

Effective Energy Audit and Energy Management of Residential Building

C. R. Saravanan, R. Rathika, S. Prakash

Abstract: Electrical energy utilization in businesses is to be around 60% of the total electricity energy generation and residential utilization is around 40% of total electricity production in India. The industrial production improvement in the nation is advancing at a quick pace because of the expansion in the number of businesses, the gap between demand and supply of power is likewise expanding on regular basis. To bridge this gap the best method is to go for energy auditing of the major energy consuming Industries on general basis and also other non-core industries. The Audit review will reveal the areas of energy wastage, losses so that we can reduce the losses or plug the wastage points. Improved Life style and integration of technology with human life leads to more power consumption in day-to-day life which create a gap between production and supply of power. This paper suggests ways and means to conduct energy audit in a small works shop of TANGEDCO/TNEB (like an industry) and a residential building.

I. INTRODUCTION

ENERGY Audit is defined as the verification, monitoring and analysis of energy use including submission of technical report containing all the recommendations for improving energy efficiency with cost analysis and an action plan to reduce consumption [1]. The energy audit was conducted at the office of the Assistant Engineer/Special Maintenance/TANGEDCO/Tirupattur a small workshop where repairing of Distribution Transformers are taken up and a residential apartment at Indra colony, Siruseri, Chennai to identify the major areas of energy losses. The above workshop is located at Tirupattur Circle office. The daily average usage is about 3000 units and for a Residential Apartment is 250 units which consists of 12 flats. It has many types of equipments and machineries like winding machines, Cutters, Air compressor, Air conditioners, Drill machines, Sheet rounding machine, Hand grinder. The total area of residential building is 12000 square feet which includes 60 residents and 4 staffs. Residential apartment has many types of electrical loads such as lights, fans, air conditioners, washing machines, refrigerators, heaters and water pumps.

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II. OBJECTIVE OF AN ENERGY AUDIT

An energy audit is a process for energy inspection, building survey and analysis of energy flow for energy conservation in a building or industry, or to reduce the amount of energy into the building without affecting the output of the workshop or the consumption pattern of the residential building. Energy audit is a process of testing and analysis of energy used in the industries and other organizations. National energy conservation laws states that the regulations for energy consumption, investigation and energy audit management. In energy audit the survey of all electrical devices which use energy in a building after a certain period of time. Energy audit includes the study of supply of energy, use of energy and energy losses occurring which can be conserved for all buildings where energy is being utilized.

III. PROPOSED WORK

The following sections are covered by proposed Work.

1. Energy Audit – Commercial Building (TANGEDCO workshop)
2. Energy Audit – Residential Building

A. Energy audit- Commercial Building:

The total area of Commercial building is 4000 Square feet and total staff strength 50 including clerical staff. It has many types of equipments and machineries like winding machines filter machines, Power press, Traditional welding sets, Cutters, Air compressor, Air conditioners, Drill machines, Sheet rounding machine, Hand grinder.

Below are details of Electrical Loads:

Sanctioned Load : 108.4KW

Connected Load : 82KW

Average Bi monthly Consumption: 3000Units

Lighting/Electrical fittings

1. Tube Light (12*40W) : 480W
2. Sodium Vapour Lamp (4*250w) : 1000W
3. Ceiling Fan (8*60w) : 480W
4. Wall Mounted Fan (4*60) : 240W
5. Exhaust Fan (4*60) : 240W

Winding Machine-I

3Phase motor, 415volt, 1.5KW/2HP, 3.5Amps- 1No

Winding Machine-II

Single Phase motor, 240volt, 0.75KW/1HP, and 6.7Amps- 1No

Filter Machine

Heater : 12Elements 4KWEach – 48KW

Inlet motor: 3phase motor, 415V, 0.75KW/ 1HP, 1.8Amps

Outlet motor: 3phase motor, 415V, 1.5KW/2HP, and 3.5Amps

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Vacuum pump motor :3φ
motor,415V,1.5KW/2HP,3.5Amps

Blotter Press Machine

3Phase motor, 415volt, 3.75KW/5HP, 9Amps- 1No

Hot Air Chamber

Heater : 12 Elements 2KW each – 24KW, Cooling fan
motor Single phase motor,415volt,0.75KW/1HP,1.8Amps

