Energy Conservation Techniques Adapted for Conservation of Electrical Energy in Grid Station

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***Abstract*—An attempt has been made in this paper to reveal the energy conservation techniques adapting for conservation of energy in grid station. The most important law governing the transfer of energy from one to the other form is the law of conservation of energy which states that energy can neither be created nor be destroyed; however, it can be converted from one form to another form. Energy auditing is not an exact science, but a number of opportunities are available for improving the accuracy of the recommendations. I began by discussing how to perform energy and demand balance. This balance is an important step in doing an energy use analysis because it provides a check on the accuracy of some of the assumptions necessary to calculate savings potential. I did energy audit of control room and residential quarters of 220/132/33 KV Grid Station Complex. There were 1 control room and 12 residential quarters having 48 fluorescent tube lamps (FTL), 51 incandescent lamps, 63 high pressure mercury vapour lamps (HPMV), 11 computers with 3 AC's. It was found that the electric fixtures installed in the control room and residential quarters are not energy efficient. Thus there is scope of audit in the control room and residential quarters. I took the half hourly readings of current drawn by various equipments manually by using clamp meter.**

Keywords—Fluorescent tube lamps, air conditioners, energy conservation measures, compact fluorescent lamp, kilovolt, kilowatt, cathode ray tube, liquid crystal diode.

I. INTRODUCTION

The most important law governing the transfer of energy from one to the other form is the law of conservation of energy which states that energy can neither be created nor be destroyed; however, it can be converted from one form to another form. It also states that total amount of energy in an isolated system remains constant [1]. Energy conservation is the practice of decreasing the quantity of energy used while achieving a similar output at the end for use [2], [3]. On a larger scale, energy conservation is an element of energy policy [4]. Cheap and sub standard gadgets consume more power as compared to expensive standard gadgets and prove to be costlier on a long run [5-13]. Consideration should be given to the Life cycle cost rather than capital cost while purchasing any gadget. It should always be kept in mind that electricity saved is money saved. The area chosen for the energy conversion opportunities is 220/132/33KV grid station situated at village Barn which is 25Kms from Jammu as shown in figure 1 and figure 2. The Grid station Barn was inaugurated in the year 2005. Today, this Grid Station has a capacity to supply 320MVA power to the Jammu province. As on date it is being receiving power from Power Grid Corporation of India Ltd at Grid Station Kishenpur at 220KV level. Further it is step down from 220KV to 132KV and this 132KV is transmitted to Jammu at Grid Station Canal. On the other hand, again it is Step down from 132KV to 33KV which is again supplied to Purkhoo, Akhnoor, Bhalwal area of Jammu Province.

Fig. 1 Switch yard of Barn Grid Station

In this energy Audit I adopt energy conservation techniques in control room and residential quarters of 220/132/33KV Grid Station complex at Barn, Jammu. There were 1 Control room and 12 Residential Quarters having 48 FTL having wattage 55W, 51 Incandescent lamps having wattage 100W, and 63 High pressure mercury vapour lamps having wattage 250W, 11 Computers having wattage 40W with 3 AC's. It was found that the electric fixtures installed in the control room and residential quarters are not energy efficient. Thus there is scope of audit in the control room and residential quarters. I took the half hourly readings of current drawn by various equipments manually by using clamp meter.

Fig. 2 Control room of Barn Grid Station

II. CASE STUDY

I suggested four energy conservation measures:

- Replacing of incandescent lamps with compact fluorescent lamps (CFL).
- Replacement of 40watts T12 FTL having 15watts magnetic ballast with 36watts T8 FTL having 4watts electronic ballast.
- Replacement of high pressure mercury vapour lamps (HPMV) with high pressure sodium vapour lamps (HPSV).
- Replacement of existing Cathode ray tube (CRT) monitor with Liquid crystal diode (LCD) Monitor.

Under first measure has very very small investment with the payback period of 1 month. Second one also has small initial investment with payback period less than one year. Third one has payback period of one year. Fourth one has large initial investment with payback period of 3.65 years.

