deliver the necessary airflow. Be sure to check with your technician or building engineer before reducing fan speeds to make sure that doing so 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.




**Use variable speed drives (VSD) for variable loads –** Some loads driven by motors don't need to operate at the same speed all the time. For example, pumps and fans often don't need to produce the same flow all the time. These types of loads offer big opportunities for savings by moderating their speed according to their load. For example, reducing a fan's average speed by 20 percent with a VSD can reduce energy consumption by more than 40 percent. Actual savings will be slightly less than those shown on the power consumption graph since variable speed drives themselves aren't 100 percent efficient. Some examples of potential VSD savings are provided in the table below.

**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 five percent energy losses due to the VSD.

**Specify energy-efficient motors –** When replacing an existing motor or when specifying new equipment, consider using a high-efficiency motor. High-efficiency motors use better quality materials and are manufactured to higher quality specifications than standard-efficiency motors. They are five to 10 percent more efficient on average than standard motors in the smaller sizes (25 horsepower or less). Federal efficiency standards now require minimum efficiencies for electric motors so the older motors in your facility are likely to be less efficient than the lowest efficiency motors of that size you can buy now.[1]

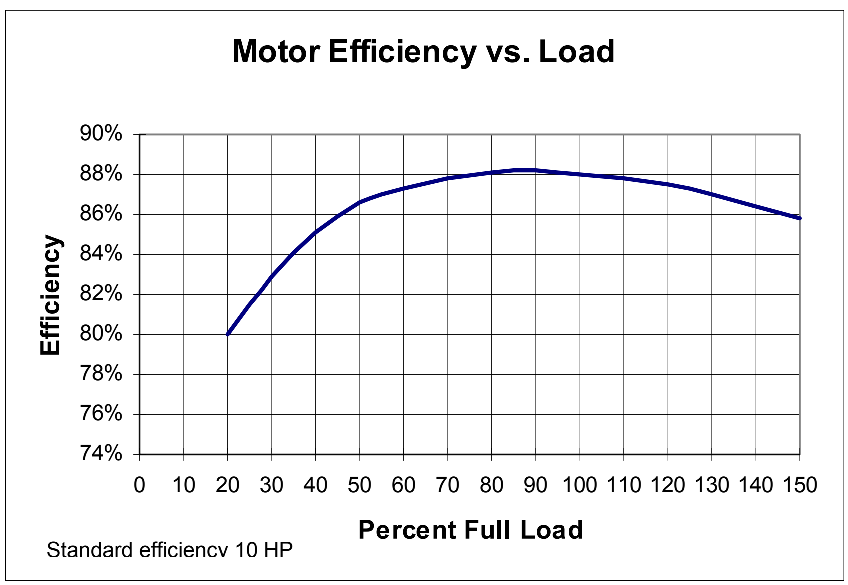
Be sure to check with the manufacturer or your building engineer when installing energy-efficient motors on fan and pump applications because some energy-efficient motors have higher speeds than standard motors. As discussed above, increasing fan or pump speed can actually result in an increase in energy use. So, it's important to specify that the new motor has a full load speed no greater than that of the motor it's replacing. The following table provides a comparison of the efficiencies of standard- and high-efficiency motors, and examples of potential savings with high-efficiency motors.

**Annual Energy Cost Savings With High-Efficiency ODP Motors**

| Motor Size (Hp) | Motor Efficiency (%) | | Annual Energy Cost Savings ($/yr) |
|---|---|---|---|
| | Standard-Efficiency Motor | High-Efficiency Motor | |
| 1 | 76.5 | 83.8 | 17.07 |
| 1.5 | 77.4 | 85.2 | 26.59 |
| 2 | 79.7 | 85.8 | 26.74 |
| 3 | 82.6 | 88.4 | 35.71 |
| 5 | 84.1 | 89.3 | 51.89 |
| 7.5 | 85.9 | 91.0 | 73.34 |
| 10 | 86.9 | 91.3 | 83.12 |

Source: Efficiencies: MotorMaster. Assumes 3500 hours per year of operation.

**Properly size motors –** Many motor systems are oversized, and a significantly oversized motor will run at low efficiency increasing energy costs. An oversized motor also costs more to buy. The efficiency of most motors peaks around 75 to 80 percent of full load and drops off sharply below 40 to 50 percent of full load, although these ranges vary by design and manufacturer.[2] High-efficiency motors tend to maintain their efficiency over a wider range of loads than standard motors. Motors loaded below 50 percent are almost always attractive candidates for replacement. However, because 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.




**Reduce the load –** Often it's possible 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. As shown above, 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.

[1] The Energy Policy Act of 1992 went in to effect October 24, 1997 establishing minimum efficiency standards for motors of NEMA design A and B, from 900 to 3600 rpm, between 1 and 200 horsepower.

[2] *Energy-Efficient Motor Systems*, ACEEE, 1991.

**Perform regular maintenance –** 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. Most maintenance actions pay for themselves with longer lasting equipment and less downtime even without the energy savings.

## Should You Buy New or Rewind?

When you have a motor failure you'll need to decide if you should buy a new motor or fix the old one. A common cause of motor failure is problems with the motor windings, and the solution often is to rewind the old motor. Because it is economical in terms of initial cost, rewinding of motors is very common particularly for motors of more than 10 horsepower. However, the motor rewinding process often results in a loss of motor efficiency. It is generally cost-effective to replace motors under 10 horsepower with new high-efficiency motors rather than rewind them. When deciding whether to buy a new motor or rewind the old one, consider the cost difference between the rewind and a new high-efficiency motor, and the potential increase in energy costs of a rewound motor that is less efficient than the original.

## For More Information on Energy-efficient Motors

Contact the Web sites of the Association of Energy Engineers, the U.S. Department of Energy's Energy Efficiency and Renewable Energy Network (EREN), and the U.S. Environmental Protection Agency's Energy Star Buildings Program. The *MotorMaster* software package is a comprehensive, user-friendly motor selection and evaluation tool that is available for download from the EREN website.

For general information regarding electric service for your business, call the APS Business Center at 602-371-6767 or 1-800-253-9407. For an on line analysis of your business energy use visit the APS Web site and take the Energy Survey at http://www.aps.com/aps_services/energysurvey/Default_BUSRES.html?type=b