Load	Quantity	Power	Total Power (W)	Units	Hours	Total Units
Tube Light	12	40W	480	0.48	16	7.68
Sodium Vapour Lamp	4	250W	1000	1	16	16
Ceiling Fan	8	60W	480	0.48	16	7.68
Wall Mounted Fan	4	60W	240	0.24	16	3.84
Exhaust Fan	6	60W	240	0.24	10	2.4
3Phase Motor	1	1.5KW	2680	2.68	12	32.16
Single Phase Motor	1	0.75KW	1340	1.34	12	16.08
Outlet Motor	1	1.5KW	2680	2.68	4	10.72
Inlet Motor	1	0.75Kw	1340	1.34	4	5.36
Vacuum Pump Motor	1	1.5KW	2680	2.68	8	21.44
Press Machine	1	3.75KW	6700	6.7	12	80.4
Hot air Chamber	1	24KW	32160	32.16	8	257.28
		Total	52020			461.04

Table: 1 Total power consumption of Different Existing Load

The Performance of the existing machines and electrical Loads for commercial building is shown in Table 1. This table shows that almost all machines were not being operated with their maximum capacity. It means that the motors used in these machines are higher rating or over sized. Existing Load should be replaced which needs to be reduced by energy auditing. Monthly Rs.1, 16,000/- (approximately) is added in

Electricity bill. It is a high cost paid by consumer which needs to be reduced by energy auditing.

For TANGEDCO's work shop (commercial building) Tube lights and Sodium Vapour lamps are to be replaced by LED lights, Ceiling fans, wall mounted fans and exhaust fans are to be replaced by BLDC motor fans.

Load	Quantity	Power	Total Power (W)	Units	Hours	Total Units
LED Light	12	20W	240	0.24	16	3.84
LED Light	4	80W	320	0.32	16	5.12
Ceiling Fan	8	35W	280	0.28	16	4.48
Wall Mounted Fan	4	30W	120	0.12	16	1.92
Exhaust Fan	6	35W	210	0.21	10	2.1
3Phase Motor	1	1.5KW	2680	2.68	12	32.16
Single Phase Motor	1	0.75KW	1340	1.34	12	16.08
Outlet Motor	1	1.5KW	2680	2.68	4	10.72
Inlet Motor	1	0.75Kw	1340	1.34	4	5.36
Vacuum Pump Motor	1	1.5KW	2680	2.68	8	21.44
Press Machine	1	3.75KW	6700	6.7	12	80.4
Hot air Chamber	1	24KW	32160	32.16	8	257.28
		Total	50750			440.9

Table 2: Total Power Consumption of Proposed Load-Commercial Building

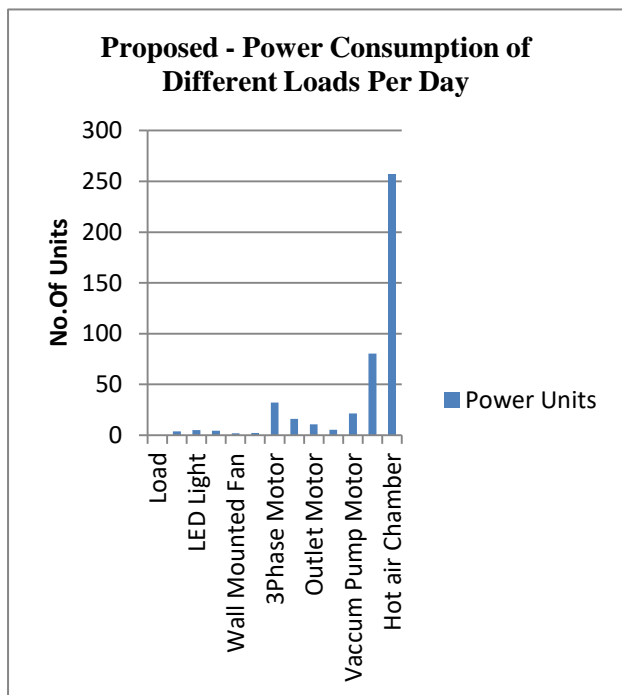


Figure 1: Bar chart of Total power consumption of Different Existing Load

The Cost expenses for replacing existing loads by proposed loads Rs.50, 600/- Which is Rs.23, 000/- higher than the existing loads?

