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Energy Conservation and Efficiency by Energy Efficient Motor in India

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Abstract: Electricity demand in India is increasing at a rapid pace because of growth in Economy, urbanization, infrastructure development and the living standard of people. According to the United Nation's world population prospects (2017), India's population is 1.34 billion which will go grow further and surpass China by 2025[1]. According to the IMF, the Indian economy is expected to grow by 7.5% in FY19-20 and 7.7% in FY20-21[2]. Increased population and growth in GDP are associated with increased energy demand. India's primary energy consumption was 754 Mtoe in 2017 and expected to reach 1928 Mtoe in 2040[3]. Major energy demand is from the Industrial sector which was 51% of total primary energy consumption in 2017 and expected to reach 990 Mtoe, by 2040 [3].

Rising energy demand and dependence on coal-based energy generation capacity, leading to the emission of Green House Gases (GHG). Most of India's Greenhouse gas emissions are from energy sector having 68.7% contribution in overall greenhouse gas emission. Agriculture, Industrial process land-use change and forestry (LUCF), and waste, contributed 6.0%, 3.8% and 1.9% respectively in overall GHG emission in 2014. [4]. Reducing the GHG emission in India is a major challenge in front of the Government as the Government has to maintain sustainable growth with the contribution in mitigating the effect of climate change. Govt. has pledged to Paris Agreement for the reduction in emission intensity of GDP by 33-35% by 2030 below 2005 level [5]. In the reduction of GHG emission, energy efficiency's contribution is estimated at approx. 51% [6]. The industrial sector can contribute most in reducing GHG emission and contributes to nationally determined contribution. Industry consumes 40%-45% of total energy consumption and motor-driven system consumes 70% [7] of total Industrial energy. Most of the energy in Industries are consumed to run the motor for various purposes and consumes a major chunk of energy which can be reduced to a significant level by replacing the standard motor with energy efficient motor. 90% of the motor in Indian industries are IE1 or below IE1 standard [8] and required replacement. By installing the energy efficient motor, the industry can save huge energy, cost and reduce CO_2 emission. Observing the opportunity for energy saving by energy efficient motor, this paper aims to analyze how energy efficient motor is capable of reducing energy consumption, and how it can contribute to energy conservation. Methodology adopted in this paper is secondary research, that answers to questions like; why Industry need energy efficient motor, how energy efficient motor can save energy and increases efficiency, cost-benefit analysis of installing energy efficient motor, barriers to the installation of energy efficient motor and solution to those barriers in migration from the standard motor to energy efficient motor in India.

Keywords: Energy efficiency, Energy conservation, Energy efficient motor, Motor Policy

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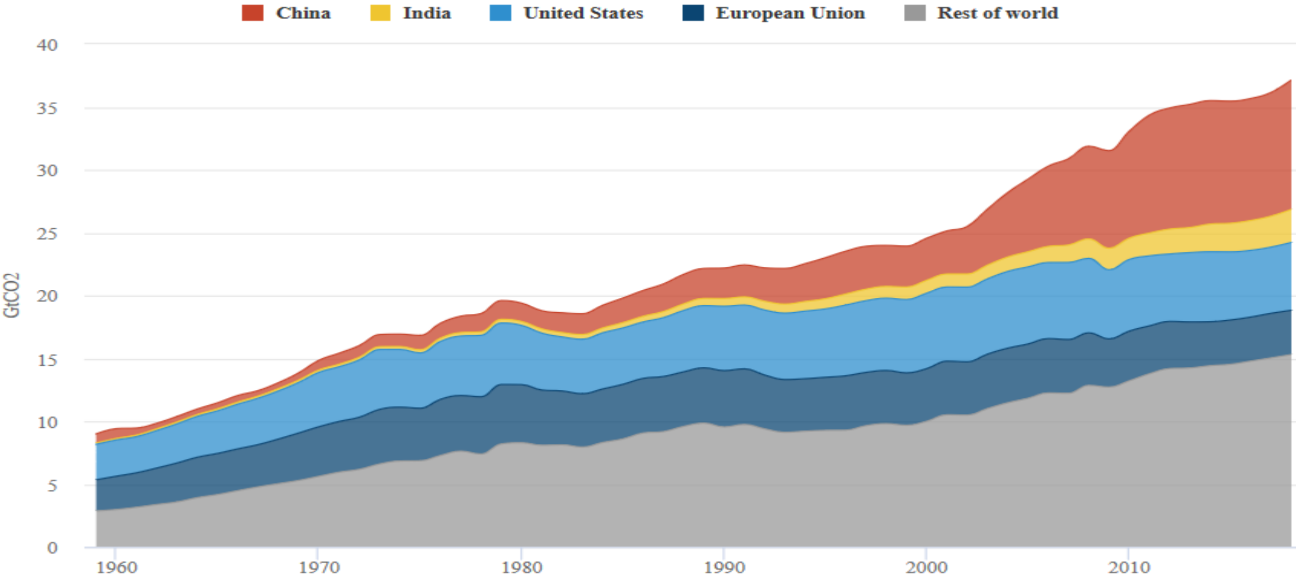
I. INTRODUCTION