ECM 1: Replacing of Incandescent Lamps with Compact Fluorescent Lamps (CFL)

TABLE I. EXISTING INCANDESCENT LAMPS AND PROPOSED CFL

S. No	Existing Incandescent Lamps	Proposed CFL	No. of Fixtures
1	100watts	20watts	51

Energy Saving achieved by replacing 100watts Incandescent Lamps with 20watts CFL's is given as under:
The use of 20watts CFL's offers the same lumen output as compared to a 100watts Incandescent Lamps.
Efficacy of Incandescent lamps is about 12 lumens/watt.
Hence, 100 × 12 = 1200 lumens/watt
Efficacy of CFL's is about 60 lumens/watt
Hence, 60 × 20 = 1200 lumens/watt

Monetary savings
Monetary savings per year = Rs.59568
Investment Required = Rs.6200
Pay Back period = 38 Days (< 1 Year)

Calculations for Energy Conservation Measures - I

There are 51 Incandescent lamps in the grid station complex, which are recommended for replacement with 20watts CFL. The economics of such a replacement is worked out as under:
Present Installed Wattage = Watts × Lamps
=100 watts × 51 = 5.10 KW
Proposed Installation wattage = 20 watts × 51 = 1.02 KW
Reduced Installation wattage = 5.10 – 1.02 = 4.08 KW
Annual savings in energy @10 hours per day and 365 days of operation with an electricity rate of Rs.4 per KWhr
= 365 × 10 × 4.08 × 4 = Rs.59568/-
Investment required including cost of CFL's
= 120 × 51 = Rs.6200/-
Payback Period = (Rs.6200 / Rs.59568) × 365 days
= 38 Days (< 1 Year)
Existing 51 Incandescent lamps energy consumption
=51×100 × 10 × 365 = 18615000Wh
=18615KWh
Proposed 51 CFL's energy consumption
=51×20 × 10 × 365 = 3723000Wh
=3723KWh
The calculated values of energy saving using ECM I as shown in figure 3.

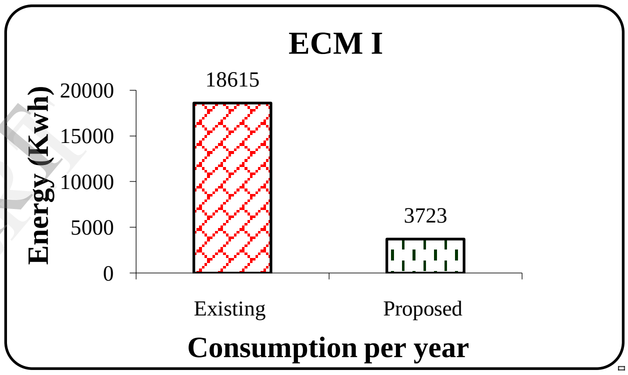

Fig. 3 Detail of energy saving using ECM-1

ECM 2: Replacement of 40watts T12 FTL having 15watts Magnetic Ballast with 36watts T8 FTL having 4watts Electronic Ballast.

TABLE II. EXISTING 40 WATTS T12 FTL WITH 15 WATTS MAGNETIC BALLAST AND PROPOSED 36 WATTS T8 FTL HAVING 4 WATTS ELECTRONIC BALLAST

S. No	Existing 40watts T12 FTL with 15watts Magnetic Ballast	Proposed 36watts T8 FTL having 4watts Electronic Ballast	No. of Fixtures
1	40 + 15 = 55watts	36 + 4 = 40watts	48

Energy saving achieved by replacing 40watts T12 FTL with 36watts T8 FTL is given below:
The use of 36watts T8 FTL offers the same lumen output as compared with 40watts T12 FTL.

Monetary savings
Unit Monetary saving per year = Rs.10512
Investment Required = Rs.9600
Pay Back period = 333 Days (< 1 Year)

Calculations for Energy Conservation Measures - II

There are 48, 40watts T12 FTL with 15watts magnetic ballast used for illumination in residential colony and control room inside the grid station complex which are recommended for replacement with 36watts T8 FTL with 4watts electronic ballast. The economics of such a replacement is worked out as under:

Present Installed Wattage = 55 watts × 48 = 2.64 KW
Proposed Installation wattage = 40 watts × 48 = 1.92 KW
Reduced Installation wattage = 2.64 – 1.92 = 0.72 KW
Annual savings in energy @10 hours per day and 365 days of operation with an electricity rate of Rs.4 per Kwhr
= 365 × 10 × 0.72 × 4 = Rs.10512/-
Investment required = 200 × 48 = Rs.9600/-
Payback period = (Rs.9600/Rs.10512) × 365
= 333 Days (< 1 Year)
Existing 48 T12 FTL energy consumption
=48×55 × 10 × 365 = 9636000Wh
=9636KWh
Proposed 48 T8 FTL energy consumption
=48×40 × 10 × 365 = 2628000Wh
=2628KWh

The calculated values of energy saving using ECM II as shown in figure 4.

