Introduction to Energy Efficient Motors

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Abstract: Selection, Design, Manufacturing, Testing & Installation of Motor is becoming critical day by day because of huge capital cost & energy saving potential involved into it. Motors manufactured prior to 1975 were designed and constructed to meet minimum performance levels as a trade-off for a lower purchase price. Efficiency was maintained only at levels high enough to meet the temperature rise restrictions of the particular motor. In 1977, National Electrical Manufacturers Association (NEMA) recommended a procedure for labeling standard three-phase motors with an average nominal efficiency.

Motor efficiency depends on mechanical and electrical imperfections of the motor. Study found that Resistance ($I^2 R$) losses in the stator windings and rotor bars can constitute up to a 15 percent loss in efficiency in three-phase motors. Magnetization losses in the stator and rotor cores cause about a 1 percent to 7 percent efficiency loss. Friction losses in the bearings and inefficiency in the cooling fans result in 0.5 percent to 1.5 percent loss in motor efficiency. Friction and magnetization losses are independent of motor load and relate solely to motor size and design. The remaining losses are referred to as stray load losses.

To minimize the above losses **Energy Efficient Motors of Efficiency Class IE1, IE2 (High), IE3 (Premium), IE4 (Super Premium)** have been introduced in the Industry. For an example, a 4 –Pole 375 kW IE3 Energy Efficient Induction Motor shall have 96 percent Nominal Efficiency according to IS 12615:2011. Thus, a motor that is 96 Percent efficient converts 96 percent of the electrical energy input into mechanical energy. The remaining 4 Percent of the electrical energy is dissipated as heat, evidenced by a rise in motor temperature. The higher efficiency is attained by improved motor design and using high quality materials to reduce motor losses.

When we consider energy efficient motors, two factors will affect the payback period: power cost and operating hours per year. Where electricity is inexpensive or operating time is low, it may take several years for the savings from installation of high efficiency motors to outweigh the difference in initial cost. On the other hand, where power costs and the operating hours per year are high, it may be possible to replace an existing standard efficiency motor with an energy efficient motor and realize a payback in less than one year.

The present trend of Energy Efficient Motors being adopted in Indian Industry and promoted by Policy Makers is really commendable. It shows the trend in terms of huge energy & cost saving drive, which is very much in need of the hour for Indian Economy.

Keywords: Motor, Energy Saving, Efficiency, NEMA, Losses, Power Cost, Operating Hour, Payback Period.

Introduction

Global warming is a reality and world over people are working towards reduction in carbon foot print. Electric motor applications, in Indian industry, consume about seventy percent of the generated electrical energy. Improving efficiency of the motor is therefore a major concern in energy-efficiency efforts. Electric motors with improved efficiency, in combination with frequency converters can save about 7% of the total worldwide electrical energy. Roughly one quarter to one third of these savings come from the improved efficiency of the motor [2].

Table 1. Estimated Energy Saving potential of Motors in various Sectors

Sector	Total Conservation Potential (%)	Energy Handled By Motors (%)
Industrial Sector	Up to 25	70-75
Agriculture Sector	Up to 25	20-25
Domestic Sector	Up to 20	2-3
Commercial Sector	Up to 30	4-5

Challenges in Implementation

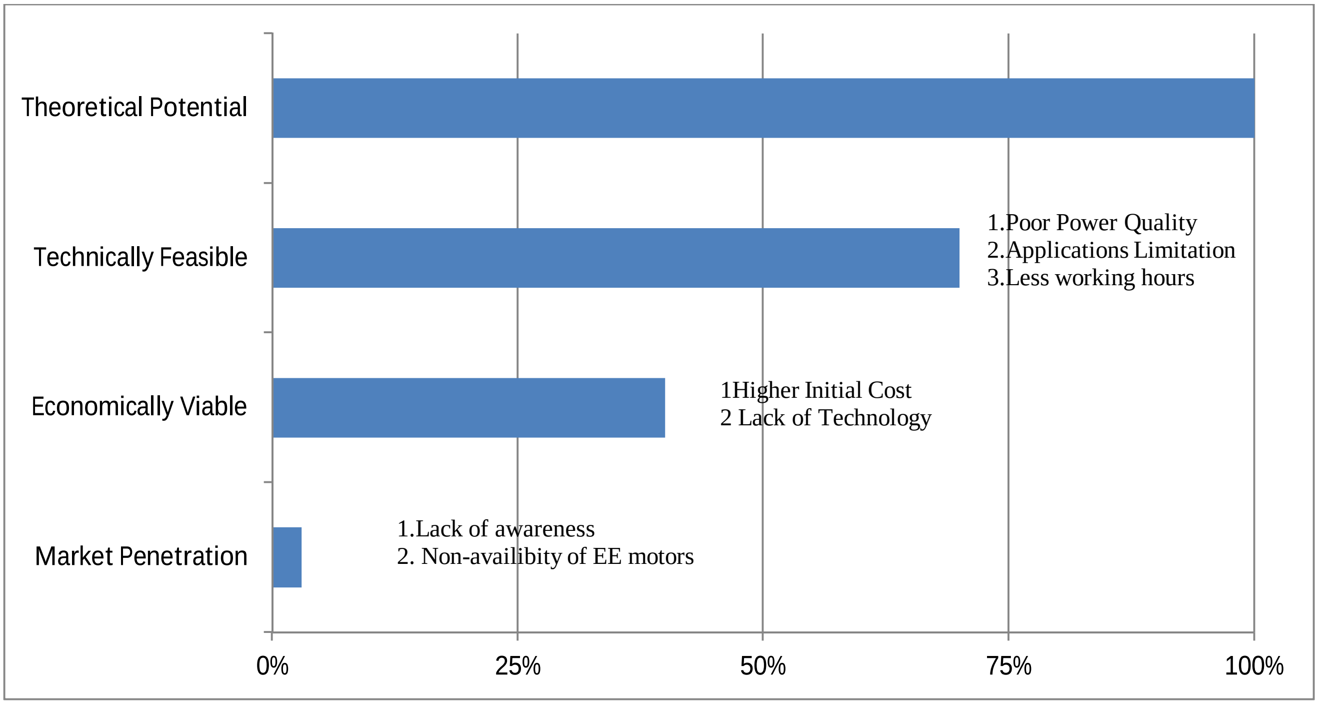
There is lack of awareness among the motor purchasers, regarding the potential for energy and cost savings by using more energy-efficient Electrical Motor Driven system (EMDS). In the Company organizational structure, Procurement budget is made independent of operations and maintenance budgets.

