Sindh Univ. Res. Jour. (Sci. Ser.) Vol.45 (3) 501-506 (2013)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Energy Conservation Through Energy Efficient Motors in Pakistan's Industrial Sector

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Received 12th April 2013 and Revised 18th August 2013

Abstract: Pakistan is facing the electricity crises in present time. Globally, it is seen that many countries use the energy efficiency standards for electric motors on voluntarily and mandatorily regulation basis. This paper presents the analysis of motors in industrial sector where the existing motors are compared and replaced with energy efficient motors. The result comes with less than 4 years payback. For countries like Pakistan where 8 to 10 hours load shedding in urban areas and 10-12 hours load shedding in rural area with deficit of 6000MW to 8000MW reduce the socio-economic development, so it is necessary to optimize the efficiency of electric motors installed in different industrial sectors.

Keywords Efficient Motors, Industrial Motors, Energy Survey.

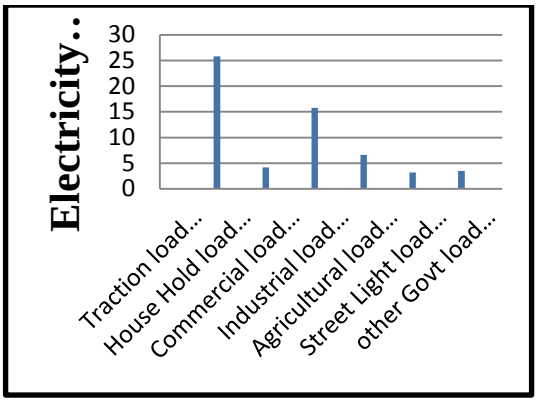
1. INTRODUCTION

The motors are back bone of any industry. According to global survey, Pakistan's industrial sector consumes about 40% of the electricity by electric motors in 2008. In different countries like Slovenia, the industrial sector utilizes approximate 52% of total electricity. Similarly in Turkey approximate 35% of entire electricity is utilized by motors in industrial side. The driven systems of motors use approximately 65% of the electricity in European industry. Similarly Jordan, industrial sector uses motor's load about 31% of total national generated electricity. In Malaysia, about 48% of total generated electricity is used by industrial motors. In many industrialized countries, more than 70% of the total produced electrical energy is used by electric motors. It means the improvements in efficiency for electrical motors can have a very large impact on electrical energy use.

1.1 Pakistan Sector Wise Energy Consumption of Electricity

The domestic sector is the largest load in Pakistan and consumes about 27 GWh of national electricity whereas the industrial sector, agriculture, commercial and other consumes 17 GWh, 7 GWh, 4 GWh and 6 GWh respectively. Industrial sector and agriculture sector widely uses the induction motor for different types of processes.

The graph 01 shows the Pakistan electricity sector wise energy consumption.



Graph.1 Pakistan electricity sector wise consumption.
Source: [2]

1.2 Electricity Forecast Supply And Demand Position from 2012-2020 In Pakistan MW

Table1, shows the total generation in 2013 is 18781MW and demand of consumer is 30944MW and Deficit in generation 12273MW, comparing it with 2020, the total generation will be 18541MW, and the demand of consumer will be 54319MW and deficit in generation will be 35738MW it is observed that with respect to time in Pakistan the total generation is going

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to be decreasing and as by increasing the demand of the consumer the gap between supply and demand will be widened, while energy efficiency has also been identified as an valuable tactic for little and average term for the trade and industry development of a country. (there is no reference)

Table.1: Pakistan Electricity Forecast Supply & Demand Position Sifatshah (2009)"

Years	2013	2014	2015	2016	2017	2018	2019	2020
Total generation (MW)	18781	18541	18541	18541	18541	18541	18541	18541
Demand of consumer (MW)	30944	33394	36217	40648	43864	46689	54319	54319
Deficit of generation (MW)	12273	14853	17676	22107	25323	28148	35778	35778

2 MATERIAL AND METHODS

2.1 Economic Analysis flow chart

The flow chart Fig. 01 shows the process of electrical energy from 1st stage to final stage of energy consumption**.**