India is focused on energy efficiency and non-fossil fuel-based measures for mitigating the effect of climate change. Reduction in GHG emission by managing demand side electricity consumption is a challenging task when demand is expected to grow exponentially. India's per capita electric consumption stood at 1075kWh/ year, in 2015 [7] which is one third [9] of the world average and increased to 4.37% in FY2016-17 to 1122 kWh/year [10]. With rising population, urbanization and increase in living standard energy demand will rise in various sectors with the majority of demand in the Industrial sector followed by the Residential sector as shown in Table **I**. India's energy demand is expected to grow at CAGR of 4.9% (2013-2040) to reach 3288 TWh [11] giving an increase of 228% over the energy consumption of FY 2015-16. The industrial sector will remain the largest consumer of electricity in India and the growth rate is expected at CAGR of 4.6% over 2013-2040. This Industrial growth is associated with growth in manufacturing activity, infrastructure development and energy access at an affordable rate. Share of residential sector electricity demand is expected to grow at CAGR of 6.4% and growth is because of India's housing programs (Affordable Housing, Housing for all), increase in urbanization and increase in per capita income. With growing energy demand across various sector CO_2 emission has also increased throughout industrialization as seen in emission patterns from 1960 to 2017 (Fig. 1). The emission pattern is divided between China, India, US, EU and rest of the world where Global emission reached approx. 37.15 billion tonnes of CO_2 in 2018 and the major contributor is China and the US. India's emission in 2018 was 2.47 $GtCO_2$, approximately 6.45% above the 2017 level [12] and placed in among the top 4 emitters of CO_2 [13]. Combating the effect of climate change seems to be a daunting task and without any policy and comprehensive approach, it is difficult to contribute in the reduction of CO_2 emission intensity. India required efficiency measures to balance economic growth and reduction in GHG emission simultaneously. Industry-wide energy efficiency measures have a promising role in Industrial growth and sustainability.

For Indian Industries to be cost competitive at the Global level, reduction in energy cost is an important element and production cost can be reduced through the implementation of energy conservation measures throughout industries from small to large.



Source: Carbonbrief.org

Fig. 1: Annual CO_2 emission from fossil fuel by countries

Table I: India energy demand forecast

Energy demand in GWh	2000	2013	2020	2030	2040	2013-2040 CAGR
Demand	376,000	896,000	1,351,000	2,241,000	3,286,000	4.9%
Industry	158,000	375,000	565,000	904,000	1,277,000	4.6%
Residential	79,000	207,000	329,000	647,000	1,115,000	6.4%
Service	46,000	133,000	207,000	332,000	450,000	4.6%
Transport	8,000	15,000	20,000	24,000	30,000	2.6%
Agriculture	85,000	160,000	222,000	324,000	401,000	3.5%
Other energy sector	-	6,000	8,000	10,000	13,000	2.9%
T&D losses	155,000	220,000	313,000	452,000	613,000	3.9%
PG own use	40,000	82,000	107,000	160,000	229,000	3.9%
Gross Generation	571,000	1,198,000	1,771,000	2,853,000	4,128,000	4.7%

Source: IEA

Bureau of energy efficiency (BEE) has started the PAT scheme to implement energy conservation measures in many identified energy intensive industries and impact of various schemes are acknowledged by the significant reduction in energy consumption in recent years. Similar to BEE, Energy Efficiency Services Limited (EESL), working under the Ministry of Power have separate national motor replacement program. Motor driven system is identified as one of the major energy consuming equipment in Industries and reduction in energy consumption at motor driven system can contribute significantly in demand side management of electricity consumption. In this context the National Motor Replacement Program is established in India to build the environment of high efficiency standard adhering to minimum IE2 and IE3 through awareness creation, Energy efficiency services, financing activities and helping in decision making for replacement of the standard motor with energy efficient motor.

II. NEED FOR ENERGY EFFICIENT MOTOR IN INDUSTRY

The motor converts electrical energy into mechanical energy to perform required work. Application of motor is seen everywhere in day to day life from domestic application to Industrial equipment. Table II shows the various application of the motor. The motor of the range of 0.12 KW to 375 KW has application in residential as well as in commercial sector whereas motor >375 KW finds application in Industrial and transport sector [14].

Motors major application is in Industries and has 64%, share, followed by 20% share in commercial, 13% share in residential and 3% share in other areas (**Error! Reference source not found.**).

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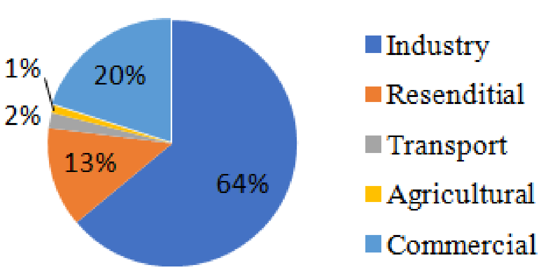
Table II: Size wise application of electric motor in various sectors

