How to Buy a Premium Energy-Efficient Electric Motor

Energy Efficiency and Renewable Energy
Federal Energy Management Program

Why Agencies Should Buy Efficient Products

- *Executive Order 13123 and FAR part 23 direct agencies to purchase products in the upper 25% of energy efficiency, including all models that qualify for the EPA/DOE* ENERGY STAR® *product labeling program.*
- *Agencies that use these guidelines to buy efficient products can realize substantial operating cost savings and help prevent pollution.*
- *As the world's largest consumer, the federal government can help "pull" the entire U.S. market towards greater energy efficiency, while saving taxpayer dollars.*

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  www.eren.doe.gov/femp/procurement
- DOE's Office of Industrial Technologies provides technical support on motors, co-sponsors with industry on the Motor Decisions Matter℠ campaign, and distributes *MotorMaster+*, a selection software package that includes a database of motors and their efficiencies.
  Phone: (800) 862-2086
  www.oit.doe.gov/bestpractices/motors
  www.motorsmatter.org
- National Electrical Manufacturers Association (NEMA) sponsors the NEMA Premium™ label for Premium energy-efficient motors and publishes a standard method for motor efficiency testing and reporting.
  Phone: (800) 854-7179
  www.nema.org/premiummotors
- Consortium for Energy Efficiency (CEE) has utility programs that promote energy-efficient motors.
  Phone: (617) 589-3949
  www.cee1.org
- Electrical Apparatus Service Association (EASA) has motor repair guidelines and service centers for motors.
  Phone: (314) 993-2220
  www.easa.com
- American Council for an Energy-Efficient Economy (ACEEE) publishes the *Guide to Energy-Efficient Commercial Equipment*, which includes a chapter on motors.
  Phone: (202) 429-0063
  aceee.org
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 646-7950

Efficiency Recommendations

NEMA™ Premium

How to Select Premium Energy-Efficient Motors

When selecting an electric motor, specify or select a model with an efficiency level that meets or exceeds the recommended levels (see pp. 3 & 4). These efficiency levels carry the NEMA Premium™ label, a program sponsored by the National Electrical Manufacturers Association (NEMA) and endorsed by the Consortium for Energy Efficiency (CEE) (see "For More Information"). In many cases, purchasing even more efficient motors can be cost-effective at average federal electricity prices. Cost-effectiveness will increase where there are higher electricity prices or peak demand charges.

Motor Sizing, Replacement, and Speed

Oversized, under-loaded motors should be replaced with smaller Premium energy-efficient motors. A motor with a higher horsepower rating than is required by the load operates at part load. Motor efficiency and power factor declines below 50% of full load, increasing utility power factor charges.

Look for a Premium energy-efficient replacement motor with a speed closely matched to the speed of the existing motor. Induction motors have an operating speed that is slightly lower than their theoretical, or "synchronous" speed. For example, a typical 1800 rpm motor will operate under full load at about 1750 rpm. 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. Depending on the system, higher loads may increase energy use and partly offset savings from more efficient motors.

ODP vs. TEFC

Motors are classified into two groups: open drip proof (ODP) and totally enclosed fan cooled (TEFC). These classifications are based on the method used to cool the motor. ODP motors can have higher maintenance costs due to the exposure of interior components to dirt and other contaminants. Because TEFC motors are designed for use in harsher environments, their first costs are typically higher than ODP motors.

Variable Frequency Drives

Variable frequency drives (VFDs), the most common type of adjustable speed drives, can be used with motors to help lower energy costs. VFDs are electronic systems used to control motor speed by changing the frequency and voltage supplied to the motor. VFDs can result in substantial energy savings, especially for varying loads. Small reductions in speed also can yield substantial energy savings. For example, a 20% reduction in fan speed can reduce energy consumption by nearly 50%. Pump, fan, and compressor systems with variable loads should be considered for retrofit with VFDs.

