International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

A Practical Approach to Energy Conservation Through Lighting in a Railway Workshop (A Practical Case Study)

J. Sathiyanarayanan,
Senior Section Engineer/Central workshop, Ponmalai, Tiruchirappalli
37, Sankar Nagar, Rajalakshmi Nivas, Srirangam, Trichirappalli, Tamilnadu, India (620006)

Sishaj P. Simon,
Assistant Professor,
Department of Electrical and Electronics Engineering,
National Institute of Technology,
Tiruchirappalli, Tamil Nadu, India

K. Sundareswaran
Professor,
Department of Electrical and Electronics Engineering,
National Institute of Technology,
Tiruchirappalli, Tamil Nadu, India

***Abstract* - There are two main forms of energy that are consumed by industries, namely, oil and electricity. Globally, industrial electrical energy usage accounts for 40% of total usage and is a major contributor to CO_2 emissions. There are several different uses of electrical energy in a factory, such as lighting, cooling, heating and supplying power to machineries. The electrical energy saving potential of industry systems largely remains unrealized because it is deeply embedded in industrial management and operational practices. Lighting is an essential part of any industrial load, and hence, it plays a vital role in reducing inflated energy bills. This paper describes two practical measures that have been implemented in a railway workshop and the energy saving achieved in lighting. Energy savings in lighting not only reduces the energy bill but also reduces CO_2 emissions.**

Index Terms: Optimum Voltage; Part Light System; Lumens reduction; Energy Saving

I. INTRODUCTION

The energy conservation is cost effective with a short payback period and modest investment. There is a good scope of energy conservation in various sectors, viz., industry, agriculture, transport and domestic. The energy audit can unearth huge profits to the industry [1]. Conservation and efficient use of energy in industry has for a long time been a priority of the Government of India. So among industrial consumers, the aspect of energy conservation is gaining due importance of the realization that “Energy Saved is Energy Produced and that too at Economical Cost [2]. The effect of CVR on energy consumption can be explained as follows. By Joule's law, the power P, voltage V and current I in a resistive circuit satisfy $P = VI$. It follows from Ohm's law $V = IR$ that lowering the voltage level reduces the power when the load consists of pure resistors with constant resistance R, because in that case we have $P = V^2 / R$. In reality, this is true if loads are constant-resistance (hot water system, fridge, oven, incandescent lighting, pool pump, etc.) [3].

There are many energy consuming components in industries and energy conservation effort should be user friendly, cost effective and less time consuming [4]. Lighting is an essential part of any commercial and industrial load. Hence it plays a vital role in increasing the profit margin by energy conservation. Lighting provides us the opportunity to implement cost effective saving measures without a substantial modification in the existing design [5]. Monitory savings and conservation of energy resources are the two major benefits of Electrical Energy Management. The Specific Electricity Consumption (SEC) is the ratio of electrical energy consumption to the production of a factory [6]. Here we are discussing two methods in lighting system to achieve higher SEC.

1. By providing Lighting Energy Saver.
2. By part light system.

The application of these two methods expected to give 6–8% saving in lighting consumption and 2–3% reduction in energy billing. The investment, resultant saving and simple payback period are discussed in detail in this paper. This paper mainly concentrates in optimal utilization of every KWH consumed in lighting circuit by increasing specific energy consumption ratio.

II. DESCRIPTION ABOUT WORKSHOP

The southern railway central workshop is situated in the Golden Rock area of the Trichirapalli District in the state of TamilNadu in India. The workshop was built the British in 1926 – 1927 and has an approximate total area of 300 acres. The workshop is undergoes a periodic overhaul of passenger coaches and diesel locomotives. The workshop has 25 smaller workshops that perform various activities that are required for the POH of coaches and locomotives. Each workshop is similar in construction and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

has one or two bays, each measuring 120 x 50 meters squared or 80 x 30 meters squared, with a ceiling height of 12 to 15 meters.

There are approximately 700 light fixtures in the workshops and 125 light fixtures in the yard. The monthly energy consumption of the workshop is approximately 6,30,000 units (approximately 76 lakhs units per annum). The contracted MD is 3 MVA. The connected load is 27500 KW.

The total lighting load is 200 KW, consisting of 175KW in floor lighting and 25KW in yard lighting. Assuming 10hrs of burning per day for 25 days in a month gives the following:

Total consumption = 200 × 10hrs × 25 days = 50,000 Units.