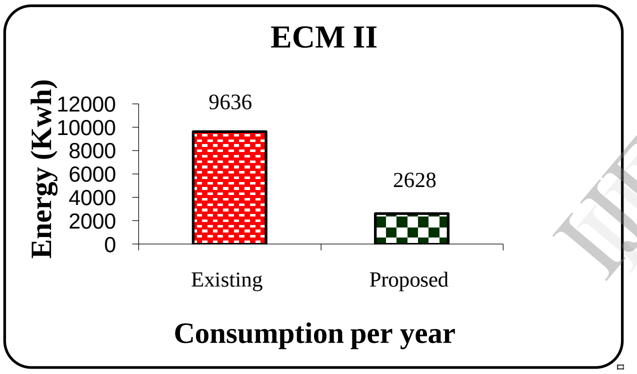

Fig. 4 Detail of energy saving using ECM-II

ECM 3: Replacement of High Pressure Mercury Vapour Lamps with High Pressure Sodium Vapour Lamps

TABLE III. EXISTING HPMV LAMPS AND PROPOSED HPSV LAMPS

S. No	Existing HPMV Lamps	Proposed HPSV Lamps	No. of Fixtures
1	250Watts, HPMV	125Watts, HPSV	63

Energy Saving achieved by replacing 250 watts HPMV Lamps with 125watts HPSV Lamps is given below:

The use of 125watts HPSV Lamp offers the same lumen output as compared with a 250watts HPMV Lamp.
HPMV Lamps provide about 50 lumens/watt.
Hence, 250 × 50 = 12500 lumens/watt
HPSV Lamps provide about 90 – 150 lumens/watt
Hence, 125 × 120 = 15000 lumens/watt

Also HPSV lamps are reliable and have long service life as compared to HPMV Lamp. colour of light from a HPSV Lamp is warm white and their colour rendering ranges from poor to fairly good.

Monetary savings
Monetary savings per year = Rs.114975
Investment Required = Rs.126000
Pay Back period = 440 Days (> 1 Year)

Calculations for Energy Conservation Measures – III

There are 63 HPMV Lamps used for Street Light and illumination in switch yard inside the Grid Station Complex which are recommended for replacement with 125watts HPSV lamps. The economics of such a replacement is worked out as under:

Present Installed Wattage = 250 watts × 63 = 15.75 KW
Proposed Installation wattage = 125 watts × 63 = 7.875 KW
Reduced Installation wattage = 15.75 – 7.875 = 7.875 KW
Annual savings in energy @10 hours per day and 365 days of operation with an electricity rate of Rs.4 per KWhr
= 365 × 10 × 7.875 × 4 = Rs.114975/-
Investment required including cost of lamp, luminaries and ballast = 2000 × 63 = Rs.126000/-
Payback Period = (Rs.138600 / Rs.114975) × 365 days
= 440 Days (> 1 Year)
Existing 63 HPMV energy consumption
=63×250 × 10 × 365 = 57487500Wh
=57487.5KWh
Proposed 63 HPSV energy consumption
=63×125 × 10 × 365 = 28743750Wh
=28743.75KWh

The calculated values of energy saving using ECM III as shown in figure 5.