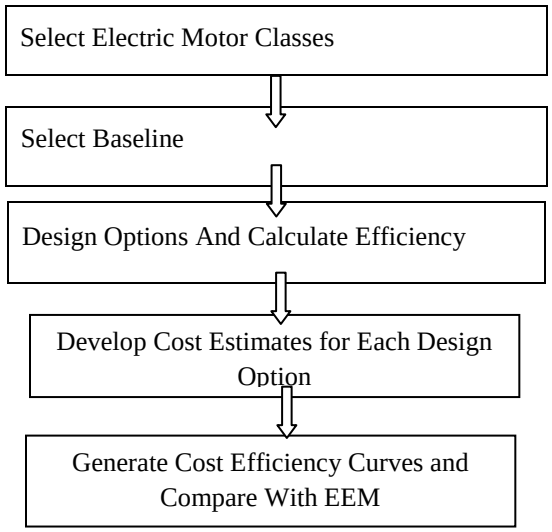


Fig.1: Economics flow chart

2.2 (a) Electric Motor Selection

First part of economic analysis is the electric motor class, which in turn depends on output power; Classes are also differentiated by energy consumption and performance of motors that affects the efficiency.

2.2 (b) Baseline Selection

Baseline selection is to explore the design of electric induction motor to improve efficiency.

2.2 (c) Design Option and Efficiency calculation

Design option is the changes for design of baseline model that improves the efficiency. The potential designs are selected by substitution of more efficient parts testing from laboratories.

2.2 (d) Efficiency Improvement from each Design

The valuation for the enhancement from the factors by changing the baseline models so that to determine the efficiency enhancement of an each design.

2.2 (e) Efficiency improvements and combine design

The cumulative changes to the design of a baseline model that improve the efficiency of the machines. The Calculations are performed for the different components. For combination design the energy used are determined through cumulative improvement of each design category.

2.2 (f) Cost estimates for each design option

The expected required costs for manufacturing, installing, and maintaining each design option is estimated, producing more efficient electric motor with new design.

2.2 (g) Cost-efficiency curves

The cost efficiency curve corresponds to calculating a life cycle cost (*LCC*) of machines.

3 STATISTICAL PRESCRIPTION

Before taking the efforts for the implementation energy efficient electric induction motors, it is necessary to calculate the efficiency of an electric motors, for this analysis single phase, 50 Hz, three phase induction motor has been taken from field, before finding efficiency of induction motor first few electrical parameters has to be find out like no load current, full load current, power output, load factor then by putting in formula as suggested be (Pinto *et al*, 2011, *Vanderley et al*, 2011, Rathi *et al*, 2012) efficiency can be found. For per KWh the electricity cost have been chosen 10 rupees. Now estimate the actual load factor on electric induction motors installed at industry

$$\gamma = 1 + (1/\alpha) * \text{Ln}(IR/IN) \quad (1)$$

and load current factor is calculated as

$$\alpha = -\text{Ln}(Io/IN) \quad (2)$$

α= actual load factor

γ=load current factor

I_{mc}= measured current
I_{rc}=rated current
I_{nlc}=no-load current

The efficiency of the installed electric induction motors is evaluated by simple formula output power to power input

$$\eta = Pout/Pin = (0.746 * PHP * \gamma)/PR \quad (3)$$

$\eta L_{=\text{installed motor efficiency}}$
Pin = measured input power
Pout = output power
γ= rated load (%)
$\eta_{=}$ efficient motor efficiency

The IEE-2B is the international method for finding the efficiency and this is only method for finding efficiency in accuracy its formula is given by:

$$IEE = (1 - \eta L/\eta) * 100\% \quad (4)$$

Kilo Watt hour saving (kWhS)

To estimate the kilo watt hour saving/year by replacing the energy efficient motor with older motor installed at industry with operation hours and its actual load factor, ***kWhS*** is given as:

$$kWhS/year = QES = 0.746 * PHP * \gamma * t * (1/\eta L - 1/\eta) \quad (5)$$

KWh Saved principles are given below. in this study the cost for B3 industrial sector is taken from the Power Distribution company (MEPCO). In which per unit of electricity is 13rupees.