The cost of energy is Rs. 8 per KWH (including MD and other charges)

Lighting energy cost/month (50000 x 8) = Rs. 4,00,000.

With a reduction of 10% in lighting, the energy consumption savings in cost per month will be = (5000units × Rs. 8) = Rs. 40,000.

Savings in cost per annum will be = 40,000 × 12 = Rs. 4,80,000.

Approximately 5 lakhs per annum can be saved.

III. METHOD I: USE OF LIGHTING ENERGY SAVERS

There are two types of loads, a constant power load and a constant resistance load. In a power load system, when the applied voltage is reduced, the current increases to deliver the rated power output, such as in motor loads. In a constant resistance load system, when the applied voltage is reduced, the power output decreases proportionately, such as in lighting loads. In lighting circuits, the lumen output is reduced when the applied voltage to the circuit is reduced. If the reduction in lumens is not visible or if it does not affect the regular work, then there is no harm in applying a reduced voltage to the system. This logic is applied in lighting energy savers.

The applied voltage is reduced to an optimum value of 205 volts from the normal 230V by use of alighting energy saver. At this voltage, the reduction in lumens is minimized and is neither recognized by the workmen nor affects regular work. The power output is reduced as described below (assuming 250W power).

Power reduction = 205 / 230 × 250 = 222 Watts (a power reduction of 28 watts in one 250W light).

Therefore, 700 lights savings = 700 × 28 = 19,600 Watts or 20kw maximum

Maximum savings= 20 × 8 × 25 =4000 units in a month.

The lighting energy saver is a two winding transformer, and its secondary voltage is always 205Volts, which is applied to the lighting circuit. The incoming supply voltage is connected to the primary. It has specified upper and lower cut off values, which are fixed by the manufacturer. Here, the uppercut-off voltage is fixed at 240V and the lower cut-off voltage is set at 190V. Above the upper cut-off value and below the lower cut-off value, the lighting energy saver will automatically change to bypass mode to protect itself, and the supply will be directly fed to the lighting load. A single line arrangement of energy savers is shown in Fig. 1a and inside view of energy saver shown in Fig. 1b.

(a) (b)

Fig-1. (a) Schematic Diagram (b) Inside view of energy saver

SCR is only used as switches to connect various tapings in the secondary winding as per varying input voltage values. A complete SCR controlled inverter circuit is avoided to reduce the cost, harmonics and maintenance complications.

The capacities of lighting savers available in the market are 3, 5, 7.5 & 10 KVA. All four capacity lighting energy savers are utilized here according to the lighting loads available in various shops. The lumens output is less than 10% of the original value, and it is not recognized by works and does not affect regular work.

The various electrical parameter values measured with the energy saver in bypass mode and in auto mode are shown in Tables 1 and 2.