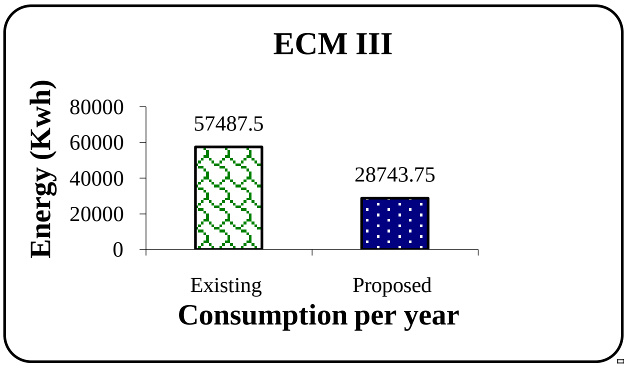

Fig. 5 Detail of energy saving using ECM-III

ECM 4: Replacement of CRT Monitors by LCD's

There are 10 pc in the control room with CRT monitor & if we replace them by LCD's then there will be following benefits:

1) The space occupied will be less.
2) The amperes drawn will be less.
3) The load on ac will be less.
4) Smaller rating UPS can be used.
5) Reduction in maximum demand.
6) Smaller ac requirement.

(note: by the use of LCD in place of CRT the area required is reduced by 1sq feet & the cost of construction of 1 sq feet is about 2000.Thus for 10 we can save 20,000.as building is already constructed and we can't do anything thus we are not putting it in our calculations)

Monetary savings
Monetary saving per year = Rs.15032.16
Investment Required = Rs.55000
Pay Back period = 1332 Days (> 3 Years)

Calculations for Energy Conservation Measures – IV
Total Load of CRT: 11 No × 40 watt = 0.44 KW
Annual energy consumed by the installed load of CRT
= 0.44 KW × 24 hrs × 365 days = 3854.40 KWhr
Annual charges of energy consumed by the installed load of CRT = 3854.40 KWhr × Rs.4/ KWhr = Rs.15417.60/-
If we replace 14watt LCD, then
Total Installed Load of LCD: 11 No × 14 watt = 0.154 KW
Annual energy consumed by the installed load of LCD
= 0.154 KW × 24 hrs × 365 days
= 1349.04 KWhr
Annual charges of energy consumed by the installed load of LCD = 1349.04 KWhr × Rs.4/ KWhr
= Rs.5396.16/-
Annual energy savings = 3854.40 – 1349.04 = 2505.36 KWhr
Assume cost of LCD = Rs.5000/-
Cost of replacement of LCD = Rs.5000/- × 11 No = Rs55000/-
Annual monetary savings = Rs. 15417.60– Rs.5396.16
= Rs.10021.44/-
We are saving 2505.36 KWhr per year = 2505360Whr
= 8543277.60 Btu (1Wh=3.41Btu)
Typical air conditioner has performance factor (k) = 2. Thus, it would require 0.5 Btu of energy to remove 1 Btu. Therefore, no. of Btu required removing 8543277.60 Btu of heat
= 8543277.60 / 2
= 4271638.80 Btu
= 1252.68 KWhr
Cost per unit = Rs.4/-
Monetary saving per year = 4 ×1252.68 = Rs.5010.72
Pay Back Period = (Cost of replacement) / (Annual savings)
= [(Rs. 55000) / (Rs. 10021.44 + Rs.5010.72)] × 365 days
= 1332 Days (> 3 Years)
Existing 11 CRT energy consumption
=11×40 × 24 × 365 = 3854400Wh
=3854.4KWh
Proposed 11 LCD energy consumption
=11×14 × 24 × 365 = 1349040Wh
=1349.04KWh
The calculated values of energy saving using ECM IV as shown in figure 6.

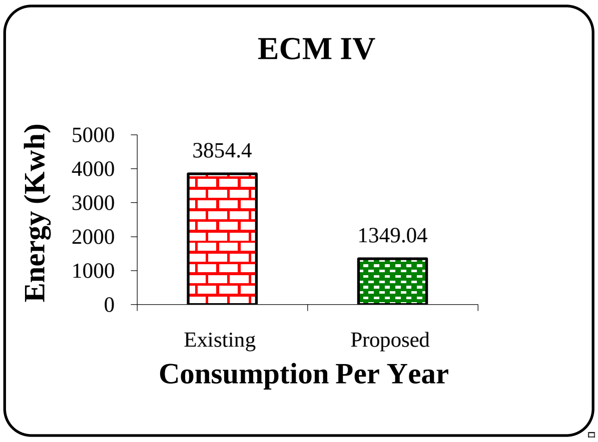

Fig. 6 Detail of energy saving using ECM-IV

III. CONSERVATION OF ELECTRICAL ENERGY BY ADAPTING SIMPLE MEAURES

1. Reducing the light sources ON Time which means improving lighting control and educating users to Turn-OFF lights when not required.
2. Using day lighting, which reduces energy consumption by replacing electric lights with natural light.
3. Ensuring simple maintenance that preserves illumination and light quality, and allows lower initial illumination level.
4. Installing LDR based automatic illumination control which automatically turns-OFF the light during day time and turns-ON the light during night.
5. Ensure simple maintenance that gives better light quality.