$$\textbf{KWh saved value} = ESV = QES * C\ (Rupees/year) \quad (6)$$

Payback period he word payback means when capital amount invested on motors divided by kWh saved value it is expressed in year its equation is given as:

$$\textbf{PBP}=SPB = MIV/ESV\ (yr) \quad (7)$$

4 RESULTS

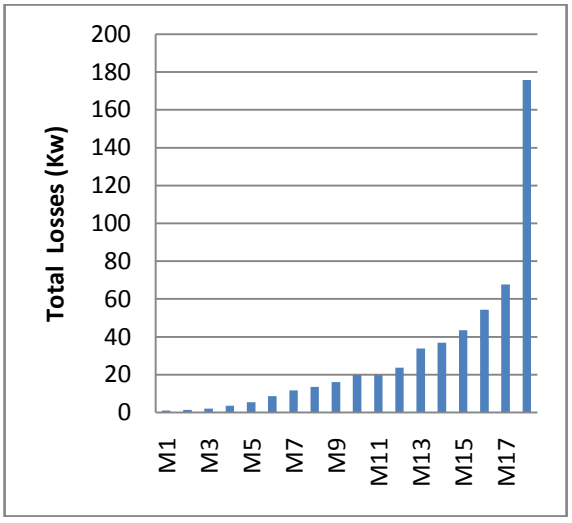
For analysis 18 different ratings of motor with each of six samples were chosen for calculation. Each of them are three phase, 50 Hz, induction motors. Total losses from each can be shown by following **(Table and Graph).**

Table: 02 Installed Motors and Their Losses

Motors Rating (Hp)	Total Losses (kW)
5.36	0.995
7.46	1.431
10	1.950
15	3.600
20	5.484
25	8.570
30	11.72
40	13.49
50	16.149
60	19.80
80	19.82
100	23.75
120	33.83
5	36.82
134	43.56
200	54.35
215	67.68
536	175.77
Total (1772.82 Hp)	**Total (538.816kW)**

The table 02 shows the total ratings of the different motors installed at industry and their combine losses.

From the given graph 02, it shows that different ratings motor and their combined losses.

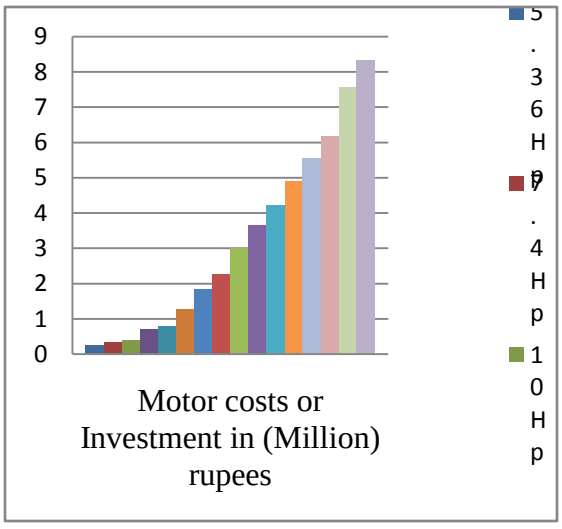


Graph 02: Motors rating versus Motor losses

Table 3: Energy, bill savings and payback period for a HEM over a failed or rewound standard motor

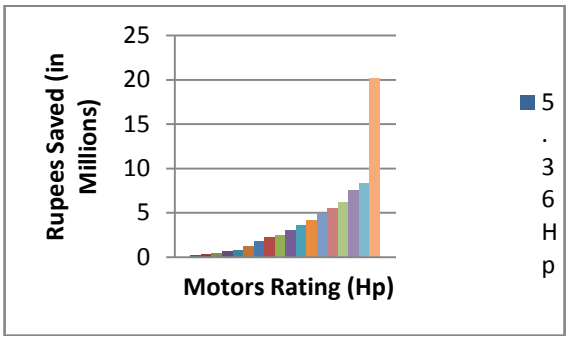
Motors Rating (Hp)	MWH saved/year	Total Rupees (Million) Saved/Year	Motor investment in (million)rupees	Pay back in years
5.36	4484	0.059413	0.233892	5.4
7.46	5596	0.07415069	0.32232	4.7
10	8838	0.117097	0.39	3.7
15	15333	0.2032	0.69	3.5
20	15674	0.2077	0.78	4
25	25694	0.340447	1.26	3.7
30	39921	0.52896	1.83	3.5
40	53421	0.70783	2.25	3.3
50	72937	0.96641	2.46	3
60	113021	1.49753	2.994	3.3
80	128516	1.70284	3.66	2.5
100	214148	2.83747	4.23	2.8
120	236314	3.13116	4.89	2.6
125	189062	2.50507	5.55	3.1
134	151072	2.0017	6.162	3.4
200	223232	2.957827	7.578	3.1
215	165632	2.19462	8.31999	4.2
536	462333	6.12592	20.1726	3.4

The given **(Graph 03)** shows the different motors ratings and their invested value in million rupees.