Table-1: Measured electrical parameters of the bypass mode

Date	Time	Hz	V	A	kW	kWh	kVAr	kVArh	KVA	kVAh	Pf
29-03-2014	16:16:00	49.72	223.10	15.80	3.01	0.05	1.87	0.03	3.54	0.06	0.85
29-03-2014	16:17:00	49.72	223.70	15.70	3.02	0.10	1.82	0.06	3.53	0.12	0.86
29-03-2014	16:18:00	49.71	223.80	15.70	3.03	0.15	1.82	0.09	3.53	0.18	0.86
29-03-2014	16:19:00	49.68	224.20	15.80	3.04	0.20	1.85	0.12	3.56	0.24	0.85
29-03-2014	16:20:00	49.65	224.20	15.80	3.04	0.25	1.84	0.15	3.56	0.30	0.86
29-03-2014	16:21:00	49.66	222.70	15.90	3.01	0.30	1.88	0.18	3.55	0.35	0.85
29-03-2014	16:22:00	49.66	223.30	15.90	3.02	0.35	1.91	0.22	3.57	0.41	0.85
29-03-2014	16:23:00	49.68	223.90	15.80	3.03	0.40	1.84	0.25	3.55	0.47	0.86
29-03-2014	16:24:00	49.67	224.40	15.90	3.05	0.45	1.86	0.28	3.57	0.53	0.85
29-03-2014	16:25:00	49.63	223.90	15.80	3.03	0.50	1.86	0.31	3.56	0.59	0.85
29-03-2014	16:26:00	49.63	224.80	16.00	3.06	0.56	1.90	0.34	3.61	0.65	0.85
29-03-2014	16:27:00	49.65	224.70	15.90	3.06	0.61	1.87	0.37	3.59	0.71	0.85
29-03-2014	16:28:00	49.65	224.50	15.90	3.06	0.66	1.89	0.40	3.59	0.77	0.85
29-03-2014	16:29:00	49.66	224.80	15.90	3.06	0.71	1.86	0.43	3.59	0.83	0.85
29-03-2014	16:30:00	49.66	224.90	15.90	3.07	0.76	1.87	0.47	3.59	0.89	0.85
29-03-2014	16:31:00	49.65	225.30	15.90	3.08	0.81	1.88	0.50	3.60	0.95	0.85
29-03-2014	16:32:00	49.66	225.70	16.10	3.09	0.86	1.92	0.53	3.64	1.01	0.85
29-03-2014	16:33:00	49.66	224.90	16.00	3.07	0.91	1.89	0.56	3.61	1.07	0.85
29-03-2014	16:34:00	49.69	225.20	16.10	3.08	0.97	1.92	0.59	3.63	1.13	0.85
29-03-2014	16:35:00	49.67	224.80	16.00	3.07	1.02	1.88	0.62	3.60	1.19	0.85
29-03-2014	16:36:00	49.66	224.90	16.00	3.07	1.07	1.90	0.66	3.61	1.25	0.85
29-03-2014	16:37:00	49.68	224.90	15.90	3.07	1.12	1.86	0.69	3.59	1.31	0.86
29-03-2014	16:38:00	49.66	224.40	15.90	3.05	1.17	1.87	0.72	3.58	1.37	0.85
29-03-2014	16:39:00	49.66	224.80	15.90	3.06	1.22	1.85	0.75	3.58	1.43	0.86
29-03-2014	16:40:00	49.62	225.00	15.90	3.07	1.27	1.86	0.78	3.59	1.49	0.86
29-03-2014	16:41:00	49.58	224.60	15.90	3.07	1.32	1.84	0.81	3.58	1.55	0.86
29-03-2014	16:42:00	49.57	224.70	15.90	3.07	1.37	1.84	0.84	3.58	1.61	0.86
29-03-2014	16:43:00	49.56	224.10	15.80	3.05	1.43	1.83	0.87	3.56	1.67	0.86
29-03-2014	16:44:00	49.55	224.30	15.90	3.06	1.48	1.84	0.90	3.57	1.73	0.86
29-03-2014	16:45:00	49.57	224.40	15.90	3.06	1.53	1.84	0.93	3.57	1.79	0.86
29-03-2014	16:46:00	49.56	223.90	15.80	3.05	1.58	1.82	0.96	3.55	1.85	0.86
29-03-2014	16:47:00	49.56	223.60	15.70	3.04	1.63	1.80	0.99	3.53	1.91	0.86
29-03-2014	16:48:00	49.58	223.20	15.70	3.03	1.68	1.79	1.02	3.52	1.97	0.86
29-03-2014	16:49:00	49.59	224.10	15.80	3.05	1.73	1.82	1.05	3.55	2.03	0.86
29-03-2014	16:50:00	49.59	224.40	15.80	3.05	1.78	1.83	1.08	3.56	2.08	0.86
29-03-2014	16:51:00	49.60	224.40	15.90	3.06	1.83	1.85	1.11	3.57	2.14	0.86
29-03-2014	16:52:00	49.58	224.30	15.90	3.06	1.88	1.84	1.15	3.57	2.20	0.86
29-03-2014	16:53:00	49.58	224.40	15.90	3.06	1.93	1.85	1.18	3.57	2.26	0.86
29-03-2014	16:54:00	49.62	225.00	15.90	3.08	1.98	1.86	1.21	3.60	2.32	0.86
29-03-2014	16:55:00	49.61	225.50	16.00	3.09	2.04	1.90	1.24	3.63	2.38	0.85
29-03-2014	16:56:00	49.63	225.20	16.00	3.08	2.09	1.89	1.27	3.61	2.44	0.85
29-03-2014	16:57:00	49.63	225.30	16.10	3.09	2.14	1.91	1.30	3.63	2.50	0.85
29-03-2014	16:58:00	49.64	226.40	16.10	3.12	2.19	1.94	1.33	3.67	2.57	0.85
29-03-2014	16:59:00	49.64	226.20	16.10	3.11	2.24	1.91	1.37	3.65	2.63	0.85
29-03-2014	17.00.00	49.67	225.10	16.00	3.08	2.29	1.91	1.40	3.62	2.69	0.85
29-03-2014	17.01.00	49.69	225.70	16.00	3.09	2.35	1.89	1.43	3.63	2.75	0.85