Size	Residential	Agricultural	Transport	Commercial	Industrial
Micro Motor >0.12 KW	Disc Drive, computer fans, hair dryers		Automotive auxiliary (windshield wiper, power window, fuel pumps)	office equipment-photo copy machine	
Small 0.12kw-0.75 kw	Large domestic application like washing machine, refrigerator	Water irrigation pumps for small fields	HVAC	office equipment large shredder	Power tools, small fans and pumps
Medium 0.75 kW–375 kW	Package HVAC systems, water pumps	Water pump for large field	Electric vehicle traction	HVAC (e.g. chillers), water pumps for large buildings	Fans, pumps, compressors, conveyors, process machines
LARGE > 375 kW			Electric vehicle traction		Fans, pumps, compressors, exhaust fans, process machines

Source: United4energy.org

Fig. 2: Electric motor application in various sectors



In Industrial sector, the motor consumes 70% of energy to run mechanical equipment in Industry but all the electrical energy is not converted into mechanical energy but wasted due to inefficient design, and material. An inefficient electric motor consumes more energy hence increases electricity cost, specific energy consumption and CO_2 emission. Energy efficiency is one of the major contributors to Nationally determined contribution (NDC) for mitigating climate change effect, and Industries can contribute to NDC with the implementation of energy efficient electric motor in the process. Implementation will help in saving energy, production cost and reduce the carbon footprint.

According to an estimate of IEA, (IEA 2011), if Globally all Industry adopted best practices that are minimum energy performance standard then approximately 322 TWh/year electricity would be saved by 2030 and contributing to an emission reduction of 206Mt of CO_2 [15]

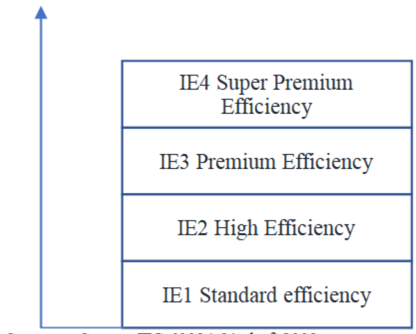
According to IEEMA, more than 2 million motors are produced annually in India, if they are replaced with energy efficient motor of IE3 standard, would have the potential to save 5 billion kWh of energy [8].

III. ENERGY EFFICIENT MOTOR AND SAVING POTENTIAL

Industries are in practice of using standard motor since last many years, and motors are re-winded many times after failure, but these practices not only increase energy consumption but also increases specific energy consumption as output becomes costlier due to energy consumption. In 1980, a study was conducted by General Electric [16] in its repair facility in the USA to know the effect of re-winding on motor efficiency.

The study concluded that motor core loss increased by 0% to 400% of the same rating of the motor when they were new.

The study further concluded 8%-10% of the motor had double the core loss and efficiency degraded by 1.5%. Energy efficient motor uses less electricity, run cooler and provide more mechanical output by consuming less electrical input energy.



Source: Source: IEC 60034-31, draft 2009

Figure 3: Energy Efficiency standard of Electric motor

In efficiency category of Electric motor, IE1 category motor is considered as standard motor and above IE1 is considered in the category of efficient motor. In India, IE2 is considered as Minimum energy performance standard [17] (Govt. notification in 2017)

At present efficiency level of motor availability is maximum for IE4 followed by IE3, IE2 and IE1 (

). The efficiency of the motor is the ratio of mechanical power output to electrical power input as given below

Output/Input=(Input-losses)/Input

=Output/ (output+losses)

From the above relation, it is clear that motor efficiency depends on losses, more the loss in motor, lower is the efficiency. Design changes, improvement in the material can reduce the losses. Day to day innovations and technology has found ways to reduce motor losses and improving its energy efficiency. Electric Motor is a combination of stator and rotor. The stator is stationary part of electric motor and the main function is to rotate magnetic field. The rotor is rotating part of a motor, placed inside the core of the stator. When the motor runs four types of losses are incurred in the motor as shown in **Table III**[18]

Table III: Loss distribution in three-phase, 4-pole, cage-induction electric motors

Loss Type	Loss %	Factors affecting losses
Fixed losses		
Core losses	20%-25%	Type of magnetic material
Friction and windage losses	5%-10%	Design of fan, bearings and seals
Variable Losses		
Stator I^2R Loss	30%-50%	Stator conductor size
Rotor I^2R Loss	20%-25%	Rotor conductor size
Stray load Losses	5%-15%	manufacturing and design

Source: IEA (2011), IEC 60034-31, draft 2009

Electric motor has majorly two types of losses Fixed loss and Variable loss which are minimized in energy efficient motor due to material and design improvement. Losses results in heating of motor and heat are rejected into the atmosphere resulting in loading on the cooling system of the facility and increased electricity consumption

Fixed losses in the motor are independent of motor loading and categorized into core loss and friction and windage loss. Core loss is 20%-25% of total loss and friction and windage loss in the range of 5%-10% of the total loss. Variable losses are categorized into stator I^2R loss, Rotor I^2R loss and stray loss. Losses are improved in energy efficient motor by employing various improvement measures as shown in Table IV[19]

Table IV: Loss minimization in energy efficient motor

Loss	Factor that minimize losses
Iron	Use of thinner gauge, lower loss core steel reduces eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operating flux densities.
Stator I^2R	Use of more copper and larger conductors increases cross sectional area of stator windings. This lowers resistance (R) of the windings and reduces losses due to current flow (I).
Rotor I^2R	Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) and losses due to current flow (I).
Friction & Windage	Use of low loss fan design reduces losses due to air movement.
Stray Load Loss	Use of optimized design and strict quality control procedures minimizes stray load losses.

