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How to Buy an Energy-Efficient Electric Motor

Energy Efficiency and Renewable Energy
Federal Energy Management Program

Why Agencies Should Buy Efficient Products

- *Section 161 of the Energy Policy Act of 1992 (EPACT) encourages energy-efficient federal procurement. Executive Order 12902 and FAR section 23.704 direct agencies to purchase products in the upper 25% of energy efficiency.*
- *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.*

Efficiency Recommendations

Federal Supply Source:

- Defense Supply Center, Richmond
  Phone: (800) 345-6333

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and World Wide Web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  http://www.eren.doe.gov/femp/procurement
- Motor Challenge Information Clearinghouse provides technical support on motors and distributes MotorMaster+, a selection software package including a database of available models with their efficiencies.
  Phone: (800) 862-2086
  http://www.motor.doe.gov
- Consortium for Energy Efficiency (CEE) provides information on utility programs promoting energy-efficient motors.
  Phone: (617) 589-3949
- Electrical Apparatus Service Association (EASA) has motor repair standards and can identify qualified motor rewind shops in your area.
  Phone: (314) 993-2220.
- 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
  http://aceee.org
- National Electrical Manufacturers Association (NEMA) publishes MG 1-1993, "Motors and Generators," which includes a standard method for motor efficiency testing and reporting.
  Phone: (703) 841-3200
  http://www.nema.org
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 484-0880

Where to find Energy-Efficient Electric Motors

The federal supply source for motors is the Defense Supply Center, Richmond (DSCR). Be sure to specify an efficiency rating that meets the Efficiency Recommendation (see pp. 3-4) for that type and size. DSCR supplies motors in sizes ranging from 1 to 200 horsepower – be sure to specify a motor that meets the Efficiency Recommendation. For more information, call DSCR (see "Federal Supply Source").

When contracting or buying from a commercial source, specify or select a motor with an efficiency that meets or exceeds the Recommended levels (see pp. 3-4). These efficiency levels are the same as those recommended by the Consortium for Energy Efficiency (see "For More Information").

Motor Sizing

90% of motors in the U.S. are oversized. When a motor has a higher horsepower rating than is required by the load it is driving, the motor operates at part load. Motor efficiency begins to drops rapidly when operation falls below 50% of full load capacity. Also, power factor declines below 75% of full load, so lightly loaded motors can increase utility power factor charges. Oversized, under-loaded motors should be replaced with smaller energy-efficient motors in most instances.

Centrifugal Loads and Motor Speed

In retrofits, look for an energy-efficient model 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 most pumps, fans, and compressors, will be affected by this higher speed: slightly more fluid or air will be delivered and energy consumption will increase proportionately.

Variable Frequency Drives

Variable frequency drives (VFDs) are the most common type of adjustable speed drives. VFDs are electronic systems that control the speed of AC induction motors by changing the frequency and voltage supplied to the motor. VFDs can result in substantial energy savings, especially for centrifugal loads with varying demands. Small reductions in speed 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, energy-efficient one. Once an energy-efficient motor has been purchased for an application, rewinding or repairing it at a quality repair shop will degrade its efficiency, but only slightly. Though it is generally not cost-effective to rewind open drip-proof (ODP) motors, rewinding is often a cost-effective option for large totally enclosed fan-cooled (TEFC) motors. The Electrical Apparatus Service Association provides listings of qualified motor repair shops (see "For More Information").

Motor Cost-Effectiveness Examples

Performance	Base Model[a]	Recommended Level	Best Available
50 Horsepower (hp), 1800 rpm			
Full-Load Efficiency	93.0%	94.5%	95.0%
Annual Energy Use	160,430 kWh	157,884 kWh	157,053 kWh
Annual Energy Cost	$9,626	$9,473	$9,423
Lifetime Energy Cost	$109,100	$107,300	$106,800
Lifetime Energy Cost Savings	–	*$1,800*	*$2,300*
5 Horsepower (hp), 1800 rpm			
Full-load Efficiency	87.5%	89.5%	90.2%
Annual Energy Use	17,051 kWh	16,670 kWh	16,541 kWh
Annual Energy Cost	$1,023	$1,000	$992
Lifetime Energy Cost	$11,590	$11,330	$11,240
Lifetime Energy Cost Savings	–	*$260*	*$350*

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), beginning October 24th, 1997.

Definition

Lifeteme 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 4.1% are based on federal guidelines (effective from April, 1998 to March, 1999). The assumed electricity price is 6¢/kWh, the 1996 federal average electricity price in the U.S. Annual energy use is based on 4,000 equivalent full-load hours per year.

Using the Cost-Effectiveness Table

In the first 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 $2,300 above the price of the Base Model.

Similarly in the 5-hp example, the Recommended and Best Available models are cost-effective if their respective purchase prices are no more than $260 and $350, respectively, above the price of the Base Model.