29-03-2014	17.02.00	49.66	225.60	16.00	3.09	2.40	1.90	1.46	3.63	2.81	0.85
29-03-2014	17.03.00	49.57	224.80	16.00	3.07	2.45	1.90	1.49	3.61	2.87	0.85
29-03-2014	17.04.00	49.54	225.10	16.00	3.09	2.50	1.87	1.52	3.61	2.93	0.85
29-03-2014	17.05.00	49.50	224.70	15.90	3.08	2.55	1.86	1.55	3.60	2.99	0.86
29-03-2014	17.06.00	49.52	224.80	16.00	3.08	2.60	1.87	1.59	3.60	3.05	0.86
29-03-2014	17.07.00	49.51	224.60	16.00	3.07	2.65	1.87	1.62	3.60	3.11	0.85
29-03-2014	17.08.00	49.51	225.20	16.00	3.09	2.71	1.87	1.65	3.62	3.17	0.86
29-03-2014	17.09.00	49.50	223.70	15.90	3.05	2.76	1.87	1.68	3.58	3.23	0.85
29-03-2014	17.10.00	49.52	224.70	16.00	3.08	2.81	1.87	1.71	3.60	3.29	0.85
29-03-2014	17.11.00	49.56	223.70	15.90	3.04	2.86	1.85	1.74	3.56	3.35	0.85
29-03-2014	17.12.00	49.59	224.50	15.90	3.07	2.91	1.87	1.77	3.59	3.41	0.85
29-03-2014	17.13.00	49.59	223.70	15.80	3.04	2.96	1.83	1.80	3.55	3.47	0.86
29-03-2014	17.14.00	49.62	223.40	15.80	3.03	3.01	1.82	1.83	3.54	3.53	0.86
29-03-2014	17.15.00	49.58	223.40	15.70	3.03	3.06	1.79	1.86	3.52	3.58	0.86

Units Consumed= 3.06 – 0.05 = 3.01 Kwh

Table-2: Measured electrical parameters of the auto mode.

Date	Time	Hz	V	A	kW	kWh	kVAr	kVArh	KVA	kVAh	Pf
29-03-2014	17.31.00	49.7	223.7	11.0	2.372	3.69	0.67	2.11	2.46	4.30	0.96
29-03-2014	17.32.00	49.8	223.9	11.0	2.376	3.73	0.68	2.13	2.47	4.34	0.96
29-03-2014	17.33.00	49.7	222.8	10.9	2.347	3.77	0.65	2.14	2.44	4.38	0.96
29-03-2014	17.34.00	49.7	223.4	10.9	2.363	3.81	0.67	2.15	2.46	4.42	0.96
29-03-2014	17.35.00	49.7	224.3	11.0	2.389	3.85	0.69	2.16	2.49	4.46	0.96
29-03-2014	17.36.00	49.6	225.0	11.1	2.412	3.89	0.71	2.17	2.52	4.50	0.96
29-03-2014	17.37.00	49.5	225.8	11.2	2.437	3.93	0.70	2.18	2.54	4.54	0.96
29-03-2014	17.38.00	49.5	226.3	11.3	2.450	3.97	0.73	2.19	2.56	4.59	0.96
29-03-2014	17.39.00	49.6	225.6	11.2	2.429	4.01	0.71	2.21	2.53	4.63	0.96
29-03-2014	17.40.00	49.6	226.8	11.3	2.459	4.06	0.76	2.22	2.58	4.67	0.96
29-03-2014	17.41.00	49.7	227.9	11.4	2.484	4.10	0.77	2.23	2.60	4.72	0.95
29-03-2014	17.42.00	49.7	227.2	11.6	2.471	4.14	0.94	2.25	2.65	4.76	0.93
29-03-2014	17.43.00	49.7	228.7	11.4	2.504	4.18	0.78	2.26	2.63	4.80	0.95
29-03-2014	17.44.00	49.7	228.3	11.6	2.499	4.22	0.88	2.27	2.65	4.85	0.94
29-03-2014	17.45.00	49.7	229.3	11.6	2.520	4.26	0.86	2.29	2.67	4.89	0.95
29-03-2014	17.46.00	49.7	229.1	11.6	2.516	4.31	0.86	2.30	2.66	4.94	0.95
29-03-2014	17.47.00	49.7	229.4	11.6	2.523	4.35	0.85	2.32	2.67	4.98	0.95
29-03-2014	17.48.00	49.7	229.3	11.4	2.519	4.39	0.72	2.33	2.62	5.02	0.96
29-03-2014	17.49.00	49.7	229.4	11.4	2.523	4.43	0.73	2.34	2.63	5.07	0.96
29-03-2014	17.50.00	49.7	229.5	11.4	2.524	4.47	0.74	2.35	2.63	5.11	0.96
29-03-2014	17.51.00	49.7	229.5	11.5	2.523	4.52	0.71	2.37	2.62	5.16	0.96
29-03-2014	17.52.00	49.8	230.4	11.5	2.541	4.56	0.81	2.38	2.67	5.20	0.95
29-03-2014	17.53.00	49.8	229.6	11.7	2.524	4.60	0.95	2.40	2.70	5.24	0.94
29-03-2014	17.54.00	49.8	231.2	11.7	2.563	4.64	0.88	2.41	2.71	5.29	0.95
29-03-2014	17.55.00	49.8	230.9	11.7	2.557	4.69	0.92	2.43	2.72	5.34	0.94
29-03-2014	17.56.00	49.8	231.2	11.7	2.565	4.73	0.90	2.44	2.72	5.38	0.94
29-03-2014	17.57.00	49.8	231.7	11.6	2.576	4.77	0.79	2.45	2.70	5.43	0.96
29-03-2014	17.58.00	49.8	231.2	11.9	2.569	4.81	0.99	2.47	2.75	5.47	0.93
29-03-2014	17.59.00	49.8	232.5	11.6	2.596	4.86	0.76	2.48	2.70	5.52	0.96
29-03-2014	18.00.00	49.8	232.8	11.6	2.604	4.90	0.77	2.50	2.71	5.56	0.96