Cost of Using Existing Loads per day
Rs.8x 37.6 Units= Rs.301.00

Cost of Using Proposed Loads per day
Rs.8x 17.46Units=Rs.140.00

Total Savings Per day Using Proposed Loads=**Rs.161.00**
Saving Per Year Using Proposed Loads=**Rs.161*365=58765.00**

Payback Time =10 months 15days
B.Energy Audit- Residential Building:

The walk-through process can be start after familiarized with the building, if the building blueprints and other electrical appliance information available describes the building and its operation accurately. In the walk-through audit, the building layout can be studied by a walk around the building. In the model analysis, the building must be divided into zones for analysis. The building survey would include that the air-conditioning system is as indicated on plans. In the building layout, the type and condition of the windows, effectiveness of window seals will be noted. In the building, typical lighting and power requirements, occupancy and space usage are also noted. This information regarding building could be compared against the recommendations in the relevant Codes of Practices. The survey of mechanical rooms and plant room can give system and plant data. Name plate information could be compared against those in the building's documents, and pumps and chillers room can be visited for estimating the load on the system.

The auditing team have discussed with the building maintenance staff further on the operating schedules and seek clarification on any unusual pattern in the trend of the utility bills. Unusual patterns such as sudden increase or decrease in utility bills could be caused by changes in occupancy in the

building, or change in use by existing tenants. It is not uncommon for tenants to expand their computing operations that may increase the energy use significantly.

The electrical devices which are connected in residential building are not energy saving devices. These devices can be changed by electrical efficient appliances. The appliances are of high watt equipment so the electrical consumption is high in Residential Building.

Now-a-days low wattage appliances are used in building. They are helpful in saving electricity. In the below table 4, some appliances which are recommended for replacement so as to save energy and the amount of investment required and its payback period is given below:

- Tubes and CFL can be replaced by LEDs.
- Normal Fan and Wall fan can be replaced by 5-star rated Fans.
- Flood lights are replaced by LED lights with adequate lumens.
- Outdoor lights are replaced by LED lights.
- Normal PC are replaced by 7th gen PCs.

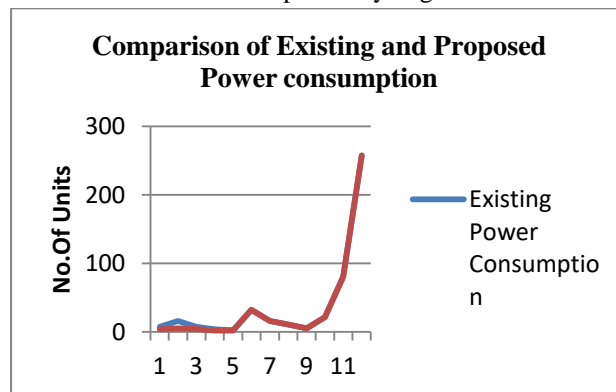


Figure 2: Comparison of Existing and Proposed power consumption

Item	Qty	Cost Per Unit	Total Cost
LED Light 20W	12	250	3000
LED Light 80W	4	700	2800
Ceiling Fan 35W	8	2600	20800
Wall Mounted Fan 30W	4	3000	12000
Exhaust Fan 35W	6	2000	12000
Proposed Cost		Total	50600
Tube Light 40W	12	150	1800
Sodium Vapour Lamp 250W	4	250	1000
Ceiling Fan 60W	8	1200	9600
Wall Mounted Fan 60W	4	2000	8000
Exhaust Fan 60W	6	1200	7200
Existing Cost		Total	27600

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Table 4: Comparison of Existing load and Proposed Load power consumption for single flat in residential building

Sl. no	Components	Watts	Units	Components	Watts	Units	Total units	Amount of units	Payback Period
1.	CEILING FAN ** (1500/-)	75w / 8h	18unit / months (8 hr / month)	SUPER FAN ***** (2600/-)	35w	8.4 unit / months	9.6 unit / months	63.36 (6.60 Rs/unit)	1 year 3 months 3 days
2.	2 STAR AC ** (20,281/-)	1709w / 8h	410.16 unit / month	5 STAR AC ***** (34,690/-)	1490w	357.6 unit/ month	52.56 unit/ month	356.896 (6.60 Rs/unit)	3 year 1 month 25 days
3.	LIGHT (2600lm) (485/-) (CFL)	40w / 8h	10.8 unit / month	LIGHT (2600lm) (680/-) (LED)	28w	6.72 unit/ month	4.08 unit/ month	26.928 /- (6.60 Rs/unit)	7 m 5days
4.	3 STAR REFRIGIRATOR 200Ltr *** 14,099/-	24.2 w / hr	17.424 unit/ month	5STAR REFRIGIRATOR 200Ltr ***** 16,990/-	14.75 w/h	10.62 unit/ month	6.804 unit/ month	44.9064 /- (6.60 Rs/unit)	2 month 4 days
5.	3 STAR WASHING MACHINE *** (7KG) 16,509/-	52.97 W / h	1.5891 unit / month	5 STAR WASHING MACHINE ***** (7Kg) 18,994/-	28.2 w / h	0.845 unit/ month	0.7441 unit/ month	4.9104/- (6.60 Rs/unit)	1 year 4 mnths 21 days
6.	3 STAR Micro Owen (20Ltr) 5,925/- ***	700 w/h	21 unit / month 2hr	5 STAR Micro Owen (20Ltr) 11,099/- *****	500 w/hr	15 unit / month 2hr	6 unit / month 2hr	39.6 /- (6.60 Rs/unit)	4 month 21 days
7.	3 STAR LED TV *** 40"/102 cms (22,990/-)	32.1 w/h	7.704 unit / month	5 STAR LED TV ***** 40"/102 cms 25,499/-	20.55 w/h	4.932 unit / month	2.772 unit / month	18.2952 (6.60 Rs/unit)	4 month 17 days
8.	3 STAR MIXER GRINDER 2337/- ***	600 w/h	9 unit / month 30 mints	5 STAR MIXER GRINDER (2835/-) *****	550 w/hr	4.95 unit / month 30 minits	4.05 unit / month	26.73 (6.60 Rs/unit)	18 days 6 hrs