Motor is often integrated as a part of main equipment produced by OEMs before sale to the final end user.

The major barrier is that SMEs have to change their mindset toward the life cycle cost of the motor. Every purchase in industry units needs to weigh the savings that can be achieved through energy-efficient motors. There is always a tendency in the Indian market to go for the lowest initial cost instead of analyzing the life-cycle cost. However, as this cost is hidden, people tend to take the decision to purchase a motor based on the initial cost. The initial purchasing cost contributes only 4 per cent compared to the 88 percent of the total lifetime cost incurred due to consumed energy or the running cost of the motor.

The unavailability of complete Technical Standard is another grey area, which need to be explored before full-fledged introduction of Energy-efficient motors into the Indian Market. Even though standards are published by Bureau of Indian Standard (BIS) & International Electrotechnical Commission (IEC) but several critical information such as practical testing of efficiency, starting time & Starting current are missing.

Hence every purchase and technical specification for these EMD systems need to be revised and updated with new standard, i.e. by including IE2 and IE3 motors in the specifications.



Graph-1 Barriers in penetration of high-efficiency motors in Indian market

Global Scenario of Energy-efficient Motors

In recent years, market share of more efficient motors has been increasing in many regions and countries. This is particularly the case for the United States, China and other countries and to a certain extent for Europe. The United States and Canada are leaders in terms of setting motor energy-efficiency standards. Four standardized efficiency classes (IE1, IE2, IE3 and IE4) are currently recognized.

The United States and Canada are leaders in terms of setting motor energy-efficiency standards, as they introduced regulations for motors in the late 1990s. As early as 2002, China defined Minimum Energy Performance Standard (MEPS) for electric motors. The European Union passed MEPS legislation for electric motors in 2009 as an implementing measure under the eco-design directive; these will replace the previous industrial voluntary agreement. Australia, Korea, Brazil, Mexico, Taiwan and some other countries with large electricity consumption from motors have already adopted MEPS. However, some large motor using economies such as India, Japan and Russia are yet to adopt MEPS.