29-03-2014	18.01.00	49.8	232.2	11.6	2.591	4.94	0.75	2.51	2.70	5.61	0.96
29-03-2014	18.02.00	49.8	232.2	11.6	2.589	4.99	0.75	2.52	2.70	5.65	0.96
29-03-2014	18.03.00	49.7	232.0	11.6	2.585	5.03	0.75	2.53	2.69	5.70	0.96
29-03-2014	18.04.00	49.6	231.9	11.6	2.583	5.07	0.82	2.55	2.71	5.74	0.95
29-03-2014	18.05.00	49.7	230.5	11.7	2.554	5.12	0.93	2.56	2.72	5.79	0.94
29-03-2014	18.06.00	49.6	229.8	11.7	2.540	5.16	0.89	2.58	2.69	5.83	0.94
29-03-2014	18.07.00	49.5	229.6	11.5	2.534	5.20	0.79	2.59	2.65	5.88	0.95
29-03-2014	18.08.00	49.5	227.3	11.7	2.483	5.24	0.98	2.61	2.67	5.92	0.93
29-03-2014	18.09.00	49.5	228.1	11.4	2.496	5.28	0.79	2.62	2.62	5.96	0.95
29-03-2014	18.10.00	49.6	227.4	11.5	2.478	5.32	0.87	2.63	2.63	6.01	0.94
29-03-2014	18.11.00	49.5	227.0	11.5	2.471	5.37	0.85	2.65	2.62	6.05	0.94
29-03-2014	18.12.00	49.5	226.9	11.3	2.465	5.41	0.70	2.66	2.56	6.09	0.96
29-03-2014	18.13.00	49.5	227.1	11.3	2.470	5.45	0.70	2.67	2.57	6.14	0.96
29-03-2014	18.14.00	49.6	227.5	11.3	2.479	5.49	0.71	2.68	2.58	6.18	0.96
29-03-2014	18.15.00	49.6	227.2	11.2	2.473	5.53	0.69	2.69	2.57	6.22	0.96
29-03-2014	18.16.00	49.6	226.9	11.2	2.462	5.57	0.67	2.71	2.55	6.27	0.97
29-03-2014	18.17.00	49.6	227.1	11.2	2.469	5.61	0.68	2.72	2.56	6.31	0.96
29-03-2014	18.18.00	49.6	226.4	11.2	2.450	5.65	0.68	2.73	2.54	6.35	0.96
29-03-2014	18.19.00	49.6	225.9	11.2	2.438	5.69	0.66	2.74	2.53	6.39	0.96
29-03-2014	18.20.00	49.6	225.3	11.1	2.421	5.73	0.67	2.75	2.51	6.43	0.96
29-03-2014	18.21.00	49.5	225.2	11.1	2.419	5.77	0.67	2.76	2.51	6.48	0.96
29-03-2014	18.22.00	49.5	224.4	11.0	2.401	5.81	0.66	2.77	2.49	6.52	0.96
29-03-2014	18.23.00	49.5	223.9	11.1	2.387	5.85	0.70	2.78	2.49	6.56	0.96
29-03-2014	18.24.00	49.5	223.9	11.0	2.384	5.89	0.66	2.80	2.47	6.60	0.96
29-03-2014	18.25.00	49.5	223.0	11.3	2.362	5.93	0.92	2.81	2.54	6.64	093
29-03-2014	18.26.00	49.6	223.9	11.0	2.381	5.97	068	2.82	2.48	6.68	0.96
29-03-2014	18.27.00	49.5	223.1	11.0	2.357	6.01	0.69	2.83	2.46	6.73	0.96
29-03-2014	18.28.00	49.7	221.8	11.1	2.318	6.05	0.84	2.85	2.47	6.77	0.94
29-03-2014	18.29.00	49.8	222.6	10.8	2.332	6.09	0.64	2.86	2.42	6.81	0.96
29-03-2014	18.30.00	49.8	221.4	11.0	2.304	6.13	0.84	2.87	2.45	6.85	0.94