Rewinding Motors

Many users choose to rewind or repair motors when they fail, a practice that is more common with motors greater than 50 horsepower. Even though rewinding a motor costs less than buying a new one, for most applications with high annual hours of operation it is cost-effective to replace a standard motor with a new, Premium energy-efficient one. The Motor Decisions Matter℠ web site provides guidance on motor replacement and rewinding (see "For More Information"). Once a Premium energy-efficient motor has been purchased, even rewinding or repairing it at a quality service center may degrade its efficiency slightly (0.5% to 1.0% per rewind is the common rule of thumb). Though it is generally not cost-effective to rewind ODP motors, rewinding is often a cost-effective option for large TEFC motors. The Electrical Apparatus Service Association (EASA) provides a list of motor service centers (see "For More Information").

Motor Cost-Effectiveness Example
50 Horsepower (hp), Open Drip Proof (ODP), 1800 rpm

Performance	Base Model[a]	Recommended Level	Best Available
Full-Load Efficiency	93.0%	94.5%	95.0%
Annual Energy Use	160,430 kWh	157,880 kWh	157,050 kWh
Annual Energy Cost	$9,630	$9,470	$9,420
Lifetime Energy Cost	$109,500	$107,700	$107,140
Lifetime Energy Cost Savings	–	**$1,800**	**$2,360**

a) The efficiencies of the Base Models are just sufficient to meet current U.S. standards, established in the Energy Policy Act of 1992 (EPAct), which took effect on October 24, 1997.

Assumptions

The cost effectiveness example assumes electricity price is 6¢/kWh, the federal average electricity price in the U.S. Annual Energy Use is based on 4,000 equivalent full-load hours per year.

Definitions

Lifetime Energy Cost is the sum of the discounted value of annual energy costs, based on average usage and an assumed motor life of 18 years. Future electricity price trends and a discount rate of 3.3% are based on federal guidelines (effective from April, 2001 to March, 2002).

Using the Cost-Effectiveness Table

In the example above, a 50-hp motor at the recommended 94.5% full-load efficiency is cost-effective if its purchase price is no more than $1,800 above the price of the Base Model. The Best Available model, with an efficiency of 95.0%, is cost-effective if its purchase price is no more than $2,360 above the price of the Base Model.

What if my Electricity Price or Load Hours are Different?

DOE's MotorMaster+ software is a screening tool that allows you to adjust the capacity, hours of operation, and electricity cost for your motor installation (see "For More Information").

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Efficiency Recommendation[a] – Open Drip Proof (ODP) Motors[b]
Nominal Full-Load Percent Efficiency[c,d]

Motor Size (Horsepower)	1200 RPM (6-pole)		1800 RPM (4-pole)		3600 RPM (2-pole)	
	Recommended	Best Available	Recommended	Best Available	Recommended	Best Available
1	82.5	84.0	85.5	86.5	77.0	87.5
1.5	86.5	87.5	86.5	87.5	84.0	87.5
2	87.5	88.5	86.5	88.5	85.5	87.5
3	88.5	90.2	89.5	90.2	85.5	87.5
5	89.5	90.2	89.5	89.5	86.5	91.0
7.5	90.2	91.7	91.0	91.7	88.5	90.2
10	91.7	92.4	91.7	91.7	89.5	91.7
15	91.7	92.4	93.0	93.0	90.2	91.7
20	92.4	93.0	93.0	93.6	91.0	93.0
25	93.0	93.6	93.6	94.1	91.7	93.0
30	93.6	93.6	94.1	94.1	91.7	94.0
40	94.1	94.5	94.1	95.0	92.4	94.5
50	94.1	94.5	94.5	95.0	93.0	94.1
60	94.5	95.4	95.0	95.4	93.6	94.5
75	94.5	95.8	95.0	95.4	93.6	95.4
100	95.0	95.4	95.4	95.4	93.6	95.8
125	95.4	95.8	95.4	95.8	94.1	95.4
150	95.4	95.8	95.8	96.2	94.1	96.2
200	95.4	96.2	95.8	96.2	95.0	96.2
250	95.4	95.8	95.8	96.2	95.0	95.8
300	95.4	95.8	95.8	96.5	95.4	96.2
350	94.5	96.0	95.8	96.2	95.4	96.2
400	95.8	n/d[e]	95.8	96.5	95.8	96.2
450	96.2	n/d	96.2	96.2	95.8	96.2
500	96.2	n/d	96.2	n/d	95.8	96.5

a) Premium energy-efficient motors usually have higher inrush current than equivalent standard efficiency models. In older buildings, make sure existing motor circuits and protection equipment are adequate to handle this higher initial current, especially when replacing "design B" with "design A" motors.