Source: BEE

Fig. 3 and Fig. 4, represents energy efficiency comparison of IE1, IE2and IE3 motor at various motor rating (KW). It is seen that IE3 motor is more efficient than IE2 and IE1. Energy efficient motor above IE3 standard like IE4 and above and can be found in many countries. In terms of numbers, there is a small difference in efficiency percentage, but it results in huge energy saving. Efficiency gains of 2% from 92% to 94% can reduce losses by up to 25%. [20]

Fig. 4: 4 Pole motor efficiency comparison

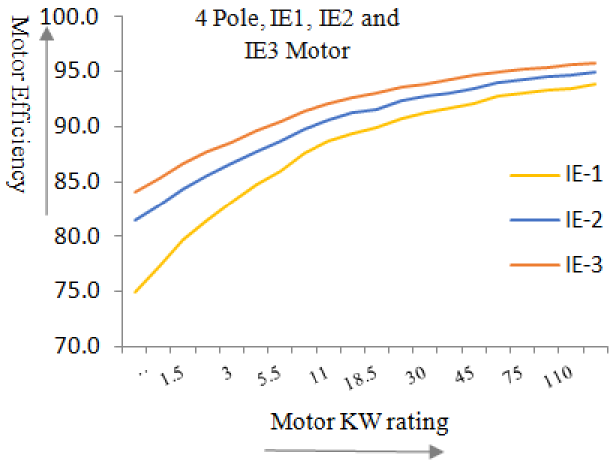
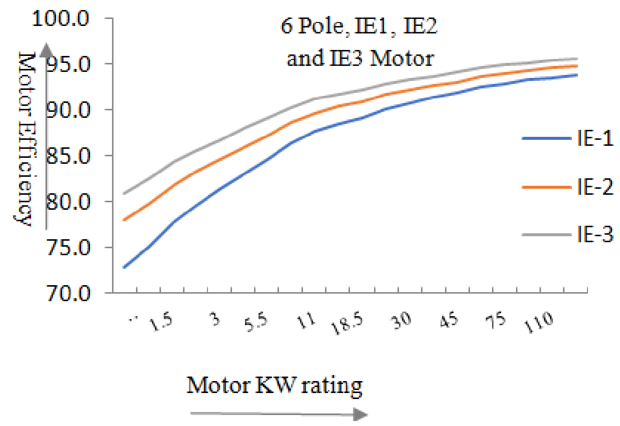


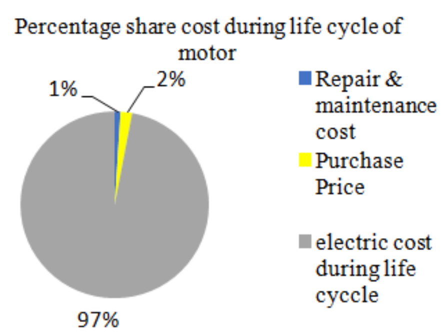
Fig. 5: 6 Pole motor efficiency comparison



IV. COST BENEFIT ANALYSIS OF INSTALLING ENERGY EFFICIENT MOTOR

Energy efficient motor pays for itself because, over the life of the motor, the major cost is the running cost of the motor, have contribution of 97% [21] in life time cost of motor. Purchase cost contributes to 2% and repair and maintenance cost to 1%. Though the motor can be repaired 2-3 times over the life of motor but if it is done unprofessionally, it results in losses and reduction in energy efficiency.

Fig. 6: Life time cost of motor



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Energy efficient (IE2, IE3 and above) motor are more efficient than standard motor of same rating and energy saving is calculated as given below:

Annual KWH saving =

$$HP \times LF \times 0.746 \times \frac{KW}{HP} \times \left(\frac{100}{ME1} - \frac{100}{ME2}\right)$$

------------------- (eq.1)

HP=Horse power rating of motor
LF=Load factor
ME1= Motor efficiency of existing motor
ME2=Motor efficiency of new motor
where load factor is calculated as:

$$LoadFcator = \frac{Avg.motorload}{Ratedmotorload}$$

Economic saving and payback period: The primary purpose of energy efficient motor is electricity saving which reduces electricity cost. Economic saving can be calculated as;

Economic saving (Rs.) =

$$AnnualKWHsaving \times EnergycostperKWH$$

Payback period analysis is an important factor which determines Return on Investment and simple payback period analysis in motor gives estimates of recovering the investment made towards energy efficient motor.