Units Consumed= 6.13 – 3.69 = 2.44 Kwh

Savings while connected to a lighting energy saver = 3.01 – 2.44 = 0.57 Kwh

The performance of various energy savers provided in different workshops is shown in Table 3.

Table-3: Performance of the lighting energy savers

Sl. No.	Shop	Rating	No. of Lamps	Watts	One week consumption ES mode (27.02.14 – 09.03.14)	One week consumption Pass mode (05.03.14 – 12.03.14)	One week Savings (Units)
1.	WCS	10 KVA	28	250W	254.30	375.24	106.94
2.	WAS	7.5 KVA	19	250W	183.75	206.66	21.91
3.	WBS	7.5 KVA	14	150W	181.14	241.93	60.79
4.	WBS	7.5 KVA	15	250W	147.12	197.73	50.61
5.	BRS /IOH	5 KVA s/Ø	13	250W	151.03	218.94	67.91
6.	WAS	5 KVA s/Ø	12	250W	143.57	167.41	23.84
7.	CRS II BAY	3 KVA s/Ø	7	250W	81.35	125.87	44.52
8.	WS RB	5 KVA s/Ø	FL 40	56W	110.52	156.61	46.09
9.	DSL CGS	3 KVA s/Ø	FL 22	56W	83.42	115.15	31.73
10.	FSS	3 KVA s/Ø	9	250W	68.9	89.3	20.4
11.	HERS	5 KVA s/Ø	13	250W	28.94	70.99	42.05

12.	CRS	3 KVA s/Ø	5	250W	42.04	66.02	23.98
13.	DSL	5 KVA s/Ø	7	250W	26.4	135.99	109.59
14.	HERS	3 KVA s/Ø	7	250W	13.31	38.9	25.59
					1515.79	2206.74	675.95

Bypass mode (normal) consumption/week : 2206.74 units

Energy saving mode consumption/week : 1515.79

Savings : 690.95

% savings : 690.95

= 31.31%

The performance test conducted with 3 KVA and 5 KVA lighting energy savers is shown in Tables 4 and 5.

Table-4: Performance Test:3 KVA (Applied Voltage: 230V, 50Hz)

Sl. No.	Load	Nos.	Total load
01	40 Watts F/L (CU Chokes)	08	(50 * 8) = 400
02	36 Watts F/L (CU Chokes)	30	(45 * 30) = 1350
03	36 Watts F/L (Electronic Chokes)	04	(36 * 4) = 144
04	23 Watts CFL	05	(23 * 5) = 115
05	250 Watts HPSV	02	(300 * 2) = 600
06	250 Watts MH	04	(300 * 4) = 1200
			3809 Watts

Table-5: Parameters Table: 3 KVA (Applied Voltage: 230V, 50Hz)

Parameters							
Without a power saver device							
Voltage (V)	Current (I)	Power Factor	Real power (W)	Energy (KWH)	App. Power (VA)	Lux level	% THD
228	11.63	0.933	2507	2.48	2669	220/ 487/ 340/ 192	2.968 (V) 15.39 (I)
With a power saver device							
206	9.045	0.954	1981	1.96	2064	215/ 429/ 225/ 155	3.263 (V) 15.88 (I)

1. Energy Saving = $\frac{2.48 - 1.96}{2.48}$ x 100 = 20.96 % (Shall not be less than 15%)
2. Lumens drop = $\frac{220 - 215}{220}$ x 100 = 2.27 % (Shall not be less than 5%)
3. Reduction in KVA = $\frac{2669 - 2064}{2669}$ = 22.67 % (Shall not be less than 12%)
4. Harmonic level is almost same.

