National Food and Energy Council

AT-122

**END USES:**
Air Handling
Water Moving
Material Handling

**OBJECTIVES:**
Strategic Conservation
Strategic Load Growth

**APPLICABILITY:**
Building Ventilation
Crop Drying Systems
Irrigation Power Units

**STATUS:**
Many Sizes Available
Compatible Replacements

Ag Technical Brief

*This work done under contract with the Electric Power Research Institute.*

# Energy-Efficient Farm Motors

## DESCRIPTION

Between the late '50s and mid-'70s, electric motors were designed for low first cost with little attention given to motor efficiency or power factor, either of which can be of importance to user and electric power supplier. Yet, a 1980 U.S. Department of Energy study reported the number of all U.S. motors, between one and 125 hp, totaled 71 million in 1977; and that of all electricity used in the U.S., about 60% was consumed by electric motors. Over 1200 billion kWh were used by motors that year, 1977.

During that late '50s to mid-'70s period—when motors were manufactured for low cost, rather than efficiency—the greatest strides were made in mechanizing American farms with electrically powered equipment. Consequently, many farms were—and still are—equipped with inefficient electric power units.

Where farm motors are used on a particular job for a reasonably small number of hours during a year, efficiency is not critical since only a limited number of kWh can be saved. For long-term operations, such as livestock/poultry building ventilation, drying farm crops or powering irrigation and drainage pumps, the newer energy-efficient motors can be of economic importance to both users and electric power suppliers. While there is no single definition of an energy efficient unit, motor efficiency can be, and normally is, defined as follows:

$$\text{Efficiency} = \frac{\text{Mechanical Energy Out}}{\text{Electrical Energy In}} \times 100\%$$

Most motors manufactured before 1975 were designed with an efficiency only high enough to meet the allowable (rated) temperature rise. This is illustrated by the horsepower-efficiency curves which represent a composite of one type of 1975 standard commercial three-phase motors. Such motors, low in first cost, have a low efficiency because of high internal power losses. These losses, in turn, are due (largely) to stator and rotor power losses and magnetic core losses. Friction windage and a few other internal losses are inherent in all motors but vary with motor design.

These three primary types of losses can be, and are, reduced in order to obtain the higher efficiency motors with a horsepower-efficiency curve similar to "A" shown in the nearby graph. With present electric rates, the average cost to operate a 10 hp standard motor on a midwest farm increased from $430 in 1972 to $1,002 in 1986. In this calculation, rates assumed were 3.0¢ and 7.0¢ per kWh, respectively, for a 60-day crop drying period.

When compared with the standard commercial units, energy-efficient motors have more conductor material in the stator winding, have increased magnetic structure length, thinner laminations and/or use silicon grades of electrical steel. Such modifications increase the cost of a given size motor that must perform a specific job. It should be noted, however, that it becomes increasingly difficult to achieve incremental levels of efficiency as the motor efficiency factor and the motor horsepower increase.

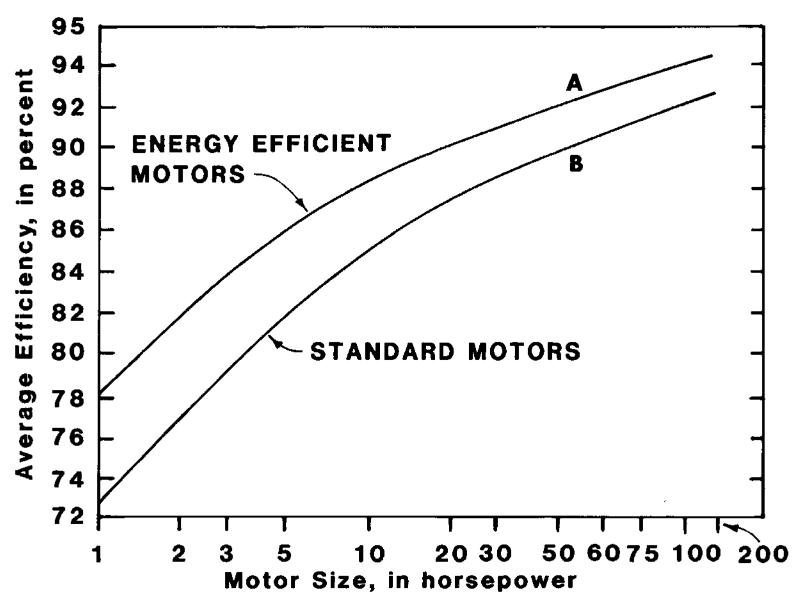
Power factor (P.F.) is related to motor efficiency and can be defined as follows:

**for single-phase motors-**

$$\text{P.F. in \%} = \frac{\text{WATTS}}{\text{Volts x Amps}} \times 100$$

**for three-phase motors-**

$$\text{P.F. in \%} = \frac{\text{WATTS}}{\text{Volts x Amps x 1.732}} \times 100$$




Typical Full Load Efficiencies of Three-Phase Four Pole Motors—Average of Several Manufacturers. As reported by Andreas, J.C., 1982.

Electric power suppliers desire as high a power factor as is possible because motors with a low power factor require more current to flow than is indicated by the ordinary watt-hour meter. Thus, electrical demand is increased with low power factor, creating the need for more generating capacity than might be anticipated.

To improve power factor, some single-phase motors are now constructed with an internal, solid state power factor controller that monitors and adjusts the phase angle between voltage and current. Some three-phase motors are similarly equipped.

### Specifications

Sizing of motors is dependent upon their individual application. While there is no single method for evaluating motor efficiency levels, the most often used references are Standard 112-1978 of the Institute of Electrical and Electronic Engineers and Publication 34-2 of the International Electrotechnical Commission. In general, the energy-efficient motors will have a 5 to 10% higher efficiency than a standard commercial motor. Many farm applications require 115 or 230 volt, single-phase, 60 H motors.

### Applicability

Energy-efficient motors can best be justified on farm applications where motors are to run 2500 or more hours per year. Thus the best candidates for reasonable payback are building ventilation fans, crop drying equipment and irrigation motors. A ¾ hp single-phase, thermostatically-controlled ventilation fan running 50% of the time will operate 4380 hours per year. If the efficiency of such a motor is increased 8 percentage points (from 70 to 78%) the annual electricity cost, at 7¢ per kWh, is decreased by $25. With greater increases in efficiencies, savings increase more.

### Implementation Considerations

Farmers are not always aware of the energy cost differences between energy-efficient vs. standard motors of a particular size. Those systems where energy-efficient motors can be most easily justified are often purchased on a competitive-bid basis. Consequently, concerned power suppliers must inform and educate customers regarding energy-efficient motor values and payback. Power suppliers may, individually or collectively, need to encourage manufacturers to equip more long-running farm machines with energy-efficient motors.

## EVALUATION

### Availability

Energy-efficient motors are more readily available in three-phase than in single-phase, due to anticipated and actual market volume. When energy-efficient motors are used to replace standard commercial motors, care must be used to ensure compatibility with controls. Energy-efficient motors are available from several major manufacturers.

### Cost Per Unit

The first cost of energy-efficient motors, as compared to standard commercial units, is 30 to 50% more. For smaller units that operate for 3,000 hours or more, the payback is normally less than two years. Selection should be based on life cycle cost comparisons that include energy savings.

### Reliability

Energy-efficient motors have been used successfully with little trouble on new farm equipment. They can be equally trouble-free in retrofit applications when properly sized and compatible with controls.

### Utility System Benefits

Energy savings with these motors help make electrically powered farm applications (such as crop drying and irrigation where large polyphase motors are often used) more competitive with alternate fuel systems. Improved power factor reduces load on transformers and distribution equipment, thus decreasing losses and need for utility penalty charges for low power factor.

### Customer Benefits

Primary customer benefits are in reduced energy costs due to higher operating efficiencies at all load levels. Most energy-efficient motors have improved ability to perform under adverse conditions such as abnormal voltage.

### Customer Acceptance

Acceptance is good where energy-efficient motors can be justified and where such applications and justifications are fully explained to user.

### Utility Programs

Few utilities have a strategic plan to encourage greater use of energy-efficient motors on farms. Because of the variation in farm motor size, applications and hours of use per year, such effort can best be effected as a part of a total agricultural marketing plan.

### Comments

For additional details on energy-efficient motors and their application, consult Energy-Efficient Electric Motors—Selection and Applications, by John C. Andreas, 1982, 200 pages, published by Marcel Dekker, Inc., New York.

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