Motor's simple payback period can be calculated as

$$= \frac{Investmentforenergyefficientmotor}{Monetory\ Saving}$$

------------------- (eq.2)

Cost-benefit analysis of Energy efficient motor can be understood with Illustration in Table V and Table VI:

Cost-benefit illustration involved following steps:

- Assumption of KW rating, Frequency, running hours, electricity cost (Table VI) for10 identified LT motors which are standard motor and need to be replaced with energy efficient motor of IE2 or IE3 standard as shown in Table V
- Energy efficiency percentage of IE2 and IE3 motors are taken from Havell's white paper on IE2 & IE3 Energy Efficient 3 Phase LV Induction Motors [22]
- Cost of energy efficient motor is taken from the quote obtained from the Vendor
- Energy saving calculation with the help of eq. 1 and motor payback period with the help of eq. 2 in Table VI
- Table VI represents calculation for energy saving, monetary saving, and payback period
- Cost of energy efficient motor is taken from the quote obtained from the Vendor

The result as shown in Table VII, represents that investment towards IE2 & IE3 motor can be recovered with an average span of 1.2 years and after the 1.2-year company will get the benefit of energy saving every year.

For 10 IE2 motors investment would be approx. Rs 35,54,960 with annual electricity cost saving of Rs 30,53,560. If the same motors are replaced with IE3 motors, then the investment would be of approx. Rs 40,60,336 which would provide annual electricity saving of approx. Rs 33,14,904. It is seen that switching from IE2 to IE3 would save 8.56% more monetary saving compared to IE2 motor, but the plant's energy managers should do the analysis that which energy efficient motor is more compatible with the process. This was the small illustration of cost-benefit analysis of energy efficient motor. In practical cases saving can be even more if energy efficient motor is accompanied with variable speed drives.

Table V: Cost benefit analysis of replacement of standard motor with energy efficient motor-Part1

S.NO	Motor KW rating	Motor Speed (RPM)	Load KW	Rated Efficiency %	Load Factor %	Poles= 120*f/ RMP	Operating Hours	Efficiency IE2, %	Efficiency IE3, %
1	110	1,485	100	85	78	4	8,000	94.50	95.40
2	110	1,485	100	85	77	4	8,000	94.50	95.40
3	75	2,970	70	85	79	2	8,000	93.80	94.70
4	75	1,480	62	85	70	4	8,000	94.00	95.00
5	110	2,980	92	85	71	2	8,000	94.30	95.20
6	90	2,980	71	85	70	2	8,000	94.10	95.00
7	120	1,485	100	85	71	4	8,000	94.50	95.60
8	82	1,490	72	85	75	4	8,000	94.20	95.20
9	160	990	134	85	71	6	8,000	94.80	95.60
10	160	988	56	85	80	6	8,000	94.80	95.60

Source: Author analysis

Table VI: Cost benefit analysis of replacement of standard motor with energy efficient motor-Part2

S.No	KWH Saving withIE2	KWH Saving with IE3	Cost of electricity Rs/Kwh	Rs Saving with IE2	Rs Saving with IE3	IE2 Price	IE3 Price	Pay back period with IE2	Pay back period with IE3
1	80,665	87,473	4	3,22,658	3,49,894	328720	378032	1.0	1.1
2	80,423	87,212	4	3,21,693	3,48,847	3,28,720	3,78,032	1.0	1.1
3	52,537	57,360	4	2,10,149	2,29,440	2,56,296	2,94,736	1.2	1.3
4	47,489	52,211	4	1,89,957	2,08,842	2,32,992	2,67,944	1.2	1.3
5	72,901	79,200	4	2,91,604	3,16,800	3,73,432	4,29,448	1.3	1.4
6	57,341	62,415	4	2,29,363	2,49,659	2,95,656	3,40,000	1.3	1.4
7	80,423	88,703	4	3,21,693	3,54,812	3,74,464	4,30,640	1.2	1.2
8	56,255	61,714	4	2,25,019	2,46,857	2,95,656	3,12,112	1.3	1.3
9	1,10,819	1,18,862	4	4,43,274	4,75,448	5,34,512	6,14,696	1.2	1.3
10	1,24,537	1,33,576	4	4,98,148	5,34,305	5,34,512	6,14,696	1.1	1.2
Total	7,63,390	8,28,726		30,53,560	33,14,904	35,54,960	40,60,336	1.2	1.2

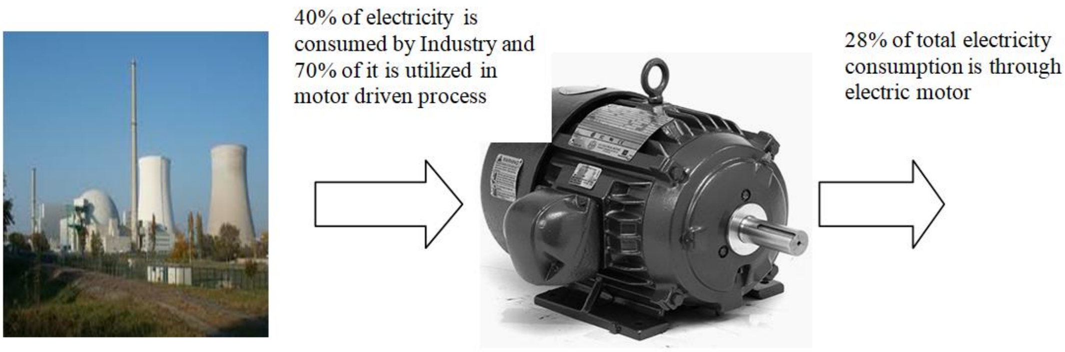
Source: Author analysis

Table VII: Result of cost benefit analysis

kWh Saving withIE2	kWh Saving with IE3	Rs Saving with IE2	Rs Saving with IE3	IE2 Price	IE3 Price	Pay back period with IE2	Pay back period with IE3
7,63,390	8,28,726	30,53,560	33,14,904	35,54,960	40,60,336	1.2	1.2