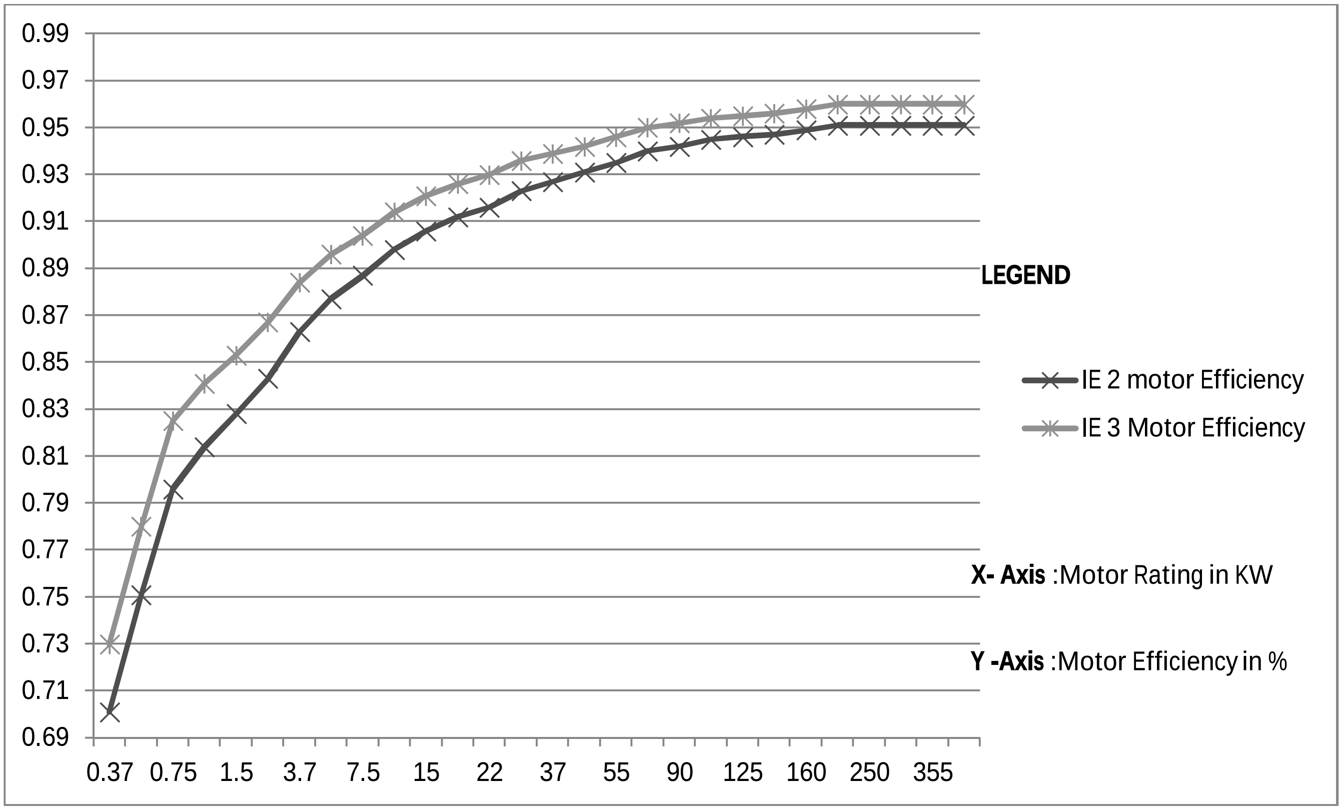
Energy efficient motor can save 3% of global annual electricity, which has a savings potential of 132 TWh. Annual global electricity consumption is 18,400 TWh. 40% of total Annual global electricity consumption of 7,360 TWh is by industrial units and 60% of the industrial consumption of 4,400 TWh is used by motor systems. A savings potential of 3% on motor system amounts to 132 TWh [6].

Scope of Energy Saving

There is huge scope in power saving specially in the Indian Power Industries. For an example ,only LT motor being used in following application are considered for our case study and outcome of the possible energy saving is tabulated below.

Table 2. Application of Motor in a Typical 660 MW Thermal Power Plant

Application (for LT Motor)	Approx. Power Consumption (in KW)	Power Saving (in KW) Using IE3 Motor
Air Conditioning	530	9.01
Ventilation	1675	30.24
Boiler & Auxlliaries	554	8.08
Turbine & Auxlliaries	335	4.05
Cooling Tower	4560	48
Balance Of Plant	3086	37.419
Coal Handling Plant	4379	61
Ash Handling Plant	3322	44.9



Graph-2 Efficiency Comparison for IE2 & IE3 Motors

The above graph shows the difference in efficiency of IE2 & IE3 Motors for the ranging starting from 0.37 KW to 355 KW.

Conclusion

With the growing energy cost, Energy Efficiency is no longer a luxury but an urgent necessity [7]. Typical useful life of motors is 15 to 20 years .Therefore investment for replacing all old motors less efficient than IE2 or IE3 can be paid back in less than 10-16 months. When entire investment can be returned in such a short period of time, the cumulative gains from life cycle cost can be much more than the initial cost of IE2/IE3 motors.

The initial purchasing cost contributes only 4 per cent compared to 88 percent of the total lifetime cost incurred due to consumed energy or the running cost of the motor.

There are other advantages for switching over to Energy Efficient Motor such as:

- Almost constant efficiency between 60 to 100 % load
- Ability to operate at Higher Temperature
- Reduction of Greenhouse Gases

For an example, When IE3 motors are used continuously for one year the power savings can be derived as mentioned in Table 3.

Table 3. Annual Power Saving by replacing IE2 with IE3 motors

Motor Rating (in KW)	Power Savings Per Year (in KW)	Motor Rating (in KW)	Power Savings Per Year (in KW)	Motor Rating (in KW)	Power Savings Per Year (in KW)
0.37	94	15	131400	125	1095000
0.55	140	18.5	162060	132	1156320
0.75	191	22	192720	160	1401600
1.1	260	30	262800	200	1752000
1.5	329	37	324120	250	2190000
2.2	463	45	394200	315	2759400
3.7	681	55	481800	355	3109800
5.5	915	75	657000	375	3285000
7.5	1117	90	788400	-	-
11	1542	110	963600	-	-

The global energy shortage has a significant impact on the design and application of electric motors. The opportunity is now available to select motors which will have substantial energy savings. Prudent decision, selection and use of energy-efficient motors not only support our national energy conservation goal but also provides an attractive financial reward to the motor end user.

The era of the energy-efficient motor has arrived. Hence energy consumption is a significant parameter, which needs to be keenly considered while selecting a motor irrespective of KW rating & area of application.

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