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Optimizing the Lighting System in a Commercial Railway Depot Using Energy Audit Technique

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Abstract
In any industrial, commercial, and residential area the three top operating expenses are found to be energy, material or machine and labor. In the present scenario India has been facing an increase in energy demand due to its growing population and economy. To maintain and stabilize the increasing energy demand, reducing energy consumption is the best option and also help in decreasing energy costs. The largest consumption goes to railway industries and workshops from all available energy consuming sectors. Site visit and visual inspection of the commercial railway depot was initiated to identify the potential area to reduce consumption of energy. All the lighting data of the depot were collected and an energy audit was conducted with the idea of replacement of high electric consumption lighting with low consumption LED bulbs with equal illumination. The main scope of this energy audit is based on the idea of energy conservation. This paper gives the initial investment and the payback period calculations of each workshop with reference to LED replacement.

Keywords: Energy audit, Railway depot, Conservation

Introduction

Electrical energy is the most expensive and the most important form of purchased energy. For this reason, its use must be confined to a minimum for efficient and economic operation [1]. In developing countries like India, where electrical energy resources are scarce and production of electricity is very costly, energy conservation studies are of great importance. Energy audit is the translation of conservation ideas into realities by blending technically feasible solutions with economic and other organizational considerations within a specified time frame [2]. An energy audit is a study of a plant or facility to determine how and where energy is used and to identify methods for energy savings. Energy audits can mean different things to different individuals. The scope of an energy audit, the complexity of calculations, and the level of economic evaluation are all issues that may be handled differently by each individual auditor and should be defined prior to the beginning of any audit activities [3,4]. Reducing the energy usage or improving the energy efficiency in mechanical and electrical installations in a building, energy can be conserved and also alleviate the resulting environmental problems, such as greenhouse effect and ozone depletion. The energy audit of an industrial unit has been explored in this work. Energy conservation can be obtained by the use of low energy consuming bulbs.

Procedure Methodology

Energy audit cannot be successfully carried out without the commitment from the top management. Management must be firstly convinced of the necessity of implementing energy management and hence energy audit [5]. Energy audit consists of several tasks, which can be carried out depending on the type of the audit and the size and the function of the audited facility [6]. Therefore, an energy audit is not a linear process and is rather iterative. The audit described in this paper has been carried out based on the following functional activities:

- Primary energy audit
- Secondary energy audit
- Detailed energy audit

A railway depot facility is selected for the energy auditing due to the fact that the number of lighting involved in a Depot building is huge and the possibility of energy conservation is more. Lighting load is where most of the energy is wasted than consumed. In any depot building, lighting load consumes more than 80% of the total electrical energy consumption. Replacing the regular tube lights employing electromagnetic ballast, metal halide high bay lights and compact florescent lamp (CFL) tubes with Light Emitting Diodes (LEDs) is discussed in the paper.

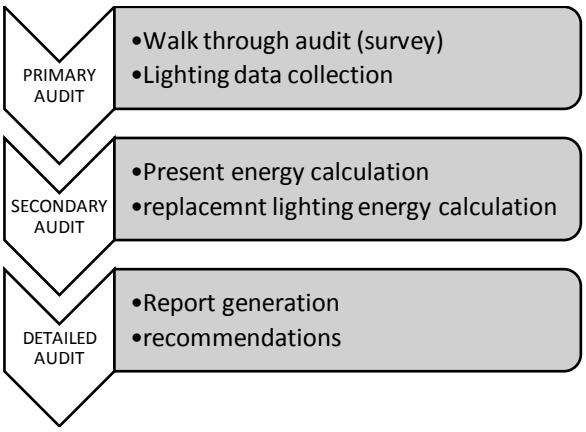

Fig. 1. Process Flowchart.

Lighting Calculation

The average cost of electricity is Rs 7 per unit based on Tamil Nadu Electricity Board (TNEB) Tariff. It is assumed the lighting energy consumption is 12 hrs per day. Full lighting is considered in all the areas under the scope. The depot layout has various sheds. The audit conducted sheds are stabling shed and rolling stock shed along with high mast lighting which is also situated in the depot.