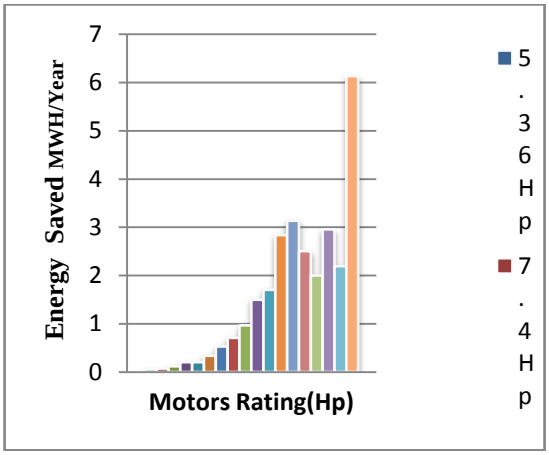
Graph 03: Motor investment value (Million Rupees) graph

The given **(Graph 04)** shows that different motors ratings and their saved value in million rupees.



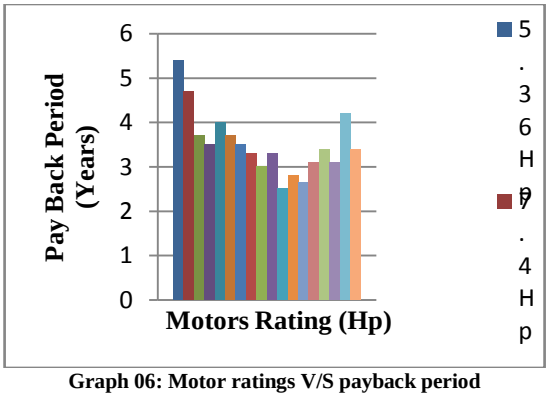
Graph 04: Motor saved value in different ratings (million rupees)

The given **(Graph 05)** shows that different motors ratings and their saved energy in MWH/year.



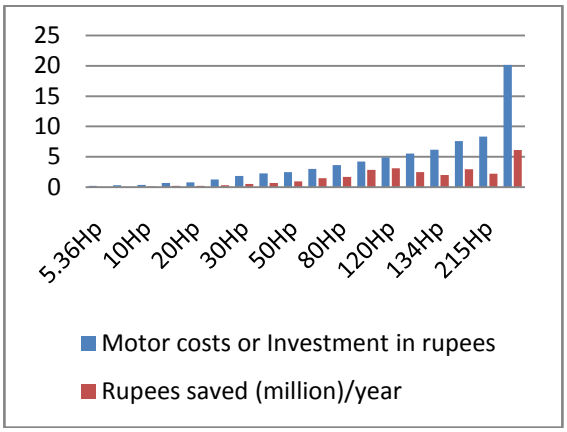
Graph 05: Motor saved MWH/year in different ratings of motor

The given **(Graph 06)** shows that different motors ratings and their payback period.



Graph 06: Motor ratings V/S payback period

The given **(Graph 07)** shows the combine graph among motor ratings versus saving of kWh/year and motor investment per year. And also shows the total kWh saving, rupees saved and motor investments which will be installed at industry.



Graph 07: Comparison among motor ratings, saving of kWh/year, rupees saved/year and motor investment/year

5 CONCLUSION

From the results it is concluded that the energy saving from an efficient electric induction motors will be 2125.3MWH/year with the investment for the replacement of motors for an efficient one will be 73.8 Million rupees and the average pay back period will become 3.5years, also it was observed that only 1% of energy saving can not only reduce the cost but also can save our country from this huge load shedding, similarly by replacing the energy efficient motor, not only saves the electricity but it reduces the co_2.

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