The test certificate on the measurement performed by the central power research institute of Bangalore for a 3 KWH lighting energy saver is shown in Table 6. (All four readings are not shown due to space constraints.)

Table-6: CPRI Test Report

Sl. No.	Measured Parameters	Without the Energy Saver	With the Energy Saver
1.	Voltage, V	224.52	227.47
2.	Current, A	15.91	11.35
3.	Power Factor	0.85	0.95
4.	Active Power, kW	3.03	2.45
5.	Apparent Power, VA	3.57	2.58
6.	Energy Consumption, kWh	3.010	2.430
7.	Lux level measured at a common point with all luminaries.	1340 lux	1260 lux
8.	V THD	2.6 %	1.98 %
9.	A THD	21.6 %	18.92 %
10.	Energy Reduction		19.269 %
11.	% of reduction in the lighting level		5.97 %
	Type of Lams used for the test		
	Type of Lams	Wattage (W)	Quantity
1.	Tube light with copper chock	40	5 Nos.
2.	Tube light with Electronic chock	40	5 Nos.
3.	Tube light with copper chock	36	31 Nos.
4.	CFL with Electronic chock	23	5 Nos.
5.	HPMV lamp with copper chock	250	2 Nos.
6.	MH Lamp with copper chock	250	2 Nos.
7.	HPSV Lamp with copper chock	250	2 Nos.

Note: The measured parameters for bypass mode are given in table 1 and for auto mode are given in table 2.

The energy saving calculation for a set of lighting energy savers is shown in Table 7.

Table-7: Energy Savings Calculation Payback period calculation: Cost of the various energy savers provided

10 KVA	Rs. 78500 × 1	78500
7.5 KVA	Rs. 53700 × 3	161100
5 KVA	Rs. 40000 × 6	240000
3 KVA	Rs. 24000 × 4	96000
		575600

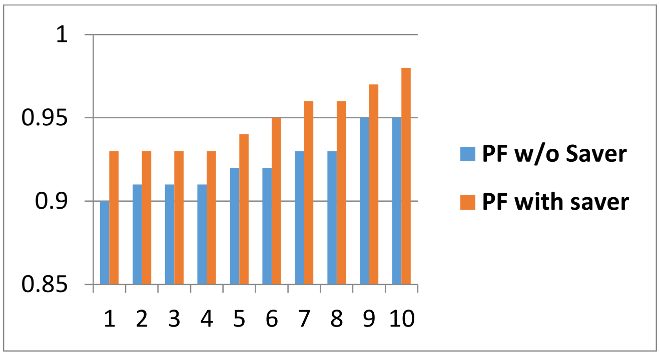
Unit Savings/Week	675
Unit Savings/day	113 (675 / 6)
Unit Savings/month	2825 (113 × 25)
Unit Savings/Year	33900 Units (2825 × 12)
Coat Savings/Year	33900 ×Rs. 8 = Rs. **2,71,200/-**
Payback period	575600 / 271200 = **2.12 Years**

The power factor of the system measured with and without an energy saver is shown in Table 8.

Table-8: Power factor with / without the energy saver

Sl. No.	Voltage	PF w/o Saver	PF with saver
1.	180	0.90	0.93
2.	185	0.91	0.93
3.	190	0.91	0.93
4.	195	0.91	0.93
5.	200	0.92	0.94
6.	210	0.92	0.95
7.	220	0.93	0.96
8.	230	0.93	0.96
9.	240	0.95	0.97
10.	250	0.95	0.98

The comparative graph is also shown.



As observed from the table, the power factor is slightly improved with the use of an energy saver.

IV. METHOD II: SUITABLE SEGREGATION LIGHTS ONTHE WORK FLOOR

By constant observation during the night shift, the following observations are made.