Storage Shed Lighting

The storage shed was entirely surveyed and all the details of the lighting of the storage shed was collected and audited. The type of bulb used is Metal Halide highbay lamp 400W each bulb. Table. 1. shows the metal halide lamp energy data.

TABLE.1. Metal Halide Lamp Energy Data

Present energy usage: (12 hrs/day timeline)		
Type of electric bulb used in shed is Metal Halide high bay lamps.		
1	Total number of lamps	252 nos
2	Total number of watts	1,00,800 W
3	Total number of watts annually	44,15,04,000 W
4	Total number of units consumed annually	4,41,504 units/yr.
5	Total cost monthly	Rs. 2,57,544
6	Cost annually	Rs. 3,090,528

The type of LED high bay lamp selected is 120 W Lionway high bay lamp. Table. 2. shows LED lamp energy calculation.

TABLE. 2. LED Energy Calculation.

Predicted energy usage: (12 hrs/day timeline)		
Lionway high bay lamp assumed to be used in shed is LED		
1	Total number of lamps	252nos
2	Total number of watts	30,240 W
3	Total number of watts annually	13,24,51,200W
4	Total number of units consumed annually	1,32,451.2units/yr.
5	Total cost monthly	Rs 77,263.2
6	Cost annually	Rs 9,27,158.4

TABLE. 3. Yearly Savings Data for Storage Shed.

Savings	
Energy saved	309,052.8 units / yr.
Money saved	Rs 2,781,475.2 per yr.

Maintenance Shed Lighting

The shed consists of the following areas:

- Office rooms (ground floor + first floor)
- Pit bay lights
- High bay lights

TABLE.4. Payback data for storage shed.

Payback time	
Price of 120 W LED: Rs 6,696 (Lionway high bay lamp)	
Total investment	(252 x 6696) = Rs 1,687,392
Payback time	(Investment cost / annual saving) x 12 months = (16,87,392 / 27,81,475.2) x12 = 7.2 months

TABLE.5. (CFL+Metal Halide+LED+Tube Light) Energy Data for Maintenance Shed.

Present energy usage: (12 hrs/day timeline)		
Type of electric lights used in shed is (CFL+Metal Halide+LED+Tubelight).		
1	Total number of lamps	1264 nos
2	Total number of watts	170,662 W
3	Total number of watts annually	747,499,560 W
4	Total number of units consumed annually	747,499.56 units/yr.
5	Total cost monthly	Rs 436,041.41
6	Cost annually	Rs 5,232,496.92

The type of LED lights selected for replacement:
14W Tube Light is replaced with 6W LED
14W Tube Light is replaced with 8W LED
18W CFL is replaced with 10W LED
28W Tube Light is replaced with 16W LED
400W Metal halide is replaced with 120W LED

TABLE. 6. Combined LED Energy Data for Maintenance Shed.

Predicted energy usage: (12 hrs/day timeline)		
Multiple type of lamps assumed to be used in shed is LED given from above list		
1	Total number of lamps	1264 nos
2	Total number of watts	91,102 W
3	Total number of watts annually	39,90,26,760W
4	Total number of units consumed annually	3,99,026.76 units/yr.
5	Total cost monthly	Rs 2,32,765.61
6	Cost annually	Rs 2,793,187.32

TABLE.7. Yearly Savings Data for Maintenance Shed.

Savings	
Energy saved	3,48,472.8 units / yr.
Money saved	Rs 2,439,309.6 per yr.

High Mast Lighting

High-mast lighting is a tall pole with lighting attached to the top pointing towards the ground, usually but not always used to light a highway or recreational field.

TABLE. 8. Payback Data for Maintenance Shed.