Source: Author analysis

V. Energy Conservation by Energy Efficient Motor: Importance for India



Energy conservation refers to the effort towards using energy efficiently. This is achieved by using less energy for product and services. Ex: Driving less, using electricity prudentially at home and outside, is energy conservation. Soaring fuel prices and increasing GHG emission demands for energy efficiency and energy conservative measures to be implemented in industries. Energy efficiency and conservation measures contribute to both sustainable development goal and emission reduction. According to the demand forecast of TERI, India's electricity demand will reach 1692 Billion kWh by FY21-22, 2,509 Billion kWh by FY26-27 and 3175 Billion kWh by FY29-30 [23] which shows huge energy saving potential by employing energy efficient practices.

Out of total electricity consumption in the country,40% of electricity is consumed by the Industrial sector and 70% of Industrial energy is consumed in running motor driven system [24]. The energy saving potential in Industrial utility is enormous just motor driven system can produce a huge amount of saving in energy. Every year Millions of motors are produced worldwide which are used in running several mechanical equipment from small to large and 28-30% of electrical energy [24] is converted to mechanical energy and most energy is wasted as a loss incurred while running motor. In most energy intensive industry like Iron and steel, cement and chemical if standard motors are replaced with energy efficient motor, electricity cost would reduce significantly. Saving potential of electricity in India by energy efficient motor is illustrated in Table 7.

Table VIII, represents two scenarios of energy saving potential where electricity demand is taken as per TERI projection [22]. In the case of 30% energy saving scenario by energy efficient motor, 142 Billion kWh can be saved by FY21-22, 211 Billion kWh by FY26-27 and 267 Billion kWh by FY29-30. In the case of 20% energy saving potential by energy efficient motor (conservative side) energy saving potential is 95 Billion kWh in FY21-22, 141 Billion kWh in FY26-27 and 178 Billion kWh by FY29-30.

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30% scenario has the potential to save money Rs 47,376 Crore by FY21-22, Rs 70,252 Crore by FY26-27 and Rs 88,900 Crore by FY29-30.

The above illustrated saving potential clarifies that why India Industries need to focus on reducing energy consumption with motor driven system

Table VIII: Energy saving and emission reduction potential

Description	Unit	FY21-22	FY26-27	FY29-30
Electricity Demand	BU (Billion kWh)	1,692	2,509	3,175
Industrial electricity Consumption 40% of Total electricity	BU (Billion kWh)	677	1,004	1,270
Motor consumes 70% of Industrial electricity	BU (Billion kWh)	474	703	889
Energy saving by energy efficient motor 30% energy can be saved	BU (Billion kWh)	142	211	267
Energy saving by energy efficient motor 20% energy can be saved	BU (Billion kWh)	95	141	178
Cost of electricity Avg. 5 Rs/KWH	Rs Crore	47,376	70,252	88,900
CO2 emission reduction (0.9Kg/Kwh) if 30% energy is saved	Million Tonnes	128	190	240
CO2 emission reduction (0.9Kg/Kwh) if 20% energy is saved	Million Tonnes	85	126	160

Source: Author analysis

Energy saved in motor driven system can be utilized elsewhere. Energy saving of 95 Billion kWh is equivalent to the consumption of energy in the commercial sector, Traction railways and others as on FY16-17(**Table IX**) [25]

Table IX: Electricity Consumption FY16-17

Sector	%age of electricity consumption	Electricity consumption (Billion Kwh)
Industry	40%	427
Agriculture	18%	192
Commercial	9%	96
Domestic	24%	256
Traction and railway	2%	21
Other	7%	75
	100%	1,066

Source: Central statistics office, Govt. of India

Energy saving contributes directly to 4 sustainability goal (Fig. 2) out of 17 sustainable development goals [26]. These goals are Good Jobs and Economic growth, Innovation and Infrastructure, Climate action and Responsible consumption

Source: un.org

Fig. 2: Sustainability Goals directly linked with energy efficient motor

VI. BARRIERS AND SOLUTION FOR IMPLEMENTATION OF ENERGY EFFICIENT MOTOR ACROSS INDUSTRIES IN INDIA

Energy efficient motor is already in practices in many countries with the willingness of Government towards energy efficiency and energy conservations with motor driven system. Table X represents MEPS (Minimum energy performance standard) for motor worldwide [27]. Many developing countries are still adopting IE2 standard while developed countries are into the transition phase of IE3 and IE4 from IE2. In March 2014, standard IEC 60034-30-1 was published which replaced the earlier IEC 60034-30:2008 standard and defined three efficiency level and now introducing IE4, super premium energy efficient motor. In India the Govt. has passed notification on March 2017 for installation of energy efficient motor of equivalent IE2 standard, to reduce energy consumption, CO_2 emission and specific energy consumption. Table X, represents the list of countries which have already implemented energy efficient motor compliances. In India, we are still in the transition phase from IE1 to IE2