Night Shift is from 10.00 PM to 00.00 and 00.00 to 06.00 AM

Activities peak from10 PM to 1 AM

Activities are moderate from 1 AM to 3 AM

Activities are almost nil from 3 AM to 6 AM

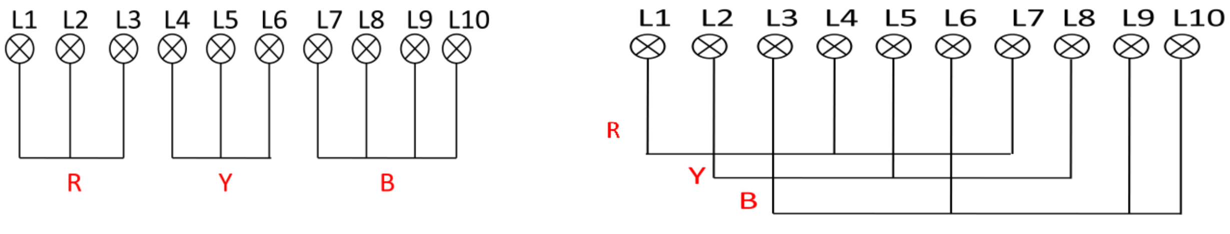
The shop floor normally consists of 10 250W high bay MH lamps that are connected to a 3-phase dedicated line called the lighting main, which is controlled by one 3-phase 10 Amp MCB. In this proposal, from 3 Am to 6 AM, some of the lights can be switched off to save energy without affecting the work force.

The lights are normally connected as shown in Fig. 2a.

L1, L2, L3 R PHASE
L4, L5, L6 Y PHASE.
L7, L8, L9, L10 B PHASE.

By suitably changing the supply arrangement by connecting alternate lights as shown in Fig. 2b, some of the lights can be switched off for savings.

L1, L4, L7 = R phase
L2, L5, L8 = Y phase
L3, L6, L9, L10 = B phase



(a) (b)

Fig-2. (a) Existing Arrangement (b) Modified Arrangement

The existing 3-phase 10 Amp MCB controlled by a 3 single phase 6 Amp MCBs can be replaced and a contactor and timer can be added in the “Y” phase to switch off 3 lights (L2, L5, and L8) after 3 AM to 6 AM, when the activities are almost nil.

The saving by switching off the 3 lights will be

For 3 light fittings of 250W each for 3 hours of consumption	2.25 units/day
For 25 days working in one month during savings	25 × 2.25 = 56 Units in one workshop
For all 10 shops where the night shift benefits from the savings	56 ×10 = 560 Units/month.
Savings per annum	560 × 12 = 6720 Units/annum
Cost savings expected	6720 × 8 = Rs. 53760 approximately.
Cost of the timer contactor and replacement of the MCB	Rs. 3000
For 10 shops	Rs. 30000.
payback period	30000/53760 = 5 months.

V.CONCLUSION

In the present case study, energy conservation according to alighting audit has shown tremendous improvement in energy savings. During the audit, the main objective was to find ways to conserve energy without sacrificing visual comfort and without affecting production. The identified methods give a scope of 2 to 3% savings from the existing consumption level. The payback period in both cases is good, particularly in the second case, where the payback period is less than half a year, and this value will be added as profit in the future of the workshop. However, the proposed audit only focuses on reducing the energy bill and does not focus on improving the comfort level in the working area or ensuring a productivity increase.

ACKNOWLEDGMENT

The author wishes to thank Mr. S. Ganesan, Sr. Section Engineer, Southern Railway and Shri. R.V. Swaminathan, Dy.CEE/Perambur for their support and valuable guidance to the project.

REFERENCES

[1] V.K. Bhansali, “Energy Conservation in India – Challenges and Achievements”, 0-7803-2081 -6195 $1 .00 © 1995 IEEE.

[2] C. Palanichamy, C. Nadarajan, P. Naveen, Natarajan Sundar Babu, and Dhanalakshmi, “Budget Constrained Energy Conservation—An Experience With a Textile Industry”, IEEE Transactions on Energy Conversion, vol. 16, No. 4, December 2001

[3] Wendy Ellens, Adam Berry, Sam West, “A Quantification of the Energy Savings by Conservation Voltage Reduction”, 978-1-4673-2868-5/12/$3l.00 ©2012 IEEE

[4] V.A. Kulkarni, Member IEEE and P.K. Katti, “Improvement of Energy Efficiency in Industries by Facility Based Energy Management”.

[5] Muhammad Usman Khalid Mariam Gul, “Energy Conservation through Lighting Audit”, 2012 IEEE International conference on Power and Energy (PECON).

[6] Putrizalilayaccob and Abdullah Ashumohd, “Electrical Energy Management in Small and Medium size industries”.