9.	2 STAR HEATER (8,372/-) 15L	2000 w/h	60 unit / month 1hr	5 STAR HEATER (10,677/-) 15L	1500	45 unit / month 1hr	15 unit / month 1hr	99 /- (6.60 Rs/unit)	24 days
10.	WATER PUMP (2hp) jet pump 11,713/-	1491 w/h (940ltr/hr)	940 ltr / hr (1491) 44.73 unit/ month	WATER PUMP (2hp) 22,260/- submersible pump	417 w/h (940ltr/hr)	3360 ltr / hr (940 ltr = 417 w) 12.51 unit/ month	32.22 unit/ month	212.65 /- (6.60 Rs/unit)	1 months 20 days
11.	3 STAR GRINDER 5499/- ***	200 w/h	40 Unit/month of 10 days	5 STAR GRINDER 6090/-	150 w/h	3 unit/ month of 10 days	1 unit/ month of 10	6.60 /- (6.60 Rs/unit)	2 months 28 days
12.	3 STAR IRON BOX 449/- ***	1200 w/h	36 unit/ month	5 STAR IRON BOX 726/- *****	1000 w/h	30 unit/ month	6 unit/ month	39.6 /- (6.60 Rs/unit)	5days 8 hrs

Table 5: Power Consumption of Existing Load per Day for single flat in residential building

EXISTING LOAD	QTY	POWER (W)	TOTAL POWER (W)	UNITS	HOURS	TOTAL UNITS
CEILING FAN	5	75	375	0.375	8	3
2 STAR AC	3	1709	5127	5.127	8	41.016
TUBE LIGHT	8	40	320	0.32	8	2.56
3 STAR REFRIGERATOR	1	24.2	24.2	0.0242	24	0.5808
3 STAR WASHING MACHIN	1	52.97	52.97	0.05297	1	0.05297
3 STAR MICRO OWEN	1	700	700	0.7	1	0.7
3 STAR LED TV	1	32.1	32.1	0.0321	8	0.2568
3 STAR MIXER GRINDER	1	600	600	0.6	0.5	0.3
2 STAR HEATER	2	2000	4000	4	1	4
WATER PUMP JET	1	1491	1491	1.491	1	1.491
3 STAR GRINDER	1	200	200	0.2	1	0.2
3 STAR IRON BOX	1	1200	1200	1.2	1	1.2
TOTAL UNITS CONSUMED PER DAY						55.35757



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PROPOSED LOAD	QTY	POWER (W)	TOTAL POWER (W)	UNITS	HOURS	TOTAL UNITS
SUPER FAN	5	35	175	0.175	8	1.4
5 STAR AC	3	1490	4470	4.47	8	35.76
LED LIGHTS	8	28	224	0.224	8	1.792
5 STAR REFRIGERATOR	1	14.75	14.75	0.01475	24	0.354
5 STAR WASHING MACHIN	1	28.2	28.2	0.0282	1	0.0282
5 STAR MICRO OWEN	1	500	500	0.5	1	0.5
5 STAR LED TV	1	20.55	20.55	0.02055	8	0.1644
5 STAR MIXER GRINDER	1	550	550	0.55	0.5	0.275
5 STAR HEATER	2	1500	3000	3	1	3
WATER PUMP SUBMERSIBLE	1	417	417	0.417	1	0.417
5 STAR GRINDER	1	150	150	0.15	1	0.15
5 STAR IRON BOX	1	1000	1000	1	1	1
TOTAL UNITS CONSUMED PER DAY						45.9146