b) An open drip proof motor has interior components that are being cooled by a fan moving cool air through intake and exhaust vents.

c) This Recommendation is for general-purpose, single-speed, polyphase induction motors. Some applications require definite-purpose, special-purpose, special frame, or special mounted polyphase induction motors. A motor meeting the Recommended efficiency level is usually available for these applications also.

d) Motor efficiency is identified on the nameplate by "nominal" efficiency, which represents the average efficiency of a large population of motors of the same design. It is measured in accordance with NEMA MG 1-1998, *Motors and Generators*, and IEEE 112 Test Method B.

e) "n/d" means data not available.

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Efficiency Recommendation[a] – Totally Enclosed Fan Cooled (TEFC) Motors[b]
Nominal Full-Load Percent Efficiency[c,d]

Motor Size (Horsepower)	1200 RPM (6-pole)		1800 RPM (4-pole)		3600 RPM (2-pole)	
	Recommended	Best Available	Recommended	Best Available	Recommended	Best Available
1	82.5	88.5	85.5	89.5	77.0	84.0
1.5	87.5	88.5	86.5	90.2	84.0	87.5
2	88.5	90.2	86.5	90.2	85.5	87.5
3	89.5	91.0	89.5	91.7	86.5	89.5
5	89.5	91.7	89.5	92.4	88.5	90.2
7.5	91.0	91.7	91.7	93.6	89.5	91.7
10	91.0	92.4	91.7	93.6	90.2	91.7
15	91.7	93.0	92.4	93.6	91.0	91.7
20	91.7	93.0	93.0	93.6	91.0	92.4
25	93.0	94.1	93.6	94.1	91.7	93.6
30	93.0	94.5	93.6	95.0	91.7	93.6
40	94.1	94.5	94.1	95.0	92.4	94.1
50	94.1	95.0	94.5	95.0	93.0	94.5
60	94.5	95.0	95.0	95.4	93.6	95.0
75	94.5	95.2	95.4	95.4	93.6	95.0
100	95.0	95.4	95.4	95.8	94.1	95.8
125	95.0	95.8	95.4	96.2	95.0	95.8
150	95.8	96.2	95.8	96.2	95.0	96.2
200	95.8	96.3	96.2	96.5	95.4	96.2
250	95.8	96.2	96.2	96.5	95.8	96.5
300[e]	95.8	96.2	96.2	96.5	95.8	96.2
350[e]	95.8	95.8	96.2	96.2	95.8	96.2
400[e]	95.8	95.8	96.2	96.2	95.8	95.8
450[e]	95.8	95.8	96.2	96.2	95.8	n/d
500[e]	95.8	n/d[f]	96.2	96.2	95.8	n/d

a) Premium energy-efficient motors usually have higher inrush current than equivalent standard efficiency models. In older buildings, make sure existing motor circuits and protection equipment are adequate to handle this higher initial current, especially when replacing "design B" with "design A" motors.

b) A totally enclosed fan cooled motor has an externally mounted fan that blows air across the motor casing. When in operation, the motor's interior components dissipates heat to a heat sink, which is the motor's casing. The casing is then cooled by the externally mounted fan.

c) This Recommendation is for general-purpose, single-speed, polyphase induction motors. Some applications require definite-purpose, special-purpose, special frame, or special mounted polyphase induction motors. A motor meeting the Recommended efficiency level is usually available for these applications also.

d) Motor efficiency is identified on the nameplate by "nominal" efficiency, which represents the average efficiency of a large population of motors of the same design. It is measured in accordance with NEMA MG 1-1998, *Motors and Generators*, and IEEE 112 Test Method B.

e) For 300 (and over) horsepower, availability of NEMA Premium™ motors from 3 manufacturers may be limited.

f) "n/d" means data not available.

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