Table X: Policies in various country for MEPS

Efficiency Level	Efficiency Classes	Testing Standard	Performance Standard
3-phase induction motors (Low Voltage < 1,000 V	IEC 60034-30-1, 2014	IEC 60034-2-1, 2014	Mandatory MEPS III
	Global classes IE-Code	Incl. stray load losses	National Policy Requirement
Super Premium Efficiency	IE4		
Premium Efficiency	IE3	Canada	0.75-150 KW
		Mexico	0.75-375 KW
		US	0.75-375 KW
		US	0.18-2.2 KW
		Republic of Korea	37-375 KW
		EU 28	0.75-375 KW
		Switzerland	7.5-375 KW
		Turkey	0.75-375 KW
		Japan	0.75-375 KW
		Taiwan	0.75-375 KW
		Saudi Arabia	0.75-200KW

Efficiency Level	Efficiency Classes	Testing Standard	Performance Standard
High Efficiency	IE2	Australia	<185 KW
		Brazil	<185 KW
		Canada	150-375 KW
		China	150-375 KW
		EU28	IE2+VFD
		New Zealand	<185 KW
		Israel	0.75-5.5 KW
		India	0.37-375 kw
		Chile	<7.5 KW

Source: united4energy

Many developed countries have adopted IE3 standard for electric motor and planning to IE4 transition and many still have to adopt energy efficient standard and implement Minimum energy performance standard into their energy policy. Most Industries in India operates with less efficient motor or standard motor and consumes energy that increases the cost of production making industry less competitive.

There are many barriers like Financial, Market, Information gap, Regulatory and technical barriers which provide roadblocks for the adoption of energy efficient motor in the system. These barriers are at the level of wholesaler and manufacturer, at planning and engineering and at the level of investor and energy managers briefly discussed in Table XI.

Table XI: Barriers for implementation of energy efficient motor

Barriers at level of wholesale and manufacturer	Barriers at level of planning and engineering	Barriers at level of Investor and energy manager
• Inability to effectively explain economic benefit of energy efficient Electric driven motor systems(EDMS) • Fear of EDMS failure • Tendency of not investing in innovation • customer demand for low investment cost	• Limited types of motor to minimize capital cost • Outdated technology and skill • Lack of information	• Complexity in understanding energy efficient measures • Purchase is based on lowest investment option • Information gap at management level • Large stock of standard motor • Huge initial investment

Source: Author

1) Barriers at the level of wholesale and manufacturer

Most of the manufacturer manufactures standard motor or below IE3/IE2 category because of their observation for the demand of low investment grade motor. As per market perception customer focuses on the initial cost of the motor, not on the life cycle cost of motor. The local manufacturer tends to sell and install standard motor unless they get a specific inquiry for energy efficient motor. Old fear persists in operation that burning of motor, stalling and failure will cause high production and loss because of this fear market is in practices of selling old type motor.

2) Barriers at the level of planning and engineering

The engineering skill of consulting engineer and plant engineers may not be updated to acknowledge energy saving opportunity exists by deploying energy efficient opportunity because of lack of training and information gap. Sometimes the wholesale manufacturer doesn't suggest going for premium energy efficient motor because of lack of stock or inventory which can be made available only on order and may take time. Engineers who plan or retrofit plant equipment installation prefer standard motor because these are available in large stock and take less time in procurement. Inefficiency at planning level for long-term cost-benefit hampers the implementation of energy saving measures.

3) Barriers at the level of Investor and energy manager

Investment and return on investment are two major concern for investment in new technology. Investment decisions are generally based on the lowest cost and to convince management for investment in higher-cost it is required to project long-term benefit. Energy manager may not explain or discover detailed cost-benefit analysis of investment in long-term because replacement of standard motor with energy efficient motor required skilled staff and advance engineering knowledge to understand the complexity of the system. Motors are in large stock in any manufacturing unit and studying cost-benefit analysis for replacement of all standard motor with energy efficient motor is time-consuming and replacement may not take place for the entire system due to high initial capital cost.

- ***The Solution to Barriers in Implementation of energy efficient motor in Industries***

Implementation of energy efficient motor required government policy support as it has been observed in many countries (US, Turkey, Japan, China, Canada) where the policy instruments was a key driving force in the implementation of minimum energy performance standard. Policy enforcement must provide support for knowledge up-gradation, training, awareness, support at the international and national level, financial support like loans for energy efficiency implementation in the organization. The government needs to enforce labelling of the motor for a clear understanding of efficiency level and testing procedure to check efficiency. Technology training and program would be the key driver for spreading knowledge and skill development. Energy service company (ESCos) should engage with management to work out on clear mapping for energy efficiency at plan and procurement plan within phases.