Table 6: Power Consumption of Proposed Load per Day for single flat in residential building

EXISTING LOAD	QTY	PRICE	TOTAL COST(Rs.)
CEILING FAN	5	1500	7500
2 STAR AC	3	20281	60843
CFL	8	485	3880
3 STAR REFRIGERATOR	1	14099	14099
3 STAR WASHING MACHIN	1	16509	16509
3 STAR MICRO OWEN	1	5925	5925
3 STAR LED TV	1	22990	22990
3 STAR MIXER GRINDER	1	2337	2337
2 STAR HEATER	2	8372	16744
WATER PUMP JET	1	11713	11713
3 STAR GRINDER	1	5499	5499
3 STAR IRON BOX	1	449	449
TOTAL COST OF EXISTING LOAD			Rs. 168488

Table 7: Total cost of existing Load for single flat in residential building

PROPOSED LOAD	QTY	PRICE	TOTAL COST(Rs.)
SUPER FAN	5	2600	13000
5 STAR AC	3	34690	104070

LED LIGHTS	8	380	3040
5 STAR REFRIGERATOR	1	16990	16990
5 STAR WASHING MACHIN	1	18994	18994
5 STAR MICRO OWEN	1	11099	11099
5 STAR LED TV	1	25499	25499
5 STAR MIXER GRINDER	1	2835	2835
5 STAR HEATER	2	10677	21354
WATER PUMP SUBMERSIBLE	1	22260	22260
5 STAR GRINDER	1	6090	6090
5 STAR IRON BOX	1	726	726
TOTAL COST OF PROPOSED SYSTEM			Rs. 245957

Table 8: Total cost of proposed system for single flat in residential building

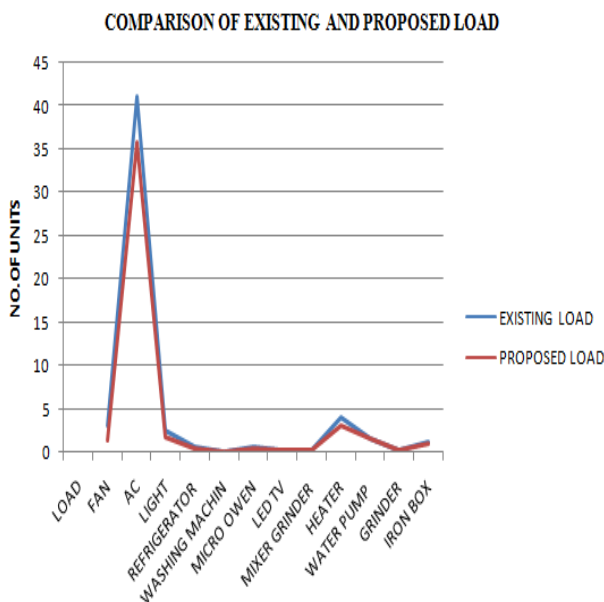


Figure 3: Comparison of Existing and Proposed Load for single flat in residential building

The Cost expenses for replacing existing loads by proposed loads Rs.2, 45,957/-. Which is Rs.77, 469/- higher than? the existing loads.

Cost of Using Existing Loads per day **Rs.5x 55.35 Units=Rs.276.75**

Cost of Using Proposed Loads per day **Rs.5x45.91Units=Rs.229.55**

Total Savings Per day Using Proposed Loads = **Rs.47.20**

Saving Per Year Using Proposed Loads = **Rs.47.20*365 = Rs.17228.00**

Pay-back Time =4 years 6 months

IV.CONCLUSION

Considering the current Scenario the loss of energy is generally done by the industrial and domestic users next to

major industries such as Cement and Steel, Paper and Pulp, Generating Stations etc., as stipulated in the Energy Conservation Act 2001. Hence recommendations were made to use the efficient and economic electric equipments for both the TANGEDCO work shop and domestic users so as to maximize the energy usage with less loss. In this way the Energy Produced can be reduced which in turn can reduce carbon emissions and also the global warming. The recommendations are to be monitored for effective implementation and Energy conservation measure should be given a top priority to achieve energy savings. After implementation are to be monitored to quantify the achievement due to energy audit measures. By implementing the proposals suggested, the following economic and environmental benefits can be achieved:

- Reduction of power cost of the TANGEDCO workshop and the Residential Building
- Prevention of atmospheric emissions which pollutes the atmosphere.

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