How to implement higher efficiency motors

Higher efficiency motors (HEMs) cost less to run than conventional motors. The savings they realise can quickly outweigh their additional cost to purchase, and ensure long term financial benefits.

The business case

An HEM typically costs more than the motor it is replacing, but its higher purchase cost is recouped by the power savings it makes during its operational life.

The cost difference depends on the motor size and efficiency classification. For example when working near full load a typical 11kW IE3 motor will be around 1.6% more efficient than an IE2 equivalent and might cost up to £200 more to buy. If the IE3 motor was running continuously, you'd save around 1,290kWh a year compared to the IE2 equivalent. With electricity costing 8p/kWh (including Climate Challenge Levy), this gives a £100 saving each year, paying back your additional investment cost in 24 months. If you were upgrading from an IE1 or lower class motor the savings will be even more.

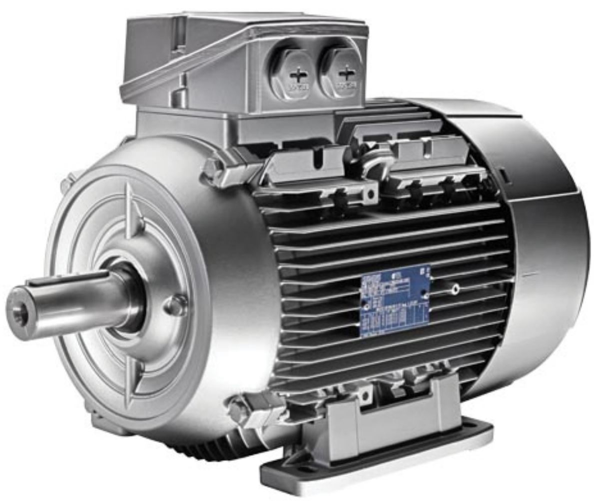


Image courtesy of Siemens

The technology

Improvements in motor efficiency have been made possible thanks to new materials, better design and better manufacturing.

An HEM may be regarded as a motor whose efficiency class is at least one level above the mandatory minimum.

Motors have been labelled according to their performance. The new IEC standard (IEC60034-30, Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors) defines three classes of motor efficiency, IE1, IE2 and IE3, where IE3 is the highest.

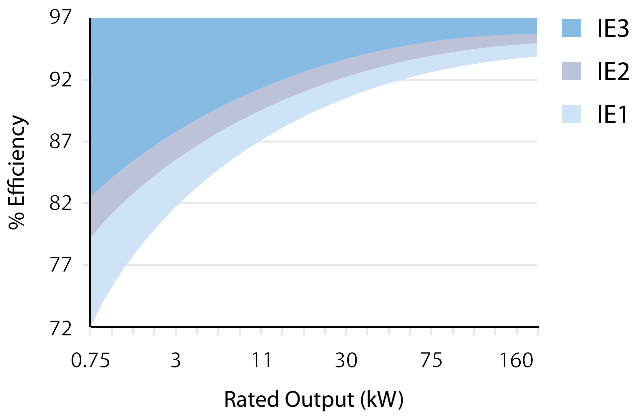
This standard supersedes the previous EU labelling scheme denoted by the labels EFF3, EFF2 and EFF1, where EFF1 was the highest efficiency.

A broad comparison of the performance labels is presented in the following table, for example EFF1 motors are roughly equivalent to IE2 from the IEC standard:

Efficiency	IEC	European (CEMEP)
Highest	IE3	
	IE2	EFF1
	IE1	EFF2
Lowest		EFF3

Figure 1 below illustrates the efficiency bands according to motor size for 4 pole motors, as defined in the IEC standard.

Figure 1 *Efficiency class bands for 4 pole AC induction motors*



Minimum motor efficiency requirements

In 2009 the European Commission announced mandatory minimum efficiency requirements for AC induction motors that are being placed on the market or put into service, according to the following stages.

Stage 1	From 16 June 2011	All motors must meet the IE2 efficiency level.
Stage 2	From 1 January 2015	Motors with a rated output of 7.5kW to 375 kW must meet either the IE3 efficiency level, or the IE2 level and be equipped with a variable speed drive.
Stage 3	From 1 January 2017	Motors with a rated output of 0.75kW to 375 kW must meet either the IE3 efficiency level, or the IE2 level and be equipped with a variable speed drive.

What this means in practice is purchasers can be confident that most AC induction motors on the market will at least meet the specified efficiency levels from the dates specified. Purchasers should note that some motor types are exempt from the requirements, such as those designed for operation in potentially explosive atmospheres, and so are advised to seek clarification from their suppliers.

Applications

HEMs can replace existing motors in most applications.

It makes financial sense to choose an HEM whenever you need to buy a new motor or equipment containing motors, and especially those in applications where there are high operating hours.

Repair or replace?