Payback time	
6W 280 x 735 *8W* - (70+71+30+64)x 645 *10W* - (16+6)x 699 *16W* - (72+204+78) x 1449 *120W* - 324 x 6696	= Rs 2,05,800 = Rs 1,51,575 = Rs 15,378 = Rs 5,12,946 = Rs 2,169,504
Total investment cost	Rs 3,055,203
Payback time	(Investment cost/annual saving) x 12 months = (30,55,203/ 24,39,309.6) x 12 = **15 months**

The pole that the lighting is mounted on is generally at least 30 meters (98 ft.) tall (under this height it is referred to as conventional lighting system), while the lighting consists of a luminaries ring surrounding the pole with one or several independent lighting fixtures mounted around it. Some units have the lighting surrounded by a circular shield to prevent or reduce light pollution or light trespass from affecting neighborhoods adjacent to the highway.

TABLE.9. Metal Halide Bulb Energy Data for High Mast.

Present Energy usage:		
Type of bulbs used is Metal Halide		
1	Total number of pillars	19 nos
2	Total Wattage per pillar	8,000 W
3	Total number of lights in each pillar	12
4	Total hours of lights used per day	12
5	Total energy consumed per pillar per day	96 kWhr
6	Total energy consumed by all 19 pillars per day	1824 kWhr
7	Total energy consumed by pillars per year	6,65,760 kWhr
8	Total number of units consumed annually	6,65,760 units/yr.
9	Monthly cost for electricity consumption	Rs 3,88,360
10	Annual cost for electricity consumption	Rs 46,60,320

TABLE.10. LED Bulb Energy Data for High Mast.

Predicted Energy usage:		
Type of bulbs used is LED		
1	Total number of pillars	19 nos
2	Total Wattage per pillar	2,400 W
3	Total number of lights in each pillar	12
4	Total hours of lights used per day	12
5	Total energy consumed per pillar per day	28,800 Whr
6	Total energy consumed by all 19 pillars per day	5,47,200 Whr
7	Total energy consumed by pillars per year	19,97,28 KWhr
8	Total number of units consumed annually	1,99,728 units/yr.
9	Monthly cost for electricity consumption	Rs 13,98,096
10	Annual cost for electricity consumption	Rs 1,16,508

TABLE.11. Yearly Savings Data for High Mast.

Savings:	
Energy saved	4,66,032 units / yr.
Money saved	Rs 32,62,224 per yr.

TABLE.12. Payback Data for High Mast.

Payback time:	
Each LED cost is Rs 11,160	
Total investment cost	Rs 25,44,480
Payback time	(Investment cost/annual saving) x 12 months = (25,44,480 / 32,62,224) x 12 **= 9.3 months**

Discussion and Result

The overall potential savings is estimated based on our audit with LED lighting as given below:

Annual savings (kWhr) : 11, 23,556
Annual savings (Rupees) : 84, 83,008
Total investments (Rupees) : 57, 67,075

TABLE.13. Summary Data.

Storage shed:		
1	Annual Savings	3,09,052 kWhr
2	Annual Savings	Rs. 27,81,475
3	Investments	Rs. 16,87,392
4	Payback	7.2 months
Maintenance shed:		
1	Annual Savings	3,48,472 kWhr
2	Annual Savings	Rs. 24,39,309
3	Investments	Rs. 30,55,203
4	Payback	15 months
High mast light:		
1	Annual Savings	4,66,032 kWhr
2	Annual Savings	Rs. 32,62,224
3	Investments	Rs. 25,44,480
4	Payback	9 months

By conducting this energy audit, we were able to find out that a lot of energy can be saved by replacing the present lights with LEDs. So, immediate steps are to be taken in order to reduce energy consumption and decrease energy demand. It will certainly help in decrease national expenditure in power

production and help in easing economic expenses of energy sector.

Conclusion

The utilization of Electrical energy in buildings is continuously increasing due to the new living standard. Electrical Energy consumption will continue to grow likely in the future. Therefore Energy Audit is essential as it determines several energy saving techniques which can be performed within an organization to reduce electrical energy utilization. To achieve optimal energy performance in buildings, energy audit is able to reduce energy wastes and provides the cost benefit and pay back periods.

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