How to adjust for different load hours and electric prices

To adjust for a different number of equivalent full load hours, multiply Lifetime Energy Cost Savings from the table by this ratio: $\left(\frac{\textit{Your annual load hours}}{4{,}000}\right)$. To calculate savings for a different electricity price, multiply the Lifetime Energy Cost Savings by this ratio: $\left(\frac{\textit{Your price in ¢/kWh}}{6.0\ ¢/kWh}\right)$. Calculations for different motor sizes can be made using MotorMaster+ (see "For More Information").

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

Motor Size (Horsepower)	1200 RPM		1800 RPM		3600 RPM	
	Recommended	Best Available	Recommended	Best Available	Recommended	Best Available
1	82.5	82.5	85.5	86.5	80.0	84.0
1.5	86.5	87.5	86.5	86.5	85.5	86.5
2	87.5	88.5	86.5	88.5	86.5	86.5
3	89.5	90.2	89.5	90.2	86.5	87.5
5	89.5	90.2	89.5	90.2	89.5	91.0
7.5	91.7	91.7	91.0	91.7	89.5	90.2
10	91.7	92.4	91.7	91.7	90.2	91.7
15	92.4	92.4	93.0	93.0	91.0	91.7
20	92.4	93.0	93.0	93.6	92.4	93.0
25	93.0	93.6	93.6	94.1	93.0	93.0
30	93.6	93.6	94.1	94.1	93.0	94.0
40	94.1	94.5	94.1	94.5	93.6	94.5
50	94.1	94.5	94.5	95.0	93.6	94.1
60	95.0	95.4	95.0	95.4	94.1	94.5
75	95.0	95.8	95.0	95.4	94.5	95.4
100	95.0	95.4	95.4	95.8	94.5	95.8
125	95.4	95.8	95.4	95.8	95.0	95.4
150	95.8	95.8	95.8	96.2	95.4	96.2
200	95.4	96.2	95.8	96.2	95.4	96.2
250	95.4	95.8	96.2	96.2	95.8	95.8
300	95.4	95.8	95.0	96.2	95.4	96.2
350	94.5	96.2	95.4	96.2	95.0	96.2
400	94.1	96.2	95.8	96.5	95.0	96.2
450	94.5	96.2	95.4	95.8	95.4	96.2
500	94.5	96.2	94.5	95.8	94.5	96.5

a) Energy-efficient motors usually have higher inrush current than equivalent standard efficiency models. In older buildings, make sure that existing motor circuits and protection equipment are adequate to handle this higher initial current.

b) 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.

c) These efficiency levels are the same as those recommended by the Consortium for Energy Efficiency (CEE) to their member utilities.

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 1-1993, "Motors and Generators," and IEEE 112 Test Method B.

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

Motor Size (Horsepower)	1200 RPM		1800 RPM		3600 RPM	
	Recommended	Best Available	Recommended	Best Available	Recommended	Best Available
1	82.5	85.5	85.5	86.5	78.5	80.4
1.5	87.5	87.5	86.5	87.5	85.5	87.5
2	88.5	88.5	86.5	86.5	86.5	87.5
3	89.5	90.2	89.5	89.5	88.5	89.5
5	89.5	90.2	89.5	90.2	89.5	89.5
7.5	91.7	91.7	91.7	91.7	91.0	91.7
10	91.7	92.4	91.7	91.7	91.7	91.7
15	92.4	92.4	92.4	93.0	91.7	91.7
20	92.4	93.0	93.0	93.6	92.4	92.4
25	93.0	93.0	93.6	94.1	93.0	93.6
30	93.6	93.6	93.6	94.5	93.0	93.6
40	94.1	94.5	94.1	94.5	93.6	94.1
50	94.1	94.5	94.5	95.0	94.1	94.1
60	94.5	95.0	95.0	95.4	94.1	94.5
75	95.0	95.0	95.4	95.4	94.5	95.0
100	95.4	95.4	95.4	95.4	95.0	95.8
125	95.4	95.8	95.4	96.2	95.4	95.8
150	95.8	96.2	95.8	96.2	95.4	96.2
200	95.8	95.8	96.2	96.5	95.8	96.2
250	95.6	95.8	96.2	96.5	95.9	96.5
300	95.4	96.2	96.1	96.5	95.8	96.2
350	94.5	95.0	96.2	96.3	94.8	95.8
400	94.5	95.0	95.8	96.2	94.5	95.8
450	94.5	95.4	94.5	95.0	94.5	95.4
500	94.5	95.4	94.5	95.4	94.5	95.4

a) Energy-efficient motors usually have higher inrush current than equivalent standard efficiency models. In older buildings, make sure that existing motor circuits and protection equipment are adequate to handle this higher initial current.

b) 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.

c) These efficiency levels are the same as those recommended by the Consortium for Energy Efficiency (CEE) to their member utilities.

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 1-1993, "Motors and Generators," and IEEE 112 Test Method B.

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