In most cases it is more cost-effective to replace a failed motor with an HEM, rather than repair it. This is because the relative cost to rewind motors, especially smaller motors can be high, and rewinding a motor may reduce its efficiency. The cost benefit of an HEM replacement will vary according to the motor size, and its operating hours.

The efficiency loss due to the rewind will vary according to the motor type and the processes used during the repair; it can be assumed that in most cases, a failed motor that has been rewound will be 0.5-2% less efficient than it was previously. Although the cost of a rewind may be less than buying a new replacement, especially for larger motors, the reduction in energy efficiency will mean that increased running costs could exceed the initial saving.

The replacement decision should be based on a comparison of the annual cost to own and operate the motors. The scenarios are generated using the following approach:

Ownership cost = capital cost + (n x annual running cost)

and

Annual running cost = (kW/eff) x L x hrs x $£_{elec}$

where:

n = time frame in years over which the payback is assessed

kW = rated kW of the motor (kW)

L = typical loading (how hard the motor is working in relation to its rated kW), use 0.75 as a default (%)

hrs = annual operating hours (hours)

$£_{elec}$ = cost of electricity (£/kWh)

eff = efficiency of the motor (%)

Consider the following example:

An 11kW IE3 motor (which is at least 91.4% efficient) running for 4,000 hours a year at 75% load consumes:

11kW/91.4% x 75% x 4,000hrs = 36,105 kWh/year

With an electricity cost of 8p/kWh, this would cost £2,888/year

The same system running an IE1 (approx. 87.6% efficiency) motor which has been rewound once (losing 2% efficiency and now at 85.6%) would consume:

11/85.6% x 75% x 4,000 = 38,551 kWh/year

With the same electricity unit cost, this would cost £3,084/year

If the cost to rewind the IE1 motor is £350 and the cost to purchase a new IE3 motor is £850, and assuming that both motors have a life of 10 years, the overall life costs are:

Rewound IE1 = £31,190

New IE3 = £29,730

Assuming similar amounts for installation and disposal costs, purchasing a new IE3 motor realises a saving of £1,460 over the motor's lifetime.

Ideally your organisation's motor management policy should give guidance on this issue. Examples of guidance that could be adopted are:

- If a motor is below 5.5kW, the motor should be replaced automatically with an HEM rather than repaired.
- Where annual running hours exceed 1,000 hours HEMs should always be the preferred replacement.
- If a failed motor is an HEM then it should be repaired.
- A motor should not be rewound more than twice unless there are exceptional circumstances.
- If very badly damaged the motor should be replaced automatically.
- Include routine cost benefit analyses and upgrades to HEMs in the maintenance schedule.

Specification checklist

The following table outlines the points to discuss with your supplier when choosing HEMs.

Considerations	Comments
Maximum power capability.	Ensure the replacement motor has sufficient rated kW for the load, and that the starting torque is sufficient for the application.
Motor electrical ratings.	Confirm the motor operating voltage, full load current and starting current expressed in amps, and the mains supply frequency.
Nominal motor speed.	Confirm the nominal speed of the motor, this corresponds with the number of poles (usually 2, 4 or 6).
Motor frame size, length and fixings.	In some cases, the replacement motor may differ in foot fixings, length of the non drive end and, possibly, in shaft height, diameter and extension.
IP protection standard.	The letters IP followed by two numbers is an indication of the motor's ability to withstand weather and foreign bodies getting into the machinery. As a general guide, IP54 is indoor protected and IP55 is outdoor protected.
Duty rating.	Whether the motor is intended for continuous (S1) operation, intermittent or other type of duty.
Motor speed.	HEMs can run at slightly higher full load speeds than standard motors. This is particularly important in pump and fan applications where the throughput may be inadvertently increased with a corresponding increase in energy consumption. Check the potential impact of higher speeds on the performance of the pump or fan, and adjust it accordingly; your pump or fan supplier will be able to advise you further.

Common problems

In some cases, the replacement motor may differ in foot fixings, length of non-drive end and, possibly, in shaft height, diameter and extension. You should check this at the specification stage.

In some pump and fan applications the energy saving due to an HEM may not be observed, the likely cause of this is the HEM operating at a slightly higher shaft speed (1.5%–3%) than the previous motor. This results in a higher throughput of the system with a corresponding larger (1.5%–9%) increase in energy consumption. The pump impeller or fan may need adjustment to account for the increased speed; your pump or fan supplier will be able to advise you further.

Commissioning procedure

HEMs need to be installed by competent electricians with electric motor experience. HEMS should be installed and commissioned to the current edition of the BS7671 IEE electrical wiring regulations.

Installers need to check alignment of the motor shaft with the load to reduce running losses, bearing wear, noise and vibration, and to maximise energy savings.

Because HEMs use less power, your installer also needs to check that the overload protection settings and fuse ratings are correct.

Finding a supplier

Higher efficiency motors come under the Government's Enhanced Capital Allowances scheme. You can see a list of ECA approved motor manufacturers at www.eca.gov.uk.

For more information see CTV048 – "Motors and drives technology overview"