There can be various solutions for implementation of energy efficient motor as shown in Fig. 3 and activities given in Table **XII** which can support minimum energy performance standard in India

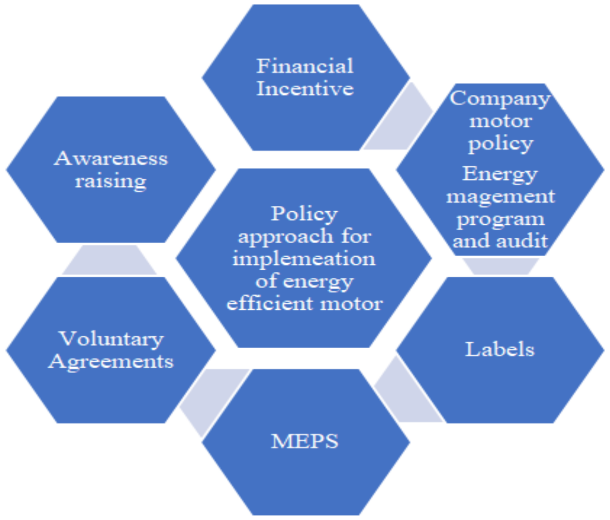

Fig. 3: Solutions for implementation of energy efficient motor

Manufacturing company should voluntary engage with Government's nationally determined contribution for mitigating climate change effect. Govt. various schemes and policies on Energy efficiency and conservation are opportunity for industries to become sustainable in long run.

Table XII: Activities supporting MEPS

Supporting activities for MEPS	Action Plan
Voluntary agreement	Voluntary agreement on implementation of energy efficiency measures and reporting timely must incentivize through lower energy tariff Capacity Building support from Government and International organization
Energy management policy of organization-should include motor policy	After the Government Mandatory energy audit for manufacturing unit under PAT scheme, industry is drafting their energy policy, but this policy must clearly state their motor replacement policy or maintenance of minimum energy performance standard of motors
Financial Instrument	Currently in India, Banks and funding institution provide traditional loans like working capital loan, term loan, capex loan but financial firm should employ innovative instruments which facilitate energy efficiency and saving
Raising awareness and information	Association of agencies International and national level with stake holder and Government should start information campaigning through training, workshop and awareness sessions
Training set up and association with international organization	Association with UNIDO United Nations Industrial Development Organization, GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit, BRESL can be helpful in removing barriers to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labelling of equipment

Source: Author

VII. INDIA'S STATUS ON IMPLEMENTATION OF MINIMUM ENERGY PERFORMANCE STANDARD FOR MOTOR

Table XIII**,** represents, currently active key policy drivers in India and their current status on implementation of energy efficient measures across Industries

Table XIII: Key policy driver of replacing standard motor in India

Key Policy Driver	Current status
The Perform Achieve Trade PAT Scheme	PAT scheme established by Govt in 2008, under its National Mission on Enhanced Energy Efficiency (NMEEE) in National Action Plan on Climate Change (NAPCC) which aims for improving plant's energy performance and energy saving
National Motor Replacement Program	Phase 1: Targeting replacement of more than 10 million motors of 1.1 kW to 22 kW, through the program in first phase
EESL (Energy efficiency services Limited)	EESL is Joint venture of PSU, NTPC Limited, PFC, REC and POWERGRID, under Ministry of Power with aim to provide consultancy services in the field of Clean Development Mechanism (CDM) projects, carbon markets, demand side management, energy efficiency, climate change and related areas
Govt Policy for implementation of Motor MEPS-IE2 and above	In 2017 Govt has announced minimum energy performance standard for motor IE2 and above

Source: EESL, BEE

VIII. CONCLUSION

From the result obtained through above discussion on why and how energy efficient motor benefits Industry, It is clear that increasing motor efficiency can be very helpful in demand side energy management of the Industry. Investment made towards energy efficient motor also return within few years of operation with enormous energy saving potential in Industry.

Currently India's energy demand is greater than energy supply and it is great opportunity to save Industrial energy which can be utilized in various other sectors and contribute in conservation of energy. Through illustration in Table VIII, it is observed that energy management by replacing standard motor with energy efficient motor, conserves energy which is not small quantity but equivalent to energy consumed by sector like railway and traction.

Realizing the energy saving opportunity in future and impact of efficiently deploying Electric driven motor system, it is important for the Industries to associate with Government schemes on energy efficiencies, International Institution for capacity-building, filling the gaps of latest technology and information. Talks about energy efficient motor is not new in India, but we still have a large inventory of standard motor which gets re-winded several times without any professional approach. Engineers in plants are not updated with efficient technology available in the market and process runs on old measures without any retrofit of new technology. Many manufacturing organizations have an energy policy in place, but it lacks at the implementation level. In the Global market, many Indian Industries in various sector like Iron & Steel, cement, petrochemical, Aluminum are not competitive because of the high production cost though we have the leverage of low manpower cost.

Lack of Information, inefficient monitoring system and lack of research and development activity are road blocks in capacity building. India needs Government policy support, the association of national and international companies for developing knowledge and technology transfer.

In recent years it is observed that Government is actively involved in energy efficiency schemes through the various institution and financing support activity, but policies are not clear and ambiguous.

Most important is a clear understanding of available policy and financing support from Government and willingness of management for change. Plant management should be involved in frequently organizing training and awareness session for human resource on energy conservation and keeping them updated with Industry-wide Minimum energy performance standard (MEPS) for energy intensive equipment in plant.

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