IV. RECOMMENDATIONS FOR THE CONSERVATION OF ELECTRICAL ENERGY IN GRID STATION

If we go for ECM 1 & ECM 2
As in ECM1 and ECM2 there is minimum initial investment with payback period less than one year. Thus we can go for them without much thought
Total no of units which we can save = 4.08 KW + 0.72 KW
=4.80 KW
Cost per unit = Rs.4.00/-
Monetary saving per day = (Rs.4 × 4.80 KW) × 10 hrs
= Rs.192/-
Monetary saving per year = Rs.192 × 365 = Rs.70080/-

If we go for ECM 3 and ECM 4
Under ECM 3 we have suggested to replace 250Watts High pressure mercury vapour lamps with 125Watts High pressure sodium vapour lamps. In this there is large initial investment required and the Payback period is 440 Days (i.e. > 1 Year). Similarly under ECM 4 we have suggested to replace Computer's CRT with LCD. In this, again the initial investment required is large and the Payback period is 1332 Days (i.e. > 3 Years). Thus it depends whether we want to go for it or not. But we can save a lot of energy if we adopt this measure.

Cost per unit = Rs.4.00
Monetary saving per year
= Rs. 10021.44 + Rs.5010.72 + Rs.114975 = Rs.130006/-

TABLE IV PRIORITY WISE RECOMMENDATIONS

Recommendations	Initial Cost	Saving in KWh (per year)	Saving in Tariff (Rs)	Pay Back Period
Replacing of Incandescent Lamps with Compact Fluorescent Lamps (CFL)	Rs.6200	14892	Rs.59568	38 Days (< 1 Year)
Replacement of 40 watts T12 FTL having 15 watts Magnetic Ballast with 36 watts T8 FTL having 4 watts Electronic Ballast	Rs.9600	2628	Rs.10512	333 Days (< 1 Year)
Replacement of High Pressure Mercury Vapour Lamps with High Pressure Sodium Vapour Lamps	Rs.126000	28743.75	Rs.114975	440 Days (> 1 Year)
Replacement of existing CRT monitor with LCD Monitor	Rs.55000	3758.04	Rs.15032.16	1332 Days (> 3 Year)

The percentage wise distribution of proposed energy by adapting all the four ECM's is shown in figure.7

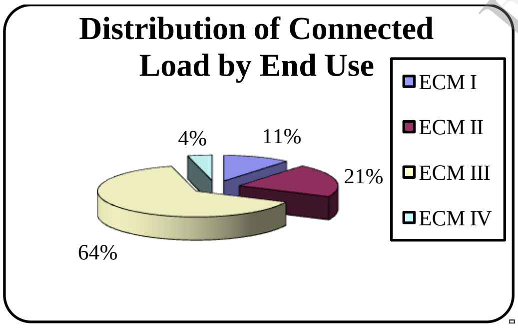

Fig. 7 Distribution of connected load by end use

V. CONCLUSION

Energy conservation is the practice of decreasing the quantity of energy used while achieving a similar output at the end for use. On a larger scale, energy conservation is an element of energy policy. Cheap and sub standard gadgets consume more power as compared to expensive standard gadgets and prove to be costlier on a long run. Consideration should be given to the life Cycle cost rather than capital cost while purchasing any gadget. It should always be kept in mind that electricity saved is money saved. The area chosen for the energy conversion opportunities is 220/132/33 KV Grid Station situated at Village Barn. By adapting four energy conservations which are discussed above we can save the energy up to greater extent because in today's scenario the generation of electrical energy is low but demand or consumption is very high. Under first measure has very very small investment with the payback period of 1 month. Second one also has small initial investment with payback period less than one year. Third one has Payback period of one year. Fourth one has large initial investment with payback period of 3.65 years

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